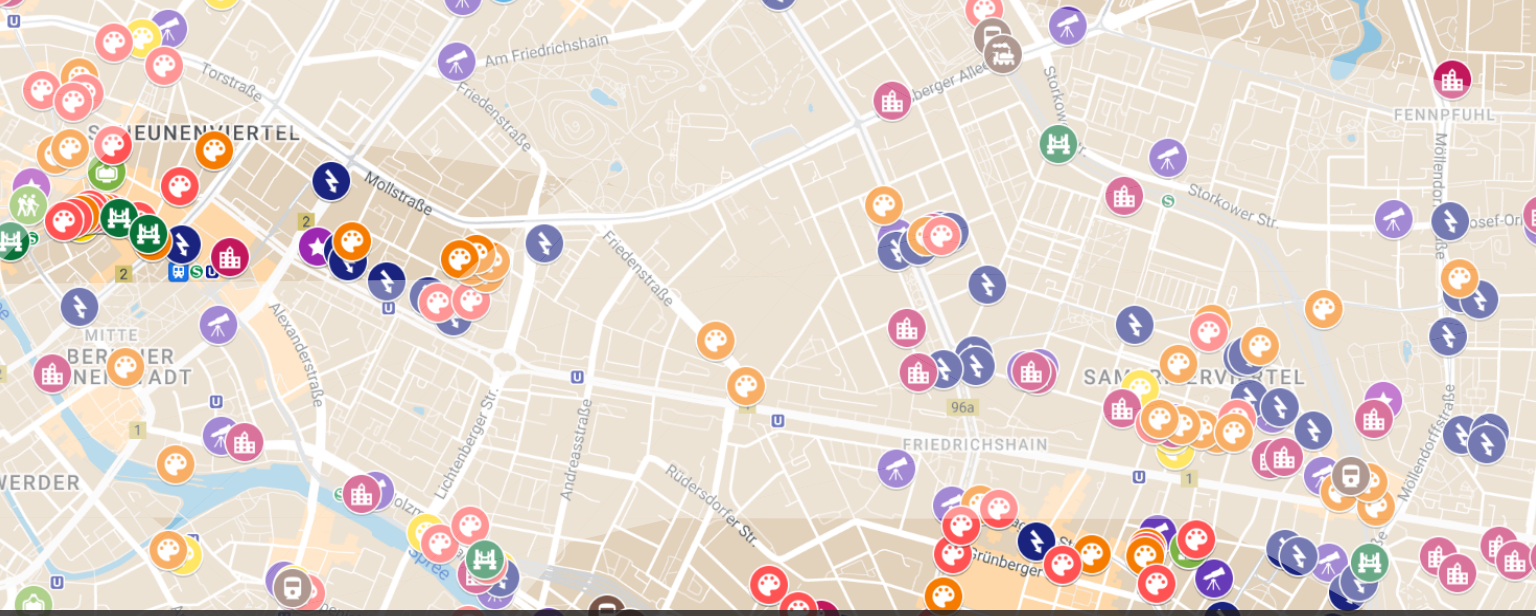

disseminate | analyse | understand graffiti-scapes

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Stefan Wogrin

Publishing
Urban Creativity / AP2 Pedro Soares Neves

Contact and information
info@ap2.pt
info@go-indigo.eu

Dissipating and Unravelling Bits of Graffiti Bytes

Geert J. Verhoeven [1,*], Jona Schlegel [2] , Benjamin Wild [3] and Stefan Wogrin [4]

[1] University of Vienna - Department of Prehistoric and Historical Archaeology, 1190 Vienna, Austria; E-Mails: geertprojectindigo.eu; geert.verhoeven@univie.ac.at
[2] Independent researcher, Vienna, Austria; E-Mail: jona.schlegel@gmail.com
[3] TU Wien - Department of Geodesy and Geoinformation, 1040 Vienna, Austria; E-mail: benjamin.wild@geo.tuwien.ac.at
[4] Spraycity, Austria; E-Mail: stefan.wogrin@spraycity.at
* Corresponding author

1. Graffiti to Disseminate | Dissemination of Graffiti

Graffiti are a form of visual mark-making involving an individual or a group. Despite their millennia-long history, modern graffiti writing became closely associated with the Hip-Hop cultural movement that emerged in the early 1970s from the Bronx in New York City. As Hip-Hop matured, the release of the movie Wild Style in 1983 became a cinematic manifesto that captured and immortalised the energy of this expanding movement. In doing so, Wild Style also spotlighted the rebellious strokes of graffiti writers, whose creations in the streets and subways of American metropoles were born from a melting pot of adversity and a desire for self-expression. However, much of the modern graffiti scene has changed since Wild Style. Contemporary graffiti metamorphosed from a localised manifestation into a global phenomenon, with graffitists who continue pushing creative boundaries, challenging societal norms, and evolving the discourse around public spaces. The varied and ever-expanding coverage of graffiti in books, movies, exhibitions, press, websites, social media, and public events was one of the reasons for, but also a direct consequence of this substantial change. Magazines, movies, photo books and exhibitions provided the initial exposure boost to contemporary graffiti and graffiti writing culture. As a result, new people started dipping their toes into graffiti (for artistic, rebellious or other reasons); this led to an extension of graffiti's graphical repertoire, triggering renewed inspiration and even more coverage. Over time, this reciprocal relationship effectuated that 'graffiti to disseminate (a message)' got increasingly complemented by the 'dissemination of graffiti'.

This process of dissemination transformation bore intriguing similarities to what had happened with ancient graffiti. *"Admiror o pariens te non cecidisse ruinis qui tot scriptorum taedia sustineas"* (I am amazed, oh wall, that you have not fallen into ruins since you hold the boring scribbles of so many writers). This graffito—found on the basilica's walls during the excavations of Roman Pompeii in present-day Italy (Ancient Graffiti Project, 2023)—attests to the large quantities of ancient graffiti that must have covered this large public building two millennia ago, thus revealing the same 'graffiti to disseminate' impulse, the same drive of modern graffiti creators to communicate with a broader audience. From the 19th century onwards, archaeologists and historians started documenting and studying such ancient graffiti: the scholarly dissemination of ancient graffiti had started.

2. One Graffito, Many Approximations

In the year 79 CE, the Pompeiian graffito mentioned above was covered by volcanic ash and pyroclastic surge deposits from Mount Vesuvius' eruption. This graffito kept existing, albeit devoid of human observation. Approximately nineteen centuries later, it resurfaced, got documented and started its second visibility period. Nowadays, that graffito is no longer observable *in situ* but displayed in the National Archaeological Museum of Naples. However, visiting the museum is only necessary to view the physical graffito. A digital representation of the graffito (e.g., as an image) along with relevant information like the language and writing style (so-called graffito metadata) can be found in various locations, the website of the Ancient Graffiti Project (http://ancientgraffiti.org) being one of them.

Such digital representations are known as digital resources in information technology. Regardless of their numerous possible forms (e.g., text files, spreadsheets, photos, three-dimensional surface meshes, databases), any digital graffito resource uses bits and bytes to encode one or more aspects of the physical graffito in some way. In archaeology, several papers pondered which terminology to use for these digital 'forms' of an original physical resource (Endres, 2012; Garstki, 2017; Rabinowitz, 2015). Are they digital representations, reproductions, surrogates, proxies, incarnations, avatars or facsimiles? Which term best conveys the deficits, commonalities, and advantages of these digital versions when compared to their physical antecedent? For many reasons, 'digital approximation' seems to be the most neutral and accurate term, simply because digitising can only approximate one of the infinite dimensions of a physical object.

When documenting a spray-painted graffito via digital photography, the resulting photos do not provide digital data on the paint's smell, temperature or thickness. In that sense, almost no digitising effort can provide data on all aspects of a physical asset. Because the digital resource is always an incomplete representation, exhaustively 'preserving' cultural heritage like graffiti in the digital realm is impossible. Even if all properties could be digitised (like for an audio signal), the resulting digital resource is still an approximation; it is imperfect because digitising uses sampling to discretise any analogue (i.e., continuous) property to a finite set of digital values.

3. Approximations Facilitate Dissipation and Analyses

In most cases, digitising all aspects of a physical, analogue resource is impossible, which is why digital documentation has only a modest role in preserving cultural heritage (Brown, 2005). However, if done correctly, the digital resources resulting from the digital documentation can still help us manage, distribute, visualise, examine and safeguard specific aspects of that physical resource. In the words of Korzybski: "A map is not the territory it represents, but, if correct, it has a similar structure to the territory, which accounts for its usefulness" (Korzybski, 1933, p. 58).

Ideally, one aims for excellent digital documentation of certain real-world graffiti aspects by purposefully acquiring data and metadata. *Data* are the raw, uncontextualised and meaningless stuff. To cite Schöch, digital data in the Humanities are "selectively constructed, machine-actionable abstraction representing some aspects of a given object of humanistic inquiry" (Schöch, 2013, p. 4). *Data* are called *information* when processed (e.g., cleaned, transformed, renamed) into a form consumable by a human. Analogous to how work is required to release potential energy, data are potential information, but work is needed to obtain it (Pomerantz, 2015). [Note that we ignore the philosophical debate about whether information only has the potential to inform or must actually inform.] Metadata are second-order (i.e., meta) data about data. Although metadata are data, it is more accurate to call them information because they should be informative. They promote the discovery of resources, structure them, support their administration and facilitate analyses.

Digital graffito documentation typically yields digital photographs. These digital resources can provide information on a graffito's colour, width and height, location, surface topography and physical surroundings. Other graffito metadata—like creator, legal character, moment of production and time of destruction—might be derived from a digital resource or obtained via observation of the physical graffito. Usually, all those metadata are stored in a spreadsheet or database, two other examples of digital graffito resources. Suppose any digital documentation is followed by strategies to digitally safeguard, disseminate, and analyse these imperfect digital resources. In that case, there is hope to (better) understand the multi-faceted nature of the ancient and contemporary graffiti-scapes from which these resources originated. This train of thought guided the organisation of the goINDIGO 2023 symposium.

4. From goINDIGO 2002 to goINDIGO 2023

In 2022, the academic project INDIGO organised the goINDIGO 2022 symposium to discuss the documentation, archiving and dissemination of graffiti-scapes (Verhoeven, Schlegel, Wild, & Wogrin, 2023). Since goINDIGO 2022

mainly covered more technical aspects of graffiti research, a second symposium tackling more humanistic-oriented aspects was conceptualised already during the INDIGO application phase. As a result, goINDIGO 2023 became a reality slightly over one year after the initial goINDIGO symposium. From 14-16 June 2023, 62 participants from 13 countries gathered in Vienna, Austria, to discuss the dissemination, analysis, and understanding of ancient and modern graffiti-scapes.

As Figure 1 visualises, "dissemination" formed the topical overlap between both symposia. This not only made the symposia's connection more explicit; it also provided extra room to cover the wide variety of graffiti dissemination activities and divided the 2023 symposium into three topical parts, similar to the 2022 symposium.

Throughout two and a half days, three keynote lectures and eighteen presentations touched upon many facets of disseminating, analysing, and understanding graffiti-scapes. The word cloud generated from the goINDIGO 2023 book of abstracts (Verhoeven, Schlegel, Wild, Wogrin, et al., 2023) reflects this topical diversity (Figure 2). Apart from one regular talk and one keynote, all presentations can be rewatched via the goINDIGO 2023 YouTube playlist (https://www.youtube.com/playlist?list=PLATjvnj_VR_BWSbqS4BiZoqFx7COBAOWf).

The dedicated "graffiti dissemination" discussion session between academics and graffiti creators was not recorded to respect the anonymity of the latter. The discussion's transcript was also omitted from this volume, as the editors felt it lacked the added value that characterised the written-out 2022 discussions (Merrill et al., 2023; Wild et al., 2023). However, these proceedings do include the thoughts and ideas shared during the opening keynote and ten of the eighteen subsequent presentations. Including one non-symposium contribution, this book bundles twelve unique viewpoints on the dissipation, exploration, and unravelling of graffiti-scapes.

5. Overview of This Volume

This volume groups all papers according to the main themes of goINDIGO 2023:

- **Disseminating** is the act of spreading (meta)data, information, knowledge or wisdom, whether in analogue, digital, or hybrid form. Scientific papers, a website, an exhibition, an archive, and a non-specialist presentation are all valid ways to disseminate (scholarly) results.
- **Analysing** refers to the entire process of quantitatively or qualitatively studying or evaluating one or more characteristics of a physical or digital resource. Depending on the (meta)data and the properties one wants to analyse, one or more methods are suitable.

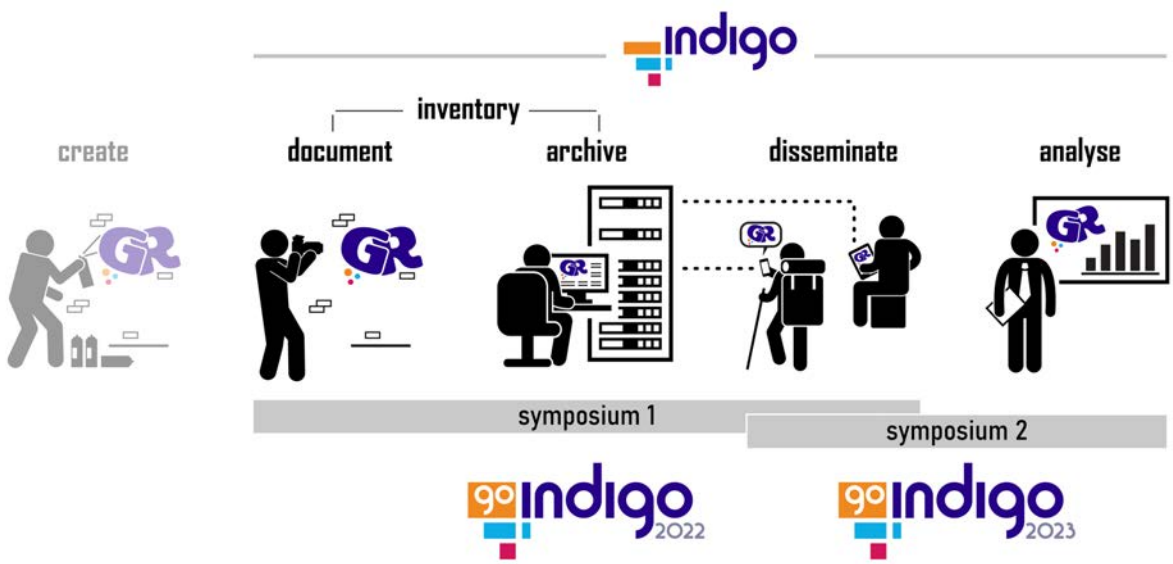

Figure 1. The main goals of project INDIGO and how they fit within the two goINDIGO symposia.

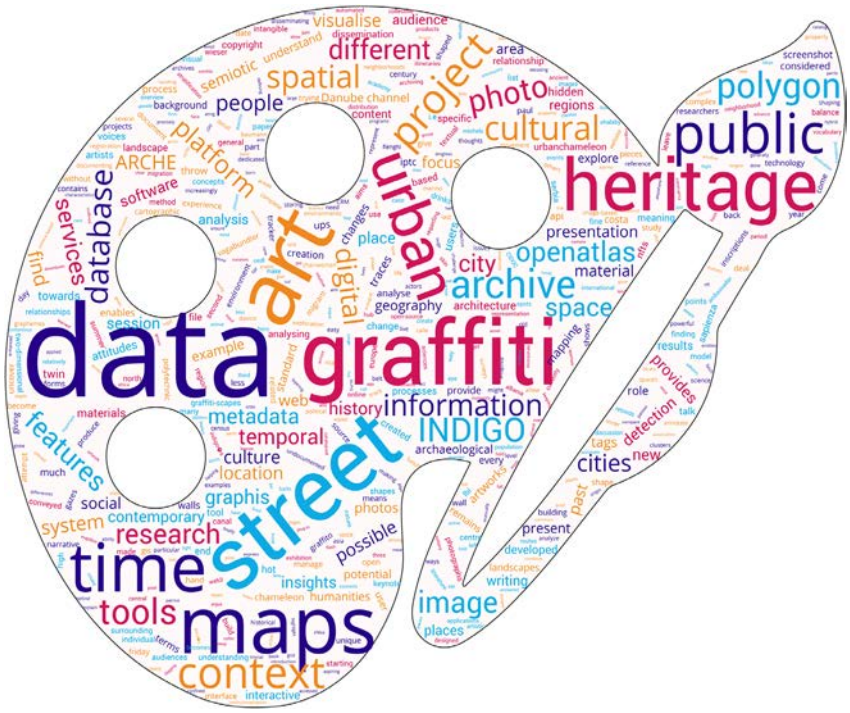

Figure 2. The word cloud extracted from the goINDIGO 2023 book of abstracts.

Analysis should be as objective and systematic as possible to make sense.

- **Understanding** implies a more profound comprehension of properties once they are analysed and contextualised. Concerning humans, understanding can also mean "looking at things from another person's point of view" to understand that person's stance on certain things. In that way, analysing could also be considered "looking at things from our point of view".

However, these proceedings had to combine the latter two themes since there was no clear-cut distinction between papers about "analysing" and "understanding" graffiti. Although this volume thus only features two main sections, some papers in these proceedings still deal with both topics. In those cases, papers were assigned a section according to their primary focus.

The first two papers in the **DISSEMINATION** section present well-known graffiti websites: Art Crimes and Vagabundler. As the opening keynote speaker of goINDIGO2023, *Brett Webb* tells his personal graffiti story in "Building Art Crimes: Highs and Lows". Art Crimes was likely the first graffiti website launched on the World Wide Web back in 1993. Despite all odds, this pioneering website is still online after three decades, continuing to inspire people. The same kind of inspiration, along with graffiti tours in many large cities worldwide, can be found on the Vagabundler website. The quantity of graffiti-related information on this website is astonishing. *Gunther Michels*, Vagabundler's driving force, details in the second paper how this information is continuously collected, managed and made accessible via maps. However, whereas Vagabundler and the vast majority of graffiti websites map graffiti in spatially two-dimensional (2D) maps, *Oskar Baumann* describes in "Graffiti Exploration via Interactive Web Maps" his academic endeavour to disseminate graffiti via three-dimensional (3D) Web-based maps, leveraging even adaptive symbols to represent graffiti optimally across various map scales.

Creating a digital 3D world is also one of the primary aims of Urban Chameleon, INDIGO's envisioned open-access

platform for visually and analytically exploring its monitored graffiti-scape. In "Getting Hold of the Urban Chameleon", *Jona Schlegel et al.* provide an in-depth overview of Urban Chameleon's development process. Urban Chameleon gets most of its input via services run by the Austrian Centre for Digital Humanities and Cultural Heritage (ACDH-CH). These services are described in the "Data Crew" paper by *Martina Trognitz et al.* The paper explains how the digital archive ARCHE, the spatial database OpenAtlas, and the Vocabs repository for controlled vocabularies are part of the core infrastructure used by the ACDH-CH to digitally safeguard, structure and disseminate much of INDIGO's (meta)data. However, other projects can also use these services to publish cultural heritage-related data and insights in ways that align with the goals and practices of the Semantic Web.

In the last paper of this section, *Geert Verhoeven et al.* delve further into the world of semantic data, more specifically, photo metadata standards and controlled vocabularies. Although discussions on standardised metadata and terminology are seldom encountered in graffiti research, scientific management and stewardship of digital resources can not work without these vital components. However, graffito metadata like type and colour often only apply to a delineated portion of a given photograph. Hence, the authors developed the open-source GRAPHIS software in which users can create image regions for metadata annotation. Since GRAPHIS can also store this region and annotated metadata inside the photograph, it enables refined dissemination and analysis of graffito-specific information. In that way, this "GRAPHIS" paper nicely bridges to the second section.

The **ANALYSING & UNDERSTANDING** section kicks off with "The first complete census of public artworks in Torino" by *Luca Davico et al.* Based on an analysis of existing collections, this public artworks census enables policymakers, artistic associations, and scholars to research these artworks. Documenting and analysing stone inscriptions is the topic of the following two papers. First, *Giulia Flenghi et al.* elaborate on their "Talking City" project, which maps little-known graffiti and epigraphy in Rome to build narrative itineraries throughout the city. *Ruth Tenschert et al.* explain in their "Eternal Witnesses" paper how examining different types of graffiti necessitated different recording methods and how weathered graffiti could be made legible again.

These three 'hands-on' contributions are followed by three more theoretical papers, each highlighting the multidimensional nature of graffiti analysis. In "Each Graffito Deserves Its Polygon", *Geert Verhoeven et al.* explore ways of tracking and managing the temporality of graffiti, hoping that one day such approaches will allow for detailed spatio-temporal analyses of entire graffiti-scapes. Space and time also play a central role in *Francisca Fernandez Merino*'s work. In her "Outer Space, Inner Time" paper, Francisca emphasises the need to consider the relationship between graffiti and their audience. To that end, she explores how embodiment can provide a fresh perspective on the meaning of context, time, and space in graffiti research. The last paper by *Valentina Tretti-Beckles* and *Adrián Vergara-Heidke* also contributes to a broader understanding of graffiti by exploring their contextualisation, intentionality, and reception. However, rather than advocating for a relational approach to time and space, the "Attitudes and Gazes from Graffiti" paper investigates how semiotic attitudes and competence shape people's perceptions of graffiti within the context of place-making.

6. Conclusion

In the year of Hip-Hop's 50th anniversary and the 40th birthday of Wild Style, goINDIGO 2023 managed to bring various disciplines together to discuss the various ways of dissipating and understanding bits of graffiti bytes. The proceedings of this symposium pick up and reiterate where the previous proceedings left off: with the contemporary ways of disseminating old or new graffiti. Afterwards, several papers discuss practical and theoretical ways to unravel graffiti-scapes and develop new insights.

In summation, tackling graffiti as sociocultural artefacts demands multidisciplinary frameworks. We, the editors, hope the interconnected graffiti themes covered here and in the goINDIGO 2022 proceedings provide inspiration and an up-to-date overview of various framework components to deal with ancient and contemporary graffiti-scapes.

Acknowledgements

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References

Ancient Graffiti Project. (2023). *Graffito AGP-EDR158840*. http://ancientgraffiti.org/Graffiti/graffito/AGP-EDR158840

Brown, M. F. (2005). Heritage Trouble: Recent Work on the Protection of Intangible Cultural Property. *International Journal of Cultural Property*, 12(01), 40–61. https://doi.org/10.1017/S0940739105050010

Endres, W. (2012). More than Meets the Eye: Going 3D with an Early Medieval Manuscript. In C. Mills, M. Pidd, & E. Ward (Eds.), *Proceedings of the Digital Humanities Congress 2012*. The Digital Humanities Institute. https://www.dhi.ac.uk/books/dhc2012/more-than-meets-the-eye

Garstki, K. (2017). Virtual Representation: The Production of 3D Digital Artifacts. *Journal of Archaeological Method and Theory*, 24(3), 726–750. https://doi.org/10.1007/s10816-016-9285-z

Korzybski, A. (1933). *Science and sanity: An Introduction to Non-Aristotelian Systems and General Semantics*. The International Non-Aristotelian Library Publishing Company.

Merrill, S., Verhoeven, G. J., Wild, B., JANER ONE, MANUEL SKIRL, SERT, SNUF, Carloni, M., de la Iglesia, M., Fernandez Merino, F., Radošević, L., Ricci, C., Schlegel, J., & Wogrin, S. (2023). 'different folks, different strokes': goINDIGO 2022's «Creators vs Academics» discussion round. In G. J. Verhoeven, J. Schlegel, B. Wild, S. Wogrin, & M. Carloni (Eds.), Document | archive | disseminate graffiti-scapes. Proceedings of the goINDIGO2022 international graffiti symposium (pp. 25–44). Urban Creativity. https://doi.org/10.48619/indigo.v0i0.701

Pomerantz, J. (2015). *Metadata. The MIT Press essential knowledge series*. The MIT Press.

Rabinowitz, A. (2015). The Work of Archaeology in the Age of Digital Surrogacy. In B. R. Olson & W. R. Caraher (Eds.), *Visions of substance: 3d imaging in Mediterranean archaeology* (27–42). The Digital Press @ The University of North Dakota.

Schöch, C. (2013). Big? Smart? Clean? Messy? Data in the Humanities. *Journal of Digital Humanities*, 2(3), 2–13.

Verhoeven, G. J., Schlegel, J., Wild, B., & Wogrin, S. (Eds.) (2023). *Disseminate | analyse | understand graffiti-scapes. Proceedings of the goINDIGO2023 international graffiti symposium*. Urban Creativity.

Verhoeven, G. J., Schlegel, J., Wild, B., Wogrin, S., Baumann, O., Bonadio, E., Carloni, M., Davico, L., DEADBEAT HERO, Egeland, S.-H., Fernández Merino, F., Flenghi, G., Guerreschi, P., Ippoliti, E., Jungfleisch, J., Koschicek-Krombholz, B., Lorah, P., Meschini, A., Michels, G., . . . Wieser, M. (2023). goINDIGO 2023 international graffiti symposium: Disseminate | analyse | understand graffiti-scapes. Book of abstracts. Vienna. project INDIGO. https://doi.org/10.5281/zenodo.8029994

Wild, B., Verhoeven, G. J., Pfeifer, N., Bonadio, E., DEADBEAT HERO, FUNKY, JANER ONE, MANUEL SKIRL, Carloni, M., Ricci, C., Koblitz, C., Niemann, S., Radošević, L., Schlegel, J., Watzinger, A., & Wogrin, S. (2023). 'imagine being a racist': goINDIGO 2022's «Ethics & legality in graffiti (research)» discussion round. In G. J. Verhoeven, J. Schlegel, B. Wild, S. Wogrin, & M. Carloni (Eds.), *Document | archive | disseminate graffiti-scapes. Proceedings of the goINDIGO2022 international graffiti symposium* (pp. 45–62). Urban Creativity. https://doi.org/10.48619/indigo.v0i0.702

Building Art Crimes: Highs and Lows

Brett Webb
Spray Street, USA; E-Mail: brett@spraystreet.com

Abstract
This keynote address for the goINDIGO 2023 symposium is a personal telling of the author's experiences in the world of graffiti documentation before, during and after working on Art Crimes (https://www.graffiti.org) with Susan Farrell. Art Crimes was created in 1993 and it was the first website dedicated to graffiti and street art. The paper attempts to highlight the risks to the practitioners and advocates of graffiti through personal stories and the challenges of organizing large quantities of images from diverse geographies.

Keywords
Graffiti; Hip-hop; Street art; World Wide Web

1. Introduction

I have been waiting for this moment for a long time. The moment when academics and librarians took a serious interest in documenting, researching and studying graffiti. I can remember sketching database schemas in my notebooks around 2000, before there was really the possibility of, or the capabilities of me personally putting a database behind Art Crimes. If you look at those sketches, they are very similar to what the INDIGO crew came up with for their ontology of classifying images for graffiti (Schlegel et al., 2023).

Before I helped run Art Crimes (http://www.graffiti.org) with the founder, Susan Farrell, I was a graffiti practitioner. Some of my early influences growing up in Fresno, California, were the local gang graffiti, primarily Mexican–American gang writing, that I saw around my town. It was always very powerful and omnipresent. I think some of the power came from the fact that when people talked about it, they were scared about what it meant. That fear made it more important to me. There were some hip-hop-style writers around, as well. Specifically, someone who wrote Scribe left a big impression on me. They were up all over

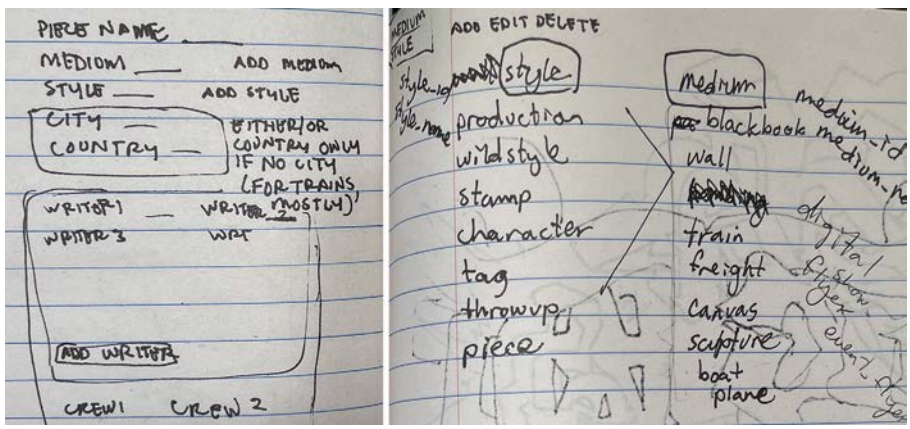

Figure 1. Images of the author's notebook, circa 2000.

my side of town and had a tag more reminiscent of New York graffiti than gang writing. I would still like to talk to Scribe and learn more about where they came from, but I have never been able to track them down.

Another influence, although not as direct, came from a road trip with my aunt in 1989 across the United States. We largely followed the Oregon Trail route in reverse in the West and continued to New York state via the north. For me, two of the monuments we saw stood out from a graffiti perspective. One was Mount Rushmore, the iconic national monument with faces of presidents carved into the side of a mountain. The other was Register Cliff in Wyoming, where settlers would carve their names into the rock as they passed. As far as I can tell, they carved their names for much the same reason graffiti writers write their names today, to say "I was here". It is a really interesting site and I easily identified with it.

Both of those monuments struck a nerve in me. They made me think about how they permanently destroyed nature and yet are revered. On the other hand, someone putting temporary markings with spray paint or marker ink on a man-made building is vilified in our current society. The two things just never added up in my mind, and they still do not. In retrospect, the two monuments were created by colonizers and celebrated, while gang graffiti is often created by marginalized groups with little real power in society and criminalized.

A little bit before that roadtrip, I remember watching Beat Street (Lathan, 1984) and learning a lot about graffiti and hip-hop, even if it was a Hollywood version of it. I remember learning about sketching your work and planning what it would take to do a piece before executing it on the wall. It really stuck in my mind. I was also lucky enough to take a trip to New York around 1986, and witness the fully painted subway trains, which blew me away. It has been pointed out to me by my mentor Mare 139 that graffiti writers using the MTA transit system in New York for their studio and art gallery was an early case of writers using technology to disseminate their work beyond just keeping it in black books and photo albums, a pre-cursor to writers adopting the internet for similar use cases.

2. Los Angeles, Graffiti Mailing List and Photo Trading

In 1990, I moved to Los Angeles to go to school at the University of Southern California, which really changed my

Figure 2. Photos of Register Cliff by the author, 2021.

life. It was not my first choice school, but I think I was drawn to Los Angeles (LA) because of the vibrant and famous hip-hop scene. I was studying computer science during the day and lived a hip-hop life in the evening. This double life was something that I started before college, in high school, and really has not changed as an adult and father.

One of the first things that made an impact on me in LA, besides all the graffiti, was a shop called the "Hip Hop Shop" that Hex TGO ran in Hollywood on Melrose Avenue. In the shop, there was always something going on—people breaking, there were records available, DJs were spinning. There were always people in there, hitting up black books. There were always amazing murals on the sides of the building and in the alleys all around. Hex was, and still is, one of the style gods of LA. It was the place where I got about spray tips. I remember a lot of photo albums being in there one day. I realized that documenting graffiti was something anyone could do and should do. With all the amazing art around LA, it felt natural to start taking photography and documentation seriously.

As soon as I got to college, I got access to the internet and spent a great deal of my time on it. Back then, submitting homework online was novel and rare, but I was doing that as a computer science student. I was exploring the different corners of the internet and found Usenet. Usenet is a form of bulletin board system that was broken up into different categories called newsgroups, that dealt with a specific subject matter. There were thousands of newsgroups, but two were important to me, in regards to people talking about graffiti: alt.graffiti and rec.music.hip-hop. I made many great connections on those newsgroups. They were really cool and great tools, but they did not have the intimacy that it felt like we needed since it was all out in the public. At this point, I created the first e-mail mailing list for graffiti writers around 1992. It was a way for me to connect with other people, get more information, and expand my network. Some well-known writers like Juice TC5 and Eros NEWAVE crew in New York were on the mailing list, as well as some well-known writers from Chicago. It was the real beginning of me taking a leadership role, albeit small, and to start building my national and international network.

Through the e-mail mailing list, and making other friends online, I started trading physical photos through the mail. They were usually 3" x 5" or 4" x 6" prints that you would get made at the local photo store. As you printed more photos and talked to other writers, you would find the places that made cheaper prints and did not care that you were printing endless copies of graffiti photos. It was a network within the network. Back then, zines were really big; almost all of them had pen-pal ads for people who wanted to trade photos. You would usually send 10–20 photos and it was rare not to get a package back. As you traded with someone, they would tell you about someone else that was trading and you'd end up sending more packages out to more strangers. I did not think of it this way at the time, but it was a way of preserving photos through creating multiple copies that were distributed around the country and world. It was a novel and unintentional approach to offsite archiving.

Recently, there was a show in San Francisco at the Letterform Archive called "Subscription to Mischief", which displayed the archives of Skills Magazine. Many of the same people that I was trading photos with were also sending in packs to magazines like Skills. Lots of those relationships were with people I am still in touch with today and it played a big part in making the scene international.

3. Art Crimes

I was busy painting, making friends, and meeting people in LA while staying active online. Suddenly, the Web started happening, with new sites popping up every day. For the first time, it was really easy to see and share images online. The major technologies, at that point, for accessing the internet, had previously made it challenging to share binary files. You could do it, but downloading them and using them was a whole other set of challenges. The web browser was a real game changer for graffiti, a visual medium.

Within those first couple thousand sites, Susan Farrell put up Art Crimes (http://www.graffiti.org). She had been working on it as a grad school project at Georgia Tech. I joined soon after she made it live in September 1994. It was an expansion of my online experimentation with the mailing list and Usenet. I saw it as an opportunity to learn new tech and

connect technology with graffiti, which had always been a theme for me. Even if it was just Susan in Atlanta, having a friend interested in graffiti in another city was significant. She had a collection of graffiti photos from Prague and Atlanta, and it felt like a way to expand my network. It was not clear if the Web was going to be a big a thing that the public ever accessed, but it was interesting and different than what was possible previously.

Although we did not have a mission statement, we had a couple of implicit goals. We wanted to change the discourse around graffiti and make it more acceptable and we also wanted to give writers more opportunities, which manifested in various ways. For publishing, we mostly focused on legal walls or walls that were tolerated in the community, even if there was no explicit permission. We linked out to crew's and writer's sites, as they sprung up. We also provided space for others who wanted their own sites, but could not figure out hosting somewhere else. There were no big public hosting services at that time, so you had to be scrappy and most likely be connected to a university.

At this time, sites were not really database-driven. They were mostly static HTML that was hand-crafted and updated manually. You had to choose your primary organizational scheme and site structure early, because it was a massive effort to change later. We organized content geographically, starting with cities, then expanding to states, regions, provinces, countries, and continents. This was mainly due to the fact that people's photo collections were from one location and it became easier to give copyright credit to a group of photos this way. Also, at the time styles were highly localized and would be mostly from one city or area. You could see influences when one person would move to another city and influence writers in the new place.

Jake Dobkin, co-creator of the ICF crew website (https://www.graffiti.org/icf), the first website published by and dedicated to a single graffiti crew, told me via text while I was preparing my talk for goINDIGO, "the internet destroyed graffiti culture by making it essentially international and losing variation, which was the thing that made it great. We need a return to artisanal, locavore graf by burning the system to the ground." I agree that a sad side effect of putting together a massive, international photo archive is that local styles have largely disappeared. It used to be really hard to learn about Philadelphia handstyles, but now you see them appear in places all around the world.

Along with the many photos that were published on Art Crimes, we created an international calendar of events, which was a significant part of the site and the culture at that time. Unfortunately, such a meaningful calendar is lacking in the current scene.

Soon after joining Susan on Art Crimes, I was sitting in the computer lab at USC. It was filled with new Mac computers, scanners and really nice monitors. It was state-of-the-art at the time. As silly as it sounds now, the university was showing off this lab to some press people. One of the PR folks from USC saw these images of graffiti on the monitor that I was working on, and asked me what I was doing. I told her about Art Crimes and she asked if we might want some press. I said, "sure" not really understanding what that meant. Very soon after she put us in touch with a Newsweek reporter who was doing a small article on the Web. We ended up being included in an article in the October 24th, 1994 edition of Newsweek, along with a screenshot of Art Crimes shown in the Mosaic browser (Rogers, 1994). It is funny, in retrospect, but it did an awful lot for us personally and the project. It drove traffic to the site and it provided a great sense of legitimacy. At the time, getting a national magazine like Newsweek to cover you was massive. Another fantastic aspect of this was it was the first time I talked about graffiti with my parents and it is a lot easier to have that conversation when your name is in an international magazine for something good.

Art Crimes continued to prosper and get accolades. We got invited to participate in an exhibition at the Historisches Museum in Baden, Switzerland in 1995. In 1996, my personal graffiti work was included in a book called Graffito (Walsh, 1996). It was not my best work. The piece was something that I did in Oakland with a now famous artist and it was not his best work either. Neither of us were happy about that. The book is not well regarded and has inaccuracies throughout.

Figure 3. Photos of Skills Magazine archive by the author, taken at the "Subscription to Mischief" show at the Letterform Archive in San Francisco, 2023.

Figure 4. Screen capture of Art Crimes (www.graffiti.org) homepage, October 2015.

The piece was included without our permission. But, even with all of that, I was okay with being featured in a book. I was excited! There is something about being included in a book that legitimizes you and is more than being included in a zine or a website for that matter, especially at that time.

During the summer of 1996 in LA, you could not miss the graffiti by the writers GK and Juse. They had pieces everywhere. Heavens (high, hard to reach locations like billboards and signs over freeway traffic), freeways, street pieces, everything in full color. In 1997 GK was arrested and ordered to pay $100,000 in restitution and spend some time in jail. Articles appeared all through the press, including the Los Angeles Times (Blankstein, 1997), highlighting the case and they always included something about the arresting officer, Randy Campbell. The day after the Times article ran in the paper, I went to Usenet on alt.graffiti and posted some of my thoughts on the case. Mostly, I poked at Randy Campbell and his handling of the case and what I thought was his desire for fame since he appeared in all of the articles. Apparently, he did not like that. The next day I was told by my boss at USC that he had visited the university and was asking about me. I was terrified. I was supporting myself for the first time. This was my first real job. I did not know what to do. Luckily, my girlfriend, now wife, had some connections to the American Civil Liberties Union (ACLU) via one of her professors at UCLA. We had some connections to the Electronic Frontier Foundation (EFF) through Art Crimes. Both were very supportive and helped out. The head of the ACLU chapter in LA got on the phone and she instructed me

to take anything out of the house that I had that might be slightly related to graffiti. I had thousands of photos, black books, paint and all kinds of things so I called a friend up to help me move everything. It was his birthday and he thought I was asking him to go out for a beer to celebrate. Instead, I totally forgot about his birthday and asked him if I could borrow his truck to move all of my stuff into his garage.

The next day, I got called into Joe Allen's office, the Dean of Admissions. Joe was a mentor and someone that I really respected. He had done a lot for me professionally. The minute I sat down in his office, he immediately started laying into me, asking me why I supported graffiti and vandalism. What made me think that I knew how the walls around a freeway should look more than the architect who designed them? The conversation was really tough and he kept going and going. It felt like a father-son moment, more than a boss-employee moment. Then, the conversation stopped and turned. He explained that when he was younger, he had protested against the war in Vietnam and someone had planted fake evidence in his apartment. That led to him going to prison for a time. He told me that he told the police officer that they could not tell him what to do with his employees, I believe in much stronger language than that. It was really a saving moment.

This event was kind of a theme for Art Crimes. We were often pressured by anti-graffiti activist individuals. Susan

Figure 5. Newsweek cover and article that included Art Crimes, October 24th, 1994.

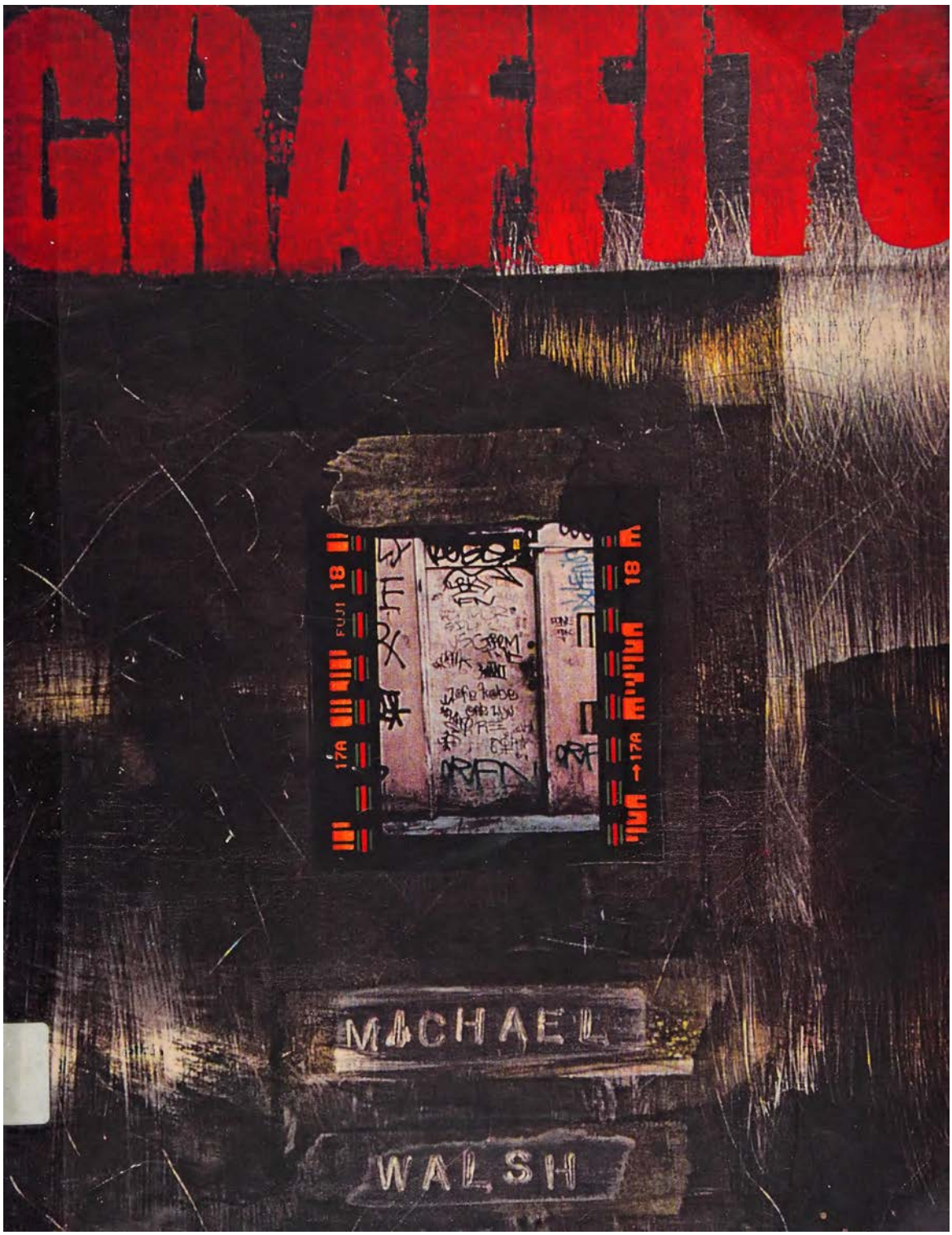

Figure 6. Graffito, October 24th, 1994.

was always adamant about retaining copies of Art Crimes on university servers. Those universities always supported us even when confronted by those anti-graffiti forces.

4. New York and Funny Garbage

At the end of 1998, I got the opportunity to move to New York City. I jumped at the chance. It was a great professional opportunity and allowed me to be closer to many of my heroes and the pioneers of graffiti. One of the places that I ended up working was a place called Funny Garbage founded by Eros and Lawe of NEWAVE crew. These two were also two giants in the design industry. It was a place where I could be myself both as a computer nerd and graffiti writer. There were always other writers of all generations coming to the office. We worked on a lot of projects related to graffiti including the book "Style master general: the life of graffiti artist Dondi White" (Witten & White, 2001). I can remember lots of people coming into the office, including Zephyr and Eric Deal from at149st.com (the site was named after the famed Writer's Bench at the 149th Street subway station in the Bronx and was the first website that focused on New York City graffiti), sharing Dondi photos and stories when that book was being worked on. We even had a wall on the roof that we would paint regularly.

New York in the early 2000s was a great place to live. My network kept expanding. I got lots of opportunities because I lived there. Not a lot has changed since these times. As my wife told me—I love graffiti; I want to look at graffiti, show people graffiti, talk about graffiti and be around people who want to do those things too.

5. Today and Conclusion

I have recently started working on an application called Spray Street (http://www.spraystreet.com) which is focused on photo sharing and storytelling for graffiti and street art. I started the work when I noticed at the end of 2022 that people had stopped posting as much on Instagram. Instagram had really taken over as the platform for all discussions in the graffiti community and became the central hub. I was kind of sad that Twitter was in shambles and I noticed other communities building their own apps catered to their needs and thought it was time for someone to try something like that for us. Some things we have done is support landscape images more akin to graffiti-style writing and lots of street art. We are in the very early stages but we are building things like classification specific to graffiti and street art images that can help drive research or get people to what they want to look at faster. As of this writing, we are not in the app store yet, but should be soon.

I have also done some early work with machine learning and classifying images. The first test was to use a fairly small amount of training data and try to get something to classify images as tags, throw-ups or masterpieces. We tried a handful of different techniques and had good results with RoboFlow for image annotation and Yolov5 for deep learning. Again, this is very early and I would love to collaborate or work with others who are interested in this type of work.

In closing, as well as sharing my story of building an early website, the intention was to convey the risks of putting this type of information out in the wild. We have learned a tremendous amount about the risks of technology and I just hope that we think about those lessons as we document art that might be considered a crime and how putting that information out in the world might have a direct impact on individual practitioners' lives. I am not saying to stop, because I am still participating as a documentarian, historian and publisher, as well. I am telling us to keep the creator's lives in mind when we are doing our research.

Conflict of Interest

The author declares no conflict of interest.

Acknowledgements

Thank you to the INDIGO team, specifically Geert, Jona, Benjamin and Stefan. My first writing and beat making partner, Sleepin' J, without you, my life would be quite different and I thank you for that. Amanda, for putting up with all those writers that have slept on our couch and listening to all the prattling on about this color or that spot. Jett, you are the best, thanks for riding along. Mare 139, we have been through some things and you have taught me a

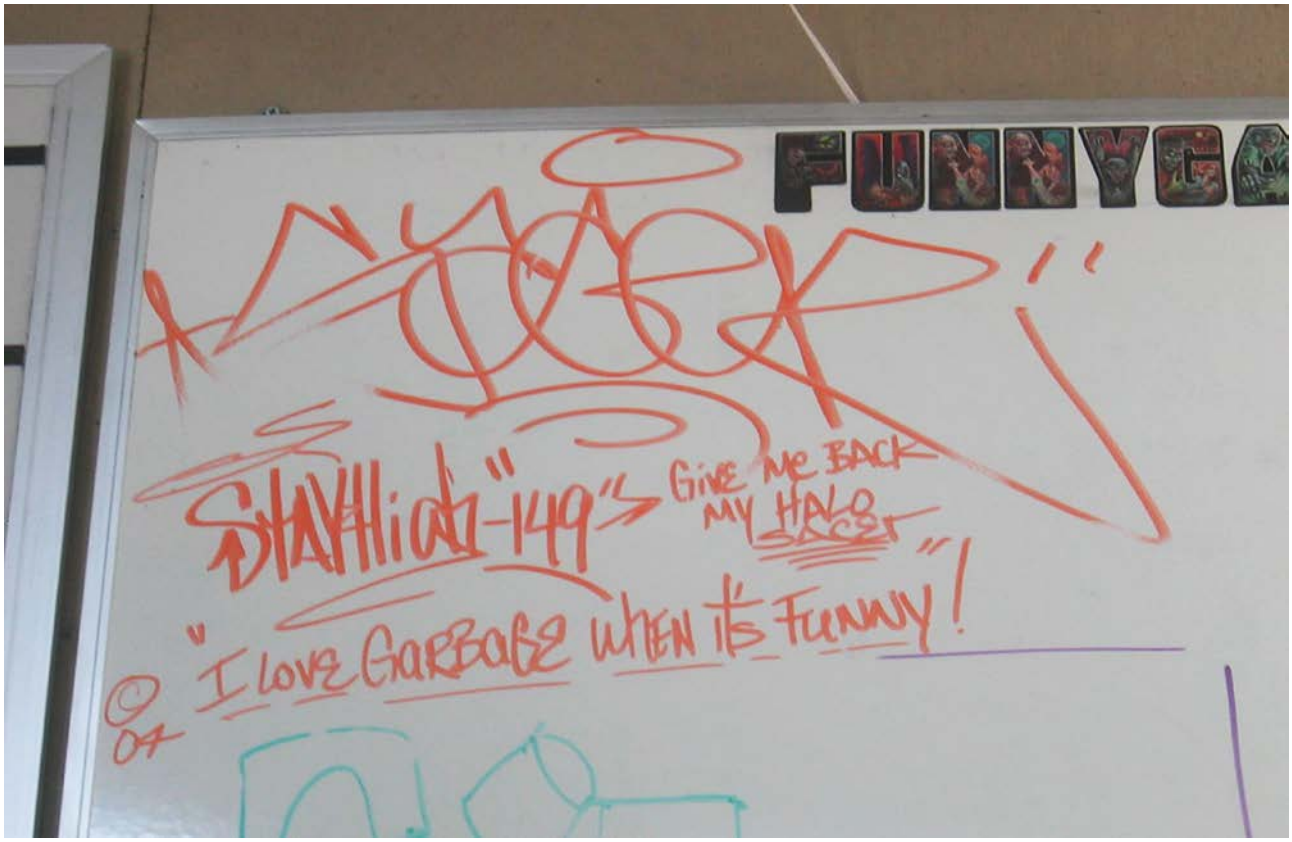

Figure 7. Photo of Sacer/Dash Snow (1981–2009) and Stay High 149 (1950–2012) tags on whiteboard in Funny Garbage offices. Photo by the author, date unknown.

ton. Peter and Chris, Eros and Lawe—what a time we had at FG. Henry Chalfant, Martha Cooper, Tony Silver and Jim Prigoff thank you for laying the groundwork for how writing should be documented, with style. Always remember to never forget, rest easy: Phase2, Bisr68, Dash Sacer Snow, Rob-One, Tempt, Dream TDK and Nace. LORDS crew por vida.

References

Blankstein, A. (1997, April 15). Tagger is ordered to pay $100,000. *Los Angeles Times*. https://www.latimes.com/archives/la-xpm-1997-04-15-me-48864-story.html

Lathan, S. (Director). (1984). *Beat Street*. Orion Pictures.

Rogers, A. (1994). Digital Graffiti. *Newsweek*, 124(17), 4.

Schlegel, J., Carloni, M., Wogrin, S., Graff, A. M., & Verhoeven, G. J. (2023). Making a mark—Towards a graffiti thesaurus. In G. J. J. Verhoeven, J. Schlegel, B. Wild, S. Wogrin, & M. Carloni (Eds.), *Document | archive | disseminate graffiti-scapes. Proceedings of the goINDIGO2022 international graffiti symposium* (pp. 203–219). Urban Creativity. https://doi.org/10.48619/indigo.v0i0.710

Walsh, M. (1996). *Graffito*. North Atlantic Books.

Witten, A. Z., & White, M. (2001). *Style master general: The life of graffiti artist Dondi White*. ReganBooks.

Urban Art Mapping and How to Deal with Hot Spots—The Vagabundler Project

Gunther Michels
Vagabundler Collective, 60433 Frankfurt, Germany; E-mail: info@vagabundler.com

Abstract
This paper presents the non-commercial online graffiti archive "Vagabundler", which holds numerous articles, interviews and city maps on urban art. The text explains the archiving system developed by the Vagabundler Collective, with examples from Buenos Aires in Argentina, Montréal in Canada and Berlin in Germany. Finally, the North Side Gallery in Berlin serves as an example to highlight the potential political influence of documentary evidence in legalising graffiti creation.

Keywords
Archiving; Berlin; Graffiti documentation; Legalisation; Localisation; Networking; North Side Gallery; Spot history; Street art photography; Urban art mapping

1. Introduction

As a start, a comparison by Jurij Paderin from the Graffiti Lobby Berlin, with whom we had an interesting interview for the Vagabundler project (Vagabundler, 2021): "In Berlin there are thousands of children who like to play football. There are soccer fields for them and new ones are constantly being built. There are thousands of children who love to play basketball. New courts are being built for them. There are many other athletes, there are musicians, actors. Practice places are designed for everyone. But for the children who want to paint on outside walls, there are no places for them. Actually nearly none at all". That is an ongoing observation; one can read all about it on their website https://www.graffiti-lobby-berlin.de and the Graffiti Lobby has been working on the legalisation of public spaces for artistic activities for many years. Before we go any further, here is a quick addition to Jurij's statement, because that really gets one thinking. Jurij: "What would happen if you took from the children who play football or basketball, the children who play the guitar or the saxophone, the children who do acrobatics or performances, what would happen if you took their places away? If you take away their football fields, the basketball courts, the music schools and all that? What would happen? They would do it anyway! Because they love it and because they want to do it. The kids would just play soccer in the streets, and the basketball players would nail their hoop to a tree and play basketball there. You can not suppress it. You have to understand it and create space for it."

At the goINDIGO Graffiti Symposium in June 2023, Gunther Michels presented the "Vagabundler" project and the idea behind the platform https://www.vagabundler.com, which this paper presents. The members of the Vagabundler Collective are not the ones who paint or create works of art. Nor are they the ones doing politics. But they are the ones who archive, take photos and document. Meanwhile, as time passes, people understand the importance of archiving. However, we would like to explain further steps one should think about. We live in the communication age, so everything "must" be communicated, from important things to nonsense. But everything must also be "proven" to get permission for anything. With documentation like digital photos, one can do that very well, especially if needing to prove to municipalities, for example, that a place "is artistically and creatively valuable". This paper will give some insights about what the Vagabundler Collective does, how they think and how an individual can contribute.

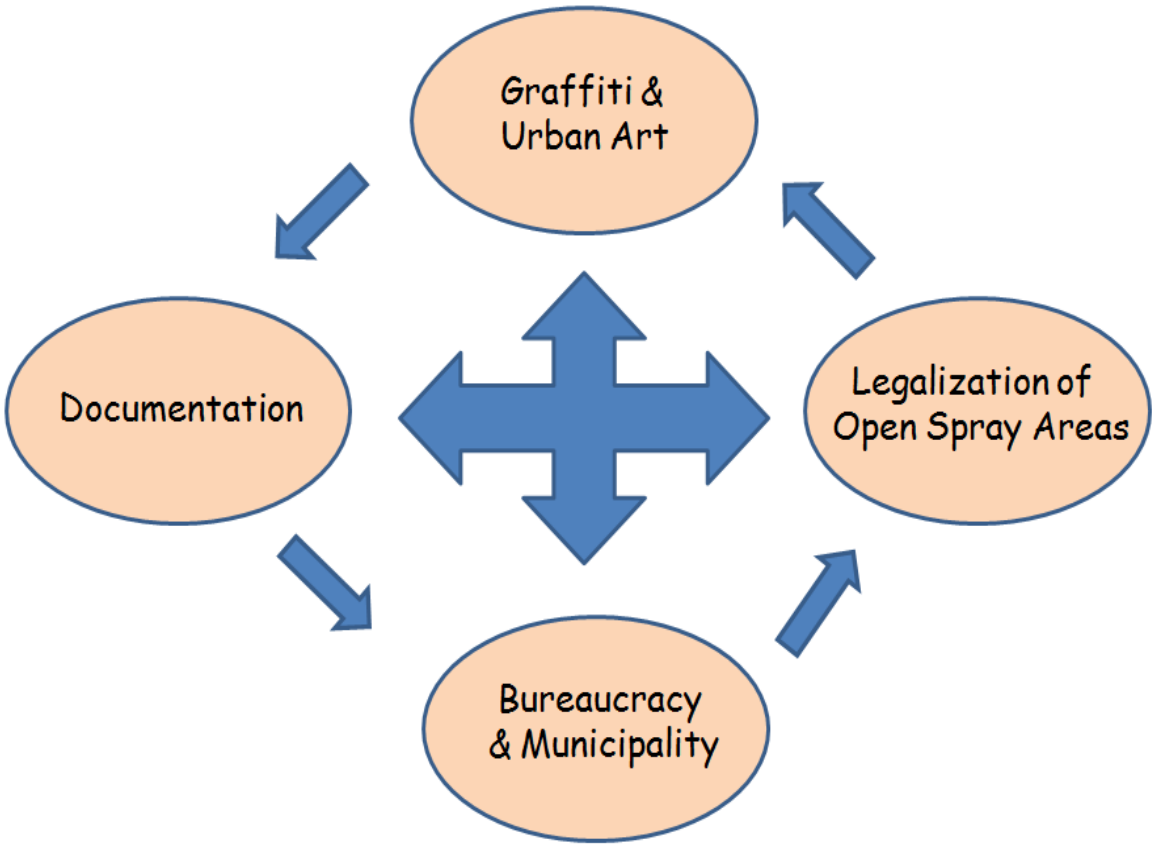

Figure 1. More graffiti locations via evidence-based value of a spot.

2. Some Facts about Vagabundler (September 2023)

- Vagabundler Collective:
  - Contains around 16 crew members in the core group and 100+ contributors.
  - Is non-commercial and non-profit. New people are welcome.
  - The website is online since August 2017.
- Contact:
  - https://vagabundler.com
  - info@vagabundler.com
- Archive:
  - 150,000 photos online on around 15,000 pages.
  - 134 maps (4 world maps, 83 country maps, 47 city maps, and 2 spot maps.
  - >170 artist profiles & interviews, >300 podcast included, >500 reports (90 % art-related).

3. Our Mission—Why Are We Doing This?

Some explanation about our "Vagabundler Project "and the people behind it. First, and foremost, we are lovers of art, colours, diversity and creativity. In addition to the joy of observing, we enjoy taking photos. But that is not enough; we also want to show others these photos. However, it is not just about our photos; it is much more about the motif itself, what is behind it, and those who made it. Our online platform is a collaboration of many creative, lovely people from all around the world, who are passionately involved in this non-profit project. Partly, it comes out of our interest, but the entire team has the solid additional motivation to make urban art, and everything that it defines and entails, better known and to provide information about it. In addition to the photo galleries, we try to let the artists and makers have their own by doing interviews. The

Vagabundler collective is a small creativity-interested family which informs, documents and archives. Many works of art in public spaces are no longer available after a short time, and often, there are no photos of them. Our website offers a database of beautiful works from places around the world. Apart from the art perspective, which is already a huge reason the works must be documented, it is also clearly a socio-cultural phenomenon. It must be reported and we try to mediate, explain, create access and even connections. Urban art, and art in general, is a form of human expression in our society. There is great value in it, and there are many messages included. We try our best to show this fantastic, colourful world and the creators behind it, explain it, and bring it closer via vagabundler.com.

4. How Do the Maps Work?

The posts, photos and interviews on the Vagabundler website (https://vagabundler.com) are linked to maps. The basic navigation is thus based on the maps. There is a world map and then maps for each country. Actually, there are several world maps, such as one with all interviews or one with all participants so far. There are city maps of the places from which we have a considerable amount of material and to which crew members also regularly contribute new photos (one could call them city ambassadors). That would then be the next "zooming in stage". Each map features markers that lead to further levels or individual pages with spot reports, interviews, or extensive articles. The idea of locating urban artworks on online maps is not new. There are already many such maps. However, most maps have the markers attached to the respective artworks. At Vagabundler, the marker is not the artwork's identifier but the spot itself. This means that if new artworks are created at that location, future photos will be added to the page that belongs to that marker. In this way, pages have already been created that show the history of a single wall with countless works of art over several years. So we can also go back in time in our documentation and add to the database content from today but also from the past. Likewise, everyone is invited to participate in this open data project. Participation is simple and can range from individual photos to extensive articles and photo collections; videos are also possible. The extent of the documentation basically depends on the person who wants to participate. If one has many photos and wants to contribute more extensively, then entire city maps or even village maps can be created. If interested, contact can be made via info@vagabundler.com.

Figure 2. The "World Map" – First level (see Figure 8 for an explanation of the 'Level' concept). Screenshot 15.09.2023. https://vagabundler.com/the-map

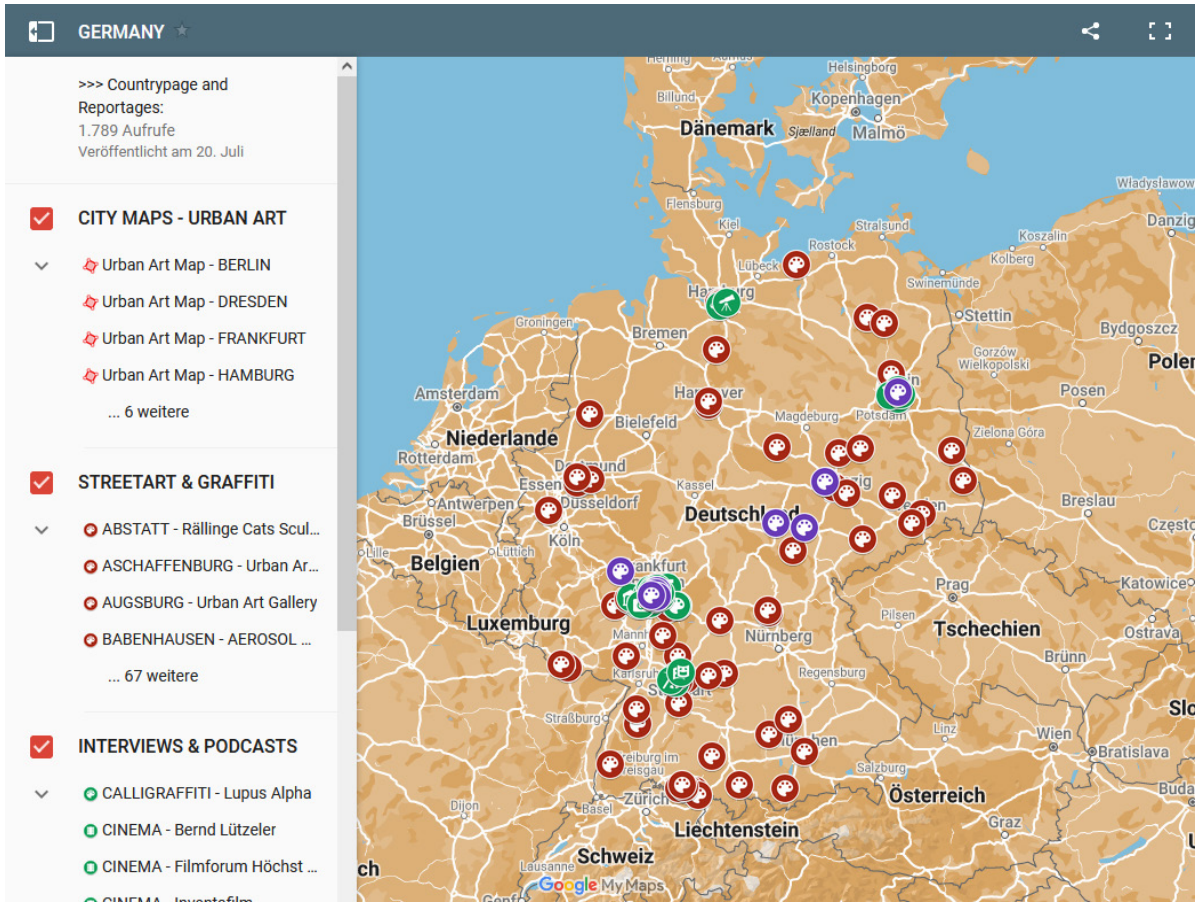

Figure 3. Example "Germany Map" – Second level (see Figure 8 for an explanation of the 'level' concept). Screenshot 15.09.2023. https://vagabundler.com/germany

All the buttons on each city map are link to a photo gallery of the spot, sometimes with only one photo, sometimes with dozens of photos or even a full report. The different symbols explain various categories like street art, urban creations and graffiti artworks. In the navigation of the map on the left, one can find the markers sorted by categories, and it is possible to hide or fade these layers. With the map application, it is only possible to include ten categories, which is restricted to this number by the app. We would use a lot more, but therefore, it also means that the many different maps on the website have evolved according to the contributing collective members. So there are different categories on the maps depending on the focus of the photographer or which art forms are often represented in that city. Some categories can be found on every map, such as "Mighty Murals" or "Halls of Fame". Some maps also feature sculptural urban artworks, while others focus on bombing. Holger from Berlin is a big fan of electricity boxes, and there are many of them, so after hundreds of photos, it made sense to introduce a separate category for them. However, there are cities without train services, where the categories to the railway stations are omitted. Some places have hardly any bridges, while other places have many. Therefore, a separate category for "bridges" exists. It varies with the place and the choice of the photographer.

Moreover, new categories can always be developed. For example, a brand new category is "Temporary Diamonds", which was recently created for artworks on temporary wooden construction fences on the map of Gothenburg,

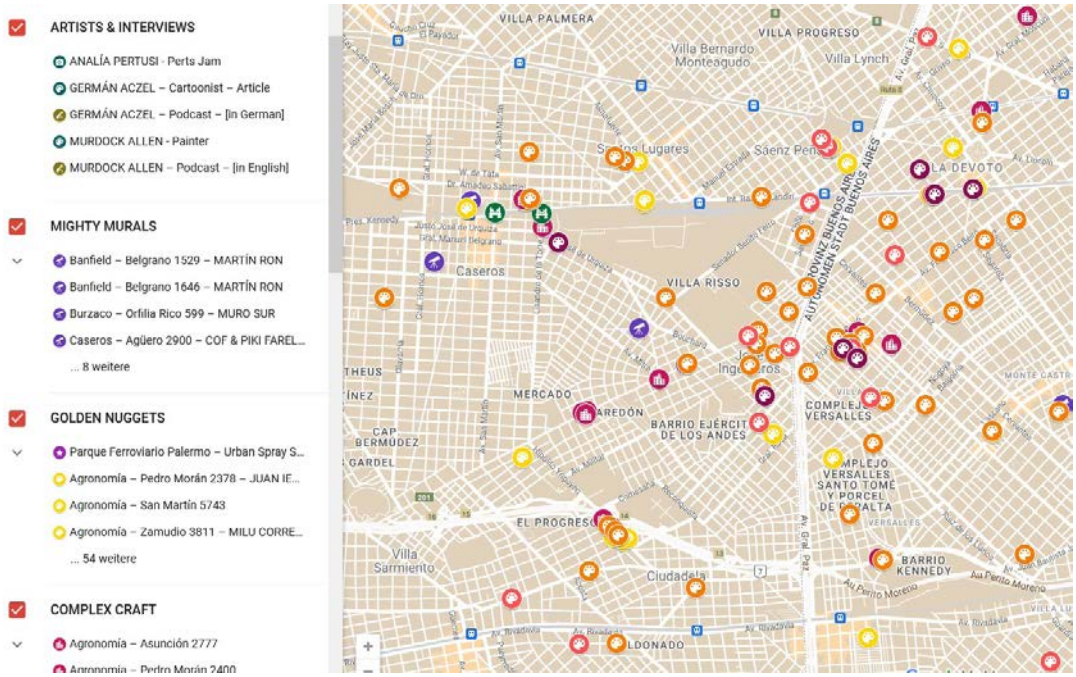

Figure 4. Example "Buenos Aires Map" – Third level (see Figure 8 for an explanation of the 'level' concept). Screenshot 15.09.2023. https://vagabundler.com/argentina/streetart-map-buenos-aires

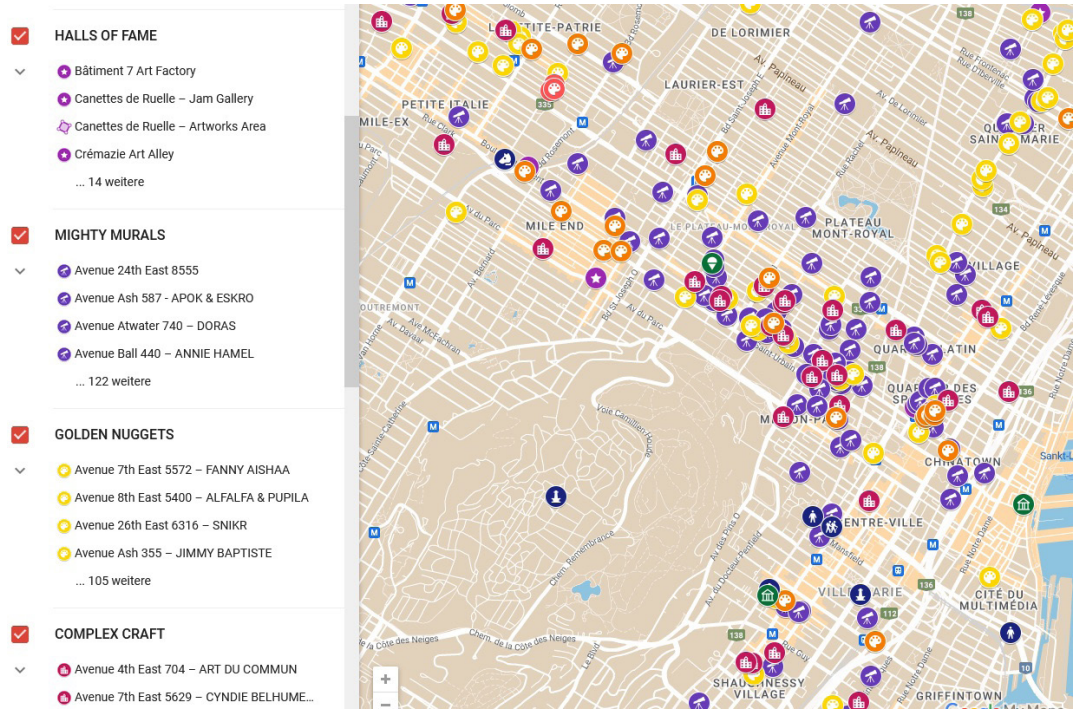

Figure 5. Example "Montréal Map" – Third level (see Figure 8 for an explanation of the 'level' concept). Screenshot 15.09.2023. https://vagabundler.com/canada/streetart-map-montreal

Figure 6. Example – Category "Temporary Diamonds"; Streetart Map Gothenburg – Södra Vägen 61 – Appear37 & Sagie. https://vagabundler.com/sweden/streetart-map-gothenburg/soedra-vaegen-61

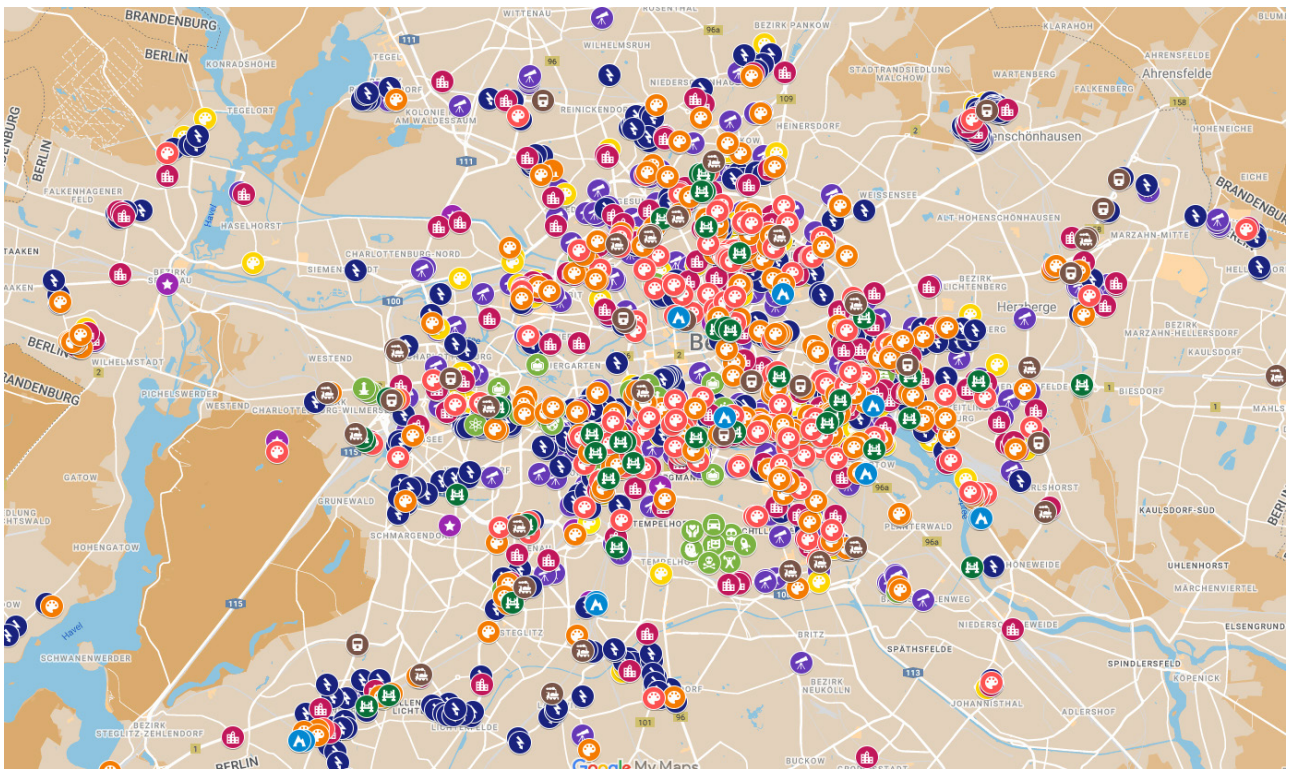

Figure 7. Example "Berlin Map" – Third level (see Figure 8 for an explanation of the 'level' concept). Screenshot 15.09.2023. https://vagabundler.com/germany/streetart-map-berlin

Sweden. The word "diamond" was chosen not because the artworks show diamond-shaped elements but because they are incredibly valuable and beautiful creations that can only be seen briefly during construction work on the wooden fences.

5. How to Deal with Hot Spots and Halls of Fame?

But how to proceed with the big hot spots, the Halls of Fame and the places where vast amounts of new works are created every day? One motivating reason for developing the presentation with those maps was how the content is handled on most of the usual social media platforms. A picture or a post is always placed on top of the previous one; after a specific time, the posts disappear in the feed, get forgotten, and hardly anyone scrolls back years. Although the photos are great, and the works were or still are fantastic, the photos are swallowed and buried by every new posting. A representation on a map definitely opens up an additional dimension and offers an equal representation of all the spots. But if we lined up all the artworks from, for example, the Mauerpark, which is one of the biggest spray spots in Berlin, on one single page, then we would have the same unwanted effect as on Instagram or Facebook. It would be an eternally long page and a jumble of information. That is why the hot spot pages are subdivided into further levels, and each artist has a separate sub-page in alphabetical order. This means that these sub-pages present the history and development of a single artist at precisely this spot.

6. Development in Difficult Times—Or Development Because of Difficult Times?

We also want to paraphrase Gunther Michels' Facebook post from the 26th July 2021 during the pandemic times, as it explains the situation quite well (the entire post can be found here: https://www.facebook.com/gunther.michels.7/posts/10165518792105603): "A few words about the Vagabundler project and all the interesting things that have happened in the meantime. Over 1000 articles, 70 country maps, 38 city maps, 7700 individual pages and more than 100,000 photos later. I am overwhelmed, excited and also very proud of our creative and international team! Thank you to everyone involved in this project! Despite the

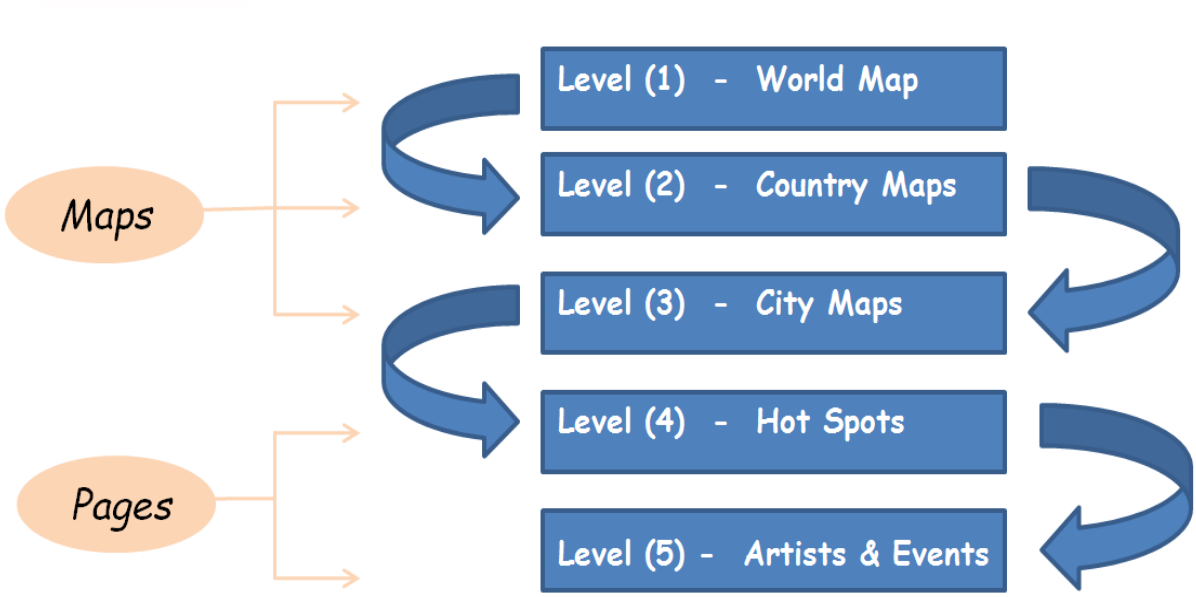

Figure 8. Mapping Design – Focus level concept.

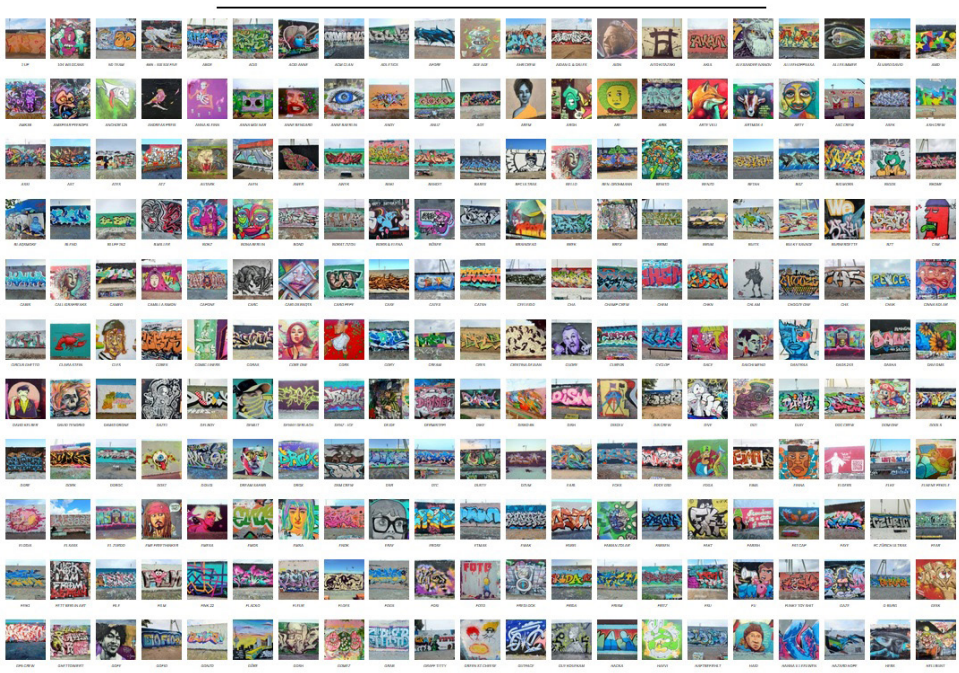

Figure 9. Example "Berlin Mauerpark" – Fourth level (see Figure 8 for an explanation of the 'level' concept). Screenshot 15.09.2023.

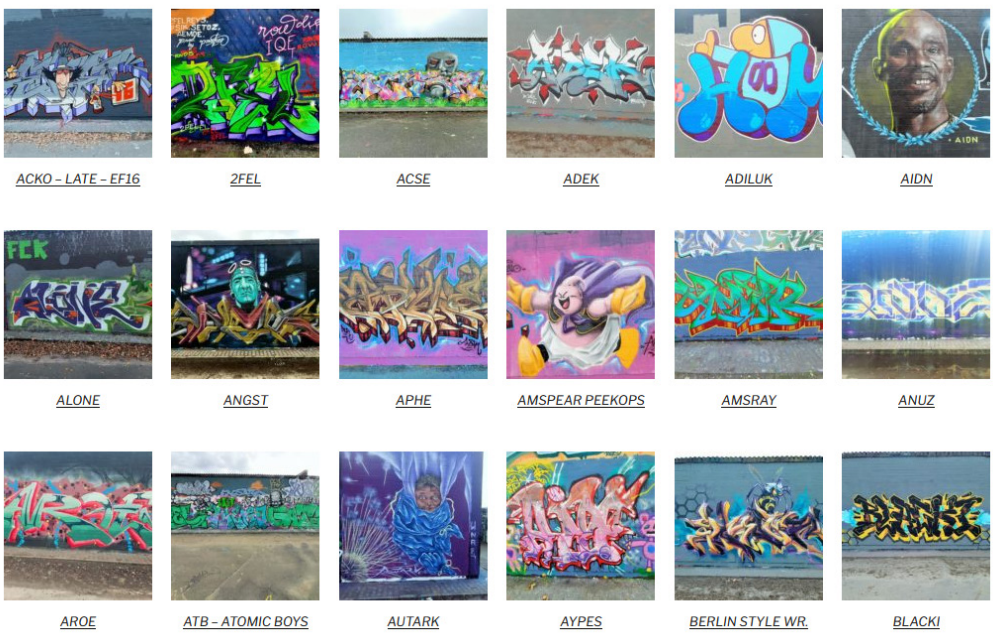

Figure 10. Example "Berlin Jungfernheide" – Fourth level (see Figure 8 for an explanation of the 'level' concept). Screenshot 15.09.2023.

many unceasing negative events in the world, something wonderful has emerged here."

The fact that this "Vagabundler Project" grew into a bigger network would have happened sooner or later because it was designed and planned like that from the start. The concept was to build up a great magazine, an interesting archive, a database, and a smorgasbord of entertaining stories. For those who are just interested in those things and by people passionate about it. But with a particular focus on street art and graffiti. I started with some first puzzle pieces, but then more contributions came from other people. And step by step, it beautifully evolved. With all these lockdown stories worldwide, we started communicating in other ways. Travelling or seeing each other was impossible, but one could still work on ideas via Internet communication and implement projects and creative things together. Vagabundler, initially a small blog by an individual, has become a collective, a team, a group, a small family that passionately works together. In addition, many people contribute with individual photos or writings.

It is nice to see how this project and idea grow and thrive. Despite the current situation with many adverse events worldwide, which does not seem to be stopping, there are also many positive things. I do not want to say that a team would not have formed around this platform without COVID-19, but it turned out differently than expected. It has even intensified many things. And in a good way, with even more deliberation. Despite lockdowns and social distancing, we were able to create things together, and thanks to the Internet, we were not that far from each other anymore. Over 150,000 photos from over 70 countries are online on over 15,000 individual pages and more than 100 maps (as of September 2023). Countless articles, reports, interviews, audio podcasts or videos are included. With a lot of research work on background information and links to the artists and cultural workers. Sometimes just photo galleries, sometimes very detailed reports or just an amusing story. Some team members already have profile pages, some send photos for posts, others write extensive articles, and others build entire graffiti maps of a city with lots of background information about the creators of the works. We try to support the art

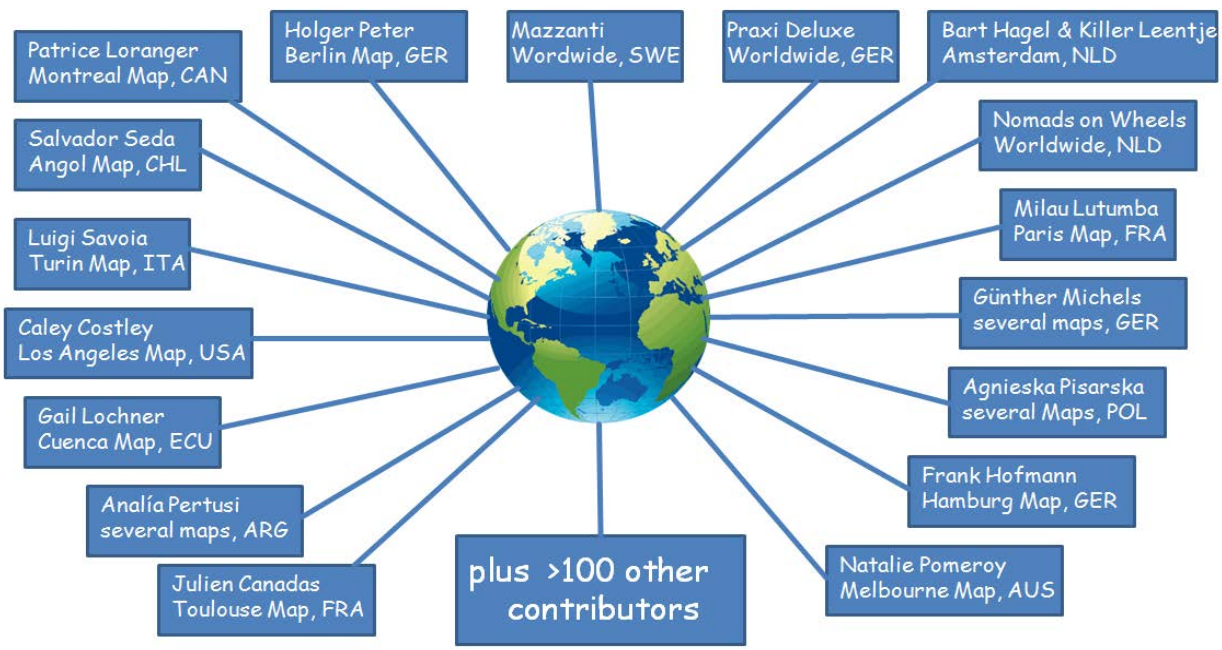

Figure 11. Vagabundler Collective – Worldwide Network.

and culture scene, especially the artists and creators of the works, as well as the organisers of events and owners of art spaces. We do that by providing information, presenting works, explaining the background and showing how cool it is. Most of all, we want to show that creativity is everywhere, all over the world, in each of us. We humans can do both. We can destroy, and we can create. With Vagabundler, we definitely promote creativity and want to motivate everyone to be creative themselves. We also try to support the ones who already are."

7. The Legalisation of the North Side Gallery

Back to here and now. However, a little explanation and a review are good for understanding how it started and showing transparency about our actions. Of course, there have been many other developments as we look ahead and towards the future. Because even if we are more the journalistic documenters, we still have a strong supportive intention for the scene. We are in favour of there being more space for graffiti and creative design everywhere around the world. By working together with other actors, we can initiate such plans, set them in motion and implement them.

An example of this is the story about the "North Side Gallery" in Berlin. An immense respect and super thank you goes to the Graffiti Lobby Berlin (https://www.graffiti-lobby-berlin.de/north-side-gallery.html), which never gives up and has stayed with its cause for many years with full passion. They deal with the politicians, they discuss and argue until there is more freedom for creativity. Not everyone likes these bureaucratic discussions and political arguments, and not everyone can do it. Any documentary material helps, of course, and can provide argumentative support because it shows evidence of the "artistic value" of a place.

The Graffiti Lobby Berlin had been discussing several spots with the municipalities for years. One was the "Park am Nordbahnhof", the park at the former northern train station, which is now the "North Side Gallery". Finally, the area was accepted as a legal spray place, but there was initially a two-year test phase to observe what was happening there and how everything was developing. During that phase, the Vagabundler Collective tried to document as much as possible. There are thousands of photos from hundreds of artists and several jams. Those municipalities' offices received extensive folders with prints full of the documented graffiti, sorted chronologically, alphabetically and thematically, as well as extensive reports and videos. The documentary work by Vagabundler, Graffiti Battle (https://www.youtube.com/graffitibattle) and Urban Presents (https://www.urbanpresents.net) helped a lot. However, also the work of many other actors and supporters has contributed to the fact that the positive decision has now been granted. Since June 2023, the "North Side Gallery" in Berlin has been an official, legal art space where spraying, painting and other creative activities are permitted. But like everywhere else: Please do not leave any rubbish to help preserve this artistic space for a long time.

8. "Wem gehört die Stadt?" or "Who Owns the City?"

To conclude, here is a fitting and even deeper metaphor story from Jurij from the Graffiti Lobby Berlin (Vagabundler, 2021): "Little Hans sprays a lot of graffiti in Berlin. He sprays his name everywhere; his tags are all over town. Still, he is depressed. He comes to the table at noon, his head is sad and he looks dejected. His mother asks him, "Hans, what is the matter, why do you look so sad?" He then says, "Mom, I am really trying my best. But I just cannot keep up with these other writers. No matter what I do, they are always better and paint even bigger". His mother tries to say some good words: "But Hans, you did a very cool one here and another cool one there. The people really liked it! "Hans answered: "Yes Mum, but the next day those other writers made something a lot bigger over it ". Then his mother says: "But Hans, if you go to other places and try it there?" Hans then says: "I really tried everything; they tag just much faster than me, and they are everywhere. They put their signature on every corner and much more often than I can manage. I cannot keep up with them." Then the mother asks: "What are these other writers actually called?". Hans replies: "Those writers have such strange names: one is called 'Coca Cola', the other 'Apple', there is one called 'Nestlé'...". "

Of course, this story is about ownership and, above all, about the view of ownership rights. Who has what right to what? Who has the right to the water, air, or neighbourhoods?

What is allowed to own? What is common property? What can one “buy”? This entire text does not provide any answers to these questions, but intends to raise and challenge them. Who owns the city? The people who live in it or others who “buy” space? It is not just about the walls for graffiti and free artistic expression. It is about thinking about how one wants to live and under what circumstances. Because at least in countries with democracy, we can all have a say. Even if it takes a long time and is complicated, it is possible. However, for that to happen, we must work together. The artists, the documenters, the organisers, the fans, the supporters, the advocates, everyone. One family and colourful creativity all over!

Conflict of Interest

The author declares no conflict of interest.

References

Vagabundler. (2021). *Graffiti Lobby Berlin - Jurij Paderin & Emily Strange - NORTH SIDE GALLERY - Aufklärung, Kreativraumgewinnung, legale Wände, Stadtkultur* - [GERMANY]. https://hearthis.at/radio-x-interviews/graffiti-lobby-berlin

Graffiti Exploration via Interactive Web Maps

Oskar Baumann
TU Wien - Department of Geodesy and Geoinformation, 1040 Vienna, Austria; E-Mail: oskar@baumanns.ch

Abstract
This article explores the intersection of graffiti, street art, and cartography through web-based maps. Graffiti and street art pose challenges in representing their diverse and short-lived nature on maps. The ephemeral and location-specific characteristics of graffiti and street art are discussed, emphasising their connection to their original urban landscapes. Maps are proposed as vital tools for preserving their context. Current graffiti web maps are evaluated, revealing common (interactive) functionalities and limitations. The article advocates for user-friendly and advanced web maps. The nuanced representation of graffiti on maps, considering factors like size, shape, and orientation, is discussed. The development of a web map prototype showcasing graffiti along Vienna's Danube Canal is detailed. The prototype utilises adaptive symbols to optimally represent graffiti across various map scales. Additionally, the option to view the map in a 3D mode is integrated to provide a more realistic view of the vertical dimensions of graffiti and their surroundings. The usability of the web map prototype is evaluated, identifying areas for improvement, especially in the visibility of graffiti features. In summary, the article underscores the unique character of graffiti and street art as map features linked to urban environments. It emphasises the potential of web maps but calls for technological and usability enhancements, contributing to a deeper understanding by preserving these art forms within their (spatial) contexts.

Keywords
3D mapping; Feature generalisation; Graffiti; Interactivity; Street art; Web mapping

1. Introduction

Nowadays, many consider graffiti and street art cultural heritage worth preserving (Bonadio, 2022; Merrill, 2015). There has been an increase in public and research interest in these artistic practices and creations, especially with the more recent rise of street art (de la Iglesia, 2015; DeTurk, 2015). While there are distinctions between graffiti, often centred on textual-based content, and the genre of street art, known for its diverse and image-based forms, this article, in alignment with the recommendation of some scholars (Avramidis & Tsilimpounidi, 2017; Parker & Khanyile, 2022), employs the terms interchangeably for simplicity.

Graffiti and street art creations are inherently ephemeral, relying on various media for preservation and dissemination. Although these works maintain a strong connection to their physical locations and continue to be produced in the physical world, their digital representations are increasingly shared online. Individuals, including graffiti artists themselves, are embracing the digital realm as an extension of the milieu for these creations. The digital realm, including its social media platforms, is witnessing increasing adoption and utilisation by graffiti and street art practitioners to gain more visibility and broaden the reach of their artistic work (Honig & MacDowall, 2017). Without such digital dissemination, as these creations are destined to be concealed, removed, or decay, their visibility would remain limited to fortunate passersby, who might still overlook them.

One of the many digital avenues for sharing and disseminating these artworks is through web maps. While there has been considerable research and attention focused on the spatial analysis of graffiti (Bartzokas-Tsiompras & Konstantinidou, 2023; Tokuda et al., 2021), exploring the intersection between the domains of street art and cartography is still a relatively unexplored area. Despite the existence of numerous (web) maps and archives dedicated to graffiti, the subject has yet to be formally addressed from a cartographic perspective, which is precisely the aim of this article as it strives to take initial steps into this direction.

This study aims to achieve several objectives. First, it seeks to identify the current state of graffiti web maps, analysing common features and patterns. The next aim is to conceptualise more effective and realistic graffiti symbolisations for individual and collective graffiti occurrences. The creation of such cartographic symbols relies on access to complex graffiti geo-data (shapes) and is guided by theoretical considerations of the spatial characteristics of graffiti. The symbols, adaptive to zoom-level or map scale, are incorporated into a web map prototype. The development of this prototype demonstrates interactive features beyond most current graffiti-dedicated web maps. It introduces a 3D map mode, enabling users to delve into the exploration of graffiti creations along the Danube Canal (Donaukanal) area in Vienna, Austria.

Finally, the article will present the evaluation of the prototype in terms of user experience and usability through a qualitative user study. The goal is to identify potential usability issues and areas for improvement. These efforts are expected to contribute to more effective map-based dissemination and produce potential insights into the phenomenon of graffiti and street art.

2. Graffiti's Dynamic Context: Spatial and Temporal Dimensions

Graffiti and street art practices produce highly contextual works that incorporate temporal and spatial aspects. These forms of artistic expression can be considered among the most spatial due to their fundamental premise: the entire urban landscape as an intricate, boundless canvas open to creative visual art-making, transcending the spatial confinements of conventional art galleries (Austin, 2010).

Each piece of graffiti is site-specific in its meaning to some degree (Bengtsen, 2013). Its chosen location becomes an integral component of its identity (Ferrell & Weide, 2010). For illustration, the content and theme of graffiti often draw inspiration from their immediate environment, including urban infrastructure, nature and other graffiti (Wild et al., 2023). Graffiti pieces can reference their surroundings and engage in a creative dialogue with them (see Figure 1). They are scaled according to the space available on their given wall or surface section. Some are tailored in a way so the usually two-dimensional surfaces they cover seem to cleverly interact with or incorporate their three-dimensional surroundings. This dialogue between neighbouring graffiti and their environment leads some to view graffiti walls as 'narrative space' (Carver, 2018; Sennett, 1990). In fact, a dual and reciprocal relationship exists between graffiti and their urban environment. Once created, graffiti become part of the environment, influencing and reshaping it in return (Chmielewska, 2007; Ermolaeva, 2014).

Most graffiti walls undergo frequent repainting, a result of the dynamic interplay between various writers who compete and collaborate on the shared public canvas. That applies to the Donaukanal area in particular, where individual works are less likely to persist for years but instead have a transient existence, often lasting for weeks or even only for mere hours.

The average time it takes for graffiti to get covered by new graffiti varies greatly from wall to wall and depends on numerous factors, including weather conditions. A compelling case study to consider is MacDowall's (2016) investigation into graffiti's temporalities. Based on near-daily visits, he tracked six walls at a fenced suburban site in Melbourne, Australia, for over 600 days starting in mid-2014. His data show a total of 186 pieces that were painted by 73 artists, resulting in a 20-day average time of visibility for each graffito. These results are interesting and help to demonstrate the short-lived nature of graffiti. However, to use the words of the study's author, "due to the many

Figure 1. Contextual graffiti. Left: Nature-themed graffito at a grassy area in Gdańsk, Poland, in 2019. Right: Pirate treasure map theme near a harbour in Szczecin, Poland, in 2019. Photos by Nathan Winder.

complex factors through which graffiti is produced, the results can't be extrapolated to other sites nor can a causal link be demonstrated" (MacDowall, 2016, p. 57).

As a highly contextual art form, losing connection to their spatio-temporal context is detrimental to graffiti's meaningfulness. When preserving and presenting graffiti data, associated geospatial information is of great importance and should not be neglected as "each instance of graffiti writing comes to life at a particular location–and within a network of locations that, taken as a whole, chart contours of status and meaning within the world of urban graffiti" (Ferrell & Weide, 2010, p. 50).

3. The Map in Preserving Spatial (and Temporal) Contexts

To visualise graffiti in their spatial context, revealing such literal contours of status and meaning within a city, one may use the established medium of a map. A map allows for a clear and intuitive way to present spatial realities and their mutual relationships. Since they excel at illustrating how graffiti and their surrounding environment spatially coexist, maps are arguably the most apt solution for precisely conveying graffiti data within its immediate spatial context. Utilising maps as a medium for presenting graffiti data inherently counters the risk of spatial decontextualisation (Bengtsen, 2019), thus preserving the essential locational information of graffiti. Preserving this attribute of graffiti contributes to obtaining a more comprehensive understanding of street art and graffiti, encompassing their content, messages, and the extractable cultural and social insights they offer.

It is vital to acknowledge that the attempt to uncover the influences between graffiti and their spatial environment solely through the medium of a map is somewhat limited. While a map alone can provide insights to some extent, it is important to recognise that, by its very nature, it is an abstract model of spatial realities (Lapaine et al., 2021). Consequently, it can only show fractions of the multifaceted relationship between graffiti and the environment. However, a map is easily merged and enriched by other media. With the steady emergence of increasingly user-friendly and more functional multimedia web mapping technologies, the

notion of abstraction being the ultimate goal in cartography seems outdated to some (Peterson, 2007). Instead, "multimedia cartography is based on the compelling notion that combining maps with other media (text, pictures, video, etc.) will lead to more realistic representations of the world" (Peterson, 2007, p. 64). Web maps can ground graffiti data spatially while complimenting it with information in various media formats. This makes multimedia graffiti web maps ideal for presenting contextual-intact graffiti and letting users interact with and gain a varied nuanced understanding of them. As remarked by Cartwright and Peterson: "People want to 'go into' the map, both spatially and conceptually. They want to explore at a deeper level" (Cartwright & Peterson, 2007, p. 2). This aspiration has transitioned from a mere desire to an actual reality. A web map may facilitate user engagement with graffiti through immersive new media experiences such as augmented reality (for instance, https://streetartifacts.xyz).

An intriguing example of the compatibility between graffiti and cartography is given by Hale and Anderson (2020) when showcasing notable graffiti works they have documented. One such piece depicts a profile portrait of a man with an open mouth, from which a speech bubble emerges containing two lines of numbers: '55.870056 – 5.306956', representing the latitude and longitude coordinates of its location in Pollphail, Scotland (see Figure 2). When these coordinates are input into online mapping tools, they direct the viewer to the central recreation block of the village. Through digital media, the work quite literally puts Pollphail on the map, allowing remote viewers to discover its location while viewing a photograph of the graffito. In doing so, the artist initiated the documentation process by geo-referencing the work for future archival purposes, prompting contemplation about the role of digital archiving and mapping in the artistic lifecycle. As the village has since been demolished (Galloway, 2022) traces of the artwork or clues on its location may have vanished in the absence of this specific documentation approach.

4. Current State of Graffiti Web Maps Found Online

There are several web-based maps accessible online that are dedicated to graffiti with the goal of engaging audiences in interactive exploration. These web maps show where street artworks are located within different urban areas and facilitate the exploration of their attributes through

Figure 2. Left: A photograph of a graffito in Pollphail, Scotland, incorporating geographical coordinates of its location into the artwork. Photo by Wikipedia user "Alexgchale". Link to the license: https://creativecommons.org/licenses/by-sa/4.0/deed.en. Right: A map showing the former location of Pollphail, with a marker placed at the coordinates displayed in the artwork, effectively geo-locating itself. Basemap provided by OpenStreetMap.

additional integrated multimedia content and descriptions. Nevertheless, the majority of these maps do not fully exhaust the technological capabilities offered by modern web mapping technologies, nor do they prioritise cartographic practices like feature-targeted generalisation for optimal graffiti representations across scales.

The eleven compiled web maps dedicated to graffiti and street art that were identified (see Table 1) show remarkable similarities, with some of them sharing common software technologies and libraries (e.g., Google My Maps), resulting in almost identical user experiences. Most web maps serve as platforms for users to explore and engage with street art on their own terms.

Across the board, these web maps provide users with a consistent set of basic functions to interact with the map and its graffiti features. These functions include zooming, panning, and retrieving information, which are listed among the interactive work operator primitives identified by Roth (2013). When users interact with features on these maps, such as clicking or hovering over them, individual popup boxes or sidebars appear, providing details on specific graffiti, such as photos, textual descriptions, artist pseudonyms, street addresses, and more. Most web maps also offer links allowing users to retrieve additional information and media related to the specific graffiti. Beyond these shared basic functionalities, some web maps facilitate users to search for a particular location or map feature of interest or to filter the map content. However, beyond these functions, the range of interactive options remains relatively limited. None of the maps introduces 3D capabilities or allows users to reproject the map in other ways.

Concerning basemaps, all employ responsive web tiles to ensure seamless user experiences and adjust the basemap's level of detail according to the map scale. Dynamic clustering is a widely utilised technique among these web maps, mainly due to the volume of data represented by map features. Most maps include collective features, which might not be due to the presence of actual and nearly impossible-to-map graffiti hotspots, but rather attributed to limitations in the spatial accuracy of the underlying data.

Regarding the level of detail, they typically provide spatial accuracy of graffiti at the level of a single coordinate pair, omitting any finer-grained spatial details indicating the actual shape and extent of an individual graffito. Also, temporal information concerning the visibility of graffiti is often lacking.

5. Graffiti: A Nuanced Primary (Web) Map Feature

Graffiti is a highly diverse and variable form of expression which presents unique challenges regarding cartographic representation. Finding a simple yet effective visual representation that accurately conveys the diverse graffiti and street art phenomenon can be challenging.

One of the primary attributes to consider, the size of these artworks, can vary drastically. It is influenced by several factors, including the artist's intention, available space, and the level of risk associated with the act of creation (Ferrell & Weide, 2010).

Over time, graffiti culture has given rise to numerous types or categories of graffiti. These types are, in part, distinguished based on their style, intricacy, location, and size (Tokuda et al., 2021). These categories exhibit general patterns, with certain graffiti types adhering to specific scales. However, these patterns are not rigid rules, as graffiti frequently deviate from the conventional size norms associated with their type.

As an exceptional case illustrating the variability in graffiti size, consider MOMO's famous Manhattan tag (Riggle, 2010). In 2006, street artist MOMO embarked on an ambitious artistic venture that left a mark, arguably the largest tag ever created, on New York City's urban canvas. The artist tagged the imprint of his name 'MOMO' across the width of New York City with a thin orange line of paint. The line measured almost 13 km in length and connected West Village to East River Park. This extraordinary creation defies conventional artistic dimensions, challenging one's capacity for visual comprehension. Interestingly, the best-suited medium for grasping the artwork in its entirety is via polyline geometry on a map (see Figure 3). MOMO's creation operates on both minuscule and monumental scales, leading some to regard it as a form of cartographic self-expression (Schacter, 2013).

Name of Web Map	Area	Number of graffiti map symbols	Link
Atlanta Street Art Map by streetartmap.org	Atlanta, USA	1274	https://streetartmap.org/atlanta-street-art-maps/all-neighborhoods-street-art-mural-map
George Floyd & Anti-Racist Street Art Map by Urban Art Mapping	Worldwide (mostly USA)	2942	https://georgefloydstreetart.omeka.net/geolocation/map/browse
Graffiti Map Vienna by SPRAYCITY	Vienna, Austria	2786	https://spraycity.at/map
Los Angeles Map by Street Art Cities	Los Angeles, USA	2246	https://streetartcities.com/cities/losangeles
Map by street artifacts project	Portland and New York City, USA; Karachi, Pakistan	213	https://streetartifacts.xyz
Mural Map - Open Urban Art Museum Mannheim by Stadt.Wand.Kunst	Mannheim, Germany	38	https://www.stadt-wand-kunst.de/mural-map
Street Art Map Berlin by Vagabundler	Berlin, Germany	1911	https://vagabundler.com/germany/streetart-map-berlin
Turin map by Arte per strada Torino	Turin, Italy, and its surrounding towns	Around 400	https://www.arteperstradatorino.it/mappa_EN.html#12
World Collection Map by Google Art Project: Street Art	Worldwide	Hundreds	https://streetart.withgoogle.com/en-gb/world-collection
World Map by Bombing Science	Worldwide	1331	https://www.bombingscience.com/graffiti-map
Worldwide Street Art, Graffiti & Urbex Map by urbanpresents	Worldwide (mostly Germany and Belgium)	227	https://www.urbanpresents.net/en/map

Table 1. Overview of the web maps dedicated to graffiti and street art that were identified and considered in the evaluation. All were accessed on 7 September 2023.

Shape is another variable aspect of graffiti that has mapping implications. As an art form unrestrained by the dimensions of regular canvases, graffiti often exhibits irregular shapes, devoid of fixed aspect ratios.

The variability is further heightened by the orientation in space. Graffiti predominantly extend along vertical surfaces, giving them a slim appearance when viewed from above. However, in less frequent instances, graffiti conform to a more horizontal plane when covering nearly level surfaces. Examples include graffiti applied directly onto roads or sidewalks, flat roofs, basketball courts, skateparks, or the upper sides of urban infrastructure elements. This diversity in shape and orientation can complicate the process of mapping graffiti effectively. In contrast to more old-school graffiti, some street art comes in the form of constructs exhibiting a three-dimensional structure and depth, such as sculptures, statues, or installations. This further underscores the need for thoughtful considerations when designing comprehensive cartographic representation for all forms of street art encountered within specific areas.

The inhomogeneous distribution of graffiti, marked by areas of intense spatial density within urban environments, poses further challenges. For instance, a single wall may be densely covered with hundreds of tags, creating a graffiti hotspot. Conversely, other city areas might display sporadic occurrences of larger murals or isolated tags. When attempting to delineate each individual graffito as a distinct map feature, these graffiti hotspots become even more prominent, further complicating the task of mapping graffiti due to the limited map space.

The decision to consider each individual mark, graffito, or complete wall a single feature on a map can significantly impact the level of detail and accuracy in graffiti mapping.

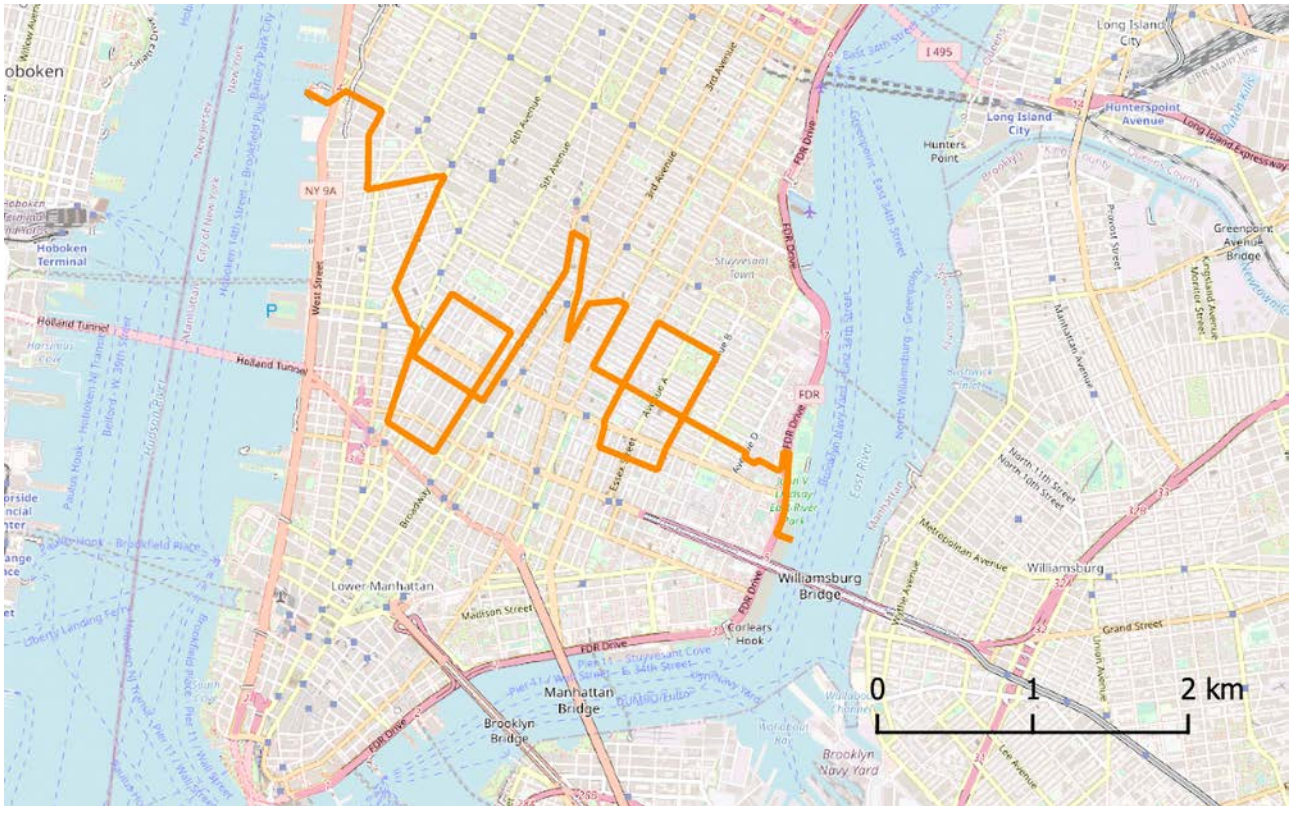

Figure 3. Possibly the longest single graffito: MOMO's Manhattan tag visualised on a map in orange. Map by the author based on the map found in The World Atlas of Street Art and Graffiti (Schacter, 2013). Basemap by OpenStreetMap.

Notably, while defining the extent of an individual graffito becomes a crucial task in accurately representing the distribution of graffiti on maps, the boundaries between individual graffiti artworks (i.e., where one work ends, and another begins) can be unclear and ambiguous. Capturing individual graffiti as features on a map can lead to information overload, visually cluttered maps, and reduced readability. On the other hand, diminishing the variability of graffiti can lead to oversimplification and loss of valuable information.

In densely graffitied areas, an alternative approach may involve treating an entire area, graffiti-covered wall, building, or a large graffito composition as a collective feature. To achieve this, the cartographic generalisation operator referred to as 'merge', 'dissolve' or 'amalgamating', first defined by Imhof (1936), may be used. This approach simplifies the map by representing graffiti as concentrated clusters or continuous stretches, reducing visual clutter while still acknowledging their presence.

Along those lines, dynamic or adaptive clustering represents a commonly used variation of collective map features in web mapping to address visual clutter, the latter often being described as simply "too many markers" (Fürhoff, 2019, p. 1). With this method, the number of individual features clustered together depends on the map's current zoom-level and the distance between these features. As the user zooms in to decrease the map scale, a growing number of clusters break down into sub-clusters, eventually revealing the individual features once the map is zoomed in sufficiently.

Ultimately, striking the right balance between providing intricate details of individual graffiti features and utilising generalisation techniques is crucial in creating effective and informative cartographic products. Given the inherent variability of graffiti and street art in size, shape, and orientation, cartographers face the challenge of effectively abstracting and displaying them on maps.

The combination of all these aspects indicates that there can be no universally correct approach to represent graffiti cartographically; instead, the choice depends on factors such as the available data, the scale, and the conditions specific to the area of interest being mapped. Interactive web maps, which allow users to adjust zoom levels dynamically, hold the potential to provide different visual representations of graffiti that automatically adapt as users zoom in or out. This adaptability may involve transitioning between point, line, and polygon symbology, provided that graffiti data of necessary quality are available.

6. Development of the Web Map Prototype

The purpose of the web map prototype is to enable users to visualise, explore, and query graffiti along Vienna's Danube Canal (Donaukanal). In that sense, this prototype aligns with the goals established by project INDIGO (IN-ventory and DI-sseminate G-raffiti along the d-O-naukanal), an academic graffiti project launched in September 2021 through funding from the Heritage Science Austria programme of the Austrian Academy of Sciences. INDIGO wanted to push the boundaries in inventorying, disseminating and understanding extensive graffiti-scapes like the one found along Vienna's Danube Canal. INDIGO aimed to create its own graffiti exploration platform using a specific technology stack (see Schlegel et al. in this volume). However, this did not exclude others from investigating alternative ways to visualise and explore INDIGO's data. In this light, the present web map prototype must be seen. Rather than being an official project deliverable, this prototype resulted from the author's master thesis.

The prototype in its finalised state (see Figure 4) as it was presented to the user study participants (see Section 7) is accessible via GitHub at: https://oacbaumann.github.io/graffiti_map_UserStudy. The web map prototype was developed using the open-source JavaScript library MapLibre GL JS, as it offers lightweight 3D mapping capabilities. Language analysis for its GitHub repository indicates that it comprises 82 % JavaScript, 9 % HTML, and 9 % CSS code.

6.1 Data Sources

For integration into the web map prototype, project INDIGO provided a sample graffiti dataset in the form of 97 orthorectified image files in the PNG format and 97 corresponding individual geo-referenced high-detail 3D polygons in ESRI shapefile format. These polygons accurately

Figure 4. The finalised web map prototype's interface (3D mode) allows for immersive graffiti exploration along Vienna's Donaukanal. Elements of the graphical user interface include a box containing filter options, a time slider, a map menu, and a sidebar listing all currently visible graffiti.

delineate the spatial dimensions of each graffiti border. A detailed explanation of the methodology used for deriving the polygons and the orthorectified graffiti images can be found in Wild et al. (2022).

The default raster tile map that acts as the base of the prototype is requested from https://basemap.at. The choice fell on this basemap as it exhibits the best alignment with the graffiti data, placing them on walls in a manner that appears highly plausible and accurate where observable.
Additional building data are sourced from Vienna's city office department 41 (Magistratsabteilung 41) as Open Government Data. This dataset offers a notably high level of detail and incorporates attributes such as absolute elevation and base markings.

6.2 2D-Map-Mode-Adaptive Graffiti Symbology

In the web map prototype's 2D mode, adaptive symbols are used to effectively represent graffiti across different zoom levels or map scales (see Figure 5). When zoomed in closely, individual graffiti are represented by the original polygon geometries. As users zoom out to smaller scales (i.e., wider views), more simple geometric representations are active, such as polylines or dynamic point clusters, to maintain optimal visual clarity. The dynamic clusters representing graffiti in smaller scales are placed at the centroid coordinates of the original polygons. The polyline geometries active in the medium to close map scale range are derived from the original polygons by retaining only the two most distant vertices of each polygon and connecting them with a line. Upon conducting a personal visual assessment and comparison of the 97 original 2D graffiti

polygons and their corresponding simplified line equivalents in a top-down view at 1:250 scale, the findings indicate that the shape of 87 of the graffiti is accurately conveyed by the line geometry. However, in the case of 10 graffiti features, the representation is less fitting due to the surfaces they adorn not being flat or potential issues with the original data. This equates to nearly 90 % of the graffiti being effectively represented in terms of their approximate shape and length. Considering that the original dataset provided by project INDIGO was derived from their experiment in which "100 graffiti were randomly selected from all graffiti documented between November and December 2021," this 90 % level of satisfactory cartographic representation via line features in the close to medium scale range provides an indication of the potential accuracy for the remaining graffiti found in the Donaukanal area that project INDIGO covered.

6.3 3D-Map-Mode

An effective solution for displaying the predominantly vertical extending phenomenon of graffiti emerges with the implementation of a 3D map mode, offering total control for interactive camera rotation of 360°. This reveals to map users what's directly above and below any given graffiti features, thereby enabling a comprehensive representation of complete graffiti-covered walls.

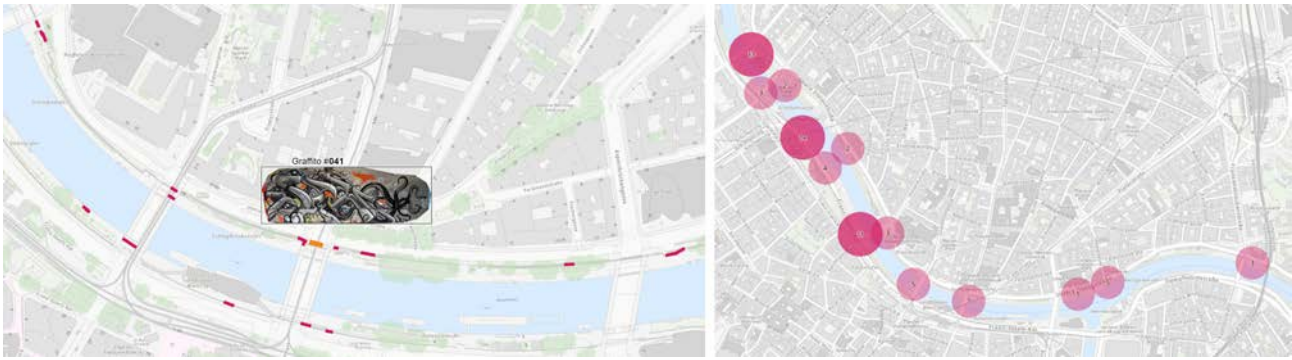

Figure 5. Partial screenshots of the web map prototype in 2D mode showing the changing representation style based on zoom level. Left: Graffiti represented as line features. Right: Dynamic graffiti clusters.

The three-dimensional graffiti features are created by extruding the flat 2D polygons. From a technical standpoint, this is accomplished by processing each vertex of the original 3D polygon and determining both the overall maximum and minimum height values. These values are subsequently used to establish the elevation above ground and height for the entire, horizontally oriented polygon forming a solid 3D feature. While this solution may not reflect perfect accuracy, it offers a more simplified approach. It contributes to creating a 3D web map that delivers fast and reliable performance, making it a more lightweight and practical choice, especially when dealing with a relatively small geographic area. In contrast, other web mapping libraries are based on entire virtual 3D globes.

The additional 3D building map features visible in this mode serve a multifaceted role: first, they offer orientation; then, they complement the graffiti, providing context to potentially unveil their interactions with one another; moreover, they guide the user's focus toward the Donaukanal, where graffiti are located; finally, they provide the area with a more pronounced three-dimensional character by hinting at the rising heights around the canal, preventing the graffiti from appearing isolated in space.

6.4 Graphical User Interface and Interactive Functionalities

The interactive prototype allows the use of the following cartographic interaction operations as defined by Roth (2013): pan, zoom, retrieve, filter, reproject, resymbolise and search.

Panning and zooming functionalities are readily available by default, courtesy of the web mapping library. They can be accessed through standard map controls: left-clicking and dragging on the basemap for panning, and using scroll inputs for zooming.

To retrieve information about the map features, users can hover over graffiti features, revealing individual graffiti popup boxes, which also triggers automatic adjustment of the sidebar to display selected graffiti fields containing additional information. For 3D building features, information is accessed by left-clicking the buildings, which opens the building popup boxes.

Filtering options are accessible through the main filters at the top-left of the interface, encompassing both spatial and semantic filter choices, as well as the time range slider for temporal filtering.

Map reprojection is possible by changing map modes from 2D to 3D or vice versa, and by rotating the 3D map via holding right-click and dragging the cursor.

Graffiti feature resymbolisation can be achieved by changing map modes or adjusting the zoom level in the 2D mode, causing symbolic representations to change.

'Search' in the context of cartographic interaction operators is defined as "interactions that identify a particular location or map feature of interest. […] Search directly enters the map to locate a feature of interest that is already known" (Roth, 2013, p. 2363). This way of interaction is available in the prototype through clicking the 'show on map' buttons within the sidebar, which triggers the virtual camera to move and face the selected graffito.

7. Evaluation of the Web Map Prototype

Since the web map prototype is to be user-friendly and practical, it is essential to assess its usability and gather insights into the user experience. To evaluate the completed web map prototype, a qualitative user study involving six participants was carried out. These individuals were observed during their interaction with the prototype and provided feedback to questions in a subsequent interview setting. As a combination of several methods is expected to provide the best results (Dicicco-Bloom & Crabtree, 2006; van Elzakker et al., 2008), the user study combined three usability testing methods applicable to maps: observation of interaction including performance measurements (Edsall, 2003), thinking aloud (Roth & Harrower, 2008), and semi-structured interviews (Slocum et al., 2004).

Besides evaluating the prototype's graphical user interface for usability, the user study served as the initial external evaluation step within the iterative user-centred design cycle (Abras et al., 2004; Roth et al., 2015), potentially guiding future enhancement and development efforts.

Although the number of study participants was relatively small, they can certainly unearth most usability issues. Nielsen (1994), for instance, based on two studies employing the thinking aloud method for user interface testing, suggested that as few as five test subjects can uncover and identify 77 % – 85 % of usability problems.

The design of the user studies was such that after initial familiarisation with the prototype and its interface, participants were given tasks to complete, such as: "Describe where graffiti with political content were located in the year 2021!". These tasks required participants to utilise the web map as a tool, using its filtering options to pinpoint specific graffiti features on the map. Subsequently, a post-use interview was conducted where participants could share their thoughts on their user experience, including any usability issues they encountered.

The user study results showed that all participants successfully completed nearly all tasks, with an average completion time of 2-3 minutes per task. Both the 2D and 3D map modes were used by participants, which may indicate that providing this choice of mode seems wise, as most users found value in both.

The findings also highlighted certain trends in usability issues, with the visual prominence of graffiti map features emerging as a prominent concern. None of the participants' initial interactions or points of focus were on the graffiti features, even when excluding the typical initial actions of testing the basic map controls and zooming out to explore the map's maximum extent. In fact, identifying the graffiti features, which are the primary focus of the map, proved to be quite challenging for participants. This difficulty stemmed

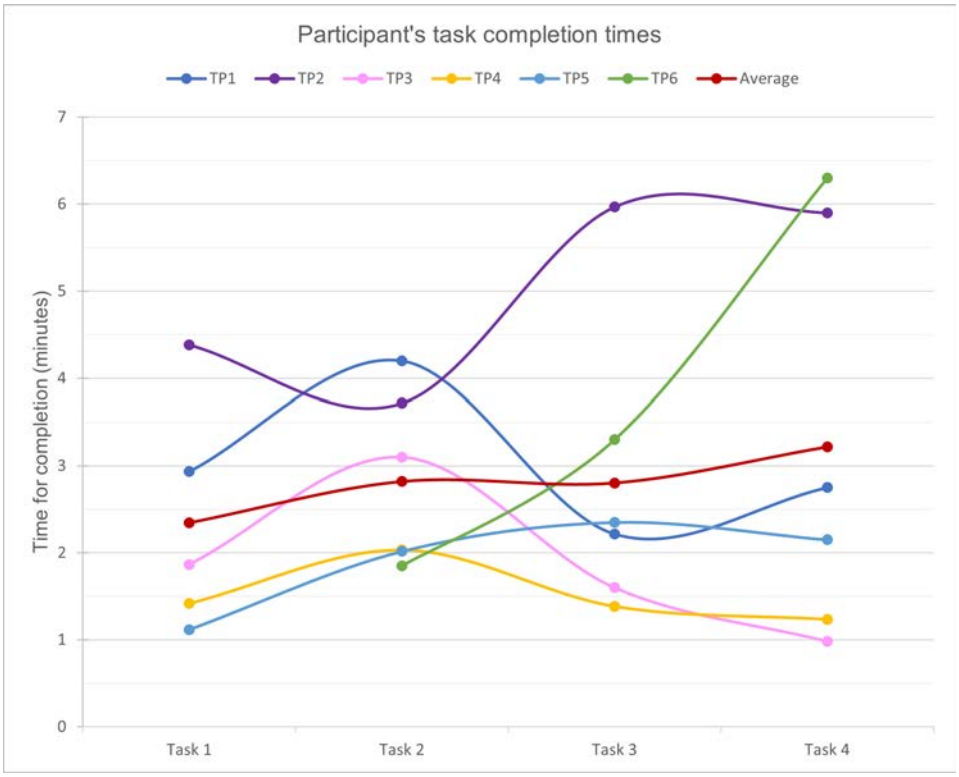

Figure 6. Line chart showing participant's task completion times and the resulting average times of completion.

from the graffiti features lacking sufficient visual prominence, especially in 3D mode, compared to the building features.

The observation and thinking-aloud methods revealed insights into other common usability issues encountered by participants. These issues are expected to be indicative of problems shared by a broader user base. The recurring patterns observed in at least two participants include, from most prevalent to less prevalent: difficulties with using the map controls in the 3D map mode, challenges in locating specific graffiti features after applying filters, issues with activating the display of the right sidebar, difficulties in finding the basemap menu, and challenges in hovering over thin graffiti map features.

8. Conclusion

Maps offer a suitable medium for showcasing graffiti especially when complemented by other media. Graffiti make for rather complex map features, primarily due to their inherent variability in size, shape, orientation, and their propensity to form dense clusters.

Graffiti's inseparable connection with their urban environments, upon which they depend for context and understanding, sets them apart as unique map features. This distinguishes them from other phenomena like billboards, which are also colourful, visible to passersby, and typically exhibit a predominantly flat and vertical spatial character.
Existing web maps dedicated to graffiti, which are available online, have the potential to be enhanced from a technological standpoint to offer a more immersive and interactive user experience. The developed web map prototype shows how current graffiti web maps could benefit from adaptive graffiti symbolisation and additional interactive functionalities, including a 3D map mode option. Different scale-dependent symbolisation styles can be implemented to accommodate the inherent variability of graffiti, as demonstrated in the prototype's 2D mode. However, it is important to emphasise

that access to highly detailed graffiti data is a prerequisite for implementing such adaptable symbology.

Moreover, despite some usability issues, the prototype successfully enabled all user study participants to answer basic spatial, temporal, and semantic questions related to graffiti. These participants could independently complete nearly all tasks they were given by applying filters to graffiti map features and adjusting the map view. It was evident that one of the foremost issues, among others, to be addressed in future design iterations is the increase in the visual prominence of graffiti features on the map. Identifying them as such proved to be a significant challenge, and improving their visibility is a priority.

Conflict of Interest

The author declares no conflict of interest.

References

Abras, C., Maloney-Krichmar, D., & Preece, J. (2004). User-Centered Design. In W. S. Bainbridge (Ed.), *Berkshire encyclopedia of human-computer interaction: When science fiction becomes science fact. Volume II: M-W* (pp. 763–768). Berkshire Publishing Group.

Austin, J. (2010). More to see than a canvas in a white cube: For an art in the streets. *City*, *14*(1-2), 33–47. https://doi.org/10.1080/13604810903529142

Avramidis, K., & Tsilimpounidi, M. (Eds.). (2017). *Graffiti and street art: Reading, writing and representing the city*. Routledge. https://doi.org/10.4324/9781315585765

Bartzokas-Tsiompras, A., & Konstantinidou, E. (2023). Visual analytics of graffiti spatial patterns across 30 European city centres. *Environment and Planning B: Urban Analytics and City Science*, *50*(2), 564-568. https://doi.org/10.1177/23998083221149426

Bengtsen, P. (2013). Site Specificity and Street Art. In J. Elkins, K. McGuire, M. Burns, A. Chester, & J. Kuennen (Eds.), *Theorizing visual studies: Writing through the discipline* (pp. 250–253). Routledge. https://doi.org/10.4324/9780203079232-57

Bengtsen, P. (2019). Decontextualisation of Street Art. In E. Bonadio (Ed.), *The Cambridge handbook of copyright in street art and graffiti* (pp. 41–52). Cambridge University Press. https://doi.org/10.1017/9781108563581.004

Bonadio, E. (2022). Preservation and heritagisation of street art and graffiti. In I. Stamatoudi (Ed.), *Research Handbooks in Intellectual Property series. Research Handbook on Intellectual Property and Cultural Heritage* (pp. 170–190). Edward Elgar Publishing. https://doi.org/10.4337/9781800376915.00017

Cartwright, W., & Peterson, M. P. (2007). Multimedia Cartography. In W. Cartwright, M. P. Peterson, & G. Gartner (Eds.), *Multimedia Cartography* (Second edition, pp. 1–10). Springer. https://doi.org/10.1007/978-3-540-36651-5_1

Carver, E. H. (2018). Graffiti Writing as Urban Narrative. *Literary Geographies*, 4(2), 188-203.

Chmielewska, E. (2007). Framing [Con]text: Graffiti and Place. *Space and Culture*, *10*(2), 145–169. https://doi.org/10.1177/1206331206298545

de la Iglesia, M. (2015). Towards the Scholarly Documentation of Street Art. *Street Art & Urban Creativity Scientific Journal*, *1*(1), 40-49. https://doi.org/10.25765/sauc.v1i1.15

DeTurk, S. (2015). The “Banksy Effect” and Street Art in the Middle East. *Street Art & Urban Creativity Scientific Journal*, *1*(2), 22–30. https://doi.org/10.25765/sauc.v1i2.25

Dicicco-Bloom, B., & Crabtree, B. F. (2006). The qualitative research interview. *Medical Education*, *40*(4), 314–321. https://doi.org/10.1111/j.1365-2929.2006.02418.x

Edsall, R. M. (2003). Design and Usability of an Enhanced Geographic Information System for Exploration of Multivariate Health Statistics. *The Professional Geographer*, *55*(2), 146–160. https://doi.org/10.1111/0033-0124.5502003

Ermolaeva, E. (2014). *Towards the semiotics of political graffiti: The example of Samara* [Master's thesis, University of Tartu, Tartu].

Ferrell, J., & Weide, R. D. (2010). Spot theory. *City*, *14*(1-2), 48–62. https://doi.org/10.1080/13604810903525157

Fürhoff, L. (2019). Rethinking the usage and experience of clustering markers in web mapping. *PeerJ Preprints*, *7*, e27858v3. https://doi.org/10.7287/peerj.preprints.27858v3

Galloway, A. (2022, November 3). Plans for distillery in 'ghost village' approved by Argyll and Bute Council. *STV News*. https://news.stv.tv/west-central/plans-for-distillery-in-ghost-village-approved-by-argyll-and-bute-council

Hale, A., & Anderson, I. (2020). Photographing graffiti. In L. McFadyen & D. Hicks (Eds.), *Archaeology and photography: Time, objectivity and archive* (151-165). Bloomsbury Visual Arts.

Honig, C. D., & MacDowall, L. (2017). Spatio-temporal mapping of street art using Instagram. *First Monday*, *22*(3). https://doi.org/10.5210/fm.v22i3.7072

Lapaine, M., Midtbø, T., Gartner, G., Bandrova, T., Wang, T., & Shen, J. (2021). Definition of the Map. *Advances in Cartography and GIScience of the ICA*, *3*, Article 9, 1–6. https://doi.org/10.5194/ica-adv-3-9-2021

MacDowall, L. J. (2016). A Boneyard of Data: Graffiti and Street Art's Temporalities. *Street Art & Urban Creativity Scientific Journal*, *2*(2), 48–59. https://doi.org/10.25765/sauc.v2i2.53

Merrill, S. (2015). Keeping it real? Subcultural graffiti, street art, heritage and authenticity. *International Journal of Heritage Studies*, *21*(4), 369–389. https://doi.org/10.1080/13527258.2014.934902

Nielsen, J. (1994). Estimating the number of subjects needed for a thinking aloud test. *International Journal of Human-Computer Studies*, *41*(3), 385–397. https://doi.org/10.1006/ijhc.1994.1065

Parker, A., & Khanyile, S. (2022). Creative writing: Urban renewal, the creative city and graffiti in Johannesburg. *Social & Cultural Geography*, 1–21. https://doi.org/10.1080/14649365.2022.2134580

Peterson, M. P. (2007). Elements of Multimedia Cartography. In W. Cartwright, M. P. Peterson, & G. Gartner (Eds.), *Multimedia Cartography* (Second edition, pp. 63–73). Springer. https://doi.org/10.1007/978-3-540-36651-5_5

Riggle, N. A. (2010). Street Art: The Transfiguration of the Commonplaces. *The Journal of Aesthetics and Art Criticism*, *68*(3), 243–257. https://doi.org/10.1111/j.1540-6245.2010.01416.x

Roth, R. E. (2013). An empirically-derived taxonomy of interaction primitives for interactive cartography and geovisualization. *IEEE Transactions on Visualization and Computer Graphics*, *19*(12), 2356–2365. https://doi.org/10.1109/TVCG.2013.130

Roth, R. E., & Harrower, M. (2008). Addressing Map Interface Usability: Learning from the Lakeshore Nature Preserve Interactive Map. *Cartographic Perspectives*, *60*, 46–66. https://doi.org/10.14714/CP60.231

Roth, R. E., Ross, K., & MacEachren, A. (2015). User-Centered Design for Interactive Maps: A Case Study in Crime Analysis. *ISPRS International Journal of Geo-Information*, *4*(1), 262–301. https://doi.org/10.3390/ijgi4010262

Schacter, R. (2013). *The world atlas of street art and graffiti*. NewSouth Publishing.

Sennett, R. (1990). *The conscience of the eye: The design and social life of cities*. W.W. Norton & Company.

Slocum, T., Sluter, R., Kessler, F., & Yoder, S. (2004). A Qualitative Evaluation of MapTime, A Program For Exploring Spatiotemporal Point Data. *Cartographica: The International Journal for Geographic Information and Geovisualization*, *39*(3), 43–68. https://doi.org/10.3138/92T3-T928-8105-88X7

Tokuda, E. K., de Arruda, H. F., Comin, C. H., Cesar, R. M., Silva, C. T., & Da F. Costa, L. (2021). Spatial distribution of graffiti types: A complex network approach. *The European Physical Journal B*, *94*(9), Article 192. https://doi.org/10.1140/epjb/s10051-021-00202-y

van Elzakker, C. P. J. M., Delikostidis, I., & van Oosterom, P. J. M. (2008). Field-Based Usability Evaluation Methodology for Mobile Geo-Applications. *The Cartographic Journal*, *45*(2), 139–149. https://doi.org/10.1179/174327708X305139

Wild, B., Verhoeven, G. J., Wieser, M., Ressl, C., Schlegel, J., Wogrin, S., Otepka-Schremmer, J., & Pfeifer, N. (2022). AUTOGRAF—Automated Orthorectification of GRAFfiti Photos. *Heritage*, *5*(4), 2987–3009. https://doi.org/10.3390/heritage5040155

Wild, B., Verhoeven, G. J., Wogrin, S., Wieser, M., Ressl, C., Otepka-Schremmer, J., & Pfeifer, N. (2023). Urban creativity meets engineering. Automated graffiti mapping along Vienna's Donaukanal. In G. J. Verhoeven, J. Schlegel, B. Wild, S. Wogrin, & M. Carloni (Eds.), *Document | archive | disseminate graffiti-scapes. Proceedings of the goINDIGO2022 international graffiti symposium* (pp. 131–145). Urban Creativity. https://doi.org/10.48619/indigo.v0i0.705

Getting Hold of the Urban Chameleon—Towards a Platform for Graffiti Visualisation and Analysis

Jona Schlegel [1,*], Martin Wieser [2] and Geert J. Verhoeven [3]

[1] Independent researcher, Vienna, Austria; E-Mail: jona.schlegel@gmail.com
[2] Independent researcher, Vienna, Austria; E-Mail: scene2map@gmail.com
[3] University of Vienna - Department of Prehistoric and Historical Archaeology, 1190 Vienna, Austria; E-Mails: geert@projectindigo.eu; geert.verhoeven@univie.ac.at
* Corresponding author

Abstract

This paper presents Urban Chameleon, an online platform currently developed within INDIGO, an academic project that aims to inventory, disseminate, and analyse contemporary graffiti along the *Donaukanal* (Eng. Danube Canal) in Vienna, Austria. Urban Chameleon serves as a digital space to visually and analytically explore these graffiti. The paper provides an in-depth overview of the platform's development process, including data modelling underpinnings and Web development technologies. The text further discusses the platform's potential applications for researchers, heritage professionals, graffitists and the wider public interested in engaging with the vibrant and dynamic graffiti-scape along the Danube Canal. In that way, the article contributes to the ongoing discourse on graffiti as a multi-faceted, modern cultural practice with heritage value.

Keywords

Cesium; Contemporary graffiti; Cultural heritage; JavaScript; Spatial and temporal context; Visualisation; Wireframe

1. Introduction

Graffiti comes in many forms: from ancient inscriptions and symbols, historical etchings, verbal and non-verbal street scribbles to contemporary graffiti writing and street art. Some of those graffiti categories have increasingly been recognised as cultural heritage. This recognition has led to a growing trend towards preserving and restoring graffiti, especially older graffiti manifestations and works considered street art. However, the ephemeral nature of graffiti presents a challenge to their physical preservation as they are often visible for only a short period and confined to their location of creation. To address this challenge, online platforms that digitally archive and disseminate graffiti have emerged as a promising solution. One such platform, Urban Chameleon, is the topic of this paper.

The online Urban Chameleon platform is currently created within project INDIGO. As its acronym reveals, INDIGO aims to IN-ventory and DI-sseminate G-raffiti along the d-O-naukanal (Eng. Danube Canal) in Vienna, Austria (Verhoeven et al., 2022). The platform serves a dual purpose: it should be a virtual environment for visualising and disseminating all graffiti digitally documented within the two-year project and enable their comprehensive analysis by everybody interested in graffiti. This aim lets the online platform touch upon the five research pillars of project INDIGO: acquisition, processing, management, dissemination and analysis (see Figure 1). By incorporating the Danube Canal's three-dimensional (3D) surface geometry and detailed temporal metadata for each graffito, the platform seeks to spatially and temporally

contextualise the graffiti. Urban Chameleon will place the digital graffiti approximations (either an orthophoto or a texture on the 3D model; see Wild et al. (2023)) into their original albeit digitised environment, thereby accounting for the intentions of the graffiti creators. The combination of such detailed visualisation with extensive metadata querying seeks to offer unique opportunities for researchers, graffitists, and the general public to engage with the rich graffiti heritage at the Danube Canal. At the time of writing (July 2023), the platform (https://www.urbanchameleon.eu) is accessible but still under construction.

This paper will first discuss the dissemination of graffiti on the World Wide Web (WWW or Web) to provide the necessary background against which INDIGO's Urban Chameleon platform must be seen. Afterwards, a comprehensive description of the platform's iterative and incremental development methodology is presented. Overall, the paper provides insights into the development of Urban Chameleon as a platform for online sharing, visualising and analysing graffiti, thereby contributing to the ongoing discourse on the significance of graffiti as cultural heritage.

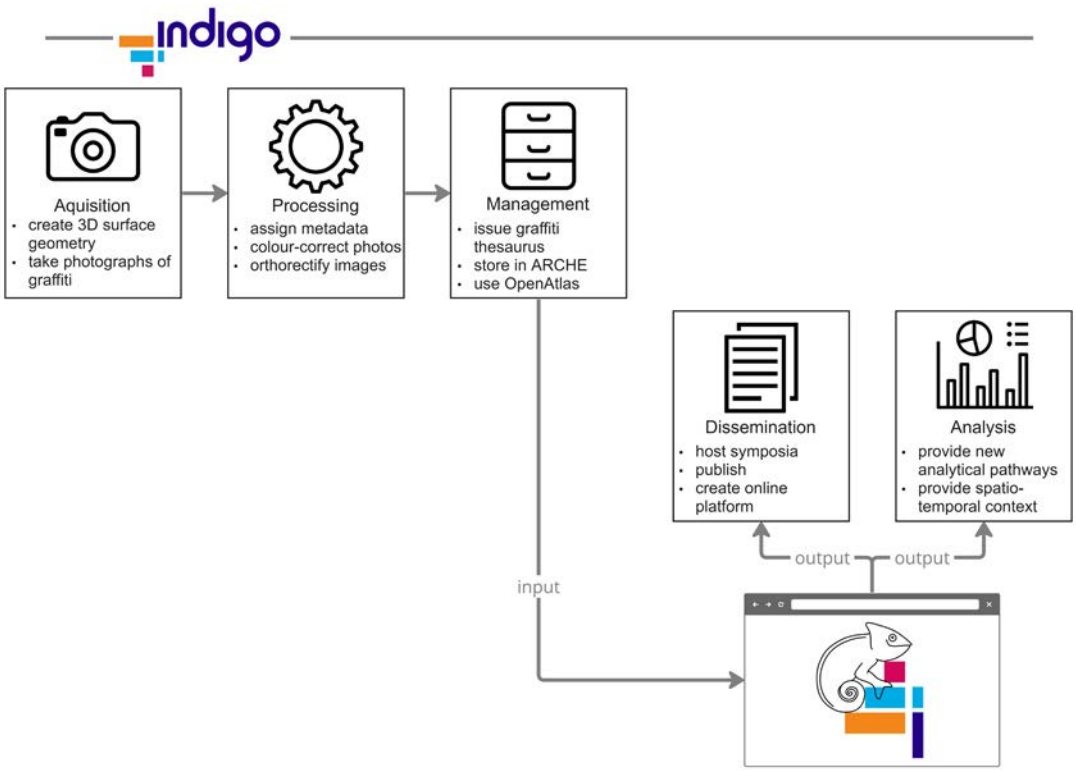

Figure 1. The online platform Urban Chameleon situated in project INDIGO's research structure.

2. Background

The history of graffiti is as diverse as their creators. From millennia-old animal rock drawings to political statements scratched in ancient Roman wall plaster to the vibrant murals of modern urban landscapes, graffiti have generally served as a mirror of society, reflecting the thoughts, feelings, and experiences of individuals and communities (Ganz, 2021). In their myriad forms, graffiti have been driven by many motivations, including artistic expression, political activism, personal proliferation and social communication. Various factors influence these motivations, such as the environment, emotions, becoming more knowledgeable and skilful, technology, and aesthetics. Artistic expression holds a central position among these motivations because graffiti provide a medium for self-expression, enabling individuals to assert their individuality and mark their presence (Sturdy

Colls et al., 2019). This aspect of graffiti is intrinsically linked to its function in social communication. As a conduit for transmitting messages, emotions, and ideas, graffiti catalyse interaction within a community (Pérez-Izaguirre & Reglero, 2023).

Furthermore, many creators use graffiti to showcase their originality and technique, thereby transforming urban landscapes into a testament to their creative prowess (Harding, 2019). Simultaneously, graffiti serve as a platform for political activism (Waldner & Dobratz, 2013), provoking discourse via political messages and symbols. They can also act as a form of social commentary, reflecting the social and cultural issues of a particular time and place (Kolmakova & Shalkov, 2021). Graffiti often invite viewers to dialogue with the work, and they always add a new layer to the urban landscape (Gartus & Leder, 2014; Waldner & Dobratz, 2013).

This multi-faceted nature has led to a gradual shift in the perception of modern graffiti over the past two decades. Once dismissed as mere acts of vandalism, some graffiti are now gradually recognised for their social and cultural significance, prompting a growing trend towards preserving and restoring the physical graffiti (Amor Garcia, 2023; Cortea et al., 2021; Thomas & Nicholas, 2020). However, the preservation of graffiti presents unique challenges. Unlike traditional artworks protected within museums or galleries, graffiti are vulnerable to weathering, urban development, and interference from other graffitists (Avrithis et al., 2010). The ephemeral nature of graffiti, often seen as an inherent characteristic of this form of expression, raises questions about the ethics and feasibility of preservation. But should all graffiti be preserved, either in their original locations or as digital surrogates, or should graffiti-safeguarding be limited to those deemed significant by specific standards? And who gets to decide what is worth preserving and how (Dovey et al., 2012)?

This is where the advent of the WWW on the Internet (from now on Web) has played a transformative role. Prior to the Web, photos of graffiti were shared through physical mediums such as magazines, zines, books, movies, and blackbooks. While these mediums were effective, they had limited reach and accessibility. Being open, cost-effective, and ubiquitous, the Web offered unprecedented reach by removing most existing geographical constraints (Dourisboure et al., 2007). Graffitists, researchers and interested parties could now easily share and exchange photos once they were digitised. In that sense, the advent of the Web kickstarted the digital documentation of graffiti. This digital shift not only enabled graffitists to gain recognition and exposure on a scale unachievable with traditional physical mediums (Wyatt, 1997), but it also led to the creation of digital graffiti archives (Chen et al., 2022). Websites like Art Crimes (https://www.graffiti.org) and Spraycity (https://spraycity.at) have been instrumental in documenting graffiti for over two decades, allowing graffiti to reach a global audience and expand the influence of this expression form.

Even though graffitists could use these initial websites (and e-mail) to connect and foster a global graffiti community (Veenendaal, 2016), that gained even more momentum when, at the dawn of the 21st century, social media platforms emerged (1997: Six Degrees; 2001: Friendster; 2003: MySpace; 2004: Flickr). Rudimentary at first, they continuously grew in functionality, ease of use, and addictiveness. Today, the role of social media platforms, particularly Instagram, in shaping cultural and symbolic practices is well established. Meta's Instagram—launched in 2010—has become a popular platform for graffiti creators, influencing how they create and share their work (MacDowall, 2019). For example, the platform's former emphasis on square-format images introduced compositional graffiti changes to better fit this format (La Rocca & Boccia Artieri, 2022).

Crowdsourcing platforms represent the most recent approach to increasing online engagement with graffiti. Instead of the structured but expert-collected photo collections of archival websites or the more random photos posted on social media, platforms like Street Art Cities (https://streetartcities.com) or the George Floyd and Anti-Racist Street Art Archive (https://georgefloydstreetart.omeka.net) involve the general public to collect graffiti-related data. Those data—usually photographs—are subsequently processed and disseminated by the platform owner. This participatory aspect further

helps to improve the recognition and appreciation of graffiti as a relevant social and cultural heritage (Ridge, 2013).

The combination of social media and dedicated, occasionally crowdsourced graffiti websites digitally immortalised and popularised the transient graffiti world, profoundly changing how humans worldwide connect with graffiti. Together with the online manifestations mentioned above, initiatives like Vagabundler (https://vagabundler.com), Street Art Bio (https://www.streetartbio.com), and the Conservation of Public Urban Space (CaPUS) project (https://www.capusproject.eu) do not only offer graffitists an avenue to extend their reach beyond their local communities, but they also provide unique opportunities for non-graffiti creators to visualise, find, research, and appreciate graffiti. These are also the goals set by the INDIGO team for the online Urban Chameleon platform. Although Urban Chameleon will only focus on graffiti along Vienna's Danube Canal, the platforms underlying Web technologies and the detail provided per graffito aim to open new pathways to visualise and analyse graffiti. The following section will outline the (currently still ongoing) development of the Urban Chamelon platform.

3. Methodology

In website development, a circular approach refers to an iterative process involving several stages: analysing, planning, designing, testing as well as deploying, getting feedback, and re-analysing (see Figure 2). This approach is the core of so-called Agile management, often used to manage software projects. Agile management focuses on continuous improvements and incorporates feedback with every iteration (Ríos & Pedreira-Souto, 2019). Developing a website using an Agile approach is comparable to creating a graffito like a mural, where the graffitist sketches, paints, steps back to review, adjusts, and repeats the process. This flexibility and adaptability starkly contrast with the traditional Waterfall management model, which is more akin to a pre-planned stencil graffito: the design is created, the stencil is cut, and the paint is applied; there is little room for modification once a stage has been completed. The Agile methodology with its circular development philosophy was selected for the INDIGO project due to its capacity for ongoing refinement and improvement of the platform based on user feedback and evolving needs. It is a more flexible approach that can adapt to changes, much like the ever-evolving culture of graffiti itself.

The first stage in the circular approach, analysis, involves gathering the requirements and understanding the needs of the platform's users and its general purpose. In the context of project INDIGO, this involved researching the demands, wishes and preferences of graffiti creators, researchers, and enthusiasts, as well as examining existing initiatives for documenting, sharing, analysing and understanding graffiti. The information gathered during this stage was used to outline the online platform's goals, scope and data input. The design stage then focused on creating the wireframe and developing prototypes to visualise the platform's layout and functionality. This part is influenced by the analysing and planning stage and should ideally result in a user-friendly interface that supports the platform's objectives. Once the design is finalised, the website gets tested and published (i.e., deployed.) Feedback from users—especially researchers—will then be collected and analysed to identify areas for improvement. This feedback informs the website's next iteration, thus starting the cycle again (Hu et al., 2008). In this way, INDIGO hopes to develop a flexible and adaptable online platform that can evolve in response to the needs of its users. The following sections provide more details on each of these development steps. Figure 2 can thereby feature as a guideline.

3.1 Analysing the Field of Graffiti

Graffiti encompass a large spectrum of mark-making content, from textual to pictorial, and spans from prehistory to the contemporary era. Graffiti have been discovered in various contexts, such as the necropolis at Saqqara in Ancient Egypt, the caves of Lascaux in France and Altamira in Spain, the Roman town of Pompeii and the urban landscapes of modern cities (Ganz, 2021). This heterogeneity has led to the involvement of various scholarly disciplines, each of them interrogating this diverse world of graffiti from their particular perspective: How do graffiti reflect the current political situation? Which are the dominant colours in a graffiti-scape? Are subversive symbols crossed (i.e., covered) quicker than pieces? Which linguistic constructions do graffiti

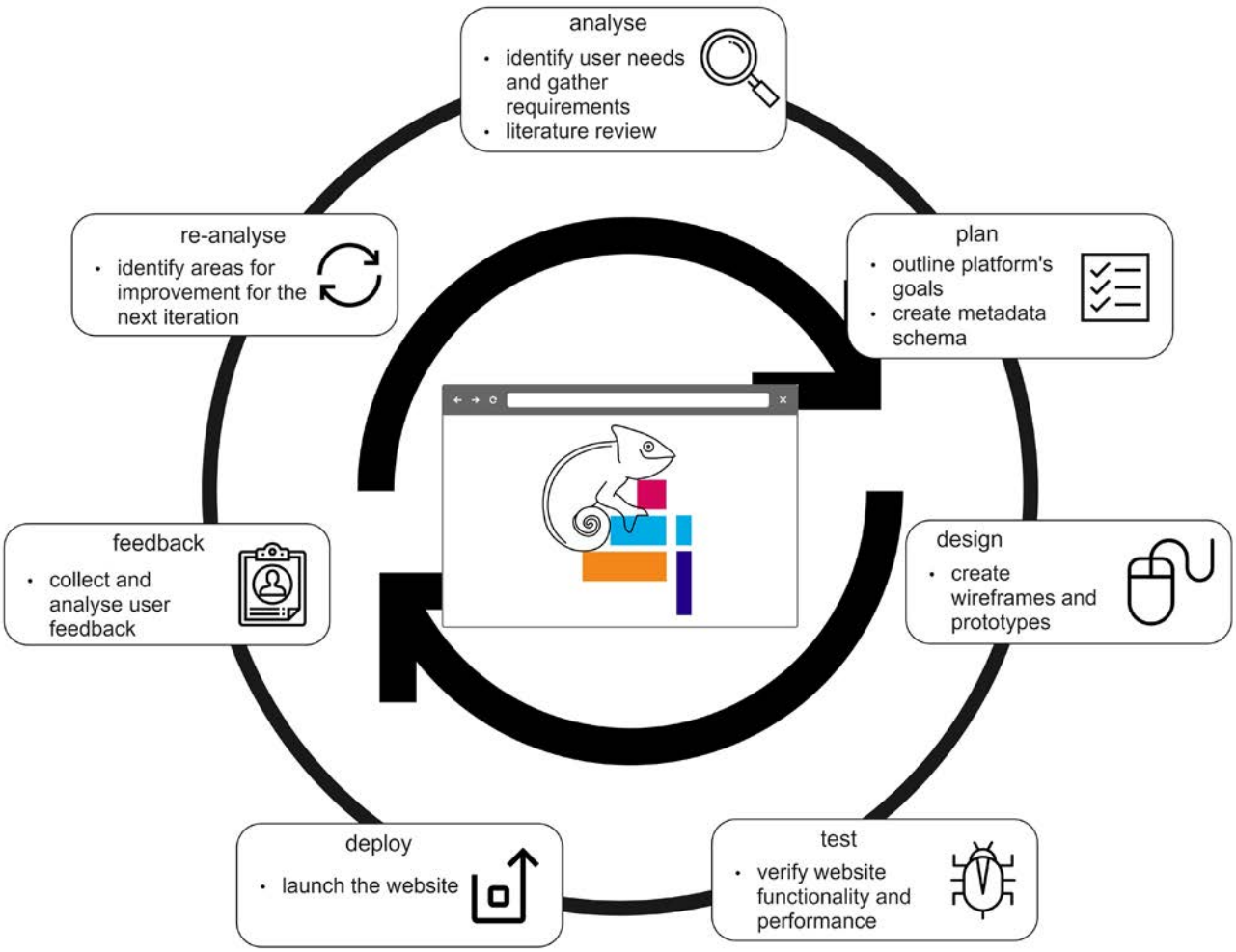

Figure 2. The circular approach (Agile development method) followed within project INDIGO for creating the online Urban Chameleon platform.

predominantly use? INDIGO tries to account for research questions like these during the platform development phase. For example, the possible database queries and graffito-specific metadata must facilitate many of these analytical pathways if the Urban Chameleon platform should be useful to as many academic fields as possible.

To this end, a systematic literature review was conducted within the framework of project INDIGO (see Figure 3). This involved a comprehensive examination of scholarly writings, non-academic grey literature, and other relevant sources to identify and understand the key concepts, theories, and practices related to graffiti. For instance, all possible graffiti terms and concepts were noted down to create a graffiti thesaurus (Schlegel et al., 2023). Developing a thesaurus significantly contributes to any research field, as it provides a standardised, hierarchically structured, comprehensive vocabulary for descriptions, interpretations, and analyses. A generally accepted thesaurus does not exist in the research field of graffiti, which may be attributed to graffiti's diverse and complex nature. The INDIGO graffiti thesaurus aims to fill this gap by following the faceted and hierarchical structure of the Getty Art & Architecture Thesaurus (AAT). Not only does the AAT provide a well-established structure

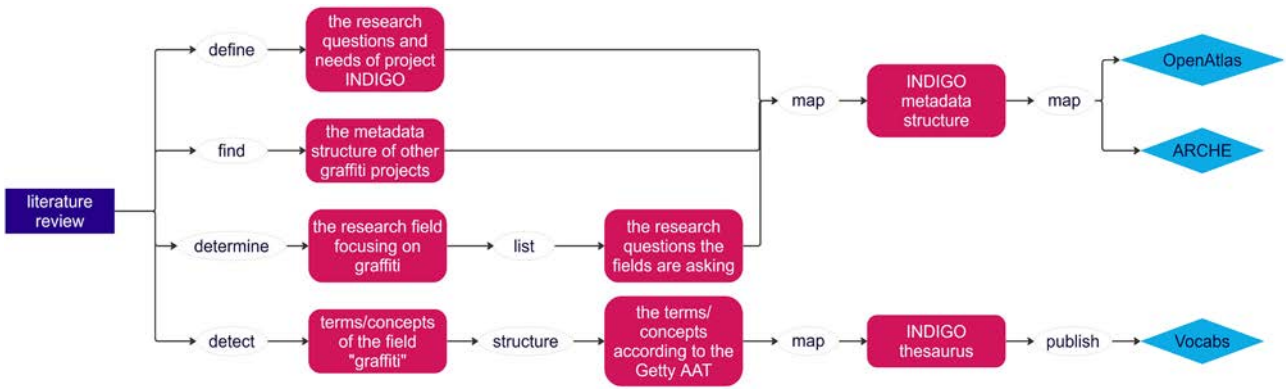

Figure 3. The workflow followed to analyse the graffiti research field (indigo-blue square: method; pink rounded squares: steppingstones; blue diamonds: ACDH-CH service tools).

and consistent framework that is also applicable for categorising and describing graffiti, modelling the INDIGO graffiti thesaurus according to the AAT also enhances its interoperability due to easier integration with other systems and databases that already rely on the AAT (see also Schlegel et al. (2023)). Moreover, the thesaurus ensures that terminology is used consistently throughout the Urban Chameleon platform. And since everybody can quickly check the thesaurus for the exact meaning and scope of every term used on the platform, it enhances the accuracy, efficiency and consistency of information retrieval.

In addition to the thesaurus, a graffiti metadata schema is being developed to capture the relevant information about each graffito (see Figure 3). Metadata, often referred to as 'data about data', provide a detailed description of the physical graffiti and its digital approximations (like a photograph) to enhance their understanding and interpretation (Borgman, 2015; Pomerantz, 2015). For example, metadata elements could be the creator and geographical location of the graffito, the approximate moment of graffito production and the materials utilised, the photographer's name and camera model used to take the photo, the graffito's surface area and dominant colour. A metadata schema is a structured framework that outlines which elements must be collected and how they should be formatted and organised (Caplan, 2003). A comprehensive and well-thought metadata schema not only aids in organising and retrieving graffiti facts but also holds the potential to provide valuable insights into the various social, political, cultural and historical aspects of graffiti.

In the scope of project INDIGO, the development of the metadata schema began by analysing the metadata schemas from the Ancient Graffiti Project (The Ancient Graffiti Project, 2023), Art Crimes (Art Crimes and the artists, 2022), INGRID (INGRID, 2019), Spraycity (SprayCity, 2023) and consulting specific resources like the Catalogue for Cultural Objects (Mugridge, 2007). All schemas were collected and compared in a spreadsheet to gain insights into the information typically recorded about graffiti and cultural objects on the one hand, and the structure and organisation of this information on the other. Additionally, the INDIGO metadata schema was informed by the research questions posed by different disciplines interested in graffiti, as identified in the literature review. For example, a historian might be interested in the date and location of a graffito, while a linguist would instead focus on the graphemes and language used. Therefore, the metadata schema must accommodate a wide range of information to cater to these diverse research interests.

Based on these requirements, a first metadata schema was created. Several people then reviewed this draft, which got revised based on their feedback. As of July 2023, the metadata schema is still not finalised but in an advanced

state. The schema still needs to be applied to a few graffiti test sets to ensure the metadata structure and elements are logical and exhaustive enough to meet the needs of the broader graffiti (research) community.

3.2 Planning–The data input

The planning stage must ensure that Urban Chameleon offers users a comprehensive, interactive, and user-friendly digital space for exploring and analysing graffiti. Creating and maintaining such an online space is only possible through sufficiently standardised management and storage of all (meta)data that form the backbone of Urban Chameleon. For these tasks, INDIGO relies on the Austrian Centre for Digital Humanities and Cultural Heritage (ACDH-CH; https://arche.acdh.oeaw.ac.at/browser), specifically its services Vocabs (https://vocabs.acdh.oeaw.ac.at), OpenAtlas (https://openatlas.eu), and ARCHE (https://arche.acdh.oeaw.ac.at/browser) (see Figure 3). Vocabs provides a platform for the collaborative creation, maintenance, and publication of controlled vocabularies such as the INDIGO thesaurus. This guarantees the accessibility of these controlled vocabularies and ensures their standardisation and interoperability across projects. OpenAtlas, an open-source database software, enables the management of research (meta)data from various fields of the Humanities. How (meta)data are structured within OpenAtlas is guided by CIDOC's Conceptual Reference Model or CRM (Filzwieser & Eichert, 2020). The CRM (Bekiari et al., 2022) is a standard ontology developed by CIDOC, the International Committee for Documentation of ICOM (International Council of Museums). CIDOC's CRM provides a shared semantic framework for storing heterogeneous cultural heritage (meta)data and information, so that different teams acquiring datasets on dissimilar topics could create databases that can be integrated (Niccolucci & Felicetti, 2018; Richards et al., 2023). Lastly, the certified data repository ARCHE (A Resource Centre for the HumanitiEs) offers a long-term hosting and dissemination platform for digital research data and resources from all Humanities fields. ARCHE will ensure the digital longevity of INDIGO's (meta)data. Since ARCHE also features its own, more generic metadata schema, INDIGO must also establish a mapping from its graffiti-specific metadata elements to the more confined set of ARCHE elements.

These three services, either independently or in conjunction, provide a comprehensive digital infrastructure for Humanities research, facilitating data management, standardisation, and dissemination. As detailed by Trognitz et al. in this volume, these services also allow for different data workflows, something project INDIGO will make good use of. What concerns the Urban Chamelon platform, all relevant photographic and 3D surface data must be cached locally on the Urban Chameleon server to support fluent data streaming to the user. Periodic queries to ARCHE will fetch all new and Urban Chameleon-relevant data for local server storage. All graffiti-relevant metadata can be fetched from OpenAtlas via an Application Programming Interface (API), a set of rules and protocols that allows different software or Web applications to communicate and interact. These data and metadata are then displayed and made queryable on the Urban Chameleon platform, enabling the discovery and analysis of the *Donaukanal*'s graffiti-scape.

3.3 Designing

The initial step in the design process of a website or application should be the creation of a wireframe. A wireframe serves as a visual guide that delineates the skeletal structure of the website. It incorporates placeholders for content, navigation elements, and interactive features but does not include detailed design elements such as colours, fonts, or images. Wireframes act as a blueprint for designers, developers and stakeholders, enabling them to comprehend, visualise, and review the overall organisation and functionality of the website before significant time and resources are invested in its development (Robinson, 2018).

Wireframes are crucial in the design and development process of Urban Chameleon. For instance, consider the landing page's image gallery. The wireframe for this page outlines the location of the image gallery and indicates that the gallery's imagery is fetched via the OpenAtlas API (see Figure 4). The gallery displays the images in a carousel format via a "react-responsive-carousel" (https://react-responsive-carousel.js.org) library. In this context, a library is like a toolbox of pre-made code developers use to build their applications. This particular library works with React (https://react.dev), a comprehensive component-based

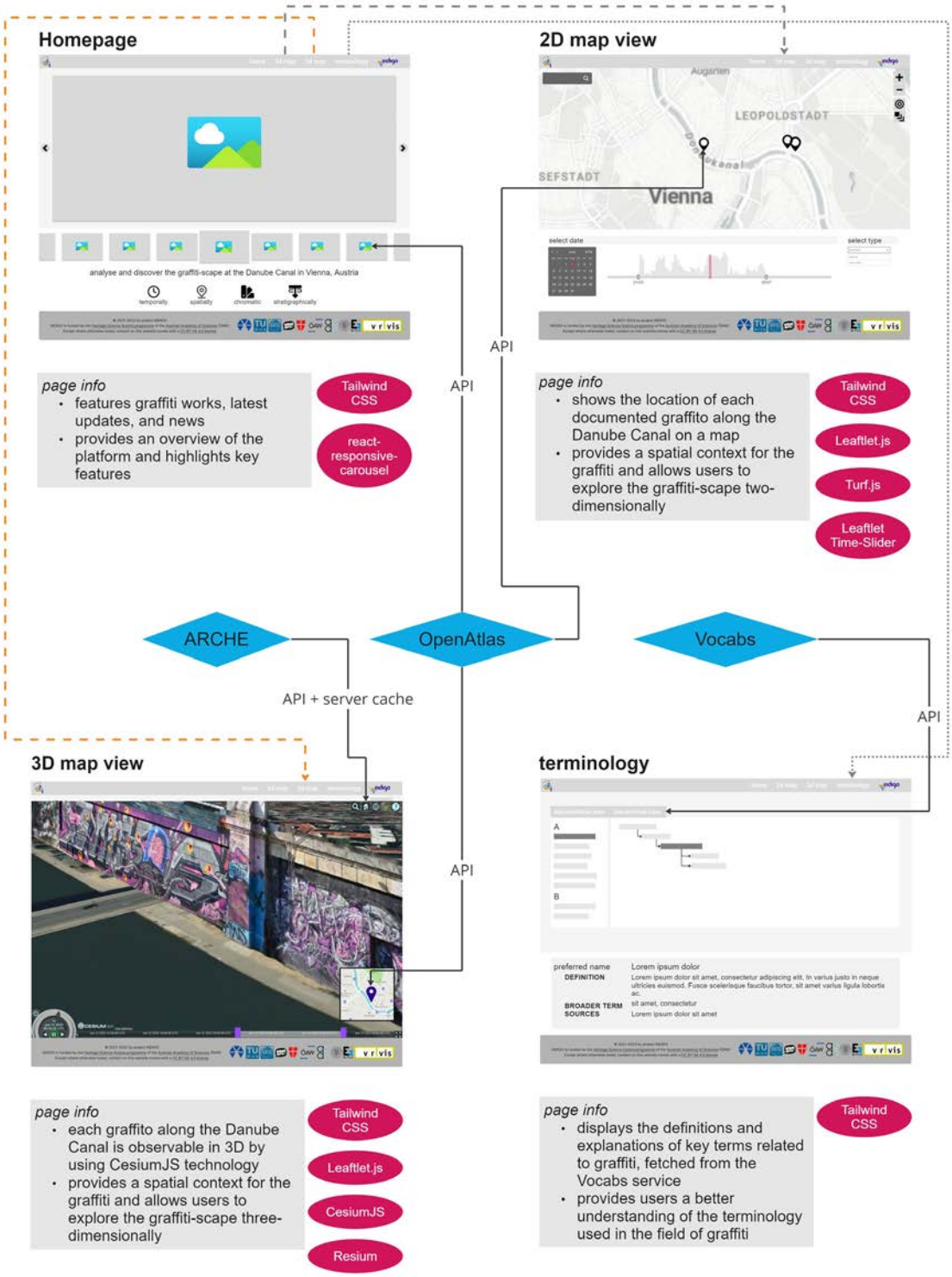

Figure 4. Wireframe of Urban Chameleon showing the data input (blue diamonds) and dependencies (pink ellipses) for every page.

open-source library popular for building user interfaces in a Web environment. React is based on JavaScript, a versatile programming language primarily used to make Web pages more interactive. JavaScript allows developers to control Web elements like forms and images; it is the backbone of modern Web applications. As a JavaScript library, React takes advantage of this flexibility and adds its own features. The carousel component is a good example of how React can help developers create dynamic and interactive Web applications that update and render efficiently in response to changed user inputs or data availability.

Another technological cornerstone for Urban Chameleon is CesiumJS (https://cesium.com/platform/cesiumjs), an open-source and JavaScript-based geospatial library to work online with virtual globes and 3D maps. Besides conventional 2D maps, Urban Chameleon aims to offer visitors a digital 3D surface model of the entire *Donaukanal*.

Component	Type	Description	Benefits	Limitations	Choice Motive	Implementation
HTML	Markup Language	Creates Web pages	Universal, easy to use, supported by all browsers	Limited to static pages	Foundation of Web pages	Structures Web content
CSS	Style-Sheet Language	Styles HTML documents	Design flexibility, separates content from design	Requires understanding of inheritance and overriding	Controls layout of Web pages	Styles HTML elements
SCSS	Preprocessor	Extends CSS, adds features	Variables, nesting, mixins	Requires a build step	Enhances CSS functionality	Generates final CSS
JavaScript	Programming Language	Enables interactive Web pages	Interactivity, rich interfaces, versatility	Browser compatibility issues	Makes Web pages dynamic	Handles form validation, data processing
React	Library	Builds user interfaces	Component-based, fast rendering, SEO-friendly	Requires in-depth JavaScript knowledge	Develops complex UIs	Builds the user interface
TypeScript	Language	Superset of JavaScript, adds static types	Error detection at compile time, enhances code readability	Requires compilation	Enhances code reliability	Writes main application logic
Next.js 13	Framework	Enables server-side rendering, generates static websites	Performance benefits, fast refresh, data fetching	Requires React knowledge	Improves performance	Structures the Web application

CesiumJS	Library	Creates 3D globes and maps	High-precision rendering, feature-rich	Requires suitable hardware, up-to-date browser	Represents geographical context	Creates 3D globes and maps
Resium	Library	Wrapper for CesiumJS, used with React	Simplifies use of CesiumJS with React	Limited community, relies on CesiumJS	Facilitates use of CesiumJS	Integrates CesiumJS into the application
Potree	Library	Renders large point clouds in the browser	Handles large data, open-source	Requires suitable hardware	Creates 3D representation of environment	Renders large point clouds
Leaflet	Library	Creates mobile-friendly interactive maps	Easy to use, high performance, cross-platform	Requires plugins for advanced features	Lightweight, efficient	Implements interactive maps
React-Responsive-Carousel	Library	Carousel component for React applications	Customisable, responsive, supports swipe	Limited to React applications	Provides dynamic image viewing	Displays image gallery
Leaflet Time Slider	Library	Time slider plugin for Leaflet	Temporal-based filtering and visualisation	Requires time-based data	Enables temporal control over map data	Controls display of time-based data
Turf.js	Library	Performs spatial analysis, map manipulation	Modular, supports GeoJSON	Requires spatial analysis knowledge	Provides geospatial capabilities	Performs spatial analysis, map manipulation
Tailwind CSS	Framework	Utility-first CSS framework	Highly customisable, low specificity, responsive	Requires CSS knowledge	Allows rapid UI development	Styles the Web application

Table 1. This table summarises the programming languages, libraries (collections of pre-written code used for common tasks), and frameworks (structures dictating the architecture of the software) utilised for INDIGO's Urban Chameleon platform. Besides a general description, each technology's benefits, limitations, selection rationale, and specific role are outlined.

Whereas this surface model digitally represents the geometry of the graffiti-scape, all documented graffiti should be visualised via time-dependent texturing of this geometry. In that way, Urban Chameleon hopes to facilitate virtual graffiti-scape walks through space and time. CesiumJS was chosen to make this entire experience responsive

and realistic. However, other libraries can enhance the capabilities of CesiumJS. Resium (https://resium.reearth.io), for instance, acts as a bridge between CesiumJS and React. It enables developers to incorporate the 3D mapping capabilities of CesiumJS within a React application, thereby combining the strengths of both libraries.

Besides CesiumJS, Resium and React, many other Web technologies will likely find their way into Urban Chameleon. Table 1 summarises all of them. The INDIGO team hopes this technological stack can facilitate a large, interactive online environment that allows one to query and download the underlying database of graffiti records on the one hand, and show those graffiti in a spatially and temporally accurate virtual context on the other. In that way, the online platform might enable a more comprehensive understanding and appreciation of graffiti as a form of cultural heritage (Statham, 2019; Ulutas Aydogan et al., 2021).

3.4 Test, Deploy, Feedback and Re-Analyse—An Outlook

The following steps are integral to developing and refining INDIGO's online platform and still follow Agile development methodologies. These stages ensure the platform undergoes comprehensive testing, is launched for public use, collects feedback, and implements necessary modifications. All steps still need to be worked out for Urban Chameleon, so here is an overview of what we envision.

The initial stage in this process, known as testing, involves various checks to confirm that the website functions as anticipated and meets the criteria set. This encompasses functional testing (which checks that all features are operating correctly), performance testing (which assesses the speed and responsiveness of the website), and usability testing to evaluate the user experience. Testing is critical to detect and rectify any issues or glitches before the website goes live (Pandey & Litoriya, 2020).

In Web development, deployment indicates the stage a website is made live and available for public use. This crucial step transitions the website from a private, controlled environment (often a developer's personal computer) to a server. A server can be considered a computer that hosts the website and ensures that anyone on the Internet can reach the website anytime. The website's amount of data, traffic and functionalities determine how powerful the server has to be. The deployment process is meticulously carried out to guarantee that the website functions smoothly and consistently for all its users, regardless of when or where they access it (Kamepally & Nalamothu, 2016).

Third, user feedback is collected from researchers, graffitists, stakeholders, and other relevant parties via surveys, user interviews, and website data analytics. Feedback is crucial as it provides insights into how users interact with the website. It identifies areas for improvement and validates the website's effectiveness in achieving its objectives (Koukopoulos & Koukopoulos, 2019). Based on this feedback, necessary adjustments to the platform's design, functionality, or content might follow. Overall, the Agile development approach adopted by INDIGO is particularly effective given the small team.

4. Conclusion

If project INDIGO manages to pull off the Urban Chameleon platform as envisioned, its data visualisation, sharing and querying capabilities will mark a significant advancement in the Digital Humanities, particularly for graffiti studies. To that end, the INDIGO team is currently integrating advanced Web development technologies with a graffiti-specific metadata schema and thesaurus, all on top of the latest standards in semantic data structuring and long-term storage. In the end, the authors hope that it all comes nicely together so that Urban Chameleon can provide a comprehensive, interactive, and user-friendly digital space for the digital exploration and analysis of an entire graffiti-scape over time. However, the entire platform development process is not a simple linear process. Many hurdles (often in the form of bespoke, iterative developments) must be taken along the way. This paper mentioned some of these developments; additional ones form the topic of other contributions in this volume (such as the temporal reasoning approach and image segmentation tool, respectively reported by Verhoeven, Schlegel & Wild and Verhoeven, Wieser & Carloni).

Conflict of Interest
The authors declare no conflict of interest.

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References

Amor Garcia, R. L. (2023). Conservation of Graffiti_Ethics and Practices. In G. J. Verhoeven, J. Schlegel, B. Wild, S. Wogrin, & M. Carloni (Eds.), *Document | archive | disseminate graffiti-scapes. Proceedings of the goINDIGO2022 international graffiti symposium* (pp. 250–259). Urban Creativity. https://doi.org/10.48619/indigo.v0i0.714

The Ancient Graffiti Project. (2023). *The Ancient Graffiti Project: A digital resource for studying the graffiti of Herculaneum and Pompeii. V 4.1.0*. http://ancientgraffiti.org/Graffiti

Art Crimes and the artists. (2022). *Art Crimes: The Writing on the Wall. Graffiti art worldwide.* https://www.graffiti.org

Avrithis, Y., Kalantidis, Y., Tolias, G., & Spyrou, E. (2010). Retrieving landmark and non-landmark images from community photo collections. In A. del Bimbo, S.-F. Chang, & A. W. Smeulders (Eds.), *Proceedings of the 18th ACM international conference on Multimedia (MM '10)* (pp. 153–162). ACM. https://doi.org/10.1145/1873951.1873973

Bekiari, C., Bruseker, G., Canning, E., Doerr, M., Michon, P., Ore, C.-E., Stead, S., & Velios, A. (June 2022). *Volume A: Definition of the CIDOC Conceptual Reference Model: Version 7.1.2*. CIDOC CRM Special Interest Group. https://www.cidoc-crm.org/sites/default/files/cidoc_crm_v7.1.2.pdf

Borgman, C. L. (2015). *Big Data, Little Data, No Data: Scholarship in the Networked World*. The MIT Press.

Caplan, P. (2003). *Metadata fundamentals for all librarians.* American Library Association.

Chen, G., Baek, S., Florez, J.-D., Qian, W., Leigh, S.-W., Hutchinson, S., & Dellaert, F. (2022). Gtgraffiti: Spray Painting Graffiti Art from Human Painting Motions with a Cable Driven Parallel Robot. In G. J. Pappas & V. Kumar (Eds.), *Proceedings of the 2022 International Conference on Robotics and Automation (ICRA)* (pp. 4065–4072). IEEE. https://doi.org/10.1109/ICRA46639.2022.9812008

Cortea, I. M., Ratoiu, L., & Rădvan, R. (2021). Characterization of spray paints used in street art graffiti by a non-destructive multi-analytical approach. *Color Research & Application*, *46*(1), 183–194. https://doi.org/10.1002/col.22561

Dourisboure, Y., Geraci, F., & Pellegrini, M. (2007). Extraction and classification of dense communities in the web. In C. Williamson, M. E. Zurko, P. Patel-Schneider, & P. Shenoy (Eds.), *Www'07: Proceedings of the 16th international conference on World Wide Web* (pp. 461–470). ACM. https://doi.org/10.1145/1242572.1242635

Dovey, K., Wollan, S., & Woodcock, I. (2012). Placing Graffiti: Creating and Contesting Character in Inner-city Melbourne. *Journal of Urban Design*, 17(1), 21–41. https://doi.org/10.1080/13574809.2011.646248

Filzwieser, R., & Eichert, S. (2020). Towards an Online Database for Archaeological Landscapes. Using the Web Based, Open Source Software OpenAtlas for the Acquisition, Analysis and Dissemination of Archaeological and Historical Data on a Landscape Basis. *Heritage*, *3*(4), 1385–1401. https://doi.org/10.3390/heritage3040077

Ganz, N. (2021). Graffiti. In T. DaCosta Kaufmann (Ed.), *Art History*. Oxford University Press. https://doi.org/10.1093/OBO/9780199920105-0159

Gartus, A., & Leder, H. (2014). The white cube of the museum versus the gray cube of the street: The role of context in aesthetic evaluations. *Psychology of Aesthetics, Creativity, and the Arts*, *8*(3), 311–320. https://doi.org/10.1037/a0036847

Harding, N. (2019). Instagraff—The Influence of Web 2.0, Social Media, and User-Created Content Upon Graffiti Culture Performed in Cyber/Space. In M. Brown & E.

Carrabine (Series Eds.) & D. Akrivos & A. K. Antoniou (Vol. Eds.), *Palgrave Studies in Crime, Media and Culture. Crime, Deviance and Popular Culture: International and Multidisciplinary Perspectives* (pp. 259–286). Springer International Publishing. https://doi.org/10.1007/978-3-030-04912-6_11

Hu, R., Wang, Z., Hu, J., Xu, J., & Xie, J. (2008). Agile Web Development with Web Framework. In *Proceedings of the 4th International Conference on Wireless Communications, Networking and Mobile Computing* (pp. 1–4). IEEE. https://doi.org/10.1109/WiCom.2008.2960

INGRID. (October 2019). *Annotationsmanual (Arbeitsversion).* https://www.uni-paderborn.de/fileadmin/ingrid/INGRID_Manual_Oktober_2019.pdf

Kamepally, A. K., & Nalamothu, T. (2016). Agile Methodologies in Software Engineering and Web Engineering. *International Journal of Education and Management Engineering, 6*(5), 1–14. https://doi.org/10.5815/ijeme.2016.05.01

Kolmakova, V., & Shalkov, D. (2021). Psychohermeneutics of graffiti: External and internal loci of control. *E3S Web of Conferences, 273*, 11021. https://doi.org/10.1051/e3sconf/202127311021

Koukopoulos, Z., & Koukopoulos, D. (2019). Evaluating the Usability and the Personal and Social Acceptance of a Participatory Digital Platform for Cultural Heritage. *Heritage, 2*(1), 1–26. https://doi.org/10.3390/heritage2010001

La Rocca, G., & Boccia Artieri, G. (2022). Interpreting the changeable meaning of hashtags: Toward the theorization of a model. *Frontiers in Sociology, 7*, 1104686. https://doi.org/10.3389/fsoc.2022.1104686

MacDowall, L. (2019). *Instafame: Graffiti and street art in the Instagram era.* Intellect.

Mugridge, R. L. (2007). Cataloging Cultural Objects: A Guide to Describing Cultural Works and Their Images. *Library Collections, Acquisitions, & Technical Services, 31*(3-4), 230. https://doi.org/10.1080/14649055.2007.10766172

Niccolucci, F., & Felicetti, A. (2018). A CIDOC CRM-based Model for the Documentation of Heritage Sciences. In A. C. Addison & H. Thwaites (Eds.), *Proceedings of the 2018 3rd Digital Heritage International Congress (DigitalHERITAGE) held jointly with 2018 24th International Conference on Virtual Systems & Multimedia (VSMM 2018) and in collaboration with UNESCO, CalParks, CNR, PNC, CAA, ICOMOS/ISPRS CIPA, Nottingham Trent Univ., ICOMOS ICIP, Space2Place, ARCHAEOVIRTUAL and the EU projects ARIADNE, E-RIHS, EMOTIVE, meSch, PARTHENOS, and REVEAL* (pp. 1–6). IEEE. https://doi.org/10.1109/DigitalHeritage.2018.8810109

Pandey, P., & Litoriya, R. (2020). Software process selection system based on multicriteria decision making. *Journal of Software: Evolution and Process, 33*(2), e2305. https://doi.org/10.1002/smr.2305

Pérez-Izaguirre, E., & Reglero, A. M. L. (2023). What Can Graffiti Tell Us About Emotions and Motivation? Some Key Points for Learning. *Trends in Psychology.* Advance online publication. https://doi.org/10.1007/s43076-023-00304-9

Pomerantz, J. (2015). *Metadata. The MIT Press essential knowledge series.* The MIT Press.

Richards, N., Eichert, S., & Watzinger, A. (2023). One Ontology to Rule Them All—CIDOC CRM in the Humanities and Its Use in OpenAtlas. In G. J. Verhoeven, J. Schlegel, B. Wild, S. Wogrin, & M. Carloni (Eds.), *Document | archive | disseminate graffiti-scapes. Proceedings of the goINDIGO2022 international graffiti symposium* (pp. 220–230). Urban Creativity. https://doi.org/10.48619/indigo.v0i0.711

Ridge, M. (2013). From Tagging to Theorizing: Deepening Engagement with Cultural Heritage through Crowdsourcing. Curator: *The Museum Journal, 56*(4), 435–450. https://doi.org/10.1111/cura.12046

Ríos, J. M., & Pedreira-Souto, N. (2019). Approach of Agile Methodologies in the Development of Web-Based Software. *Information*, *10*(10), Article 314. https://doi.org/10.3390/info10100314

Robinson, A. (2018). *Sketch2code: Generating a website from a paper mockup* [Master thesis, University of Bristol, Bristol]. http://arxiv.org/pdf/1905.13750v1

Schlegel, J., Carloni, M., Wogrin, S., Graff, A. M., & Verhoeven, G. J. (2023). Making a mark—Towards a graffiti thesaurus. In G. J. Verhoeven, J. Schlegel, B. Wild, S. Wogrin, & M. Carloni (Eds.), *Document | archive | disseminate graffiti-scapes. Proceedings of the goINDIGO2022 international graffiti symposium* (pp. 203–219). Urban Creativity. https://doi.org/10.48619/indigo.v0i0.710

SprayCity. (2023). *Spraycity.At - Graffiti-Writing Archive Wien - Vienna - Austria.* https://spraycity.at

Statham, N. (2019). Scientific rigour of online platforms for 3D visualization of heritage. *Virtual Archaeology Review*, *10*(20), 1. https://doi.org/10.4995/var.2019.9715

Sturdy Colls, C., Bolton-King, R., Colls, K., Harris, T., & Weston, C. (2019). Proof of Life: Mark-Making Practices on the Island of Alderney. *European Journal of Archaeology*, *22*(2), 232–254. https://doi.org/10.1017/eaa.2018.71

Thomas, S., & Nicholas, L. E. (2020). Preventing crime against cultural and archaeological sites. In J. F. Donnermeyer (Series Ed.) & A. Harkness (Vol. Ed.), *Routledge Studies in Rural Criminology. Rural Crime Prevention: Theory, Tactics and Techniques* (p. 12). Routledge.

Ulutas Aydogan, S., Münster, S., Girardi, D., Palmirani, M., & Vitali, F. (2021). A Framework to Support Digital Humanities and Cultural Heritage Studies Research. In F. Niebling, S. Münster, & H. Messemer (Eds.), Communications in *Computer and Information Science: Vol. 1501. Research and Education in Urban History in the Age of Digital Libraries: Second International Workshop, UHDL 2019, Dresden, Germany, October 10–11, 2019, Revised Selected Papers* (pp. 237–267). Springer International Publishing. https://doi.org/10.1007/978-3-030-93186-5_11

Veenendaal, B. (2016). Eras of web mapping developments: Past, present and future. *ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, *XLI-B4*, 247–252. https://doi.org/10.5194/isprs-archives-XLI-B4-247-2016

Verhoeven, G. J., Wild, B., Schlegel, J., Wieser, M., Pfeifer, N., Wogrin, S., Eysn, L., Carloni, M., Koschiček-Krombholz, B., Molada-Tebar, A., Otepka-Schremmer, J., Ressl, C., Trognitz, M., & Watzinger, A. (2022). Project INDIGO – document, disseminate & analyse a graffiti-scape. *ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, *XLVI-2/W1-2022*, 513–520. https://doi.org/10.5194/isprs-archives-XLVI-2-W1-2022-513-2022

Waldner, L. K., & Dobratz, B. A. (2013). Graffiti as a Form of Contentious Political Participation. *Sociology Compass*, *7*(5), 377–389. https://doi.org/10.1111/soc4.12036

Wild, B., Verhoeven, G. J., Wogrin, S., Wieser, M., Ressl, C., Otepka-Schremmer, J., & Pfeifer, N. (2023). Urban creativity meets engineering. Automated graffiti mapping along Vienna's Donaukanal. In G. J. Verhoeven, J. Schlegel, B. Wild, S. Wogrin, & M. Carloni (Eds.), *Document | archive | disseminate graffiti-scapes. Proceedings of the goINDIGO2022 international graffiti symposium* (pp. 131–145). Urban Creativity. https://doi.org/10.48619/indigo.v0i0.705

Wyatt, J. C. (1997). Commentary: Measuring quality and impact of the World Wide Web. *BMJ (Clinical Research Ed.)*, *314*(7098), 1879–1881. https://doi.org/10.1136/bmj.314.7098.1879

The Data Crew—Archive with ARCHE and Enrich with OpenAtlas

Martina Trognitz [1,*], Massimiliano Carloni [1] and Bernhard Koschiček-Krombholz [1]

[1] Austrian Centre for Digital Humanities and Cultural Heritage, Austrian Academy of Sciences, 1010 Vienna, Austria; E-Mails: Martina.Trognitz/Massimiliano.Carloni/Bernhard.Koschicek-Krombholz@oeaw.ac.at
* Corresponding author

Abstract
In digital humanities research, different tools and services need to be integrated to allow for a seamless and streamlined workflow. With the example of project INDIGO, the tasks of archiving, annotating, enriching, and disseminating data with the digital archive ARCHE, the spatial database OpenAtlas, and ACDH-CH's Vocabs Repository are described in detail. Each of the three services is presented along with its core tasks and how it is used within the exemplary workflow of project INDIGO. New functionality that was necessary for the integration of these services within INDIGO was implemented and is also described.

Keywords
Controlled vocabulary; Data enrichment; Long-term preservation; Metadata; Spatial database

1. Introduction

Research with digital methods often requires the interplay of different tools and services responding to diverse needs. Examples include archiving, annotating, and enriching data, as well as disseminating data and results to a wider audience. Since each task may be the domain of one or more separate pieces of software, a robust and streamlined workflow between the different components is essential to ensure the sustainability of the research project's data and its adaptability to different scenarios.

The graffiti along Vienna's Donaukanal (Eng. Danube Canal), which are documented and disseminated within project INDIGO for future reusability and further analysis (Verhoeven et al., 2022), pose an example of the use of several tools and services. From their initial acquisition until their dissemination, the data undergo an extensive workflow across five so-called 'research pillars': Acquisition, processing, management, dissemination, and analysis (Verhoeven et al., 2022, p. 514). All these phases involve the collaboration of various institutional partners.

We will focus on the research pillars 'management' and 'dissemination' and explore in more detail the workflow being developed to enable information exchange between the digital archive ARCHE, the spatial database OpenAtlas, and ACDH-CH's Vocabs Repository (Figure 1). These three services are developed at, and hosted by, the Austrian Centre for Digital Humanities and Cultural Heritage (ACDH-CH) of the Austrian Academy of Sciences. Within the context of project INDIGO, ARCHE, OpenAtlas, and the Vocabs Repository are used for archiving, enriching, and disseminating the data created and collected during the project.

After a brief presentation of each service and its main functionalities, the contribution will focus on how these services are joined and which tasks are solved with each service in the overall workflow. New functionality implemented to streamline the workflow is also presented along the way.

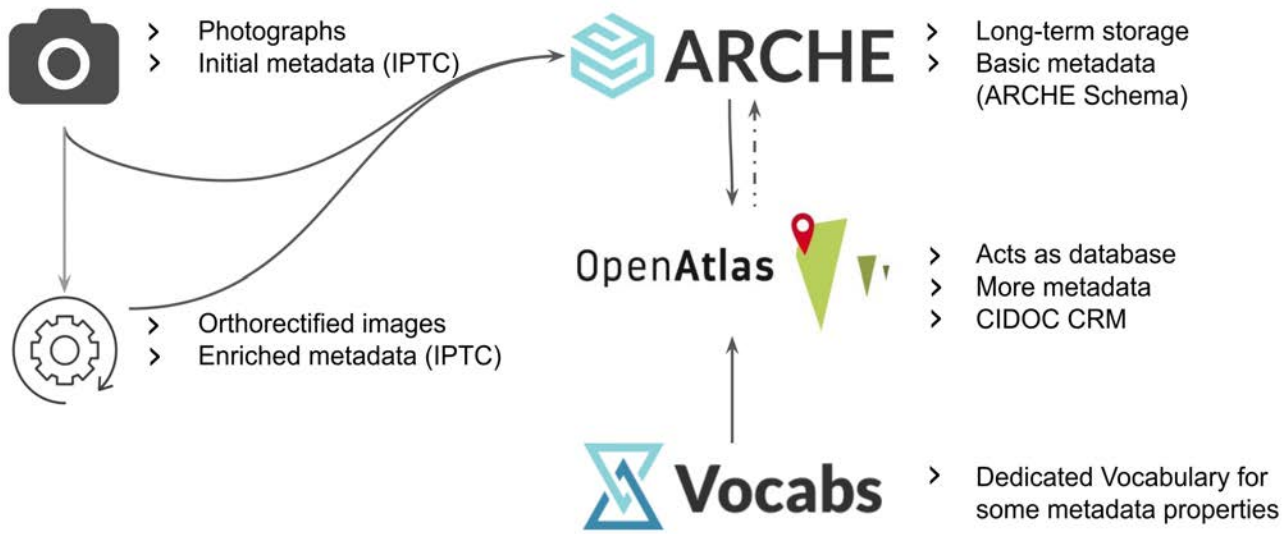

Figure 1. Schematic of the workflow enabling the information exchange between the digital archive ARCHE, the spatial database OpenAtlas, and ACDH-CH's Vocabs Repository. Source: Martina Trognitz.

2. ARCHE

ARCHE, A Resource Centre for the HumanitiEs (ACDH-CH, n.d.–c), is a digital archive established in 2017 and certified with the CoreTrustSeal (CoreTrustSeal, n.d.), a core-level certification for trustworthy data repositories. It offers long-term digital preservation of humanities research data, either related to or originating from Austria. ARCHE does not only aim at the long-term preservation of data, but has a broader perspective that also includes data dissemination to enable data publication, permanent referenceability, sustainable reusability, and reproducibility of research results (Trognitz et al., 2022, p. 231). Preservation and dissemination of the data underlying research results is an important cornerstone of conducting research conforming to general rules of good scientific practice (ALLEA, 2023), including principles such as Open Science (FOSTER, n.d.; Open Knowledge Foundation, n.d.) and FAIR data (Wilkinson et al., 2016).

ARCHE is specialised in preserving research data, which is something few repositories in Austria do (Trognitz, 2021). Supported data types include images, texts, structured and tabular data, audio recordings, videos, 3D models, geographic information, and many more. Individual files are grouped within collections, which can be nested. The technical infrastructure, underlying policies, and design principles behind ARCHE fully embrace and support the FAIR principles for Findable, Accessible, Interoperable, and Reusable data and metadata.

Findability is ensured by the assignment of persistent identifiers to all resources and collections as well as by extensive accompanying metadata. A custom metadata schema was developed for ARCHE to allow for the description of heterogeneous data from a wide range of humanities disciplines (Trognitz & Ďurčo, 2018). Findability is further improved by the fact that resources deposited in ARCHE are harvested by a wide range of aggregators, which include domain-specific portals, such as the CLARIN Virtual Language Observatory (CLARIN, 2023) for linguistic resources, and general-purpose databases about research data, like OpenAIRE (OpenAIRE, 2023) or Europeana (Europeana, n.d.).

Accessing data and metadata is not only possible via a GUI but also via an ever-growing range of dissemination services that adhere to Semantic Web and Linked Open Data (LOD) (Berners-Lee, 2006) standards (Żółtak et al., 2022). Dissemination services are applications capable of presenting specific data types online or delivering them in different formats, thus further enhancing data

interoperability. Examples of dissemination services include a IIIF (International Image Interoperability Framework)-based image viewer and endpoint, and the ExifTool service. The IIIF service allows viewing images online and can disseminate images in various formats and sizes. The ExifTool service is based on the eponymous command-line tool by Phil Harvey (Harvey, 2023) and can read embedded metadata like Exif (Exchangeable Image File Format) and IPTC (IPTC Photo Metadata Standard), and delivers them in JSON (JavaScript Object Notation) format.

Similarly, metadata stored in ARCHE can be delivered in various metadata formats with an OAI-PMH templating system (Żółtak et al., 2022), such as the Europeana Data Model (EDM), which is harvested by the Austrian aggregator for Europeana.

Reusability of data and metadata is further strengthened by the provision of an Application Programming Interface (API), which offers a way to search and retrieve data programmatically. This allows (re-)users to integrate data stored in ARCHE directly within their custom web applications. By allowing the storage of extensive metadata and thus contextualising the data, e.g. with information about applied methods and used software, reusability is further improved.

Within the context of project INDIGO, ARCHE serves as the place where all project data are preserved for the long term.

3. OpenAtlas

OpenAtlas (OpenAtlas team, 2023) is an open-source database project, developed to acquire, edit, and manage geospatial data and information from humanities disciplines, including history, prosopography, archaeology, and heritage science, as well as related data coming from the natural sciences (Richards et al., 2023). OpenAtlas' data model is mapped to the CIDOC Conceptual Reference Model (CRM) developed by the International Council of Museums (ICOM, n.d.) in the background of the application, allowing users to easily create data conforming to CIDOC CRM without the necessity to be familiar with all the complexities of the ontology. OpenAtlas embraces the principles of FAIR data (Wilkinson et al., 2016), adheres to the standards of LOD (Berners-Lee, 2006), and whenever possible aims for openness in all its aspects (Richards et al., 2023).

OpenAtlas allows to record and display relations between different entities, like actors, events, or places, and can be customised with a bespoke set of categories and classification options. The software allows linking data to external online and offline sources. These include authority files like the Getty Arts and Architecture Thesaurus (AAT), GeoNames, or a Museums' inventory number. Data in OpenAtlas can be visualised, e.g. as network graphs (Watzinger & OpenAtlas team, n.d.–b). Machine-readability of all data is provided via an API, which serves data in standard formats such as JSON-LD (Sporny et al., 2020). The API allows information to be fetched for reuse in bespoke web applications or local software for further dissemination, processing, and analysis.

The development, expansion, and overall improvement of OpenAtlas are often carried out in collaboration with research projects. In the context of each project, consideration is also given to extending the data model or adding further functionality to the software (Filzwieser & Eichert, 2020). Usually, the expansions are then added to the core code of OpenAtlas, thus allowing future projects to benefit from past projects. Functionalities introduced during project INDIGO are detailed in Section 5.

Within project INDIGO, OpenAtlas, with its powerful API, serves as a middleware between the data archived in ARCHE and the separate frontend platform. Furthermore, OpenAtlas can be used to record and edit all metadata related to an individual graffito, such as the creator(s), location, creation time, style, colour(s), and dimensions.

4. ACDH-CH's Vocabs Repository

The Vocabs Repository of ACDH-CH (ACDH-CH, n.d.–a) is a service based on Skosmos (Suominen et al., 2015) to provide hosting, browsing, and visualisation of controlled vocabularies modelled in Simple Knowledge Organization System (SKOS) (Isaac & Summers, 2009). Skosmos implements Linked Data principles and provides an API that allows fetching the vocabulary data and presenting them in custom project applications (Andorfer & Illmayer, 2023). Controlled vocabularies are essential to ensure consistent

use of values in a database (Harpring, 2013, p. 13). In the realm of Semantic Web and LOD, controlled vocabularies are important tools to achieve semantic interoperability across multiple data sources (Zaytseva & Ďurčo, 2020).

The repository does not solely host controlled vocabularies from and for ACDH-CH, but has a much wider scope and is part of the services for the Austrian national CLARIAH-AT consortium, for the Thesaurus Maintenance working group in DARIAH-EU (Tsoulouha & Goulis, n.d.), for WP6 – Services and tools in PARTHENOS (Sbarbati, 2015), and, in a separate instance, for the Social Sciences & Humanities Open Cloud (SSHOC) (Vocabs SSHOC, n.d.).

The Vocabs Repository is used to host the INDIGO Graffiti Thesaurus (Schlegel, Carloni, et al., 2023; Schlegel, Wogrin, et al., 2023), which will also be used to populate controlled lists in OpenAtlas. In addition, the Vocabs Repository hosts a controlled vocabulary used in the GRAPHIS application (as described in Section 4.2 of the contribution by Verhoeven, Wieser, & Carloni in this volume).

5. Joining the services for INDIGO

Before reaching any of the presented services, INDIGO data will already have undergone an extensive acquisition and processing workflow (see left side of Figure 1) described in (Verhoeven et al., 2022; Verhoeven et al., 2023; Wild et al., 2023), with various file types as output: The raw photographs, masked and colour-corrected photographs, orthophotographs generated from the colour-corrected images, 2D polygon files, 3D mesh files, and metadata included in sidecar files or directly embedded in the image files. File formats in the submitted data package include Nikon's raw image format NEF (Nikon Electronic Format), XMP (Extensible Metadata Platform) sidecar files with metadata, processed TIFF (Tag Image File Format) and JPEG (Joint Photographic Experts Group) images, spatial information in GeoJSON (Geo JavaScript Object Notation) and GeoTIFF format, 3D models in PLY (Polygon File Format, Stanford Triangle Format) with JPEG texture files, and documentation in TXT (plain text) and DOCX (Microsoft's Office Open XML) files. Among the processed image files, there are so-called orthophotos in GeoTIFF format, which are merged from multiple individual colour-corrected raw images, georeferenced, and orthorectified. Each of them represents an individual graffito (Molada-Tebar & Verhoeven, 2023; Wild et al., 2022).

The first contact point of INDIGO data with the software and services offered by ACDH-CH is the digital archive ARCHE, which will take care of the long-term preservation and publication of the data. The data and metadata undergo an extensive curation process, guided by a curator from ARCHE, that comprises several checks in order to ensure the quality, consistency, and usability of the data. After an initial automatic validation of file formats, reporting of file names, and identification of possible duplicates with the tool repo-file-checker (Czirjak et al., 2023), the metadata are checked for compliance with ARCHE's minimum requirements. Based on these results, a curation strategy is devised. It includes the necessary steps and changes to be applied to the submitted dataset to transform it into the Archival Information Package (AIP) to be ingested. The AIP is an information package type defined by the Open Archival Information System (OAIS) reference model (Consultative Committee on Space Data Systems, 2012), which ARCHE implements (Trognitz & Ďurčo, 2018). Data from INDIGO are expected to come with extensive metadata following the IPTC standard, in XMP sidecar files, and also included within the image files. The curation strategy will cater to this, and a mapping to the ARCHE metadata schema will be prepared, together with an automated workflow for reading and ingesting the metadata into the archive. The final number of raw photographs is estimated at around 150,000. It is expected that raw photographs will not be needed to be served one-by-one to other services and that requests for individual images by users of the archive are unlikely. Therefore, to avoid any performance issues due to the large number of files, batches of raw images comprising one graffito will be grouped into single BagIt packages (Kunze et al., 2018).

After successful curation of the data and ingestion of the AIP, the data are publicly available on ARCHE with a Persistent identifier (PID) assigned to each resource. PIDs are based on the Handle system (Corporation for National Research Initiatives, 2023) for persistent identification and stable

reference. The data and metadata can now be accessed and reused either manually via ARCHE's web portal, or automatically via the API or the various dissemination services. This is where the next service, OpenAtlas, comes into play.

The import of data from ARCHE into OpenAtlas is performed through a bespoke interface developed for project INDIGO (Watzinger & OpenAtlas team, n.d.–a). The activation of this interface requires specific parameters in a configuration file, including the identifier of the collection that needs to be fetched and the base URI of the ARCHE instance which must be queried. The latter is especially useful in testing environments, when data are still temporarily stored on the staging instance with data collections still undergoing curation, and not yet on the production instance of ARCHE with datasets actually ingested into the archive.

Within the import interface, users with respective rights can check which data available in the collection in ARCHE have not yet been imported into OpenAtlas. These data are displayed in a table (based on the 'Artifact' class), as can be seen in Figure 2, and can be selected and imported, respectively.

In the case of project INDIGO, not all data stored in ARCHE are needed in OpenAtlas. For example, only merged orthophotographs representing one graffito, and not the individual source photographs, are selected for import. Not only data, but also metadata are imported into OpenAtlas. These include metadata pertaining to the image files, which are modelled according to the ARCHE metadata schema, as well as metadata directly embedded within an image file. The former are exposed and fetched via ARCHE's core API and the latter are fetched through the ExifTool service.

The mapping of metadata coming from ARCHE to OpenAtlas' data model is visualised in Figure 3. This mapping is specific to project INDIGO and assumes that each image represents one artefact, i.e. a graffito, which is an instance of the class E22 Human-Made Object in CIDOC CRM. The import automatically creates instances of relevant classes,

Figure 2. Tabular view of data archived in ARCHE that can be imported into an OpenAtlas project. Source: OpenAtlas.

like 'Artifact', 'Agent', or 'Place'. Most of the metadata to be mapped are fetched from the data served via the ExifTool service and in Figure 3 are indicated with the namespaces 'EXIF', 'IPTC', and 'XMP'.

While the actual graffito is represented as an artefact in OpenAtlas, its digital counterpart, i.e. the orthophoto coming from ARCHE, is treated as a related file (which is modelled as an instance of E31 Document in CIDOC CRM). Thus, the graffito and the image of the graffito are described with different properties in OpenAtlas, as Figure 3 exemplifies.

Once data and metadata are imported, it is possible to enrich them through the OpenAtlas web interface. In the data model of OpenAtlas, entities are described with types, i.e. attributes or properties, which correspond to the class E55

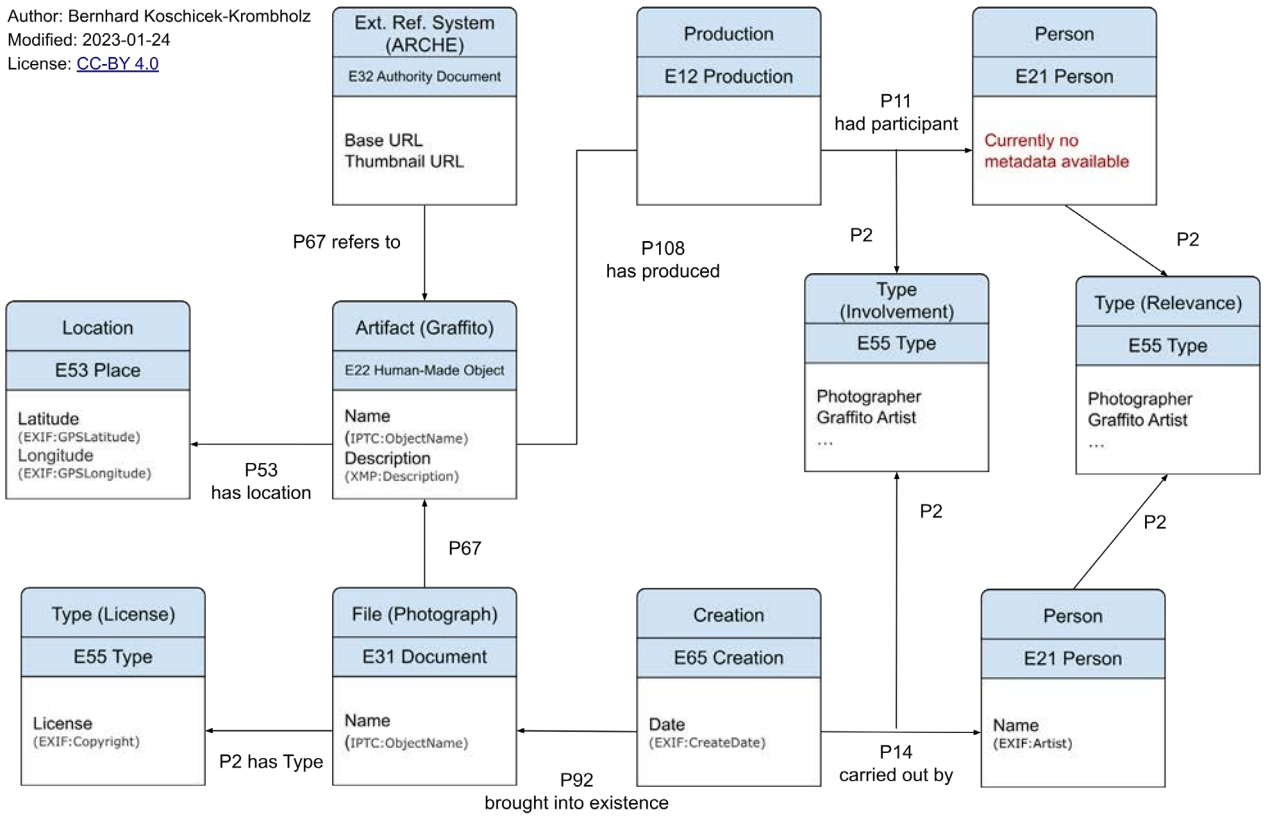

Figure 3. Mapping of ARCHE metadata to the OpenAtlas data model. The namespaces EXIF, IPTC, and XMP indicate metadata fetched by ARCHE's ExifTool service. Source: Bernhard Koschiček-Krombholz via (Watzinger & OpenAtlas team, n.d.–a), CC BY 4.0.

in CIDOC CRM. Hierarchical trees of types can be defined or imported, where the types at a higher level are more general, and those at a lower level, i.e. the subtypes, are more specific. OpenAtlas already ships with some standard types, but each project can define types tailored to their research purposes. In the example of project INDIGO, a standard type is 'Artifact'. Project INDIGO added further custom subtypes to the tree 'Artifact', such as 'visual works', 'graffiti', and 'pieces (graffiti)'. In terms of a database or metadata schema, a type like 'Artifact' can be thought of as the equivalent of a property, while subtypes, like 'visual work', can be considered values for that property. By using types and assigning one or even multiple subtypes to an artefact, like a a graffito, a user can describe it in a more specific and expressive way, thus enabling interesting insights and cross-queries.

For project INDIGO, new functionality was implemented in OpenAtlas to allow controlled vocabularies from ACDH-CH's Vocabs Repository to be imported into OpenAtlas types. This was implemented by using the API of the Vocabs Repository, which is based on the Skosmos software (ACDH-CH, n.d.–b). More specifically, the new functionality enables to access and retrieve concepts present in a controlled vocabulary, their relevant metadata properties, such as preferred and alternative labels, and their mutual hierarchical relationships, which can be transposed into the hierarchical organisation of type trees in OpenAtlas. For example, the concept 'pieces (graffiti)' (https://vocabs.acdh.oeaw.ac.at/indigo/piecesGraffiti) is narrower than the concept 'graffiti' (https://vocabs.acdh.oeaw.ac.at/indigo/graffiti);both concepts would be imported as subtypes into an OpenAtlas

type and 'pieces (graffiti)' would then be a type subordinate to the type 'graffiti'. In addition, the integration between ACDH-CH's Vocabs Repository and OpenAtlas also allows access to concepts that are arranged into collections, i.e. groupings of concepts that are related and can be identified through a common label. One example presented in Figure 4 is the Vocabs Repository collection 'sign and element' (https://vocabs.acdh.oeaw.ac.at/indigo/signAndElement), which includes the concepts '@ signs (motif)' (https://vocabs.acdh.oeaw.ac.at/indigo/atSignsMotif) and 'anarchy symbols' (https://vocabs.acdh.oeaw.ac.at/indigo/anarchySymbols). In OpenAtlas, the collection 'sign and element' will be imported as a type, of which the two concepts '@ signs (motif)' and 'anarchy symbols' will be subtypes.

By leveraging the capabilities of both ACDH-CH's Vocabs Repository and OpenAtlas together, it is possible to arrange and describe necessary type trees in an external knowledge organisation system, providing hierarchical and associative relations between the types and subtypes as well as rich metadata about them, including definitions and sources for each of them. This also allows for wide accessibility and reusability of the hierarchical type trees across different systems. In project INDIGO, the Graffiti Thesaurus (Schlegel, Wogrin, et al., 2023) has been published on the Vocabs Repository and will be used to populate specific predefined and custom types in OpenAtlas.

6. Conclusions

The necessary functionality for the integration of the digital archive ARCHE, the spatial database OpenAtlas, and ACDH-CH's Vocabs Repository is already implemented and has so far been tested with exemplary test data. The main implemented features include ARCHE's ExifTool service for the dissemination of embedded metadata of files stored within ARCHE, OpenAtlas' ARCHE module to allow fetching data and metadata from ARCHE, and OpenAtlas' feature to import concepts and collections from ACDH-CH's Vocabs Repository.

Currently, the OpenAtlas' ARCHE module is tailored for importing INDIGO data from ARCHE into an OpenAtlas instance for project INDIGO. Thus, the mapping of ARCHE's and the images' metadata to the data model of OpenAtlas

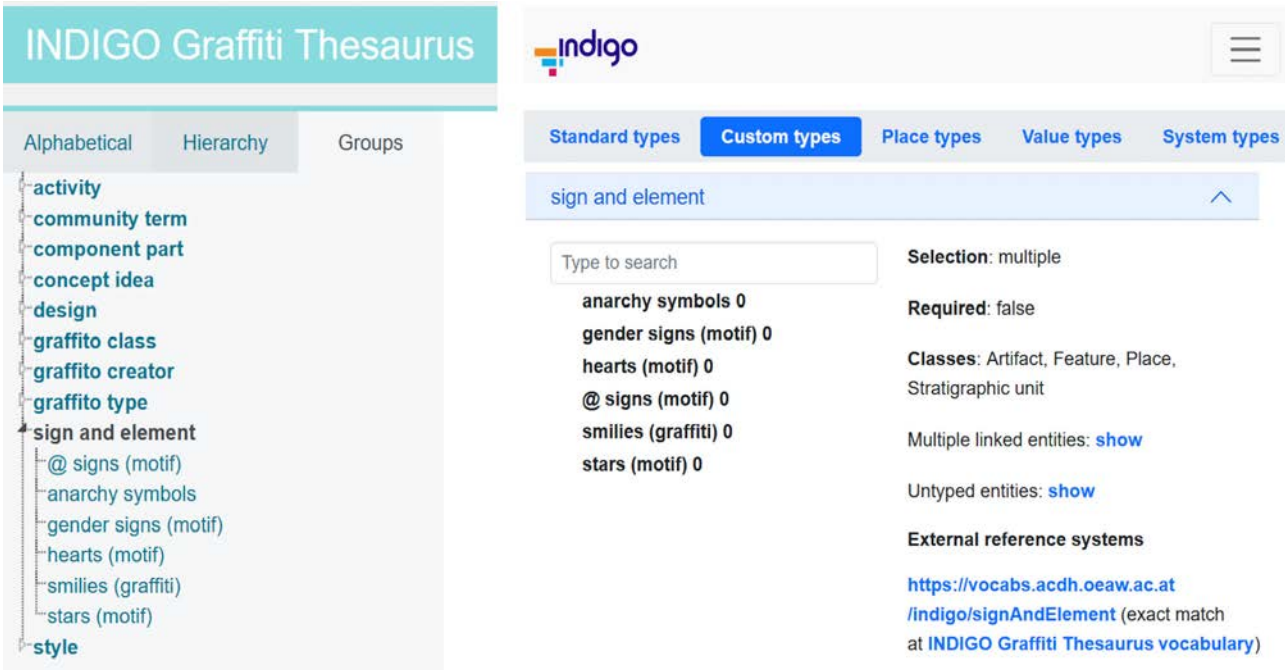

Figure 4. The collection 'sign and element' in ACDH-CH's Vocabs Repository and as a type in OpenAtlas. Source: Martina Trognitz via ACDH-CH's Vocabs Repository and OpenAtlas.

is highly customised and can not be reused for any other file structure or project setup. Further work on this module is needed to implement a more flexible or generalised mapping. This would then allow other OpenAtlas projects to use it.

The next steps will include a full ingest of all INDIGO data into ARCHE, which will take some time due to the large amount of files, about 430,000, which include around 150,000 RAW photographs, and accumulate to a total estimated size of 20 TB for the whole dataset. Once ingested, the data can then be imported into OpenAtlas and further enriched. The enrichment of data after they have been archived poses another question to be solved: How can this additional information be fed back into ARCHE to allow the data and metadata to be preserved without depending on OpenAtlas?

As of June 2024, ARCHE has so far archived one dataset originating from an OpenAtlas project: Mapping Medieval Conflict (MEDCON) (Preiser-Kapeller, 2020). The data were archived as a database dump in SQL format with accompanying documentation files. For some other OpenAtlas projects, archiving will be performed in a similar way. Project INDIGO poses a new case because archiving of project data is done first and then an instance of OpenAtlas is set up that fetches data and metadata from ARCHE for further enrichment. While implementing a solution to feed back the data enriched in OpenAtlas to ARCHE is still open, such a solution would help integrate data management tasks related to long-term preservation into the research workflow. This would ensure the correct preparation of data and a smooth transition into the archive from the early stages of the project.

Conflict of Interest

The authors declare no conflict of interest.

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References

ACDH-CH. (n.d.–a). *ACDH-CH/DARIAH Vocabularies.* Retrieved July 9, 2023, from https://vocabs.acdh.oeaw.ac.at/en

ACDH-CH. (n.d.–b). *ACDH-CH/DARIAH Vocabularies - API.* Retrieved August 16, 2023, from https://vocabs.acdh.oeaw.ac.at/en/about#api

ACDH-CH. (n.d.–c). *ARCHE - A Resource Centre for Humanities Related Research in Austria.* Retrieved June 9, 2023, from https://arche.acdh.oeaw.ac.at

ALLEA. (2023). *The European Code of Conduct for Research Integrity.* https://allea.org/code-of-conduct

Andorfer, P., & Illmayer, K. (2023). *Vocabs Editor and vocabulary management at OEAW ACDH-CH.* https://doi.org/10.5281/zenodo.7963135

Berners-Lee, T. (2006). *Linked Data.* https://www.w3.org/DesignIssues/LinkedData.html

CLARIN. (2023). *CLARIN Virtual Language Observatory.* https://vlo.clarin.eu

Consultative Committee on Space Data Systems. (June 2012). *Reference Model for an Open Archival Information System (OAIS)* (Recommended Practice CCSDC 650.0-M-2).

CoreTrustSeal. (n.d.). *CoreTrustSeal.* Retrieved November 27, 2023, from https://www.coretrustseal.org

Corporation for National Research Initiatives. (2023). *Handle.Net Registry.* https://www.handle.net

Czirjak, N., Żółtak, M., Trognitz, M., & Ďurčo, M. (2023). *acdh-oeaw/repo-file-checker* (Version 3.1.2) [Computer software]. Zenodo. https://zenodo.org/records/8232570

Europeana. (n.d.). *Discover Europe's digital cultural heritage.* Retrieved September 12, 2023, from https://www.europeana.eu/en

Filzwieser, R., & Eichert, S. (2020). Towards an Online Database for Archaeological Landscapes. Using the Web Based, Open Source Software OpenAtlas for the Acquisition, Analysis and Dissemination of Archaeological and Historical Data on a Landscape Basis. *Heritage*, *3*(4), 1385–1401. https://doi.org/10.3390/heritage3040077

FOSTER. (n.d.). *Open Science Definition.* Retrieved February 10, 2023, from https://www.fosteropenscience.eu/foster-taxonomy/open-science-definition

Harpring, P. (2013). *Introduction to controlled vocabularies: Terminology for art, architecture, and other cultural works* (Updated edition). Getty Research Institute.

Harvey, P. (2023). *Exiftool - Read, Write and Edit Meta Information!* https://exiftool.org

ICOM. (n.d.). *The CIDOC CRM.* Retrieved August 16, 2016, from http://www.cidoc-crm.org

Isaac, A., & Summers, E. (2009, September 18). *SKOS Simple Knowledge Organization System Primer.* W3C Working Group Note. https://www.w3.org/TR/skos-primer

Kunze, J., Littman, J., Madden, E., Scancella, J., & Adams, C. (2018). *The BagIt File Packaging Format (V1.0)* (Request for Comments No. 8493). RFC Editor. https://doi.org/10.17487/RFC8493

Molada-Tebar, A., & Verhoeven, G. J. (2023). Towards colour-accurate documentation of anonymous expressions. In G. J. Verhoeven, J. Schlegel, B. Wild, S. Wogrin, & M. Carloni (Eds.), *Document | archive | disseminate graffiti-scapes. Proceedings of the goINDIGO2022 international graffiti symposium* (pp. 86–130). Urban Creativity. https://doi.org/10.48619/indigo.v0i0.704

Open Knowledge Foundation. (n.d.). *Open Definition 2.1 - Defining Open in Open Data, Open Content and Open Knowledge.* Retrieved February 10, 2023, from https://opendefinition.org/od/2.1/en

OpenAIRE. (2023). *OpenAIRE.* https://www.openaire.eu

OpenAtlas team. (2023). *OpenAtlas.* https://openatlas.eu

Preiser-Kapeller, J. (2020). *Mapping Medieval Conflict (MEDCON) [Data set].* https://hdl.handle.net/21.11115/0000-000C-D99B-1

Richards, N., Eichert, S., & Watzinger, A. (2023). One Ontology to Rule Them All—CIDOC CRM in the Humanities and Its Use in OpenAtlas. In G. J. Verhoeven, J. Schlegel, B. Wild, S. Wogrin, & M. Carloni (Eds.), *Document | archive | disseminate graffiti-scapes. Proceedings of the goINDIGO2022 international graffiti symposium* (pp. 220–230). Urban Creativity. https://doi.org/10.48619/indigo.v0i0.711

Sbarbati, S. (2015). *Activities and Workflow – PARTHENOS Project*. https://www.parthenos-project.eu/activities-and-wps

Schlegel, J., Carloni, M., Wogrin, S., Graff, A. M., & Verhoeven, G. J. (2023). Making a mark—Towards a graffiti thesaurus. In G. J. Verhoeven, J. Schlegel, B. Wild, S. Wogrin, & M. Carloni (Eds.), *Document | archive | disseminate graffiti-scapes. Proceedings of the goINDIGO2022 international graffiti symposium* (pp. 203–219). Urban Creativity. https://doi.org/10.48619/indigo.v0i0.710

Schlegel, J., Wogrin, S., Carloni, M., & Verhoeven, G. J. (2023). *ACDH-CH/DARIAH Vocabularies: INDIGO Graffiti Thesaurus v1.0.0.* https://vocabs.acdh.oeaw.ac.at/indigo/Thesaurus

Sporny, M., Longley, D., Kellogg, G., Lanthaler, M., Champin, P.-A., & Lindström, N. (2020). *JSON-LD 1.1: A JSON-based Serialization for Linked Data.* W3C Recommendation. https://www.w3.org/TR/json-ld

Suominen, O., Ylikotila, H., Pessala, S., Lappalainen, M., Frosterus, M., Tuominen, J., Baker, T., Caracciolo, C., & Retterath, A. (2015). *Publishing SKOS vocabularies with Skosmos.* https://skosmos.org/publishing-skos-vocabularies-with-skosmos.pdf

Trognitz, M. (2021). Saving us from the Digital Dark Age: The Austrian perspective. *Internet Archaeology, 58*. https://doi.org/10.11141/ia.58.2

Trognitz, M., & Ďurčo, M. (2018). One Schema to Rule them All. The Inner Workings of the Digital Archive ARCHE. *Mitteilungen der Vereinigung Österreichischer Bibliothekarinnen und Bibliothekare, 71*(1), 217–231. https://doi.org/10.31263/voebm.v71i1.1979

Trognitz, M., Ďurčo, M., & Mörth, K. (2022). Text Technology for the Digital Humanities. In A. Witt (Series Ed.) & D. Fišer & A. Witt (Vol. Eds.), *Digital Linguistics: Vol. 1. CLARIN: The infrastructure for language resources* (pp. 223–247). De Gruyter. https://doi.org/10.1515/9783110767377-009

Tsoulouha, E., & Goulis, H. (n.d.). *Thesaurus Maintenance | DARIAH*. Retrieved June 5, 2023, from https://www.dariah.eu/activities/working-groups/thesaurus-maintenance

Verhoeven, G. J., Wild, B., Schlegel, J., Wieser, M., Pfeifer, N., Wogrin, S., Eysn, L., Carloni, M., Koschiček-Krombholz, B., Molada-Tebar, A., Otepka-Schremmer, J., Ressl, C., Trognitz, M., & Watzinger, A. (2022). Project INDIGO – document, disseminate & analyse a graffiti-scape. *ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XLVI-2/W1-2022*, 513–520. https://doi.org/10.5194/isprs-archives-XLVI-2-W1-2022-513-2022

Verhoeven, G. J., Wogrin, S., Schlegel, J., Wieser, M., & Wild, B. (2023). Facing a chameleon—How project INDIGO discovers and records new graffiti. In G. J. Verhoeven, J. Schlegel, B. Wild, S. Wogrin, & M. Carloni (Eds.), *Document | archive | disseminate graffiti-scapes. Proceedings of the goINDIGO2022 international graffiti symposium* (pp. 63–85). Urban Creativity. https://doi.org/10.48619/indigo.v0i0.703

Vocabs SSHOC. (n.d.). *SSH Vocabulary Commons*. Retrieved June 5, 2023, from https://vocabs.sshopencloud.eu/browse/en

Watzinger, A., & OpenAtlas team. (n.d.–a). *ARCHE — OpenAtlas 7.16.0 documentation*. Retrieved October 7, 2023, from https://manual.openatlas.eu/admin/arche.html

Watzinger, A., & OpenAtlas team. (n.d.–b). *Network visualization — OpenAtlas 7.16.0 documentation*. Retrieved October 7, 2023, from https://manual.openatlas.eu/tools/network.html

Wild, B., Verhoeven, G. J., Wieser, M., Ressl, C., Schlegel, J., Wogrin, S., Otepka-Schremmer, J., & Pfeifer, N. (2022). AUTOGRAF—Automated Orthorectification of GRAFfiti Photos. *Heritage, 5*(4), 2987–3009. https://doi.org/10.3390/heritage5040155

Wild, B., Verhoeven, G. J., Wogrin, S., Wieser, M., Ressl, C., Otepka-Schremmer, J., & Pfeifer, N. (2023). Urban creativity meets engineering. Automated graffiti mapping along Vienna's Donaukanal. In G. J. Verhoeven, J. Schlegel, B. Wild, S. Wogrin, & M. Carloni (Eds.), *Document | archive | disseminate graffiti-scapes. Proceedings of the goINDIGO2022 international graffiti symposium* (pp. 131–145). Urban Creativity. https://doi.org/10.48619/indigo.v0i0.705

Wilkinson, M. D., Dumontier, M., Aalbersberg, I. J. J., Appleton, G., Axton, M., Baak, A., Blomberg, N., Boiten, J.-W., Da Silva Santos, L. B., Bourne, P. E., Bouwman, J., Brookes, A. J., Clark, T., Crosas, M., Dillo, I., Dumon, O., Edmunds, S., Evelo, C. T., Finkers, R., . . . Mons, B. (2016). The FAIR Guiding Principles for scientific data management and stewardship. *Scientific Data, 3*, 160018. https://doi.org/10.1038/sdata.2016.18

Zaytseva, K., & Ďurčo, M. (2020). *Controlled Vocabularies and SKOS: Version 1.1.0*. DARIAH-Campus. https://campus.dariah.eu/id/D8d6OrLdpLlGRqBSQDVN0

Żółtak, M., Trognitz, M., & Ďurčo, M. (2022). ARCHE Suite: A Flexible Approach to Repository Metadata Management. In M. Monachini & M. Eskevich (Eds.), *Linköping Electronic Conference Proceedings: Vol. 189, Selected Papers from the CLARIN Annual Conference 2021* (pp. 190–199). Linköping University Electronic Press. https://doi.org/10.3384/p18917

GRAPHIS—Visualise, Draw, Annotate, and Save Image Regions in Graffiti Photos

Geert J. Verhoeven [1,*], Martin Wieser [2] and Massimiliano Carloni [3]

[1] University of Vienna - Department of Prehistoric and Historical Archaeology, 1190 Vienna, Austria; E-Mails: geert@projectindigo.eu; geert.verhoeven@univie.ac.at
[2] Independent researcher, Vienna, Austria; E-Mail: scene2map@gmail.com
[3] Austrian Centre for Digital Humanities and Cultural Heritage, Austrian Academy of Sciences, 1010 Vienna, Austria; E-Mail: Massimiliano.Carloni@oeaw.ac.at
* Corresponding author

Abstract

A digital photo file contains the image pixel values along with associated photo metadata. Storing those metadata is enabled by various standards. For instance, the Exif standard enables the recording of technical photo metadata like the camera's serial number and focal length, while the IPTC Photo Metadata Standard is the widely accepted norm for storing copyright and descriptive information in images (from unedited photos to AI-generated pictures). Since its 2019.1 version, the IPTC Photo Metadata Standard has facilitated the creation of image regions: groupings of image pixels—defined by a circle, rectangle, or any other polygonal shape—which can be annotated with region-specific metadata. Given the potential of image regions for graffiti photo annotation, the open-source and freely available software GRAPHIS was developed within the academic graffiti project INDIGO. GRAPHIS (Generate Regions and Annotations for PHotos using the IPTC Standard) allows users to generate and visualise image regions, annotate them with graffiti descriptions or transcriptions, and save them as metadata within the image. To adhere to the IPTC Photo Metadata Standard at every stage, project INDIGO also created a dedicated controlled vocabulary to contain all relevant concepts that can be used to define each image region's role and content type. This paper starts with a general overview of metadata concepts, followed by a more in-depth look at Exif and IPTC photo metadata. After describing the IPTC *Image Region* property, the text details the workings of GRAPHIS and the controlled vocabulary development. An overview of use cases and potential software improvements conclude the text.

Keywords

Annotate; Graffiti-scape; Graffito; GRAPHIS; Image region; IPTC; Metadata; Photograph; Polygon

1. Introduction

1.1. Data and Metadata

The two photographs in Figure 1 depict graffiti created along Vienna's *Donaukanal* (Eng. Danube Canal). Each photo was acquired on the 30th of October 2023 with a Nikon Z7 II full-frame mirrorless camera paired with a Nikon NIKKOR Z 20mm f/1.8 S lens. For both photos, the lens featured an aperture of f/5.6. However, the camera's shutter speed and ISO were 1/400 s and 320 for the left photo, and 1/1250 s and 64 for the right photo. The photo on the left was taken forty-two minutes before the photo on the right, created at 11:12:11 Central European Time (CET).

Nikon Z7 II Nikon NIKKOR Z 20mm f/1.8 S	**camera model** **lens model**	Nikon Z7 II Nikon NIKKOR Z 20mm f/1.8 S
30 October 2023 10:30:52 CET	**acquisition date** **acquisition time**	30 October 2023 11:12:11 CET
aperture priority 1/400 s *f*/5.6 320	**exposure program** **exposure time** **aperture** **ISO**	aperture priority 1/1250 s *f*/5.6 64

Figure 1. Two graffiti photos and some of their technical metadata.

In information science jargon, the photos are called *data*, *subjects*, *potentially informative objects* or (*information*) *resources*, while the information describing those photos is termed *metadata* (Pomerantz, 2015). Metadata are information on the "what, when, where, how and who" of data. The ISBN or title of a book are examples of metadata, but so are the genre and rating of a movie or a photo's exposure parameters and creation date. Metadata often unlock the value of resources, because metadata elements can describe, locate and explain the data, making them retrievable, (re-)useable, and manageable. That is why the ISO 15489-1:2016 Information and documentation standard defined metadata as "structured or semi-structured information, which enables the creation, management, and use of records through time and within and across domains" (International Organization for Standardization, 2016, p. 2). Since data is a plural noun (Borgman, 2015; Bryson, 2008), data—and thus metadata—'are' when referred to as entities rather than concepts.

So, metadata are statements about data or resources. These statements usually take the form of *triples* (see Figure 2); in other words, they feature three parts:

- The *subject*—or (information) resource, data, potentially informative object;
- The *predicate*—or element, property, field, attribute, characteristic;
- The *object*—or value.

For example, taking Banksy's Flower Thrower graffito as the starting point, it can be stated that Banksy (object) is the creator (predicate) of the Flower Thrower graffito (subject). Note that *object* is what we call *subject* in grammar. Yes, it is somewhat confusing! In metadata schemes, the predicates are referred to as metadata elements or fields, but they can also be considered the resource's attributes, properties or characteristics. Each metadata element has a value (here, Banksy), although some might also be left blank. Such an element-value pair is a single statement about a resource

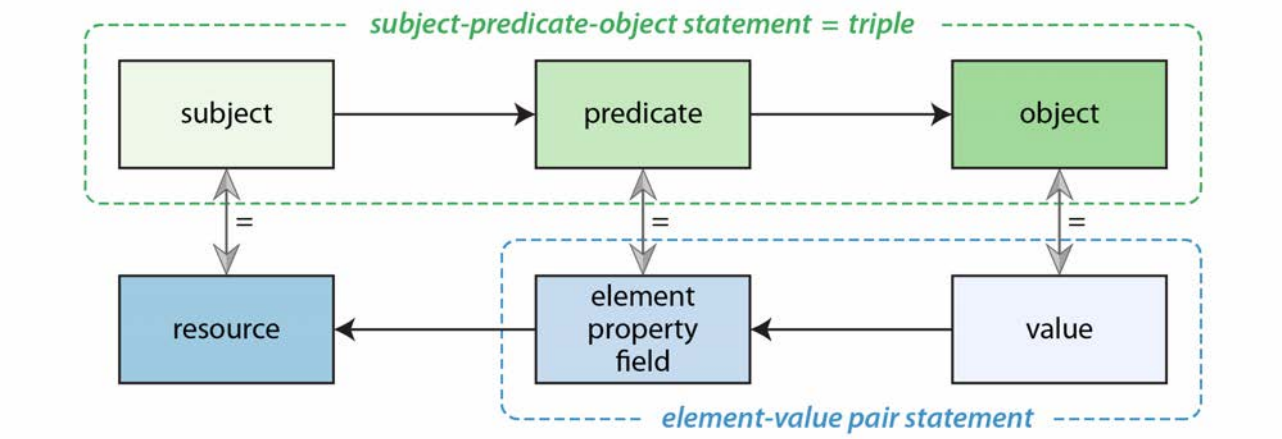

Figure 2. The basic elements of metadata.

(see Figure 2), while a set of statements is a metadata record (Pomerantz, 2015).

Many different element-value pairs constitute all the statements (or the metadata record) about the resource. A *metadata schema* defines which elements are allowed, their optionality, how many separate values they can have, as well as any potential parent/child relationships between these elements. Most metadata schemas include an *application profile* that delineates how and when to use the metadata elements, while the rules for selecting or constructing these elements' values are specified in the metadata *encoding scheme* (although different communities put different emphasis on these two terms; ISO/TC 46/SC11, 2008). The encoding scheme consists of a *syntax encoding* to stipulate how specific values must be represented (for example, data elements should follow the ISO 8601 encoding scheme) and *controlled vocabularies* to provide finite lists of values for specific elements. So overall, a metadata schema is a formal description for data, containing a set of rules about the subject-predicate-object statements that can be made (Pomerantz, 2015).

Since various general and domain-specific metadata schemas have been developed over the past decades, it is seldom necessary to create a new one, and it is typically better to adopt (and maybe adapt) a proven, well-supported metadata schema. One or more of these schemas often form accepted *metadata standards* like Dublin Core (https://www.dublincore.org), IPTC Photo Metadata Standard (https://iptc.org/standards/photo-metadata/iptc-standard) or Darwin Core (https://dwc.tdwg.org).

1.2. Encoding Metadata Schemas: RDF and XML

Metadata are partly founded on structured data, which are data organised or structured according to a data model. A data model is a framework, a logical structure to represent all the resource types contained by the data, the properties of those resources, and the relationships between them (Pomerantz, 2015). Many data models exist, but the *Resource Description Framework* (RDF; https://www.w3.org/RDF) developed by the World Wide Web Consortium (W3C) is the data model that structures most metadata. In other words, RDF is a generic data model or logical structure that defines how resources should be described.

RDF is based on the triples or subject-predicate-object statements introduced in Section 1.1. For example (see Figure 3), the statement "indigo is the colour of that mural" can be broken down into:

- "Mural" or the resource being described, known as the *subject;*
- "Indigo" or the value of that description, known as the *object;*

- "Colour", which establishes the relationship between the *subject* and *object*, known as the *predicate*. Sometimes, the predicate would also be written as "hasColour".

When additional metadata statements about that mural (e.g., "2023-06-15 is the creation date of that mural" and "Cope26 is the creator of that mural") complement the above statement, one ends up with a set of RDF triples. Such a set of entities connected by relationships is known as a *graph* (see Figure 3). Now imagine that Mr. Wogrin would photograph that mural, resulting in a digital photo called muralPhoto.jpg. At that moment, there would be two resources—a physical one (i.e., the mural, a real-world graffito) and its digital approximation (i.e., the muralPhoto.jpg file, a digital photograph)—each featuring the *Creator* or *hasCreator* predicate (see Figure 3). Since this distinction between physical and digital resources is important but often ignored, Section 1.3 will further explore it.

The specific syntax used for encoding the RDF triples in a metadata schema is typically XML-based. XML, or the eXtensible Markup Language, describes a set of rules for structuring documents in a human- and machine-readable format (Adobe Systems Incorporated, 2012). XML contains instructions or *tags* (enclosed in angle brackets) that can be incorporated into text documents, but these tags can also structure arbitrary data. The tags (which have nothing to do with the eponymous graffito type) are placed around some content to make up an *element*. Consider again the assertion "Cope26 is the creator of that mural", which can be represented with some simplifications in XML as:

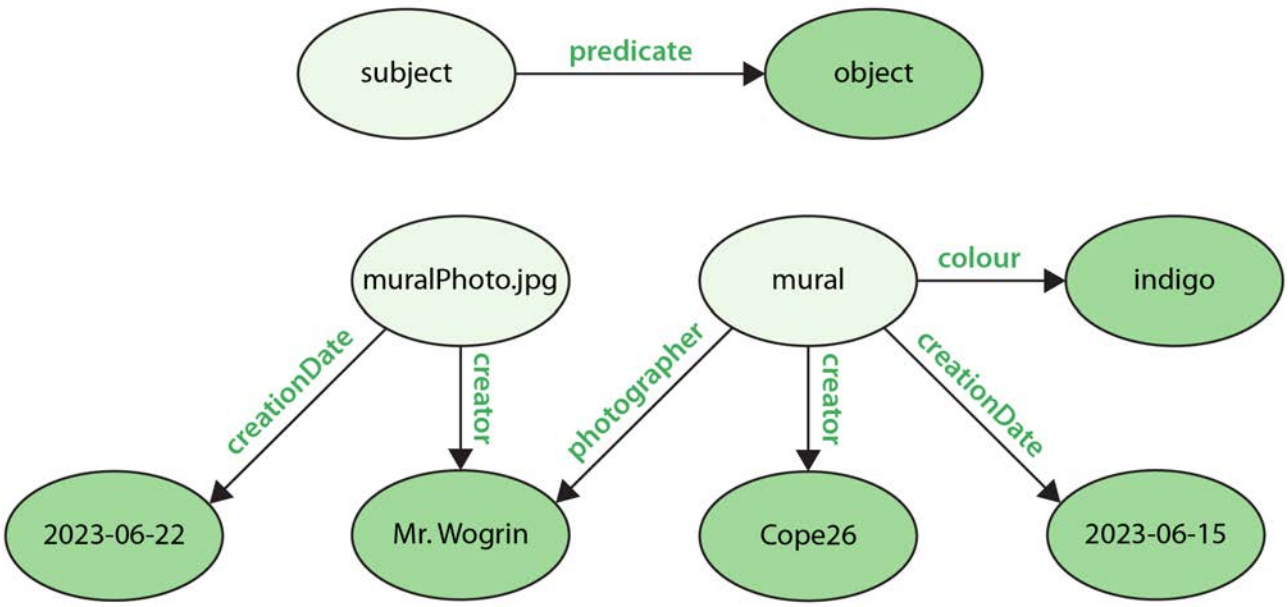

Figure 3. Top: RDF structures metadata in subject-predicate-object triples. Bottom: many RDF triples may link up to form a graph.

```
<mural>
  <creator>
    <name>Cope26</name>
  </creator>
</mural >
```

The element <creator> consists of a sub-element <name>. This sub-element has some text as content. Note that a slash character precedes the closing tag and that the hierarchy among the elements lends itself to a tree representation. XML documents are always formed as *element trees*. Every

XML tree starts at a root element and branches to sub-elements, which themselves can further branch to sub-elements. However, the XML tags one can use are not predefined. A specific tagset can be defined for each use case, making this markup language *extensible*.

By encoding RDF graphs via an XML document, RDF information is easily exchangeable between different computers using differing operating systems and applications. The XML syntax used for RDF is known as RDF/XML, a standard developed by the W3C and available at https://www.w3.org/TR/rdf-syntax-grammar. RDF/XML lies at the core of the Semantic Web (Yu, 2014) as well as Adobe's XMP technology, which is leveraged by the IPTC Photo Metadata Standard (see Section 2.4).

1.3. Resource-Specific Metadata

Much like how "A map is not the territory it represents, but, if correct, it has a similar structure to the territory, which accounts for its usefulness" (Korzybski, 1933, p. 58), a photograph of a physical, real-world graffito is not the graffito, but an approximation which can be analogue or digital. Similar to how different maps represent different characteristics of the physical world (e.g. road maps, nautical maps, topographical maps), different approximations like photos, sketches, and digital 3D surface models can be used to boil down all of a physical graffito's complexity to those aspects that are needed for a particular purpose or in a specific situation.

In the academic graffiti project INDIGO (https://projectindigo.eu), all graffiti approximations were digital, and none of these digital approximations equal the analogue physical graffito. Still, they allow us to obtain information about it. Although the original graffito and its digital approximations are both referred to as data or resources, they are separate entities that need their specific metadata in terms of the metadata elements and their values (see Figure 4). For example, "camera model" is an irrelevant metadata element for the real graffito (which is a physical resource), but valuable information about the digital graffito photo (which is an electronic or digital resource); "creator" and "copyright" are elements relevant for both but populated with different, resource-dependent values.

Creating metadata for cultural heritage assets often ignores this distinction between original and derived resources, even though the guidelines formulated by the Visual Resources Association for cataloguing cultural objects have already advocated this in 2006 (Baca et al., 2006). INDIGO made the distinction between these resources explicit and created a metadata schema for physical graffiti that differs from the metadata attached to the digital (ortho)photos or textured 3D surface models of those graffiti (see Figure 4). Since there should always be exactly one metadata record for a single resource—known as the *one-to-one principle* in information science (Pomerantz, 2015)—one metadata record per graffito, per graffito photo, per graffito orthophoto, per graffito 3D model was the correct way to proceed.

In addition, distinguishing between the physical graffito and its digital approximations also helps improve metadata provenance tracking. For example, much of the physical graffito's metadata cannot, or not easily, be observed *in situ*. Good examples are a large graffito's maximum dimensions or total area, which are much easier to derive via a digital 3D model. Afterwards, one can transfer that information to the metadata of the physical graffito (see Figure 4). This train of thought guided the development of GRAPHIS, a software tool to trace and annotate a graffito's border and store that information as a so-called image region in the photo's metadata. This image region is useful for a multitude of purposes, including calculating the dimensions and area of that graffito.

The remainder of this paper will first provide an overview of the two prevalent metadata standards for digital photographs (Section 2) and focus on the *Image Region* metadata element introduced in 2019 by one of them (Section 3). Section 4 then details the inner workings of the GRAPHIS tool built to create, visualise, and manage this *Image Region* element, as well as the controlled vocabulary used to limit some of the region's attributes. Before concluding the paper, Section 5 delves deeper into the multiple purposes this image region could serve.

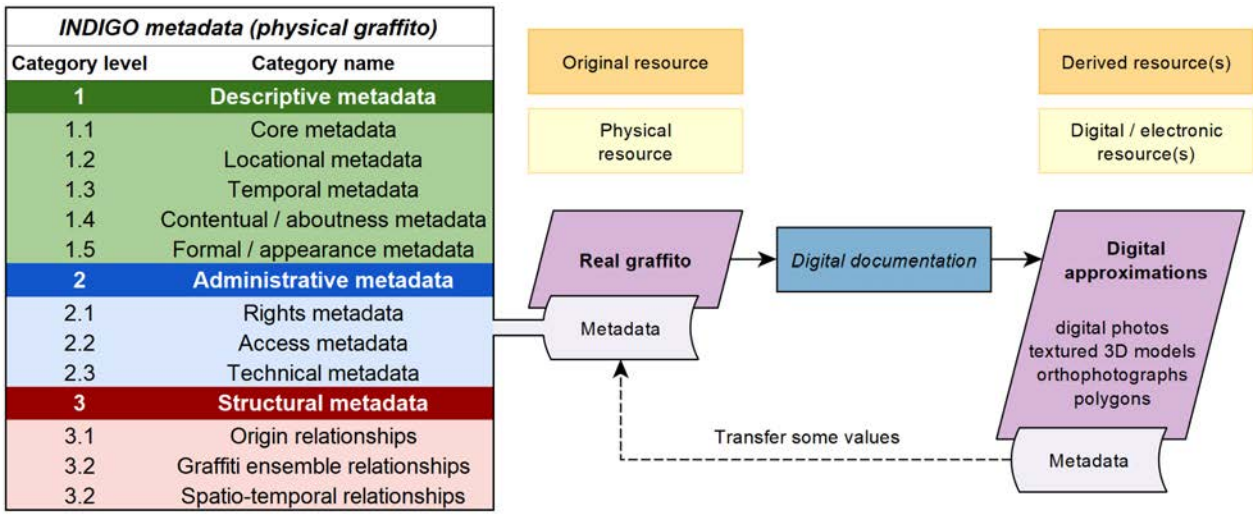

Figure 4. Various ways exist to categorise or group metadata. To describe a physical graffito, INDIGO's metadata schema groups information into descriptive, administrative, and structural sections, a grouping that follows Gartner (2016) and Horodyski (2022). Values for some descriptive metadata fields of a real graffito (like "surface area" or "colours used") are sourced from the metadata of its digital approximations. Besides some information on the descriptive and administrative metadata of digital graffiti photos—implemented via the Exif and IPTC Photo Metadata Standards—the details of INDIGO's metadata schema for each type of digital approximation are beyond the scope of this paper.

2. Photo Metadata

2.1. Flavours of Pixel Values

Photographs created by a digital camera typically come in two main types: photos containing raw pixel values and fully processed photos where every pixel has a Red-Green-Blue (RGB) colour value. This dichotomy or 'choice' is also reflected in many digital cameras, which can usually produce and store both image types:

1. An image with one digital value per pixel, corresponding to the amount of photons captured by the camera's imaging sensor for that location. This image is typically referred to as the RAW photo or RAW file. RAW is not an acronym nor a file extension. It only signifies raw or minimally processed image sensor data with pixel values that are linearly related to the incoming radiation in the Red, Green or Blue visible spectral band. RAW can thus be considered the only scientifically justifiable file format (Verhoeven, 2010). However, RAW files come with manufacturer-specific structures and extensions (like .nef for Nikon, .raf for Fuji, and .crw or .cr2 for Canon RAW photos), and the raw data need many processing steps to produce the second image type: a normal-looking photo.
2. A highly processed viewable image with pixels nonlinearly related to the captured amount of photons. This image is usually expressed in the sRGB colour space and saved as a *.jpg/*.jpeg or *.tiff file. This viewable type of image is commonly meant when talking about a photo. Even though some dedicated cameras (and smartphones) might not offer the option to save the RAW image, the latter always internally forms the basis to yield a viewable output photo.

A digital photo can thus store two 'types' of primary image data; typically, one of these two types is stored, although some RAW files might also contain a viewable output photo. Besides those data, the photo file might include one or more thumbnails. Together, the primary image data and the thumbnail(s) constitute all the pixel values of a digital photo file (see Figure 5). However, that photo file can also serve as a container for metadata.

2.2. Metadata Containers

Metadata state something about an analogue or physical resource, but those metadata must also exist in a physical or digital container. In other words, metadata can be located inside or outside the resource, and the location often depends on the resource and its use case. Examples of internal metadata are the copyright and title of a book on its copyright page. However, one could also save this info in a library catalogue card box as external metadata. For a digital photo (see Figure 5), the metadata record is either:

- Embedded in the photo file, therefore known as *internal metadata*. The Exif information (see Section 2.3) or IPTC-IIM values (see Section 2.4) stored in the header of a digital photograph are prime examples of this. Upon acquisition, RAW and JPEG or TIFF photos have their Exif metadata automatically stored within the file by the digital camera;
- Stored externally, either in:
  - A separate but related file (like an *.xmp sidecar file for RAW digital photographs; see Section 5.2);
  - A database like a Digital Asset Management (DAM) or Media Asset Management (MAM) system that links to the photo file via a unique identifier. Besides a DAM or MAM, metadata can be stored in a data repository (like ARCHE; see the paper by Trognitz et al. in this volume).

Some metadata fields must be populated manually, while software applications or firmware auto-generate the values of others. IPTC metadata—detailed in Section 2.4—are an example of the former, while Exif metadata (described in the following section) are typically auto-generated within the digital camera.

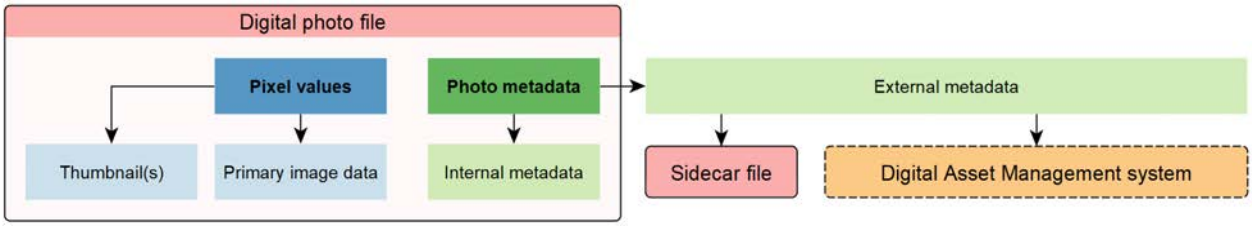

Figure 5. Photo metadata are either stored internally beside the pixel values or externally in a sidecar file or database.

2.3. Exif Metadata

In addition to the pixel values that encode the real-world scene, RAW files and JPEG or TIFF photos contain Exif or *Exchangeable image file format* metadata. These technical metadata describe image acquisition parameters—such as the serial number and model of the camera, the aperture, focal length, shutter speed, possible flash compensation, and the date plus time of photo acquisition—in mandatory, recommended, and optional fields (called *tags*) stored in a separate segment of the photo file (Camera & Imaging Products Association, 2023). Suppose the camera is GNSS (Global Navigation Satellite System)-enabled. In that case, tags can also hold the latitude, longitude, and altitude of the camera's geographical location. All these Exif-defined tags are created by the camera and stored simultaneously with the pixel values in the image file, making it possible to analyse them afterwards.

The first Exif standard (version 1.0) was released in October 1995 by JEIDA, the Japan Electronic Industries Development Association (see Figure 6). JEIDA also published versions 1.1 (May 1997), 2.0 (November 1997), and 2.1 (June and December 1998). Because JEIDA became JEITA (Japan Electronics and Information Technology Industries Association) in November 2000 (JEITA, 2000), Exif version 2.2 (April 2002) was established by JEITA. Since 2009, JEITA has been launching the Exif standard jointly with CIPA, the Camera & Imaging Products Association. CIPA and JEITA co-published Exif version 3.0 in May 2023.

2.4. IPTC Metadata

Whereas Exif metadata mainly contain technical information about the digital photo creation process, the IPTC Photo Metadata Standard is widely accepted for storing non-technical information about photos (or, more generally, images). Professional photographers, news agencies, museums, and libraries rely on the IPTC metadata properties to describe the image content (i.e., descriptive metadata), provide instructions for the users (i.e., access metadata) or store its copyright information (i.e., rights metadata). These descriptive, access, and rights-related properties are stored within or along the image file. Ideally, all tools that read

Exif metadata specification history

Version	Standard Number	Issue Date	Published by
1.0		1995 | 10 |	JEIDA
1.1		1997 | 05 |	JEIDA
2.0		1997 | 11 |	JEIDA
2.1		1998 | 06 |	JEIDA
2.1 (DCF version)	JEIDA-49-1998	1998 | 12 |	JEIDA
2.2	JEITA CP-3451	2002 | 04 |	JEITA
2.21	JEITA CP-3451-1	2003 | 09 |	JEITA
Unified version 2.21	CIPA DC-008-2009 / JEITA CP-3451A	2009 | 09 | 01	CIPA & JEITA
2.3	CIPA DC-008-2010 / JEITA CP-3451B	2010 | 04 | 26	CIPA & JEITA
2.3 (Revised 2012)	CIPA DC-008-2012 / JEITA CP-3451C	2012 | 12 |	CIPA & JEITA
2.31	CIPA DC-0008-2016 / JEITA CP-3451D	2016 | 07 |	CIPA & JEITA
2.32	CIPA DC-0008-2019 / JEITA CP-3451E	2019 | 05 | 17	CIPA & JEITA
3.0	CIPA DC-008-2023 / JEITA CP-3451F	2023 | 05 | 29	CIPA & JEITA

Figure 6. The history of the Exif metadata specification.

and write IPTC image metadata should keep all metadata embedded into the image file (for *.jpg, *.tiff or *.png files) or saved as an identically named sidecar *.xmp file (for RAW files) persistent when exchanged between various software and users.

As in every metadata standard, each IPTC Photo Metadata field is tightly defined. The latest version of the IPTC Photo Metadata Standard (i.e., version 2023.2; https://iptc.org/std/photometadata/specification/IPTC-PhotoMetadata-2023.2.html) defines 62 top metadata fields (IPTC Photo Metadata Working Group, 2024) (see Figure 7). Many of those 62 are *single fields* that store one value to express the desired information, but some are *field structures* that contain multiple sub-fields. In Figure 7, field structures have *struct* as their data type. The IPTC uses the generic term *property* for a *field structure* or a *single field* (commonly shortened to *field*).

Those 62 properties are divided into two metadata schemas: the IPTC Core and the IPTC Extension schema, each with a specific development history and version (see Figure 8). The IPTC Photo Metadata Standard 2023.2 contains the IPTC Core schema 1.4 with 25 top properties and the IPTC Extension schema 1.8 with 37 top properties (see Figure 7).

Initially, the *IPTC Core schema* started in 2004 as a revamp of the *Information Interchange Model* (IIM; https://www.iptc.org/standards/iim) standard by the IPTC and the American Newspaper Publishers Association (ANPA) (see Figure 9 on the left). The first version of the IPTC IIM multimedia standard was launched in 1990. Since ANPA became the Newspaper Association of America (NAA) in 1992, the IPTC IIM standard also became known as the IPTC-NAA IIM standard.

The IIM defined a series of metadata fields such as *Object Name*, *Edit Status*, *Urgency*, *Date Created*, and *Keywords* to aid the interchange of news between computerised systems. Even though those metadata fields were media-type agnostic (i.e., useable for text, video, audio, and photos), they could be embedded inside digital images thanks to the *image resource block* technology developed by Adobe Systems Incorporated (Adobe Systems Incorporated, 1991-2008).

Property	Schema	Data type	Data format	Occurrence	Required	Part of IIM	XMP identifier
Alt Text (Accessibility)	IPTC Core	struct	AltLang	single	☐	☐	Iptc4xmpCore:AltTextAccessibility
City (legacy)	IPTC Core	string		single	☐	☑	photoshop:City
Copyright Notice	IPTC Core	struct	AltLang	single	☐	☑	dc:rights
Country (legacy)	IPTC Core	string		single	☐	☑	photoshop:Country
Country Code (legacy)	IPTC Core	string		single	☐	☑	Iptc4xmpCore:CountryCode
Creator	IPTC Core	string		multi	☐	☑	dc:creator
Creator's Contact Info	IPTC Core	struct	CreatorContactInfo	single	☐	☐	Iptc4xmpCore:CreatorContactInfo
Creator's jobtitle	IPTC Core	string		single	☐	☑	photoshop:AuthorsPosition
Credit Line	IPTC Core	string		single	☐	☑	photoshop:Credit
Date Created	IPTC Core	string	date-time	single	☐	☑	photoshop:DateCreated
Description	IPTC Core	struct	AltLang	single	☐	☑	dc:description
Description Writer	IPTC Core	string		single	☐	☑	photoshop:CaptionWriter
Extended Description (Accessibility)	IPTC Core	struct	AltLang	single	☐	☐	Iptc4xmpCore:ExtDescrAccessibility
Headline	IPTC Core	string		single	☐	☑	photoshop:Headline
Instructions	IPTC Core	string		single	☐	☑	photoshop:Instructions
Intellectual Genre (legacy)	IPTC Core	string		single	☐	☑	Iptc4xmpCore:IntellectualGenre
Job Id	IPTC Core	string		single	☐	☑	photoshop:TransmissionReference
Keywords	IPTC Core	string		multi	☐	☑	dc:subject
Province or State (legacy)	IPTC Core	string		single	☐	☑	photoshop:State
Rights Usage Terms	IPTC Core	struct	AltLang	single	☐	☐	xmpRights:UsageTerms
Scene Code	IPTC Core	string		multi	☐	☐	Iptc4xmpCore:Scene
Source (Supply Chain)	IPTC Core	string		single	☐	☑	photoshop:Source
Subject Code (legacy)	IPTC Core	string		multi	☐	☑	Iptc4xmpCore:SubjectCode
Sublocation (legacy)	IPTC Core	string		single	☐	☑	Iptc4xmpCore:Location
Title	IPTC Core	struct	AltLang	single	☐	☑	dc:title
Additional Model Information	IPTC Extension	string		single	☐	☐	Iptc4xmpExt:AddlModelInfo
Artwork or Object in the Image	IPTC Extension	struct	ArtworkOrObject	multi	☐	☐	Iptc4xmpExt:ArtworkOrObject
Code of Organisation Featured in the Image	IPTC Extension	string		multi	☐	☐	Iptc4xmpExt:OrganisationInImageCode
Contributor	IPTC Extension	struct	EntityWRole	multi	☐	☐	Iptc4xmpExt:Contributor
Copyright Owner	IPTC Extension	struct	CopyrightOwner	multi	☐	☐	plus:CopyrightOwner
CV-Term About Image	IPTC Extension	struct	CvTerm	multi	☐	☐	Iptc4xmpExt:AboutCvTerm
Data Mining	IPTC Extension	string	uri	single	☐	☐	plus:DataMining
Other Constraints	IPTC Extension	struct	AltLang	single	☐	☐	plus:OtherConstraints
Digital Image GUID	IPTC Extension	string		single	☐	☐	Iptc4xmpExt:DigImageGUID
Digital Source Type	IPTC Extension	string	uri	single	☐	☐	Iptc4xmpExt:DigitalSourceType
Embedded Encoded Rights Expression	IPTC Extension	struct	EmbdEncRightsExpr	multi	☐	☐	Iptc4xmpExt:EmbdEncRightsExpr
Event Identifier	IPTC Extension	string	uri	multi	☐	☐	Iptc4xmpExt:EventId
Event Name	IPTC Extension	struct	AltLang	single	☐	☐	Iptc4xmpExt:Event
Genre	IPTC Extension	struct	CvTerm	multi	☐	☐	Iptc4xmpExt:Genre
Image Creator	IPTC Extension	struct	ImageCreator	multi	☐	☐	plus:ImageCreator
Image Rating	IPTC Extension	number		single	☐	☐	xmp:Rating
Image Region	IPTC Extension	struct	ImageRegion	multi	☐	☐	Iptc4xmpExt:ImageRegion
Image Registry Entry	IPTC Extension	struct	RegistryEntry	multi	☐	☐	Iptc4xmpExt:RegistryId
Image Supplier	IPTC Extension	struct	ImageSupplier	multi	☐	☐	plus:ImageSupplier
Image Supplier Image ID	IPTC Extension	string		single	☐	☐	plus:ImageSupplierImageID
Licensor	IPTC Extension	struct	Licensor	multi	☐	☐	plus:Licensor
Linked Encoded Rights Expression	IPTC Extension	struct	LinkedEncRightsExpr	multi	☐	☐	Iptc4xmpExt:LinkedEncRightsExpr
Location created	IPTC Extension	struct	Location	single	☐	☐	Iptc4xmpExt:LocationCreated
Location Shown in the Image	IPTC Extension	struct	Location	multi	☐	☐	Iptc4xmpExt:LocationShown
Max Avail Height	IPTC Extension	number	integer	single	☐	☐	Iptc4xmpExt:MaxAvailHeight
Max Avail Width	IPTC Extension	number	integer	single	☐	☐	Iptc4xmpExt:MaxAvailWidth
Minor Model Age Disclosure	IPTC Extension	string	uri	single	☐	☐	plus:MinorModelAgeDisclosure
Model Age	IPTC Extension	number	integer	multi	☐	☐	Iptc4xmpExt:ModelAge
Model Release Id	IPTC Extension	string		multi	☐	☐	plus:ModelReleaseID
Model Release Status	IPTC Extension	string	uri	single	☐	☐	plus:ModelReleaseStatus
Name of Organisation Featured in the Image	IPTC Extension	string		multi	☐	☐	Iptc4xmpExt:OrganisationInImageName
Person Shown in the Image	IPTC Extension	string		multi	☐	☐	Iptc4xmpExt:PersonInImage
Person Shown in the Image with Details	IPTC Extension	struct	PersonWDetails	multi	☐	☐	Iptc4xmpExt:PersonInImageWDetails
Product Shown in the Image	IPTC Extension	struct	ProductWGtin	multi	☐	☐	Iptc4xmpExt:ProductInImage
Property Release Id	IPTC Extension	string		multi	☐	☐	plus:PropertyReleaseID
Property Release Status	IPTC Extension	string	uri	single	☐	☐	plus:PropertyReleaseStatus
Web Statement of Rights	IPTC Extension	string	uri	single	☐	☐	xmpRights:WebStatement

Figure 7. The 62 top metadata properties of the IPTC Photo Metadata Standard 2023.2 are divided into 37 single fields and 25 field structures. All information originates from the IPTC Photo Metadata Technical Reference Documentation (https://iptc.org/std/photometadata/specification/iptc-pmd-techreference_2023.2.json).

IPTC Core schema specification history

Version	Revision	Approval date	Approved by	In Standard Version
1.0		2004 | 10 | 08	IPTC Standards Committee	2004
1.0	1	2004 | 10 | 10	IPTC Standards Committee	2004
1.0	2	2004 | 10 | 14	IPTC Standards Committee	2004
1.0	3	2004 | 11 | 09	IPTC Standards Committee	2004
1.0	4	2004 | 12 | 23	IPTC Standards Committee	2004
1.0	5	2005 | 01 | 11	IPTC Standards Committee	2004
1.0	6	2005 | 01 | 27	IPTC Standards Committee	2004
1.0	7	2005 | 02 | 01	IPTC Standards Committee	2004
1.0	8	2005 | 03 | 15	IPTC Standards Committee	2004
1.1		2008 | 07 | 02	IPTC Standards Committee	2008
1.2		2014 | 06 | 18	IPTC Standards Committee	July 2014
1.3		2021 | 10 | 20	IPTC Standards Committee	2021.1
1.4		2022 | 10 | 19	IPTC Standards Committee	2022.1

IPTC Extension schema specification history

Version	Revision	Approval date	Approved by	In Standard Version
1.0		2008 | 07 | 02	IPTC Standards Committee	2008
1.1		2009 | 06 | 17	IPTC Standards Committee	July 2009
1.2		2014 | 10 | 22	IPTC Standards Committee	July 2014
1.3		2016 | 10 | 26	IPTC Standards Committee	October 2016
1.4		2017 | 05 | 17	IPTC Standards Committee	2017.1
1.5		2019 | 10 | 16	IPTC Standards Committee	2019.1
1.6		2021 | 10 | 20	IPTC Standards Committee	2021.1
1.7		2022 | 10 | 19	IPTC Standards Committee	2022.1
1.8		2023 | 10 | 04	IPTC Standards Committee	2023.1

Figure 8. The history of the IPTC Core and Extension schemas.

Although image resource blocks were introduced in 1992 with Adobe's Photoshop 2.5 (Murray & VanRyper, 1994), embedding IPTC-NAA IIM metadata in *.jpg, *.tiff, and *.psd image files only became possible in 1994 with the release of Photoshop 3 (Adobe Systems Incorporated & Knoll, 1990-2019). Since then, IIM metadata embeddings have been referred to as *IPTC file headers*. Due to the development of new data representation standards (like XML) in the mid-1990s, further enhancements to the IPTC-NAA IIM came to a halt in 1999 (Comité International des Télécommunications de Presse & Newspaper Association of America, 1999)—apart from a minor revision of the 1999 IIM standard in 2014 (International Press Telecommunications Council & Newspaper Association of America, 2014) (see Figure 9 on the left).

In the spring of 2004, the IPTC initiated the creation of a photograph-only metadata standard, primarily focusing on its usefulness for photographers, metadata editors, and digital image processing software. The first round of this "IPTC for XMP" or "IPTC4XMP" initiative tried to marry a set of widely used IPTC-NAA IIM metadata properties to Adobe's XMP framework (personal communication with Michael W. Steidl). XMP (or the eXtensible Metadata Platform) was introduced in 2001 by Adobe Systems Incorporated as an RDF/XML-based metadata embedding technology (Adobe Systems Incorporated, 2001a, 2001b). Using XMP, metadata could now be embedded into digital files (images and others) in an inherently extensible manner. [Note that in early 2001, Adobe initially called this metadata initiative XAP or eXtensible Authoring and Publishing (Adobe Systems Incorporated, 2002; Chapman & Brailsford, 2001). The appearance of the strings "XAP", "xap" (e.g., http://ns.adobe.com/xap/1.0) or "authoring and publishing" (e.g., Adobe Systems Incorporated, 2001b) in many of the first XMP-related documents or URIs (Uniform Resource Locators) reflects this].

In the world of XMP, specific metadata properties are grouped into *namespaces*. For example, Adobe's basic XMP namespace (https://developer.adobe.com/xmp/docs/XMPNamespaces/xmp) contains properties that provide primary descriptive information (such as *Identifier*, *CreatorTool*, *CreateDate*, and *Rating*), and the Photoshop namespace (https://developer.adobe.com/xmp/docs/XMPNamespaces/photoshop) specifies metadata elements used by Adobe Photoshop. Adobe also introduced the XMP Rights Management namespace (https://developer.adobe.com/xmp/docs/XMPNamespaces/xmpRights) for metadata properties on legal restrictions, a Camera Raw namespace (https://developer.adobe.com/xmp/docs/XMPNamespaces/crs) for development settings associated with RAW photos and even an Exif namespace (https://developer.adobe.com/xmp/docs/XMPNamespaces/exif) for specific properties typically stored in the native Exif metadata. Each namespace has a specific name, a URI, and a preferred prefix (see Figure 11). XMP properties are then commonly written in a ***prefix:property*** style, for example, ***Iptc4xmpCore:Location*** (see Figures 7 and 10).

In the years before the IPTC started to work on a specific photo metadata standard in 2004, Adobe had already mapped nineteen IPTC-NAA IIM properties to the Photoshop and Dublin Core XMP namespaces for use in Photoshop's "File Info" panel (Riecks, 2005). For compatibility, the IPTC retained those mappings (personal communication with David Riecks). However, the IPTC4XMP working group also introduced in their IPTC Core namespace a few IIM properties previously not used by Adobe, as well as a handful of newly defined properties. After various revisions (see Figure 8 on the left), the first version of the XMP-based IPTC Core schema—covering a subset of the IPTC-NAA IIM properties with a few new ones—was finalised in early 2005 (International Press Telecommunications Council, 2005). However, it took three more years and the release of an IPTC Extension schema (see Figure 8 on the right) before the first IPTC Photo Metadata Standard saw the light of day in 2008 (International Press Telecommunications Council, 2008) (see Figure 9 on the right).

The IPTC Core schema currently combines properties from the Dublin Core, Photoshop, XMP Rights Management, and IPTC Core namespaces. In the column "XMP identifier" of Figure 7, these four XMP namespaces are indicated by the prefixes *dc*, *photoshop*, *xmpRights* and *Iptc4xmpCore*, respectively. Although the IPTC Core metadata schema

IPTC-NAA IIM specification history

Version	Revision	Issue Date	Approved by
1		1990 | 06 |	IPTC; American Newspaper Publishers Association (ANPA)
2		1993 | 04 | 14	IPTC; Newspaper Association of America (NAA)
3		1995 | 10 |	IPTC; Newspaper Association of America (NAA)
4	1	1999 | 07 |	IPTC; Newspaper Association of America (NAA)
4	2	2014 | 07 |	IPTC; Newspaper Association of America (NAA)

IPTC Photo Metadata Standard specification history

Version	Revision	Issue Date	Approved by	IPTC Core	IPTC Extension
2008	1	2008 | 07 | 14	IPTC Standards Committee	1.1	1.0
2008	2	2008 | 07 | 18	IPTC Standards Committee	1.1	1.0
July 2009	1	2009 | 07 | 07	IPTC Standards Committee	1.1	1.1
July 2010	1	2010 | 07 | 08	IPTC Standards Committee	1.1	1.1
July 2014	1	2014 | 06 | 27	IPTC Standards Committee	1.2	1.1
October 2014	1	2014 | 11 | 25	IPTC Standards Committee	1.2	1.2
October 2014	2	2014 | 11 | 28	IPTC Standards Committee	1.2	1.2
October 2014	3	2015 | 01 | 23	IPTC Standards Committee	1.2	1.2
October 2016	1	2016 | 11 | 15	IPTC Standards Committee	1.2	1.3
2017.1	1	2017 | 06 | 19	IPTC Standards Committee	1.2	1.4
2017.1	2	2018 | 06 | 11	IPTC Standards Committee	1.2	1.4
2017.1	3	2019 | 03 | 18	IPTC Standards Committee	1.2	1.4
2019.1	1c	2020 | 01 | 24	IPTC Standards Committee	1.2	1.5
2021.1	1	2021 | 10 | 21	IPTC Standards Committee	1.3	1.6
2022.1	0	2022 | 11 | 04	IPTC Standards Committee	1.4	1.7
2022.1	1	2023 | 01 | 16	IPTC Standards Committee	1.4	1.7
2022.1	2	2023 | 03 | 01	IPTC Standards Committee	1.4	1.7
2023.1	0	2023 | 10 | 04	IPTC Standards Committee	1.4	1.8
2023.2	0	2024 | 03 | 22	IPTC Standards Committee	1.4	1.8

Figure 9. The specification history of the IPTC-NAA IIM and IPTC Photo Metadata Standard. There are two essential things to note: (1) The IIM uses integer Version numbers to reflect significant changes to the specification, while Revision numbers denote minor changes. The Version of a Photo Metadata Standard uses the year of initial release. From 2009 until 2016, this four-digit number features an appendix representing the month of the initial release (e.g., July 2014). In 2017, this appendix was replaced by a sequential integer starting at 1. In contrast to the IIM, Photo Metadata Standard Revision numbers do not indicate changes to the specification but merely the correction of one or more errors. From 2022, all initial releases of the Photo Metadata Standard feature a Revision number 0 (zero), indicating that nothing has been revised at that point in time. (2) The issue date of the first IIM standard is no longer well-known. Several sources provide contradicting dates, a discrepancy likely attributable to parallel work by two organisations on this standard. Personal communication with Michael W. Steidl revealed that the IPTC must have adopted the IIM standard in 1990, while ANPA took that decision later, likely in 1991.

draws upon identifiers from different namespaces, all metadata fields from the IPTC Core namespace are members of the IPTC Core schema.

The same applies to the IPTC Extension metadata schema, whose fields have identifiers from five intentionally adopted namespaces: IPTC Extension, PLUS, XMP Basic, XMP Rights Management, and Exif (respectively indicated by the prefixes *Iptc4xmpExt*, *plus*, *xmp*, *xmpRights* and *exif* in Figure 7). However, note that the *exif* prefix does not appear in Figure 7 even though the IPTC Extension metadata schema uses four GNSS-related identifiers originating from the Exif XMP namespace. These four identifiers are—amongst several other ones—part of the *Location* structure. The IPTC Photo Metadata Standard often uses such metadata field structures as the data type for some of the 62 top properties. For example, this *Location* structure consists of twelve sub-properties, four of which come from the Exif namespace. Using one or more of the *Location* structure's sub-properties, one can provide detailed information about two top properties: *Location created* (***Iptc4xmpExt:LocationCreated***) and *Location Shown in the Image* (***Iptc4xmpExt:LocationShown***) (see Figure 7). Similarly, the *Image Region* top property (***Iptc4xmpExt:ImageRegion***) has the *Image Region* structure as its data type. Because this IPTC *Image Region* structure lies at the centre of this paper, it will be detailed in the next section.

3. Image Regions

3.1. In With the New: IPTC Image Regions

The IPTC Photo Metadata Standard 2019.1 (IPTC Photo Metadata Working Group, 2020), released in December 2019, introduced the *Image Region* (***Iptc4xmpExt:ImageRegion***), a new top property to define one or more areas within an image and store them as disks (i.e., the region of the plane bounded by a circle) or any arbitrary *simple polygon*. Polygons are geometrical shapes bounded by a closed polyline: a curve consisting of connected line segments without any gap. Even though these line segments (also known as *edges*) may intersect, "simple polygon" denotes non-intersecting line segments (Preparata & Shamos, 1985; Schneider & Eberly,

2003). These line segments or edges meet at corners or *vertices* (singular: *vertex*), whose spatial position is described by x and y coordinates. Polygons are thus always spatially two-dimensional or 2D (Berger, 2010). As a 2D object, "polygon" refers to the polyline perimeter and the region it bounds (Preparata & Shamos, 1985; Schneider & Eberly, 2003). Some types of polygons are well known, like triangles (shapes formed by three line segments and three vertices) and rectangles, but polygons can have an arbitrary number of edges *n*. These *n*-edged polygons are called *n*-gons (Preparata & Shamos, 1985). Since a circle does not feature line segments, a disk is not a polygon.

IPTC image regions thus allow for saving disks, triangles, rectangles, or any non-intersecting *n*-gon within the image metadata. A region is stored via the *Image Region* structure (https://www.iptc.org/std/photometadata/specification/IPTC-PhotoMetadata-2019.1.html#image-region-structure). Figure 10 specifies that this structure consists of:

- A *Region Boundary* structure (***Iptc4xmpExt:RegionBoundary***), which holds various fields to define the region's measurement unit (in relative image size values or pixel count), position, and shape (rectangle, circle, or polygon). Even though a rectangle is a polygon, notice that the IPTC considers it a separate entity. Consequently, it should not be defined by the *x* and *y* coordinates of its vertices, as for a polygon, but by the *X*- and *Y*-axis coordinates of the rectangle's upper left corner and its width and height relative to that corner. Although this representation implies that the rectangle shape cannot feature any rotation, one could always use a polygon to encode a rotated rectangle. In addition, the IPTC mixes terminology used for different spatial entities: boundaries and regions. "Circles" and "closed polylines" only refer to boundaries (i.e., excluding the enclosed region), while "disks" and "polygons" include the interior. Given that the structure is a *Region Boundary* structure, the former should be the correct terms (and then rectangle cannot be used since it refers to a specific type of four-sided polygon). Likely, the IPTC went for less mathematical rigorousness and chose terminology common in everyday non-technical conversations. The remainder of this paper will also use "circle" and "polygon" to conform to the IPTC Photo Metadata Standard. However, it must be clear that an image region, as defined by the IPTC, comprises the pixels of the boundary and those enclosed by it.
- Four properties to store general characteristics of the image region:
  - A *Region Identifier* (***Iptc4xmpExt:rId***), a string to uniquely identify a specific region amongst potential others within the image (the "Occurrence" column in Figure 7 shows that one image can feature multiple regions);
  - A *Region Name* (***Iptc4xmpExt:Name***) or free-text name of the region;
  - A *Region Content Type* (***Iptc4xmpExt:rCtype***) to define what is shown inside the region;
  - A *Region Role* (***Iptc4xmpExt:rRole***) to indicate the region's role among other regions of this image or other images.
- Finally, a region can have any valid XMP metadata property attached, such as a *Description* (***dc:description***) or *Keywords* (***dc:subject***). However, the property must apply to the image region, not the entire document. This feature makes image regions compelling entities, as they facilitate linking specific metadata (such as existing or future IPTC Photo Metadata properties) to designated pixel groupings.

The *Region Content Type* and *Region Role* get their value from a *controlled vocabulary*. Controlled vocabularies enforce the idea that only a limited set of terms, names, or phrases, collectively called *concepts*, can be used to describe something, thus ensuring consistency and reducing ambiguity across descriptions (Harpring, 2013; Schlegel et al., 2023). Suppose a list with terms, names, or phrases claims that "one can only use these concepts". In that case, it is a controlled vocabulary. The IPTC Photo Metadata Standard uses so-called *Entity* or *Concept* structures to store information about the concept used (see Figure 10). The structure consists of the concept's *Name* (e.g., "plant") and a globally unique *Identifier* like a URI where one can retrieve the definition of that concept (e.g., https://cv.iptc.org/newscodes/imageregiontype/plant). To aid users, the IPTC

Property	Sub-property (L1)	Sub-property (L2)	Sub-property (L3)	Data type	Occurrence	XMP identifier	User notes
Image Region				Image Region structure	multi	Iptc4xmpExt:ImageRegion	
	Region Boundary			Region Boundary structure	single	Iptc4xmpExt:RegionBoundary	
		Boundary Shape		String	single	Iptc4xmpExt:rbShape	Rectangle, circle or polygon
		Boundary Measuring Unit		Text	single	Iptc4xmpExt:rbUnit	Pixel or relative
		X-Axis Coordinate		Decimal	single	Iptc4xmpExt:rbX	
		Y-Axis Coordinate		Decimal	single	Iptc4xmpExt:rbY	
		Rectangle Width		Decimal	single	Iptc4xmpExt:rbW	
		Rectangle Height		Decimal	single	Iptc4xmpExt:rbH	
		Circle Radius		Decimal	single	Iptc4xmpExt:rbRx	
		Polygon Vertices		Region Boundary Point structure	multi	Iptc4xmpExt:rbVertices	
			X-Axis Coordinate	Decimal	single	Iptc4xmpExt:rbX	
			Y-Axis Coordinate	Decimal	single	Iptc4xmpExt:rbY	
	Region Identifier			String	single	Iptc4xmpExt:rId	
	Region Name			Text	single	Iptc4xmpExt:Name	
	Region Content Type			Entity or Concept structure	multi	Iptc4xmpExt:rCtype	
		Identifier		URI	multi	xmp:Identifier	
		Name		Text	single	Iptc4xmpExt:Name	
	Region Role			Entity or Concept structure	multi	Iptc4xmpExt:rRole	
		Identifier		URI	multi	xmp:Identifier	
		Name		Text	single	Iptc4xmpExt:Name	
	Other Metadata Property			Not defined	single	any:any [<>]	Any valid XMP property

Figure 10. All information related to the *Image Region* top property is combined into an *Image Region* structure containing five properties besides any valid XMP property (all listed in the column "Sub-property (L1)", where L1 stands for Level 1). The "Data type" information does not follow the convention of Figure 7 but mimics the more verbose style used at https://iptc.org/std/photometadata/specification/IPTC-PhotoMetadata-2023.2.html.

has created the *IPTC Region Content Type NewsCodes* (https://cv.iptc.org/newscodes/imageregiontype) and *IPTC Image Region Role NewsCodes* (https://cv.iptc.org/newscodes/imageregionrole) controlled vocabularies.

3.2. Out With the Old: MWG and Microsoft Image Regions

The possibility of defining and storing image regions was not standardised by the IPTC only. Almost a decade earlier, in 2010, the Metadata Working Group (MWG) proposed a way to deal with image regions. The MWG organisation was based on a 2006 proposal by Microsoft Corporation. In 2007, four other leading companies in the digital media industry joined, creating a consortium of five founding members: Adobe Systems Incorporated, Apple Incorporated, Canon Incorporated, Microsoft Corporation and Nokia Corporation (Metadata Working Group, 2008a).

Sony Corporation joined this variety of vendors in 2008. In September of that year, the MWG launched their first version of "Guidelines for handling image metadata". The document specified how to prioritise Exif, IPTC-NAA IIM, and XMP-based metadata to avoid metadata conflicts and confusion due to content overlap between these commonly used standards (Metadata Working Group, 2008b). In other words, the guidelines addressed how the metadata of digital still images should be stored and exchanged so that photographers (both amateur and professional), camera manufacturers, software developers, and service providers could achieve better compatibility and consistency in their use. A few months later, in February 2009, version 1.0.1 fixed a few grammar mistakes and reformulated or expanded some descriptions (Metadata Working Group, 2009). A substantially updated and expanded second version of these guidelines saw the light of day in November 2010, covering text encoding, hierarchical metadata, and image collections (Metadata Working Group, 2010). In addition, this 2010 MWG standard also provided guidelines on dealing with image regions.

Nowadays, nearly all photo editors and DAMs supporting image regions still stick to this standard. The MWG region information is also embedded via XMP tags, defined in the MWG Regions namespace (Metadata Working Group, 2010). This standard thus seems to have broad support. However, preferring it over the *Image Region* property of the IPTC seems sub-optimal for two reasons. First, the MWG image region recommendations only support four types of content: Face, Pet, Focus, and BarCode. If the content of the image region is not one of those four types, the *Type* field must be left empty. [Note that in 2017/2018, the IPTC tried to

contact the MWG to extend this closed *Type* list and clarify other details about these image region recommendations. Since the MWG never responded, the IPTC created their own *Image Region* property (personal communication with Michael W. Steidl)]. Second, the MWG organisation no longer exists, so their Regions namespace will not evolve anymore. Both issues make the MWG image region less flexible and future-proof than its IPTC alternative.

The same must also be said about an attempt by Microsoft. The Microsoft Photo 1.2 namespace provides a minimal set of XMP properties to deal with image regions (Microsoft, 2021). Although this namespace was already proposed in the mid-2000s (the authors of this paper could not retrieve

Name	URI	Preferred prefix	Dereferenceable
Adobe PDF	http://ns.adobe.com/pdf/1.3/	pdf	no
Camera Raw	http://ns.adobe.com/camera-raw-settings/1.0/	crs	no
Dublin Core	http://purl.org/dc/elements/1.1/	dc	yes
Exif 2.2 or earlier	http://ns.adobe.com/exif/1.0/	exif	no
Exif 2.21 or later	http://cipa.jp/exif/1.0/	exifEX	no
IPTC Core	http://iptc.org/std/Iptc4xmpCore/1.0/xmlns/	Iptc4xmpCore	yes
IPTC Extension	http://iptc.org/std/Iptc4xmpExt/2008-02-29/	Iptc4xmpExt	yes
Microsoft Photo 1.2	https://ns.microsoft.com/photo/1.2/	MP	no
MWG Regions	http://www.metadataworkinggroup.com/schemas/regions/	mwg-rs	no
Photoshop	http://ns.adobe.com/photoshop/1.0/	photoshop	no
PLUS	http://ns.useplus.org/ldf/xmp/1.0/	plus	no
TIFF Rev. 6.0	http://ns.adobe.com/tiff/1.0/	tiff	no
XMP	http://ns.adobe.com/xap/1.0/	xmp	no
XMP Media Management	http://ns.adobe.com/xap/1.0/mm/	xmpMM	no
XMP Rights Management	http://ns.adobe.com/xap/1.0/rights/	xmpRights	no

Figure 11. An overview of the name, URI, and preferred prefix for all XMP namespaces mentioned in this paper, along with a few other common ones. Note that namespace names might differ depending on the source. For instance, the Exif and TIFF namespaces are called differently on Adobe's XMP website (https://developer.adobe.com/xmp/docs/XMPNamespaces) and in their official XMP document (Adobe Systems Incorporated, 2005). "Dereferenceable" means that the URI has a representation accessible through a web browser. XMP properties are commonly written in a ***preferredPrefix:property*** style, for example ***Iptc4xmpCore:Location*** (see Figures 7 and 10).

the exact year of release), these image region properties are barely used outside some default Windows photo applications.

4. GRAPHIS: Under the Hood

Since its inception in September 2021, project INDIGO has sought a way to properly segment and annotate graffiti photographs. Although various software tools exist to accomplish that, they are either based on the MWG XMP properties or use proprietary ways, so results are not portable between applications. That is why INDIGO wanted to leverage the relatively new IPTC *Image Region* property for this task. However, in 2021 and even 2022, barely any software could visualise, let alone create and save, IPTC-based image regions via a graphical interface. That is why GRAPHIS came into existence at the start of 2023.

GRAPHIS (Generate Regions and Annotations for PHotos using the IPTC Standard) is an open-source and freely available Windows-based software to create image regions, annotate them with graffiti descriptions or transcriptions, and visualise them. The backend of GRAPHIS is programmed

in Python 3 (https://www.python.org), while PySide—also known as Qt for Python (https://wiki.qt.io/Qt_for_Python)—was used for the Graphical User Interface (GUI). In addition, GRAPHIS relies on many other pieces of software, of which the most prominent ones function as interfaces for data handling: ExifTool (https://exiftool.org) to read and write photo metadata, the Python wrapper rawpy (https://pypi.org/project/rawpy) for LibRaw (https://www.libraw.org) to read the primary image pixels of RAW photo files, and the database engine SQLite (https://www.sqlite.org) for intermediate data storage. Luckily, thanks to GRAPHIS' GUI, one does not need to know and understand how these separate software components operate. Finally, the *GRAPHIS Image Region* vocabulary (https://vocabs.acdh.oeaw.ac.at/graphis-imgreg) provides GRAPHIS with a controlled list of concepts defined explicitly for graffiti image regions. The entire GRAPHIS source code repository is available at https://github.com/GraffitiProjectINDIGO/GRAPHIS, while the latest compiled release—ready for direct installation on a Windows machine—can be found at https://github.com/GraffitiProjectINDIGO/GRAPHIS/releases.

Rather than detailing the individual software components of GRAPHIS, the following section will provide an overview of GRAPHIS' GUI and simultaneously explain the software's general operating principles. A comprehensive account of the *GRAPHIS Image Region* vocabulary follows in Section 4.2.

4.1. The GRAPHIS GUI: a One-Stop-Shop for Image Region Operations

4.1.1. User Info

Upon starting GRAPHIS, a welcome screen asks the user for identification in the form of a name and a non-obligatory URI, such as an ORCID (https://orcid.org) (see Figure 12 on the left). This information is saved, allowing one to choose an existing identification profile upon second use (see Figure 12 in the middle). GRAPHIS uses this information to populate the *Contributor* property (***Iptc4xmpExt:Contributor;*** https://iptc.org/std/photometadata/specification/IPTC-PhotoMetadata#contributor). The *Contributor* top property

Property	Sub-property	Data type	Occurrence	XMP identifier
Contributor		Entity or Concept with role structure	multi	Iptc4xmpExt:Contributor
	Identifier	URI	multi	xmp:Identifier
	Name	Text	single	Iptc4xmpExt:Name
	Role	Text	multi	Iptc4xmpExt:Role

Figure 12. GRAPHIS starts by asking for user identification. One can create a new user (left) or choose an existing one (middle). This information then populates the *Name* and *Identifier* properties of the *Entity or Concept with role* structure (right), which is the structure used to define the *Contributor* property of the IPTC Photo Metadata Standard.

was introduced in November 2022 when the IPTC published the Photo Metadata Standard 2022.1 (IPTC Photo Metadata Working Group, 2023). Contributors are stored via an *Entity or Concept with role* structure (see Figures 7 and 12 on the right), a *field structure* almost identical to the *Entity or Concept* structure used in the *Region Content Type* and *Region Role* properties (see Section 3), but with an added *Role* field. Upon login, GRAPHIS uses the ORCID and user name to populate this structure's *Identifier* and *Name* fields (see Figure 12 middle and right). The *Role* field gets populated later, as its value depends on the action performed on the image region (see further).

After the initial user info screen, GRAPHIS displays its main window and directly presents two pieces of information:

- The user login in the upper right corner (see Figure 13-A);
- A welcome message in the console pane on the lower left (see Figure 13-B). Keeping an eye on the console while working with GRAPHIS pays off, as it displays error messages or auxiliary information on the finished processes.

4.1.2. Database Feedback

GRAPHIS stores all its operations on the fly in an SQLite database, a small file characterised by its .sqlite extension. This database makes it possible to quit GRAPHIS at any

point and continue later by reloading that database file. Therefore, one should first create a new database (or load an existing one) when working in GRAPHIS, operations which are all enabled via GRAPHIS' main menu. After loading the SQLite database file into GRAPHIS, new information will be displayed in three places:

- First, the database name will be shown at the top of the GUI (see Figure 13-C);
- Second, the "Database statistics" window will be updated (see Figure 13-D). For a new database, the number of images and image regions will be zero;
- Third, the console pane will announce that an *.sqlite file has been created or loaded (see Figure 13-B).

4.1.3. Adding Images

GRAPHIS supports the most common raster image file formats that store IPTC metadata: JPEG, TIFF, PNG, and many RAW formats. Images can be added to the active database anytime via the main menu. One can add all images in a folder (with or without its subfolders) or import images on a per-image basis. Each of these operations works on one file type at a time. For example, imagine a folder with *.jpg

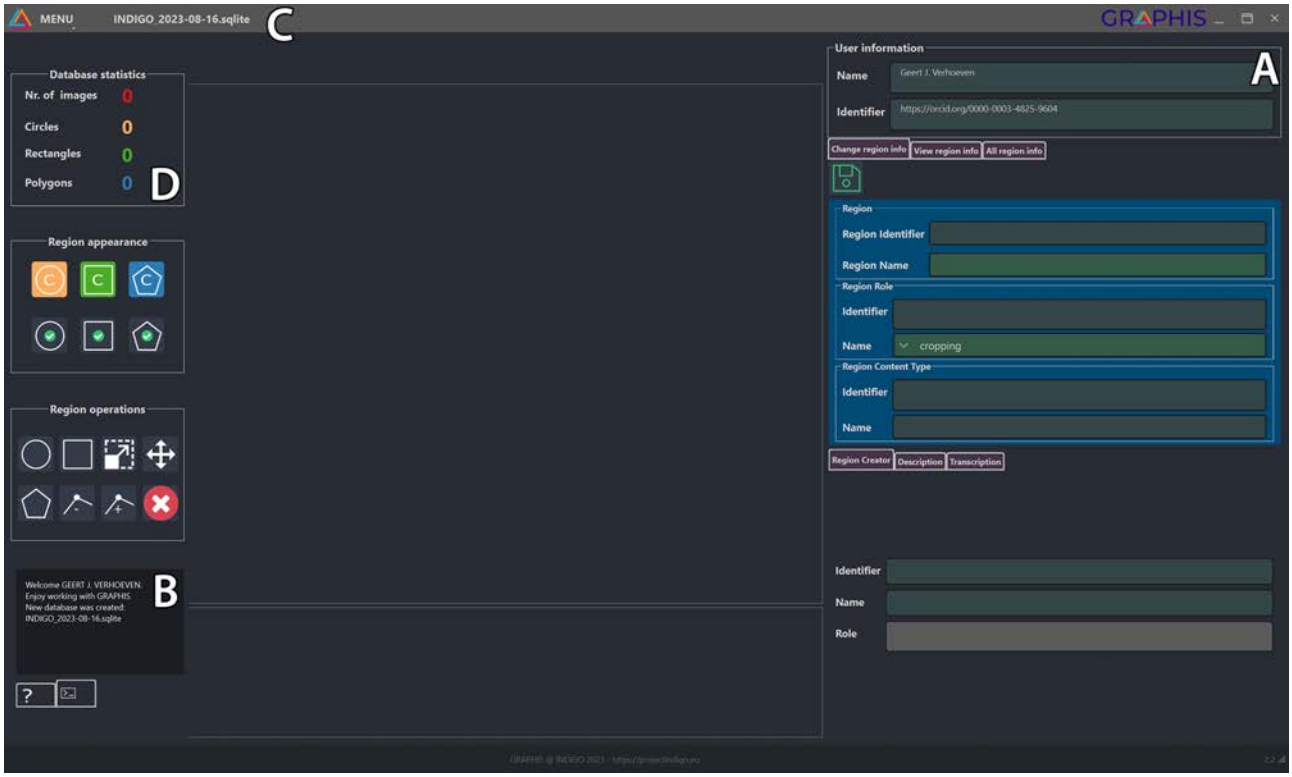

Figure 13. GRAPHIS displays general information about its status and the underlying SQLite database in four places: the user currently working with GRAPHIS (A); all the actions currently performed by GRAPHIS (B); the name of the active SQLite database (C); statistics about the image regions currently stored in the active database (D).

and *.tiff files. If the user wants to import all JPEG images into GRAPHIS, one *.jpg file must be selected. Since this operation discards all files without a .jpg extension, a second operation must be executed to import other file types, like TIFFs or RAW photos. Upon addition, the path of each image is stored as a path relative to the folder of the *.sqlite file. Consequently, the images and database must be stored on the same drive (C:\, D:\,...), or image import will result in an error. Images already part of the database will not be added once more.

Like most DAM or MAM systems, GRAPHIS manages metadata internally by reading them from the added images and writing them into the local SQLite database (and embedding that database info into the image file during export, an operation described later). To ensure that metadata are accurately read and written, GRAPHIS relies on a stand-alone Windows executable version of ExifTool (https://exiftool.org). ExifTool can be considered the Swiss army knife of file metadata manipulations. It is a command-line application, but GRAPHIS' GUI means that users do not need to know how to work with ExifTool. Figure 14 shows the updated data statistics (see Figure 14-A) and console (see Figure 14-B) after loading one NEF (i.e., Nikon Electronic Format, Nikon's RAW image file format) and four JPEGs.

The images get loaded as small previews (see Figure 14-C) whose size and order cannot currently be altered; as prescribed by the IPTC, GRAPHIS discards any rotation value for the image stored in the Exif metadata. Two of the loaded JPEG images in Figure 14 are files distributed by the IPTC (a Photo Metadata reference image from https://iptc.org/std/photometadata/examples/IPTC-PhotometadataRef-Std2023.2.jpg and an Image Region example image from https://www.iptc.org/std/photometadata/examples/image-region-examples). Since both files feature image regions, GRAPHIS has read and stored that info upon import. Double-clicking a photo displays it in the main window, with its image regions on top (see Figure 14-D); above the image, GRAPHIS displays its folder path and file name (see Figure 14-E).

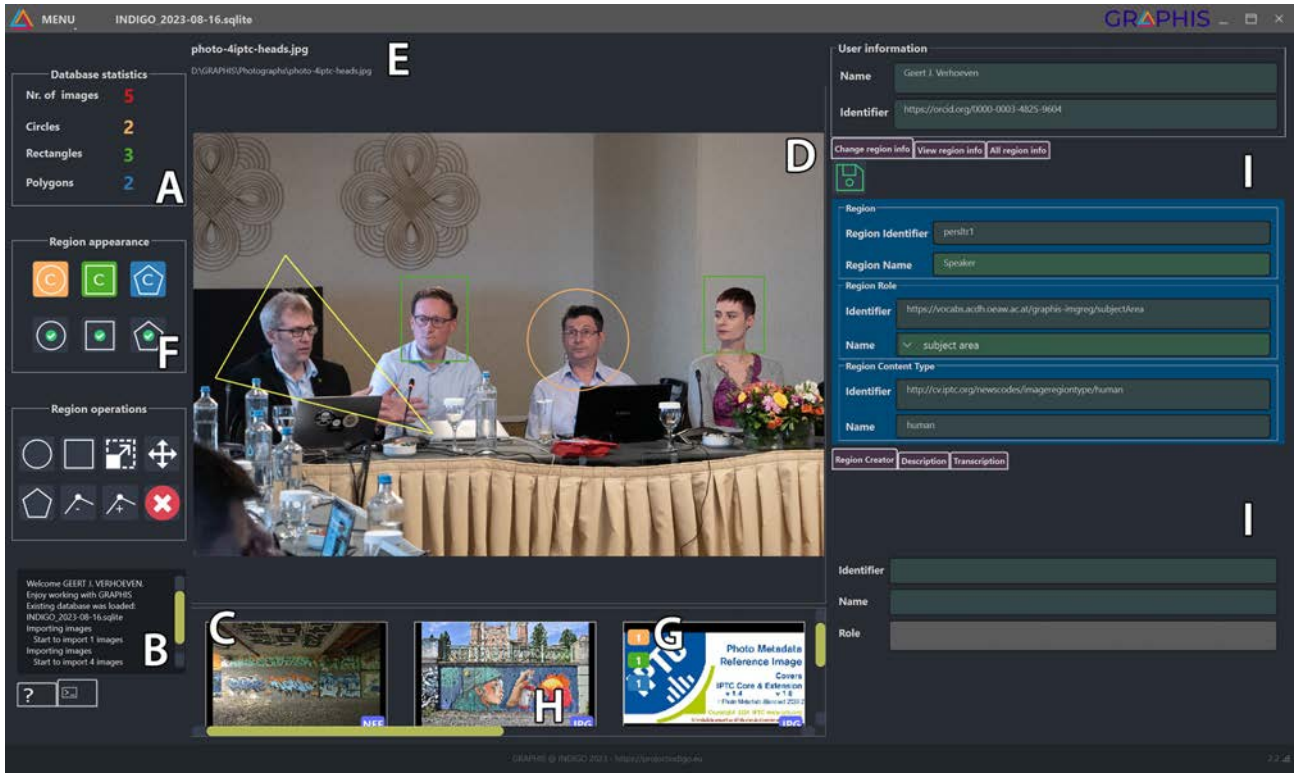

Figure 14. Importing images (with or without image regions) updates many aspects of the GRAPHIS GUI: the database statistics (A) and console (B) are refreshed; all images are rendered as small previews (C) and double-clicking one of them displays the image in large size (D) with its folder path and file name above it (E); each preview gets numbered insets (G) reflecting the number of shape-specific regions, while a small inset (H) also shows the file type of each image in the underlying database. The numbers in (A) and (G) inherit the colour settings determined in the "Region appearance" window (F). The editable properties of the selected image region are grouped below the "Change region info" tab (I).

4.1.4. Visualising Regions and Metadata

The “Region appearance” window controls the look of region boundaries via customisable colours, while the user can also hide/display one or more of those shapes (see Figure 14-F). The default colour values are defined in the graphis.config file, a text-based configuration file. Any change in these colours is reflected in the appearance of the numbers in the “Database statistics” window (see Figure 14-A) and in the number insets depicted on top of each preview image (see Figure 14-G). These number insets inform the user about the shape-specific region count per image. In addition, a small inset also conveys the image file type (see Figure 14-H).

Hovering over an image region turns it semi-transparent green and displays its region identifier. Double-clicking on the region turns its boundary yellow (indicating it is selected) and loads most of the image region properties on the right side of the GRAPHIS GUI in the “Change region info” tab (see Figures 14-I and 15-A). The information in these fields can be changed, as described in the following paragraph. In the “View region info” tab, all properties of the selected region can be consulted in a more structured way (see Figure 15-B). The metadata in this view are not editable, but properties can be collapsed or expanded at will. Finally, the “All region info” tab groups all the information available on each active image region, again in view-only mode but expandable or collapsible at will (see Figure 15-C).

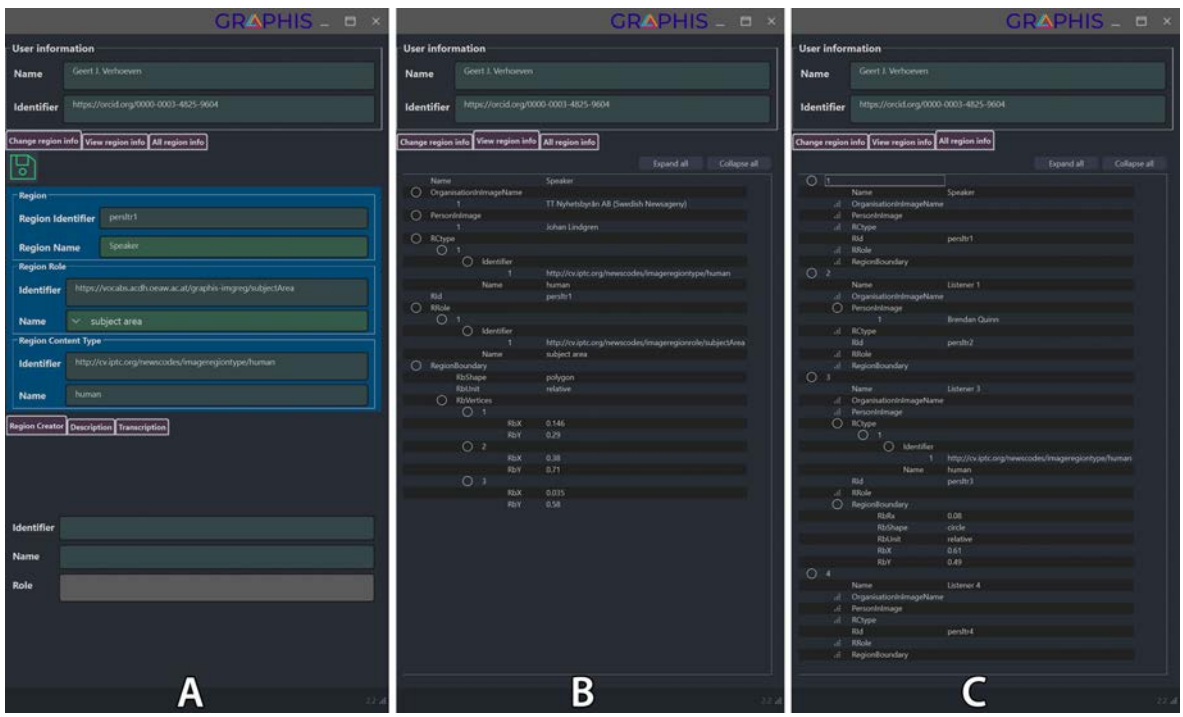

Figure 15. The editable properties of the selected image region are grouped below the “Change region info” tab (A). The “View region info” tab (B) displays all the properties of the *Image Region* structure of the selected region. The “All region info” tab (C) lists all properties of every image region in the active image. In the last two tabs, properties can be expanded or collapsed at will.

4.1.5. Creating Regions and Metadata

To create or alter an image region, the user should select one of the region operators with a left mouse click. With the circle and rectangle tools, drawing starts and ends with a right mouse click. Polygons are finished with a left click because every right click of the mouse creates a new vertex. Upon finishing the creation of a shape, its *Region Boundary* information gets automatically stored in the SQLite database, while the *Image Region* property gets the following default values:

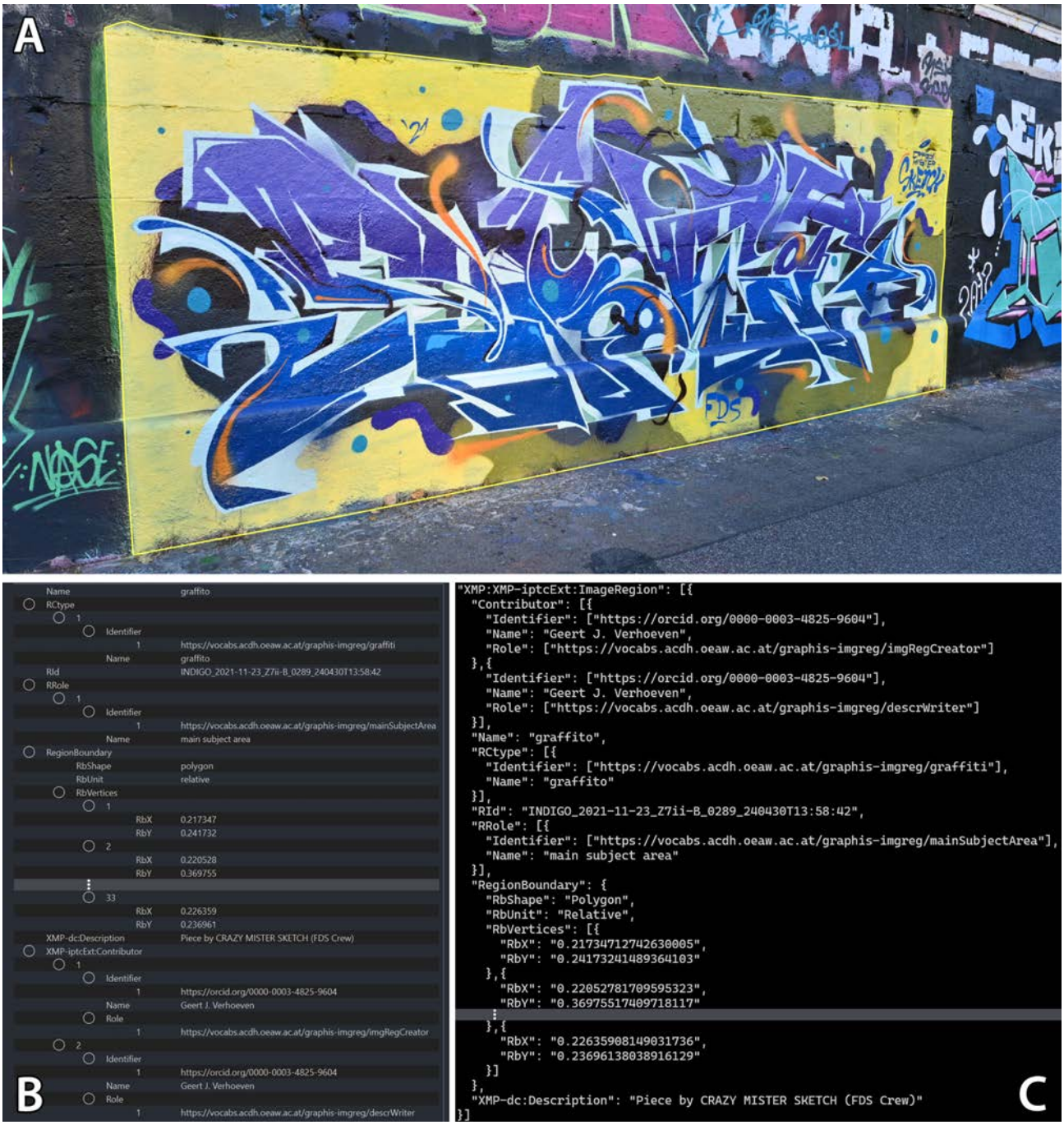

Figure 16. A 33-gon or 33-sided polygon (A) indicates the border of a graffito. The metadata of that image can be shown inside GRAPHIS (B) or visualised in the Windows command-line interface with ExifTool (C) after GRAPHIS has updated the image file metadata. For brevity, (B) and (C) only depict the coordinates of the first two and last vertices. The three dots and light grey bar indicate where the GRAPHIS and ExifTool output were partly removed.

- A *Region Identifier*, in the form of "imageFileName_YYMMDDThh:mm:ss", where "YY" indicates a two-digit year, 00 through 99; "MM" runs from 01 through 12, denoting the month of the year; "DD" indicates a two-digit day of that month, 01 through 31; "T" indicates Time; "hh" indicates a zero-padded hour between 00 and 24; "mm" refers to a zero-padded minute between 00 and 59 and "ss" refers to a zero-padded second between 00 and 60.
- A *Region Name*, which depends upon the shape:
  - A rectangle gets "graffito text" because a rectangle is the default shape to delineate and transcribe textual elements for most machine learning software;
  - A polygon and a circle both get "graffito", as a polygonal shape assumes that a graffito is outlined in detail, while a circle enables a quick indication of a graffito.
- A *Region Role Identifier* and *Region Role Name*, both coming from a controlled vocabulary. Although the IPTC has created a controlled vocabulary for this purpose (https://cv.iptc.org/newscodes/imageregionrole), GRAPHIS uses its own graffiti-specific controlled vocabulary (see Section 4.2). Following the reasoning of the *Region Name* property, the *Region Role Identifier* and the *Region Role Name* get default values based on the region shape:
  - Rectangle: https://vocabs.acdh.oeaw.ac.at/graphis-imgreg/areaOfInterest and "area of interest";
  - Polygon and circle: https://vocabs.acdh.oeaw.ac.at/graphis-imgreg/mainSubjectArea and "main subject area".
- A *Region Content Type Identifier* and *Region Content Type Name*. Since a controlled vocabulary must populate both fields, shape-dependent values come again from the dedicated *GRAPHIS Image Region* vocabulary (see Section 4.2):
  - Rectangle: https://vocabs.acdh.oeaw.ac.at/graphis-imgreg/textGraffito and "text (graffito)";
  - Polygon and circle: https://vocabs.acdh.oeaw.ac.at/graphis-imgreg/graffiti and "graffito".
- A *Region Creator*, stored as the *Contributor* property of the IPTC Photo Metadata Standard (***Iptc4xmpExt:Contributor***).
  - The *Identifier* and *Name* are those used to log in;
  - The *Role* field equals https://vocabs.acdh.oeaw.ac.at/graphis-imgreg/imgRegCreator, which is the URI from the *GRAPHIS Image Region* vocabulary identifying the concept "image region creator".

Although all these values are auto-generated upon region creation, two critical comments are necessary:

- A user can set most of these predefined values in the graphis.config file, a text-based configuration file (but see Section 5.3 for some comments);
- Each value can be changed in the "Change region info" tab. Pressing the green floppy disk icon (see Figure 15-A) or the shortcut CTRL+S saves all changes to the database.

Descriptions or transcriptions are not auto-generated. The former is saved in the *Description* property of the IPTC Extension schema (***dc:description***) (see Figure 16-B & C), while the latter gets stored in the *Title* property of the IPTC Core schema (***dc:title***) (see Figure 17-B & C). When a description or transcription is added, the current user information populates a new *Contributor* property, but now the *Role* field gets either the "description writer" URI (i.e., https://vocabs.acdh.oeaw.ac.at/graphis-imgreg/descrWriter; see Figure 16-B & C) or the "transcript writer" URI (i.e., https://vocabs.acdh.oeaw.ac.at/graphis-imgreg/transcrWriter; see Figure 17-B & C) of the *GRAPHIS Image Region* vocabulary (see Section 4.2). Several contributors, each with a different role, can be stored per region as the IPTC has allowed multiple values for this property (see Figure 7). However, GRAPHIS only stores one entry per contributor role. For instance, if Person A creates an image region and writes its description, Person A is stored as the image region creator and the description writer. If Person B opens the database and alters that description, Person B becomes the description writer, overwriting Person A. However, Person A remains the creator of the image region until another user adapts the region's shape.

When drawing a region, the last-used drawing tool remains active (indicated by its yellow icon), allowing the user to keep drawing with the same tool without activating it

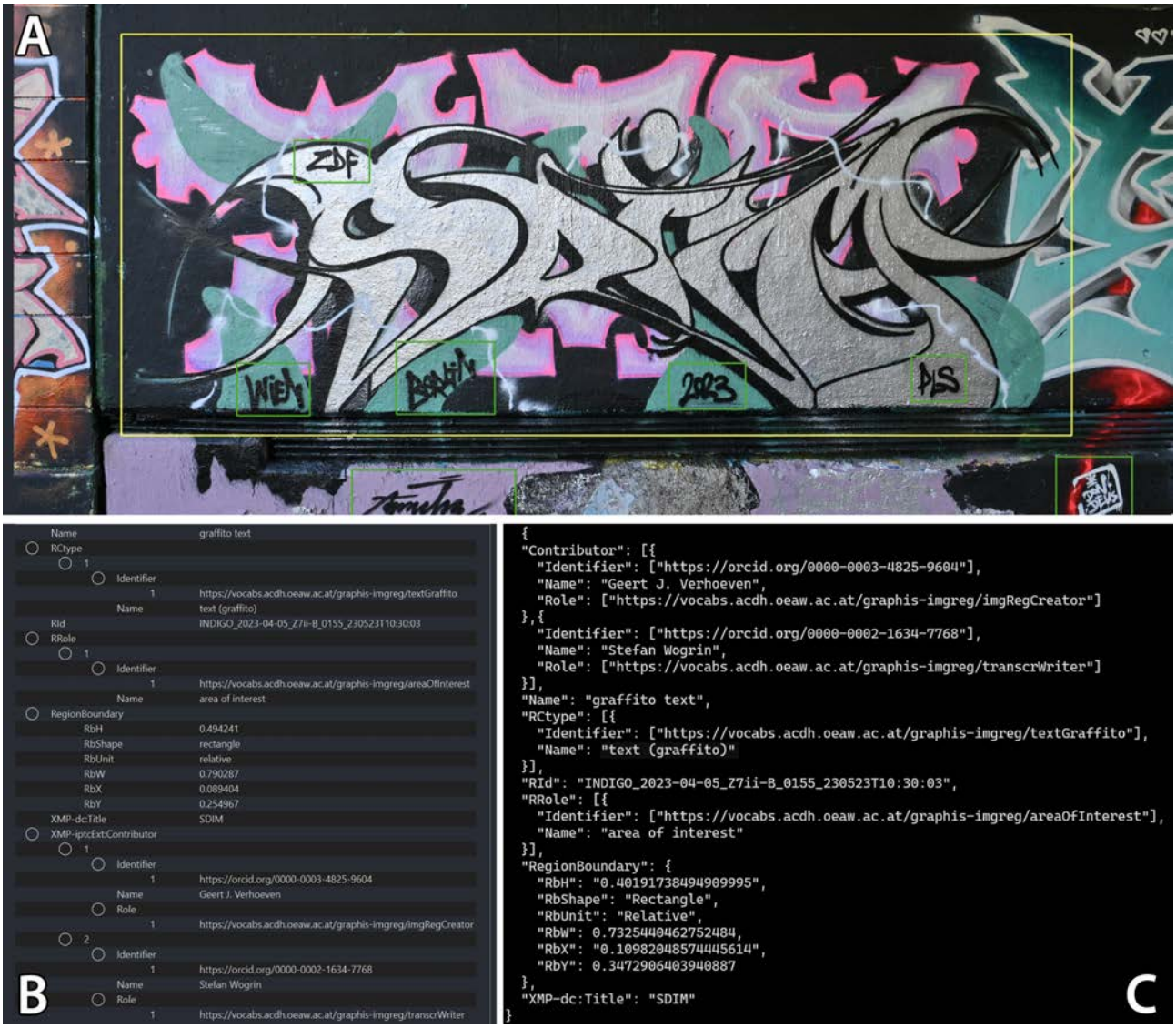

Figure 17. Various rectangles indicate regions with text on a photo of a graffitied wall (A). The metadata of the active image region can be shown inside GRAPHIS (B) or, after saving the region metadata within the image, visualised via ExifTool (C).

every time. Suppose metadata properties need to be added (like a description) or changed (like the region name) after drawing that region. In that case, the user can quickly save that new information with CTRL+S, avoiding a mouse click on the saving icon. The Enter and Backspace buttons allow navigation to the next or previous image. However, this will only work if the cursor is not on a metadata field, as one would otherwise start typing in that field. These features support the rapid creation of polygons with minimal mouse clicks. GRAPHIS also ensures that a region cannot be finalised if it partly lies outside the image boundaries. In addition, intersecting polygon edges are not allowed.

Once an image region has been created, it is possible to modify its shape in various ways using some of the tools provided by GRAPHIS. For example, circles and rectangles can be resized, while the same tool can also be used to move polygon vertices. Other tools allow the user to shift

or delete the entire shape, or to add or remove individual polygon vertices. As with the drawing tools, a left mouse click activates these shape modification tools, while a right mouse click executes the action.

4.1.6. Saving Results

Photo metadata management in software typically involves extracting embedded metadata from an image upon file import, assigning extracted field values to corresponding metadata pane fields, changing or adding metadata values, and re-embedding these updated values back into the image file upon saving or exporting. Thanks to ExifTool, GRAPHIS can also store the (newly created or altered) image regions and their annotations back into the original images at any time. GRAPHIS either saves all metadata to the original image files, or into a backup of these files. If something goes wrong, the latter option ensures that the original image files stay unharmed. Feedback on this process is again provided in the console window. In its current version (i.e., 2.2), GRAPHIS embeds metadata into every image file, even RAW photographs. Section 5.2 will explain why this behaviour should be changed in the future.

Finally, "Save bounding boxes to CSV file" is a function that creates a Comma-Separated Values file of all the image regions in the database. This *.csv file contains image region information useful for machine learning purposes (see Figure 18). In machine learning, image labelling/tagging/annotating software is used to draw bounding rectangles around objects and attach labels to them. The coordinates of these rectangles and their labels are then typically exported into a text-based *.csv file. Although many free

Image	Type	RId	UpperLeftX	UpperLeftY	Width	Height	XMP-dc:Description	XMP-dc:Title	Polygon vertices
INDIGO_2023-04-05_Z7ii-B_0002.jpg	rectangle	INDIGO_2023-04-05_Z7ii-B_0002_230521T23:10:30	1047	3492	1186	1025		CRIME AFTER CRIME	
INDIGO_2023-04-05_Z7ii-B_0017.jpg	rectangle	INDIGO_2023-04-05_Z7ii-B_0017_230523T10:10:49	5502	3624	546	389		YUZI	
INDIGO_2023-04-05_Z7ii-B_0035.jpg	polygon	INDIGO_2023-04-05_Z7ii-B_0035_230521T23:16:14	1794	1316	4954	3099	Piece and character by JAKOB		[[1794.417884031533, 1355.5133933927827], [1820.6776579441894, 2060.150660049068], [1886.3270927258309, 3158.6845353952017], [1916.9634956239302, 3845.8152861097237], [1957.6727272727271, 4415.70909090909], [3159.926127489675 8, 4222.2053788578 12], [4297.84966370481, 3990.2440426293415], [5497.046005716127, 3745.152819444536], [6713.748863669214, 3469.4251933616383], [6726.878750625543, 3110.5416165553 32], [6713.748863669214, 3066.7753267009043], [6687.489089756558, 3049.2688107591325], [6696.242347727444, 2874.2036513414228], [6713.748863669214, 2690.3852339528257], [6713.748863669214, 2414.6576078699313], [6735.632008596429, 2213.3326745395643], [6748.761895552758, 2051.3974020781 82], [6748.761895552758, 1924.4751615003 42], [6748.654545454545, 1813.8181818181818], [6204.50909090909, 1751.2727272727 27], [5076.889623113 6205, 1679.3839363155473], [5037.499962244636, 1644.3709064320 05], [5006.863555936537, 1657.5007933883335], [4722.382675292758, 1626.8643904902342], [4634.850095583903, 1639.9942774465621], [4359.122469501008, 1613.7345035339058], [4332.862695588352, 1578.7214716503 64], [4280.343147763038, 1596.2279875921 35], [3400.640721689027, 1495.5655209285 12], [3194.9391593732175, 1486.8122629560658], [2424.652457935291, 1412.4095702035388], [2207.854545454545, 1382.2545454545455], [1930.0933825802585, 1316.1237325237978], [1868.8205767840595, 1329.2536194801262]]
INDIGO_2023-04-05_Z7ii-B_0035.jpg	circle	INDIGO_2023-04-05_Z7ii-B_0035_230521T23:16:29	353	659	1495	1801			
INDIGO_2023-04-05_Z7ii-B_0035.jpg	rectangle	INDIGO_2023-04-05_Z7ii-B_0035_230521T23:15:44	1408	2265	321	181		SAES.	

Figure 18. An example of a *.csv output file (slightly formatted to improve presentation).

and payware labelling solutions exist, GRAPHIS can also be used to accomplish this, with the added benefit that the bounding rectangles and their labels can be stored in the images according to a prevailing photo metadata standard. For polygons or circles, GRAPHIS will compute and export the coordinates of the smallest rectangle that encompasses that shape, the so-called *minimum bounding rectangle*.

4.2. The GRAPHIS Image Region Vocabulary

As mentioned in Section 3.1, image regions can be annotated to provide further information about what they depict or why they were created. This can be done using the *Region Content Type* (***Iptc4xmpExt:rCtype***) and *Region Role* (***Iptc4xmpExt:rRole***) properties, which store the information in an *Entity or Concept* structure. This structure consists of a

concept's *Name* (***Iptc4xmpExt:Name***) and a URI as a unique *Identifier* (***xmp:Identifier***) for that concept (see Figure 10). For this purpose, the IPTC has published two controlled vocabularies which provide a set of predefined concepts for both properties: the *Image Region Type* vocabulary (http://cv.iptc.org/newscodes/imageregiontype) and the *Image Region Role* vocabulary (http://cv.iptc.org/newscodes/imageregionrole). For example, the *Image Region Type* vocabulary contains concepts such as "animal", "artwork", "human", and "rock formation", while "recommended cropping", "subject area", "area of interest", and "business" are concepts of the *Image Region Role* vocabulary. Both vocabularies are maintained as part of the IPTC NewsCodes (https://cv.iptc.org/newscodes) and may be updated with new concepts over time. The use of these controlled vocabularies is not mandatory but recommended.

Both the *Region Role* and the *Region Content Type* fields are available in GRAPHIS. They can be found in the right pane when editing the metadata of an image region, under the headings "Region Role" and "Region Content Type" (see Figure 15-A). For the *Region Role* property, a user can either enter a URI by typing it into the "Identifier" field, or select one of the predefined terms from the drop-down menu next to "Name" (which will automatically fill in the corresponding value for "Identifier"). This drop-down menu contains three terms defined by the IPTC *Image Region Role* vocabulary: "area of interest", "main subject area", and "subject area". As mentioned in Section 4.1.5, creating a new region assigns default values to *Region Role* fields. These default values can be set in the graphis.config file, but any initial value can be changed later.

Setting the values for the *Region Content Type* fields works similarly, except for the lack of a drop-down menu (which is something the next version of GRAPHIS should solve). In addition, the automatically assigned default values do not come from the recommended IPTC *Image Region Type* vocabulary, since the concepts of that vocabulary do not cover various use cases encountered in project INDIGO. For example, there are many reasons why it is helpful to define which part of a photo contains a specific graffito, or where textual graffiti elements are present (see Section 5.1).

The controlled vocabulary used by GRAPHIS should thus include concepts to indicate these types of image regions. In addition, INDIGO wanted to go one step further and exploit the full potential of the *Contributor* property of the IPTC Photo Metadata Standard (***Iptc4xmpExt:Contributor***) (see Sections 4.1.1 and 4.1.5). This property helps define the role in which a particular actor (such as a person or organisation) has contributed to an image. The IPTC created a controlled vocabulary for this field too, the *Content Production Party Role* vocabulary, which can be accessed at http://cv.iptc.org/newscodes/contentprodpartyrole (as with the previous examples, use of this vocabulary is not mandatory). The concepts in this vocabulary include "Author", "Description Writer", and "Generative AI Prompt Writer", to name a few. However, no concept defines the "creator of an image region". The inability to assign such a value to a specific actor makes it difficult to trace the provenance of image regions. Also, when textual elements are present in an image, someone might write a transcription of that text and include it in the image metadata. To record who created this transcription, a controlled vocabulary should also include a value such as "transcript writer".

Therefore, project INDIGO decided to create a new controlled vocabulary comprising both selected values from the ITPC vocabularies (i.e., only those values strictly necessary for the purposes of GRAPHIS) and the additional values created within the scope of INDIGO. The resulting product, the *GRAPHIS Image Region* vocabulary, is hosted on the Vocabs service of ACDH-CH (Austrian Centre for Digital Humanities and Cultural Heritage, one of the institutions involved in project INDIGO) and can be accessed with a web browser via its URI https://vocabs.acdh.oeaw.ac.at/graphis-imgreg. This URI automatically redirects to the presentation page https://vocabs.acdh.oeaw.ac.at/graphis_imgreg_browse/en (see Figure 19).

The vocabulary was formalised according to a widely used RDF-based data model, the Simple Knowledge Organization System or SKOS (Miles & Bechhofer, 2009). SKOS enables the definition of controlled vocabularies, even when they include hierarchical and associative relationships between the concepts, thus allowing the construction of very complex

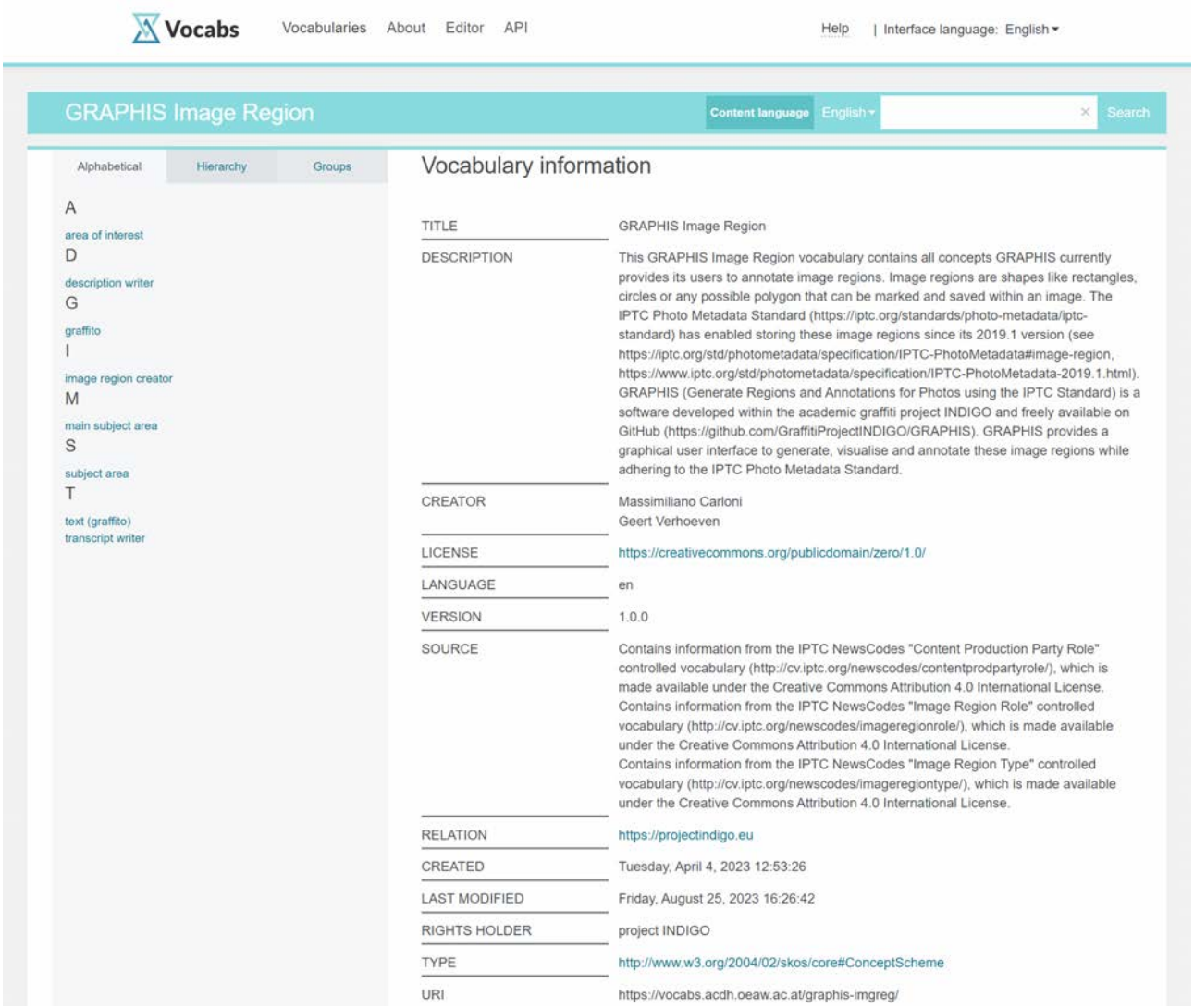

Figure 19. The main page presenting the *GRAPHIS Image Region* vocabulary (https://vocabs.acdh.oeaw.ac.at/graphis_imgreg_browse/en) shows the vocabulary title as well as additional metadata fields such as "description", "creator", and "license". Individual concepts can be accessed by clicking on them in the left pane. The default view of the concept list is "Alphabetical", but other options are available (see also Figure 20).

vocabularies such as thesauri (see Schlegel et al. (2023) for more details). SKOS also facilitates the inclusion of terms in different languages that refer to the same concept, as well as the establishment of mapping relationships that create 'matches' between concepts of different vocabularies. For example, if the concept "graffiti" defined in one vocabulary can be considered equivalent to the concept "graffiti" in another vocabulary (such as the Getty Art & Architecture Thesaurus; http://vocab.getty.edu/aat), a relationship of the kind ***skos:exactMatch*** can be established between the first and the second concept.

In the case of the *GRAPHIS Image Region* vocabulary, the concepts are organised according to a flat hierarchy: all

concepts are listed one after the other, and all are on the same hierarchical level because no concept is 'narrower' (i.e., a sub-concept) than another (see Figure 20 on the left, where the "Hierarchy" tab is selected). However, to provide a clear view for users, values related to a specific metadata field have been grouped using another SKOS-specific construct, i.e. ***skos:Collection.*** The grouping of the concepts by collections can be viewed by clicking on the "Groups" tab (see Figure 20 on the right). Each of the three collections corresponds to the metadata property for which the contained values (visible when expanding the collection) can be used.

Figure 20. Vocabs can display the concepts of a controlled vocabulary according to different criteria. The "Hierarchy" tab (on the left) shows the hierarchical relationships between the concepts; however, in the case of the *GRAPHIS Image Region* vocabulary, all concepts are placed on the same hierarchical level. The "Groups" tab (on the right) shows the same concepts according to their collection (collection names are in bold; all collections have been expanded by clicking on the small arrow next to them).

As shown in Figure 20 (on the right), the *content production contributor roles* collection contains three concepts relevant to the *Contributor* property: "description writer" comes from the IPTC *Content Production Party Role* vocabulary, whereas "image region creator" and "transcript writer" have been created specifically for GRAPHIS. Within the *image region roles* collection, there are three concepts ("area of interest", "main subject area", and "subject area"), all taken from the IPTC *Image Region Role* vocabulary. Finally, the collection of *image region types* is populated by two concepts related explicitly to graffiti research: "graffito" and "text (graffito)".

Metadata are available for the entire vocabulary as well as for individual concepts. The main page shown in Figure 19 includes general vocabulary information, while clicking on a concept in the left pane displays the metadata associated with that concept (e.g., "text (graffito)", shown in Figure 21). These concept-specific metadata include: a preferred term (i.e., the preferred way to refer to this concept) in English; a definition (which, for concepts borrowed from the IPTC, was derived from the respective IPTC vocabulary with appropriate attribution); additional documentary notes (if available); and the URI of the concept. Metadata for collections are also included in the vocabulary and can be viewed by clicking on a collection after selecting the "Groups" tab in the left pane.

These concept URIs and their respective preferred terms are used in GRAPHIS; for example, when selecting the term "area of interest" for the "Name" field of the *Region Role* property, the "Identifier" field is automatically filled with the URI https://vocabs.acdh.oeaw.ac.at/graphis-imgreg/areaOfInterest. The authors of this paper (who also authored

Figure 21. This is an example of a presentation page for a single concept, in this case "text (graffito)", accessible at https://vocabs.acdh.oeaw.ac.at/graphis_imgreg_browse/en/page/textGraffito. Entering the URI of the concept (https://vocabs.acdh.oeaw.ac.at/graphis-imgreg/textGraffito) in a web browser automatically redirects to this page.

the GRAPHIS vocabulary) decided to create new URIs in the https://vocabs.acdh.oeaw.ac.at/graphis-imgreg/ namespace for concepts—like "area of interest"—already existing in the IPTC vocabularies. This is why GRAPHIS uses https://vocabs.acdh.oeaw.ac.at/graphis-imgreg/areaOfInterest instead of http://cv.iptc.org/newscodes/imageregionrole/areaOfInterest as the URI for "area of interest". However, if applicable, each concept still includes the original IPTC URI in the "exactly matching concepts" metadata field (based on the ***skos:exactMatch*** property). In addition, the preferred terms for the GRAPHIS concepts closely mirror their corresponding IPTC concepts (when present), except that all are written in lowercase for consistency.

Recreating URIs and metadata for the IPTC concepts directly in the *GRAPHIS Image Region* vocabulary has a few advantages. Since one source contains all information relevant to GRAPHIS (i.e., the vocabulary as modelled in Vocabs), adding, altering, or accessing concepts needed for GRAPHIS is easier. At the same time, those concepts also feature consistent URIs. Finally, this solution avoids visualisation issues in the Vocabs service and potential semantic conflicts due to future updates of the IPTC vocabularies. Applications other than GRAPHIS can reuse these concepts by indicating the URIs assigned to them in the *GRAPHIS Image Region* vocabulary. Metadata about the concepts (including mapping relationships to external resources) can be retrieved directly from the concept's URI if the requesting application supports RDF, or via the API of Skosmos (https://skosmos.org), the open-source software on which the Vocabs service is based. To facilitate reuse, the *GRAPHIS Image Region* vocabulary has been released under a CC0 public domain licence (https://creativecommons.org/publicdomain/zero/1.0).

5. GRAPHIS: Considerations

5.1. INDIGO Workflow

GRAPHIS is generally helpful in any workflow where users want to attach specific metadata to one or more regions of an image. This is especially true for graffiti photos as they usually depict multiple graffiti. GRAPHIS allows graffiti scholars to annotate each graffito in an image with a general description and a unique identifier. Within project INDIGO, GRAPHIS also became an essential part of the processing pipeline developed to compute each graffito's surface area and track its existence in time. To that end, the spatial extent of each graffito (as depicted by an overview photograph) can be defined with a polygon within GRAPHIS. However, this polygon has 2D pixel coordinates defined relative to the image. As a result, one cannot use this polygon to compute the surface area of the physical graffito. This is where AUTOGRAF—INDIGO's bespoke software for orthorectifying graffiti photographs (Wild et al., 2022; Wild et al., 2023)—enters the workflow.

AUTOGRAF reads the polygon vertex coordinates saved by GRAPHIS in the photo and projects those vertices onto a georeferenced triangle-based mesh that digitally represents the graffito surface in 3D. Using photogrammetric and computer vision principles, AUTOGRAF can extract this

digital 3D surface mesh for every graffito from the series of overlapping photographs acquired during INDIGO's photo tours (Verhoeven et al., 2023). Since every point on this meshed, digital 3D surface features accurate 3D coordinates expressed in a standard coordinate reference system for East Austria (MGI/Austria GK East, EPSG:31256; https://epsg.io/31256), it is possible to end up with exact real-world 3D coordinates (x, y, and z) for each projected polygon vertex. AUTOGRAF thus turns the 2D image polygon defined within GRAPHIS into a 3D shape bounded by a polyline with real-world 3D coordinates (see Figure 22). Since the area of this 3D digital surface approaches the real-world area occupied by the graffito, it can be computed and stored as metadata for the real graffito (see Figure 4).

In the future, the authors also hope to use these 3D polylines to automatically find overlaps between graffiti and—depending on the photography date—temporally stamp how long each graffito segment was visible (with a lower and upper bound). The contribution by Verhoeven, Schlegel, & Wild in this volume provides more details on this idea.

Finally, GRAPHIS has also been used to create rectangles around verbal graffiti and annotate them with transcriptions (see Figure 17). It is straightforward to export those results into a *.csv file (see Figure 18), which can be input for machine learning systems trained to read graffiti automatically.

5.2. JPEG or TIFF Versus RAW+XMP

Anno 2024, XMP is the industry standard for storing metadata in the image or as separate *.xmp sidecar files. Where those metadata are stored is file-dependent. XMP data are embedded within the image file for JPEG, PNG, TIFF, PSD, PSB, DNG, GIF, PDF and a few other file formats. Formats without support for embedded XMP must store the XMP metadata in a separate but associated *.xmp sidecar file. The same holds for RAW photographs. Although these files can have an embedded XMP metadata record, an unwritten rule in the photo industry stipulates leaving RAW files untouched, hence the need for a sidecar *.xmp file with the same name as the original RAW photo.

Figure 22. AUTOGRAF can compute a 3D surface mesh (A) with texture (B) from the series of overlapping photos acquired per graffito. On this textured mesh, the GRAPHIS image polygon can be projected (C) to yield a 3D closed polyline whose vertices have real-world 3D coordinates.

The only way to avoid metadata sidecar files is not to use RAW file formats. However, this is unattainable from an academic point of view as RAW is the only scientifically justifiable photo file format to store the initially acquired photographs (Verhoeven, 2010). However, the RAW format is not all roses. Even though most dedicated digital cameras support saving RAW files, these files feature proprietary structures and manufacturer-specific extensions. Adobe also

launched its open-source Digital NeGative (DNG) format in 2004 (Adobe Systems Incorporated, 2004), attempting to standardise the RAW file format. However, most camera manufacturers refrain from implementing it. On the positive side, *.dng files are the exception to the "do not embed XMP metadata in RAW files" mantra because their file structure was designed to carry embedded metadata.

GRAPHIS version 2.2 (i.e., the most recent version at the time of writing) does not support the creation of sidecar *.xmp files. Even though LibRaw and ExifTool enable GRAPHIS to visualise and process RAW files, the authors, for now, advise users to avoid working with RAW files unless they are in the DNG file format.

5.3. Issues and Improvements

GRAPHIS and the IPTC Photo Metadata Standard on which it is based currently only allow the creation of *simple polygons*, i.e. planar regions enclosed by a single closed polyline that does not intersect itself. Simple polygons do not allow holes, but this lack of holes can be problematic when, for instance, one needs to denote all the pixels of the character "O" sprayed without a background. Figure 23 depicts three graffiti for which a *polygon with holes* (O'Rourke, 1987) would be necessary to indicate the image pixels that belong exclusively to each graffito. Since the IPTC wants to keep the Photo Metadata Standard and its implementation in software as straightforward as possible, there are no plans to support polygons with holes (personal communication with Michael W. Steidl). Users who need image regions with

Figure 23. Three examples of a graffito featuring spray-painted characters without a dedicated background. The spaces between those characters are thus not a part of the graffito and should, *stricto sensu*, be excluded from the image region polygon.

holes must thus develop creative solutions. One possibility could be to define the maximum extent of the entire graffito with one polygon, and delineate each hole with a separate polygon. Afterwards, those hole-indicating polygons could be subtracted from the overall polygon in dedicated software. However, it must be clear that the IPTC *Image Region* property cannot correctly store the resulting polygon with holes.

Since GRAPHIS is not meant for image processing, there is no risk of violating the integrity of the image region metadata. However, manufacturers of image processing software must take measures to avoid invalidating the coordinate definitions of the image regions when resizing, rotating, straightening, and cropping the images (or any other operation that changes the mapping of the input pixels to the output pixels, such as the correction of lens distortion or perspective). Suppose those software packages do not adequately update the image region metadata in an automated manner. In that case, all the region boundary coordinates become nonsensical and will no longer represent the initially defined image region(s).

Users must also be aware that GRAPHIS is not meant to be a DAM or MAM replacement, meaning it lacks functions to monitor file locations or check metadata integrity. Altering image regions outside of GRAPHIS while the SQLite database still holds image region metadata that are not written back into the image file, or changing the relative location of the SQLite database versus the image files, will lead to errors.

Besides the correction of some minor issues and the necessary support for sidecar *.xmp files (see Section 5.2),

there are four prominent features that GRAPHIS still would need to make the software even more straightforward to use and beneficial for various image-centric fields besides the graffiti community:

- The GUI should support removing images from the SQLite database and facilitate sorting and resizing the previews;
- The GUI should allow the annotation of image regions with any valid property of the IPTC Core and Extension schemas, not just the ***Iptc4xmpExt:Contributor***, ***dc:description***, and ***dc:title*** properties. For example, the image region metadata of the IPTC test image in Figure 15 (B & C) show how the ***Iptc4xmpExt:PersonInImage*** and ***Iptc4xmpExt:OrganisationInImageName*** fields can function as additional metadata properties;
- The GUI should automatically fetch the preferred terms and corresponding URIs from the *GRAPHIS Image Region* vocabulary. Any change in the latter would then automatically be reflected in the GRAPHIS GUI. Users could also sync GRAPHIS with the latest terms and URIs defined by another controlled vocabulary simply by specifying the URI of that vocabulary. This leads directly to the next improvement;
- The graphis.config file should be slightly restructured for ease of use and expanded with the base URI of a controlled vocabulary plus a custom pattern for the *Region Identifier*.

With the GRAPHIS source code freely available on GitHub (https://github.com/GraffitiProjectINDIGO/GRAPHIS), the authors hope that other projects or individual developers will help to implement such features.

6. Conclusion

Image file metadata are typically applied to the entire image content. Nevertheless, applying metadata to specific parts of the image can be essential for many images, such as photographs of graffiti. Defining image regions and annotating them with metadata should, however, follow specific requirements to make these regions useful, transferrable between software packages, and suitable for inventorying purposes. This paper proposed GRAPHIS, a tool to visualise, create and annotate image regions based on the IPTC Photo Metadata Standard. As with every software package developed within project INDIGO, GRAPHIS is freely available. In this way, the authors hope GRAPHIS gets adopted within the academic (graffiti) community and integrated into existing image annotation workflows. In addition, GRAPHIS' open-source nature makes it more likely that a few enthusiastic developers will implement improvements to steadily increase its user-friendliness and relevance for various non-graffiti-specific use cases.

Conflict of Interest

The authors declare no conflict of interest.

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References

Adobe Systems Incorporated. (1991-2008). *Photoshop Image Resources.* https://web.archive.org/web/20090306165311/https://www.adobe.com/devnet/photoshop/psir/ps_image_resources.pdf

Adobe Systems Incorporated. (2001a). *Adobe® XMP. Adobe Extensible Metadata Platform integration technology built on W3C standards.*

Adobe Systems Incorporated. (2001b, September 14). *XMP – Extensible Metadata Platform. Version 1.5*. https://xml.coverpages.org/XMP-MetadataFramework.pdf

Adobe Systems Incorporated. (2002). *Adobe Solutions Network: Developer Knowledgebase. Known Issue: The metadate framework name was changed from XAP to XMP.*

http://web.archive.org/web/20020307124612/http://support.adobe.com/devsup/devsup.nsf/docs/51840.htm

Adobe Systems Incorporated. (2004). *Digital Negative (DNG) Specification. Version 1.0.0.0. September 2004*. Adobe Systems Incorporated. https://web.archive.org/web/20041204034106/http://www.adobe.com/products/dng/pdfs/dng_spec.pdf

Adobe Systems Incorporated. (2005). *XMP specification. September 2005*.

Adobe Systems Incorporated. (April 2012). *XMP specification part 1. Data model, serialization, and core properties*. https://github.com/adobe/XMP-Toolkit-SDK/blob/main/docs/XMPSpecificationPart1.pdf.

Adobe Systems Incorporated, & Knoll, T. (1990-2019). *Adobe Photoshop File Formats Specification*. https://www.adobe.com/devnet-apps/photoshop/fileformatashtml.

Baca, M., Harpring, P., Lanzi, E., McRae, L., & Whiteside, A. (2006). *Cataloging cultural objects: A guide to describing cultural works and their images*. American Library Association.

Berger, M. (2010). *Geometry Revealed: A Jacob's Ladder to Modern Higher Geometry*. Springer. https://doi.org/10.1007/978-3-540-70997-8.

Borgman, C. L. (2015). *Big Data, Little Data, No Data: Scholarship in the Networked World*. The MIT Press.

Bryson, B. (2008). *Bryson's dictionary for writers and editors*. Broadway Book.

Camera & Imaging Products Association (2023, May 29). *CIPA DC-008-Translation-2023. Exchangeable image file format for digital still cameras: Exif Version 3.0* (CIPA DC-008-2023 / JEITA CP-3451F). CIPA-JEITA. https://www.cipa.jp/std/documents/download_e.html?DC-008-Translation-2023-E.

Chapman, C., & Brailsford, D. F. (2001). Navigating a corpus of journal papers using Handles. In A. C. Hübler, P. Linde, & J. W. T. Smith (Eds.), *Electronic publishing '01: 2001 in the digital publishing odyssey. Proceedings of the 5th ICCC/IFIP conference held at the University of Kent at Canterbury, Kent, United Kingdom, 5-7 July, 2001* (pp. 249–255). IOS Press. https://elpub.architexturez.net/system/files/pdf/200123.content_0.pdf.

Comité International des Télécommunications de Presse, & Newspaper Association of America. (July 1999). *IPTC-NAA Information Interchange Model Version 4. Revision 1*. https://iptc.org/std/IIM/4.1/specification/IIMV4.1.pdf.

Gartner, R. (2016). *Metadata: Shaping Knowledge from Antiquity to the Semantic Web*. Springer International Publishing. https://doi.org/10.1007/978-3-319-40893-4.

Harpring, P. (2013). *Introduction to controlled vocabularies: Terminology for art, architecture, and other cultural works* (Updated edition). Getty Research Institute.

Horodyski, J. (2022). *Metadata matters*. CRC Press.

International Organization for Standardization (2016, April 7). *Information and documentation — Records management — Part 1: Concepts and principles* (ISO/TC 46/SC 11 ISO 15489-1:2016). International Organization for Standardization. https://www.iso.org/standard/62542.html.

International Press Telecommunications Council. (2005, March 15). *"IPTC Core" Schema for XMP. Version 1.0. Specification document Document. Revision 8*. https://iptc.org/std/Iptc4xmpCore/1.0/specification/Iptc4xmpCore_1.0-spec-XMPSchema_8.pdf.

International Press Telecommunications Council. (2008). *IPTC Photo Metadata Standard 2008. Document Revision 1*. IPTC. https://iptc.org/std/photometadata/2008/specification/IPTC-PhotoMetadata-2008_1err.pdf.

International Press Telecommunications Council, & Newspaper Association of America. (July 2014). *IPTC-NAA*

Information Interchange Model Version 4. Revision 2. https://iptc.org/std/IIM/4.2/specification/IIMV4.2.pdf.

IPTC Photo Metadata Working Group. (2020). *IPTC Photo Metadata Standard 2019.1*. IPTC. https://iptc.org/std/photometadata/specification/IPTC-PhotoMetadata-2019.1.html.

IPTC Photo Metadata Working Group. (2023). *IPTC Photo Metadata Standard 2022.1*. IPTC. https://iptc.org/std/photometadata/specification/IPTC-PhotoMetadata-2022.1.html.

IPTC Photo Metadata Working Group. (2024). *IPTC Photo Metadata Standard 2023.2*. IPTC. https://iptc.org/std/photometadata/specification/IPTC-PhotoMetadata-2023.2.html.

ISO/TC 46/SC11. (2008). *N800r1: Where to start. Advice on creating a metadata schema or application profile*. International Organization for Standardization. https://committee.iso.org/files/live/sites/tc46sc11/files/documents/N800R1%20Where%20to%20start-advice%20on%20creating%20a%20metadata%20schema.pdf.

JEITA. (2000). *Japan Electronics and Information Technology Industries Association (JEITA) Inaugurated Today*. https://web.archive.org/web/20211016115710/https://www.jeita.or.jp/english/press/2000/1101.

Korzybski, A. (1933). *Science and Sanity: An Introduction to Non-Aristotelian Systems and General Semantics*. The International Non-Aristotelian Library Publishing Company.

Metadata Working Group. (2008a, September 24). *Metadata Working Group Introduces First Specification for Interoperability and Preservation of Metadata in Digital Photography [Press release]*. http://www.metadataworkinggroup.com/info/pdf/photokina_pr_2008_09_24.pdf.

Metadata Working Group. (2008b). *Guidelines for handling image metadata: Version 1.0*. Metadata Working Group. https://web.archive.org/web/20171011044821/http://www.metadataworkinggroup.com/pdf/mwg_guidance_v100.pdf.

Metadata Working Group. (2009). *Guidelines for handling image metadata: Version 1.0.1*. Metadata Working Group. https://web.archive.org/web/20180303110558/http://www.metadataworkinggroup.com/pdf/mwg_guidance_v101.pdf.

Metadata Working Group. (2010). *Guidelines for handling image metadata: Version 2.0*. Metadata Working Group. http://www.metadataworkinggroup.com/pdf/mwg_guidance.pdf.

Microsoft. (2021). *People Tagging Overview*. https://learn.microsoft.com/en-us/windows/win32/wic/-wic-people-tagging#microsoft-photo-12-schema.

Miles, A., & Bechhofer, S. (2009). *SKOS Simple Knowledge Organization System Reference. 18 August 2009*. W3C. W3C Recommendation. http://www.w3.org/TR/2009/REC-skos-reference-20090818/.

Murray, J. D., & VanRyper, W. (1994). *Encyclopedia of graphics file formats*. O'Reilly & Associates.

O'Rourke, J. (1987). *Art gallery theorems and algorithms. The International series of monographs on computer science: Vol. 3*. Oxford University Press.

Pomerantz, J. (2015). *Metadata. The MIT Press essential knowledge series*. The MIT Press.

Preparata, F. P., & Shamos, M. I. (1985). *Computational Geometry: An Introduction. Texts and Monographs in Computer Science*. Springer. https://doi.org/10.1007/978-1-4612-1098-6.

Riecks, D. (2005, March 21). *IPTC - IIMv4 & IPTC Core XMP Schema v1.0 Fields mapped to Imaging Program Labels*. https://web.archive.org/web/20050326111959/https://www.controlledvocabulary.com/imagedatabases/iptc_core_mapped.pdf.

Schlegel, J., Carloni, M., Wogrin, S., Graff, A. M., & Verhoeven, G. J. (2023). Making a mark—Towards a graffiti thesaurus. In G. J. Verhoeven, J. Schlegel, B. Wild, S. Wogrin, & M. Carloni (Eds.), *Document | archive | disseminate graffiti-scapes. Proceedings of the goINDIGO2022 international graffiti symposium* (pp. 203–219). Urban Creativity. https://doi.org/10.48619/indigo.v0i0.710.

Schneider, P. J., & Eberly, D. H. (2003). *Geometric tools for computer graphics. The Morgan Kaufmann series in computer graphics and geometric modeling.* Morgan Kaufmann Publishers.

Verhoeven, G. J. (2010). It's all about the format – unleashing the power of RAW aerial photography. I*nternational Journal of Remote Sensing*, *31*(8), 2009–2042. https://doi.org/10.1080/01431160902929271.

Verhoeven, G. J., Wogrin, S., Schlegel, J., Wieser, M., & Wild, B. (2023). Facing a chameleon—How project INDIGO discovers and records new graffiti. In G. J. Verhoeven, J. Schlegel, B. Wild, S. Wogrin, & M. Carloni (Eds.), *Document | archive | disseminate graffiti-scapes. Proceedings of the goINDIGO2022 international graffiti symposium* (pp. 63–85). Urban Creativity. https://doi.org/10.48619/indigo.v0i0.703.

Wild, B., Verhoeven, G. J., Wieser, M., Ressl, C., Schlegel, J., Wogrin, S., Otepka-Schremmer, J., & Pfeifer, N. (2022). AUTOGRAF—Automated Orthorectification of GRAFfiti Photos. *Heritage*, *5*(4), 2987–3009. https://doi.org/10.3390/heritage5040155.

Wild, B., Verhoeven, G. J., Wogrin, S., Wieser, M., Ressl, C., Otepka-Schremmer, J., & Pfeifer, N. (2023). Urban creativity meets engineering. Automated graffiti mapping along Vienna's Donaukanal. In G. J. Verhoeven, J. Schlegel, B. Wild, S. Wogrin, & M. Carloni (Eds.), *Document | archive | disseminate graffiti-scapes. Proceedings of the goINDIGO2022 international graffiti symposium* (pp. 131–145). Urban Creativity. https://doi.org/10.48619/indigo.v0i0.705.

Yu, L. (Ed.). (2014). *A Developer's Guide to the Semantic Web (Second edition).* Springer. https://doi.org/10.1007/978-3-662-43796-4.

The First Complete Census of Public Artworks in Torino

Luca Davico [1,*], Paola Guerreschi [2] and Luisa Montobbio [1]

[1] Interuniversity Department of Regional and Urban Studies and Planning, Politecnico di Torino, viale Mattioli 39, 10125 Torino, Italy; E-Mails: luca.davico/luisa.montobbio@polito.it
[2] Interuniversity Department of Regional and Urban Studies and Planning, Università degli Studi di Torino, viale Mattioli 39, 10125 Torino, Italy; E-Mail: paola.guerreschi@unito.it
* Corresponding author

Abstract
Since the end of the 20th century, public art has registered a new tendency towards growing institutionalisation. The self-managed spontaneity of murals is increasingly conveyed in projects conceived or supported by public or private institutions. Public art has played an important role in the policies aimed at reviving cities. Since this was implemented in Torino in the last quarter of the century, public art has grown remarkably in the city, especially in the outskirts. The project *Arte per strada Torino* (https://www.arteperstradatorino.it) aimed to create a portal containing the first complete census of artworks in public spaces in Torino (Italy) and its belt. This census was carried out through an analysis of existing repertoires of public art works in the city, integrated by interviews with qualified witnesses and detailed field surveys. The project also collects publications, documents and other websites related to the field of public art. The data for the census were collected from existing repertoires of public artworks in Torino, through systematic site inspections, as well as from the Municipality of Torino and local art associations. The period considered is from 1990 to the present, that is to say, the age in which Torino experienced a great flourishing of public art. The *Arte per strada Torino* website offers three different ways to access the artworks collected: a textual list, a photo gallery and an interactive map. This project offers a solid basis for analysing public art in Torino and its outlying area, which will be useful for policymakers, artistic associations, researchers and interested citizens.

Keywords
Public art; Public spaces; Street art; Torino; Urban redevelopment

1. Introduction. Public Art and Its Evolution

Since ancient times, the idea of collecting objects and materials to which cultural and artistic values are attributed has been established in many cultures, in order to preserve them as works of 'human ingenuity', to build a collective memory among contemporaries, to strengthen the identity of a people, and to transmit a shared heritage to new generations. According to historians' findings, the first museum collections date back to ancient Egypt, when in Alexandria, at the Hellenistic age, King Ptolemy I created what is considered the first true museum in human history (Rossi & Nicolai, 2003). For long centuries, however, such collections almost always remained private—the property of monarchs, wealthy individuals, patrons—and enjoyed in private or, at most, exhibited as status symbols in front of prestigious guests or peers. In this respect, we can mention, for example, the Giardino del Belvedere built at the beginning of the sixteenth century for Pope Julius II, which contained many statues realised during the classical era, or the Tribuna degli Uffizi in Firenze, where was gathered the private collection of the 'de Medici family.

A first significant transformation of the museum concept occurs in the modern age. As the focus on public opinion, modern democracy and civil rights becomes more widespread, the world of culture also becomes progressively less elitist, moving increasingly towards collections that are open to the public, to civil society. This was to be, for example, the distinctive and innovative feature of some great museums opened in the second half of the 18th century, such as the British Museum in London or the Collections Royales in Paris, not by chance in the capitals of two nations that were in the vanguard of modernity from both cultural and political points of view.

Outside museums, in public spaces, for much of human history, art and architecture have performed a function of public legitimisation, of celebration of power, whether religious, economic or military (Bolle et al., 2017).

This celebratory function performed by public art has been maximised and exalted by anti-democratic regimes. Even relatively recently, for instance, in the 20th century, various totalitarian regimes did not fail to fill cities with celebratory works of art. In many communist countries, these mainly took the form of large murals depicting symbols, leaders and heroes of the regime. In fascist Italy, they mainly took the form of large sculptural works, with a careful selection of materials (e.g. marble to recall imperial Rome) and symbolism: fasces lictor, imperial eagles, as well as a great variety of representations of the dictator's head, to the point of turning it into a cult icon (see Figure 1).

Even on the democratic front, however, public art has often been used as an instrument of legitimisation to strengthen social cohesion. To cite just one example, following the great crisis of 1929, in the United States, President Franklin Delano Roosevelt launched a public art funding and development programme with the New Deal, in order to stimulate national identity pride, counteract the collective depression that followed the economic one, and reaffirm the relevance of the 'American Dream' (Bolle et al., 2017).

From the end of the 20th century, we enter a new phase, which further amplifies the trend towards the dissemination of cultural and artistic heritage, even in territories and among subjects once excluded from its enjoyment: artworks begin to disseminate outside the historic centres, in the working-class neighbourhoods, while—with the spread of literacy—literature and libraries increasingly open up to the poor class too. From the 1960s onwards, and even more so from the 1970s, works of art began to be taken out of the canonical places designated for their preservation, spreading more and more into urban public spaces. This first occurred thanks to 'bottom-up' initiatives (Montaldo, 2021), with projects by artists who, wishing to be involved in a

Figure 1. Use of public art to celebrate totalitarian regimes (in Italy, Germany, USSR) and the American Dream during the New Deal.

militant and organic way in workers' struggles, for housing, in schools, in neighbourhoods, also put their creativity and technical expertise at the service of these political instances. In projects of this kind, it often happens that the inhabitants themselves were involved in the production processes of the works of art: in the preliminary phase (e.g. by consulting them on the themes to be represented in the work, where to realise it, etc.), but sometimes also in the realisation phase, thus opening the season of 'participatory' art.

The term 'public art', as we understand it today, was coined precisely in this context, to define a new conception of presenting and enjoying art, inserting it into the living fabric of the city, going beyond the traditional conception of a passive public, silently parading in front of the works in a museum. However, regarding terminology, there is today a considerable confusion between different concepts (such as urban art, public art, graffiti or street art, used sometimes as mere synonyms, sometimes to name different artistic styles), especially in their linguistic declinations in different nations (Montaldo, 2021).

The same government bodies in various nations began to develop growing attention and sensitivity for public art, albeit in a continuous dialectical confrontation, not infrequently conflictual, with the more 'underground' and antagonistic art forms, in the grey zone between art and non-art, legal and illegal. During the 1990s, in particular, the phenomenon of street art exploded, at first mostly in the form of writings—usually in block letters—on out-of-the-way walls or on stationary railway carriages in stations and depots (see Figure 2), i.e. in 'backstage' areas, to refer to a classic definition by Erving Goffman (1963).

This phenomenon developed—initially mainly in the United States, then spread to many other countries—generally on the initiative of young people (especially males) in marginal neighbourhoods, often in small groups and 'urban tribes' that reaffirmed their citizenship through "leaving a sign of themselves" on the territory (Sennett, 1992). A trace of this tradition is still very evident in some contemporary public art, for instance, in the street artists that create inscriptions and works in cities generally bound to an ephemeral destiny, i.e. to be covered in short order by other works.

The last few decades have witnessed a process, which is still ongoing, of progressive transformation of the concept of public art and its many stylistic 'souls', to the extent that it is now becoming increasingly difficult to precisely define its boundaries both externally and internally. That is to say that, alongside the historical schools of 'murals' or figurative art, more recent traditions from the world of graffiti and underground street art are being inserted, producing a growing contamination between genres and between projects, being—at the same time—fully recognised as artworks (see Figure 3). Thus, for example, figurative works

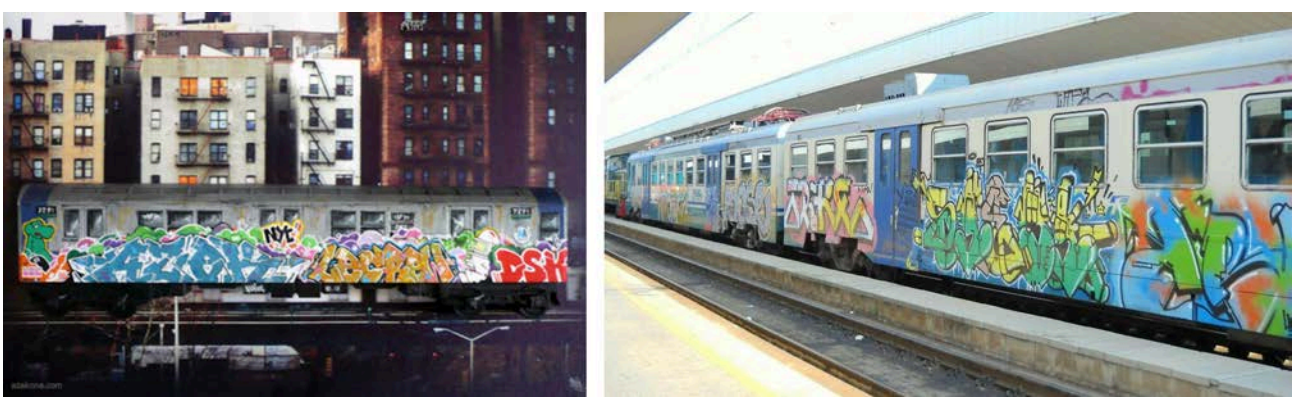

Figure 2. Lettering on railway carriages, in the United States and Italy.

with realistic features are hybridised with caricature and cartoonish signs; the 'writing on the walls' often becomes more and more elaborate, with clear artistic ambitions, and specialises in precise stylistic sub-fields: tags, lettering, puppetry, throw up, etc. At the same time, works of "lettering" or "writing" (once created illegally and overnight) have increasingly entered institutional projects.

Recently, a growing virtuous circle has therefore been developing between a world of increasingly professionalised artists, attentive to the care of works, with more aesthetic ambitions, and an institutional front increasingly willing to accept these works and promote their realisation as part of urban development strategies. A growing number of administrations have identified art as a strategic element for attracting investment, resources, tourists (generating positive economic impacts on the city), and as a way of redeveloping urban spaces and neighbourhoods, thus also aiming to revitalise their social fabric (Crivello, 2020; Griffiths, 1995).

The gradual institutionalisation of public art has led, since the 1990s and even more so since the beginning of the 21st century, to a very significant growth in the number of works present in cities, often disseminated through processes of progressive diffusion in all neighbourhoods. In addition, works have begun to be conceived and designed to last, opening up a whole new problem front. If public art is less and less ephemeral, it also becomes important to take census, document and catalogue an increasingly rich public art heritage. The *Arte per strada Torino* project,

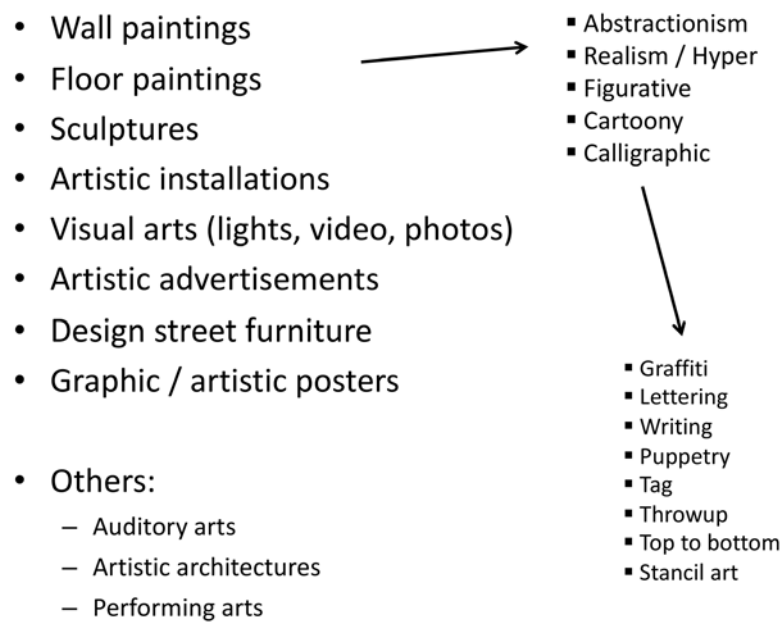

Figure 3. The variegated universe of public art today. Source: Montaldo, 2021.

described in the following paragraphs, tries to respond to this purpose. The need also arises to adopt actions aimed at the protection and enhancement of works and, therefore, criteria for selecting which works to preserve, the most appropriate restoration techniques, etc.

2. The *Arte per strada Torino* Project

In the case of Torino—as part of an epochal transformation, in which the city left behind the 'one company town' model that had characterised it for most of the 20th century—since the 1990s, local administrations have increasingly focused

on tourism, culture and art as new strategic development axes. Urban spaces are being radically transformed, reconverting square kilometres of disused industrial areas into new neighbourhoods, where housing, shopping centres, services and parks are being built. In many run-down neighbourhoods, redevelopment projects (called Pru, Priu, Urban, etc.) are implemented to improve the physical environment (recovery of real estate, re-functioning of spaces and services, adaptation of infrastructures, etc.) and the social environment (empowerment of inhabitants, better quality of daily life, more social cohesion). Public art plays an increasingly important role in such planning interventions. It is gradually expanding both quantitatively and geographically, reaching neighbourhoods that have never before been affected by the presence of artistic works.

In order to document this phenomenon, starting in 2017, a research team from the DIST (Interuniversity Department of Regional & Urban Studies and Planning) carried out a complete census of all artworks in public spaces in Torino, the first one made in an Italian city. The fact of documenting the totality of public artworks, instead of a limited sample of the most significant works, constitutes a significant methodological breakthrough, as it makes it possible for the first time to have an overall picture for conducting quantitative and qualitative analyses on public art production.

To carry out this first census, some partial repertoires of works (e.g. those of projects such as the MAU–Museo Arte Urbana or PicTurin) were identified, collected and systematised. Subsequently, an extensive interview campaign was conducted with qualified operators of public art in Torino (art associations, public project managers). Finally, the picture was completed through systematic and capillary inspections—district by district, street by street—in search of other lesser-known works of art, unrelated to the more structured projects and often expressions of 'underground' cultures.

In the first phase, all works visible in the streets of the city were surveyed, including monuments and sculptures from past centuries, excluding works that no longer exist (since removed or covered by other works), temporary works (e.g. the *Luci d'artista* installed only during the Christmas period) and works that are an organic part of buildings (such as decorations on buildings, monumental tombs in cemeteries, etc.).

A very delicate question that had to be addressed was the threshold of artistic content to be set as a discriminating factor to include or exclude works, as there is obviously a grey area on this topic between widely recognised works of art and graphic interventions socially labelled as "vandalism" (see Figure 4). This question, in fact, refers to the long-standing problem typical of modernity of establishing a boundary between what is definable as an 'artistic' product and what should not be considered as such. In the specific case of *Arte per strada Torino*, after careful consideration, it was decided to adopt a relatively low threshold—inclusive, for example, of works created by 'non-professional' artists (see Figure 5)—excluding only trivial graffiti interventions or wall writings without any obvious aesthetic research.

This census—the results of which are published in a volume by Bolle, Davico, & Scira (2017)—identified 440 works, including 189 wall paintings, 128 sculptures and monuments, 98 installations and 25 other works; these types of works (pre-1990) were largely concentrated in the city centre; 46 of these works were created before 1900, 30 in the first half of the 20th century, 99 in the second half and 265 at the beginning of the 21st century. Of the monuments, 66 were concentrated in the historical centre and depicted 22 military personnel, 20 political figures, 11 monarchs and members of the royal house of Savoia and 13 other figures (see Figure 6).

In the two-year period 2021–22, the census of public art in Torino was deepened, updated and supplemented. For this second census, the choice was made to narrow the time span considered, focusing on the most recent works, created since 1990. On the other hand, it was decided to broaden the geographical boundaries of the area considered, including the numerous works of public art in the municipalities in the belt of Torino.

A website has been developed as a public showcase of the census, a flexible communication tool that can be

Figure 4. Examples of writings included in (left) or excluded from (right) the census of *Arte per strada Torino*.

Figure 5. Examples of artworks created by 'non-professionals' included in the census of *Arte per strada Torino*: Collettivo Crossfade Idea with schoolchildren, 1994 (left); unknown artists, 2009 (right).

1 2 3 4

Figure 6. Examples of public art works included in the first census. (1. Carlo Marocchetti, *Carlo Alberto*, 1860; 2. Cesare Reduzzi, *Quintino Sella*, 1894; 3. Giuseppe Canavotto, *Cesare Battisti*, 1929; 4. Goffredo Verginelli, *All'Autiere d'Italia*, 1965). Source: Bolle et al., 2017.

continuously updated and integrated, therefore useful for adequately documenting a constantly evolving heritage such as that of public art. The new website (www.arteperstradatorino.it) was conceived as a portal that brings together the entire production of public art and gives prominence through links and cross-references to other portals, publications and documents on this topic.

The second census also used analyses of existing partial repertoires, systematic reconnaissance in the neighbourhoods and municipalities of the belt and interviews with the municipalities and the main art associations. The site project was also discussed and developed in close synergy with the portals *Arte urbana a Torino* by Città di Torino, *Geografie metropolitane* by Urban Lab and the Accademia Albertina di Belle Arti.

Each work was photographed, and information was filed on the author, title, year of creation, category, project, address, district or municipality, geographical coordinates, author of the photograph and any links for further information (see Figure 8). The data was organised in a database, which was then used to compile the HTML files. In many cases, it was not possible to trace the name of the author, the title of the work, the project or the year of realisation.

Six categories of works were identified: multiple paintings (e.g. 'jam walls'), single paintings, installations, mosaics, panels and sculptures.

The location on the territory is indicated with the street address, the district in the case of the city of Torino or the municipality in the belt, and the geographical coordinates expressed in degrees, obtained from the metadata of the photograph taken. Each tab on the site shows one or more photographs of the works, the catalogued data and a topographical map with toponymic indications, with a pointer indicating the location of the work from which the Google Street View screen can be accessed.

The cards can be accessed through a textual list, divided into city districts and municipalities in the belt, from a photo gallery or an interactive map.

The map was created using cartographic software (QGIS). Geographic coordinates were used to georeference the position on the territory and obtain a punctual vector file (shapefile). The internal attribute table was suitably prepared to report all the information useful for presentation on the website. From the general database of the census, the main data were poured in, and some HTML code strings

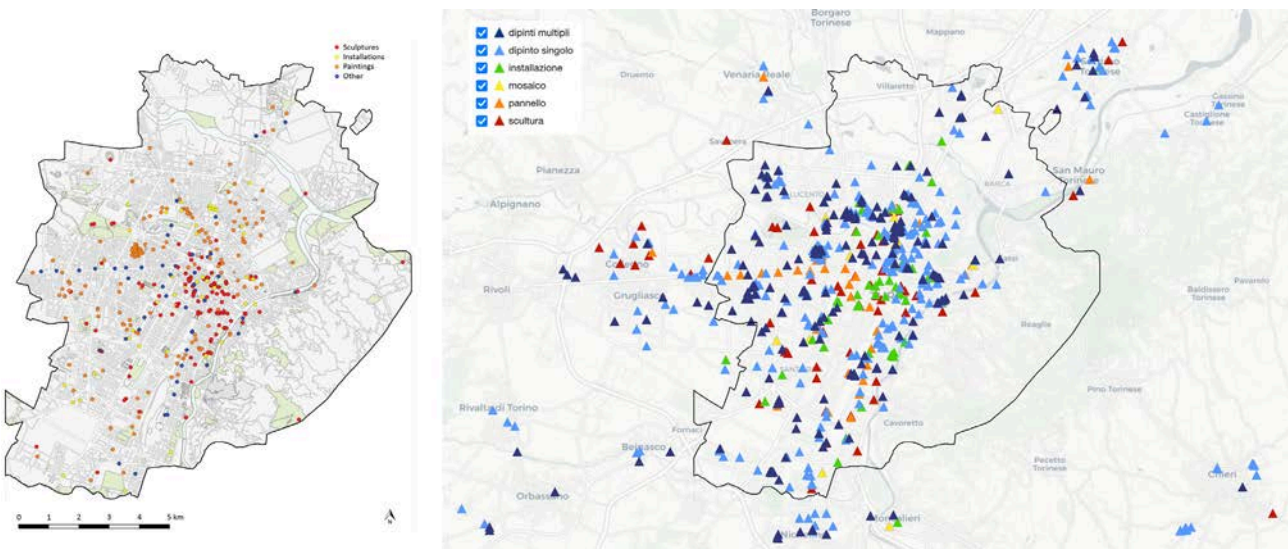

Figure 7. Maps of the first census of public artworks in Torino, 2017 (left) and of *Arte per strada Torino*, update to spring 2023 (right).

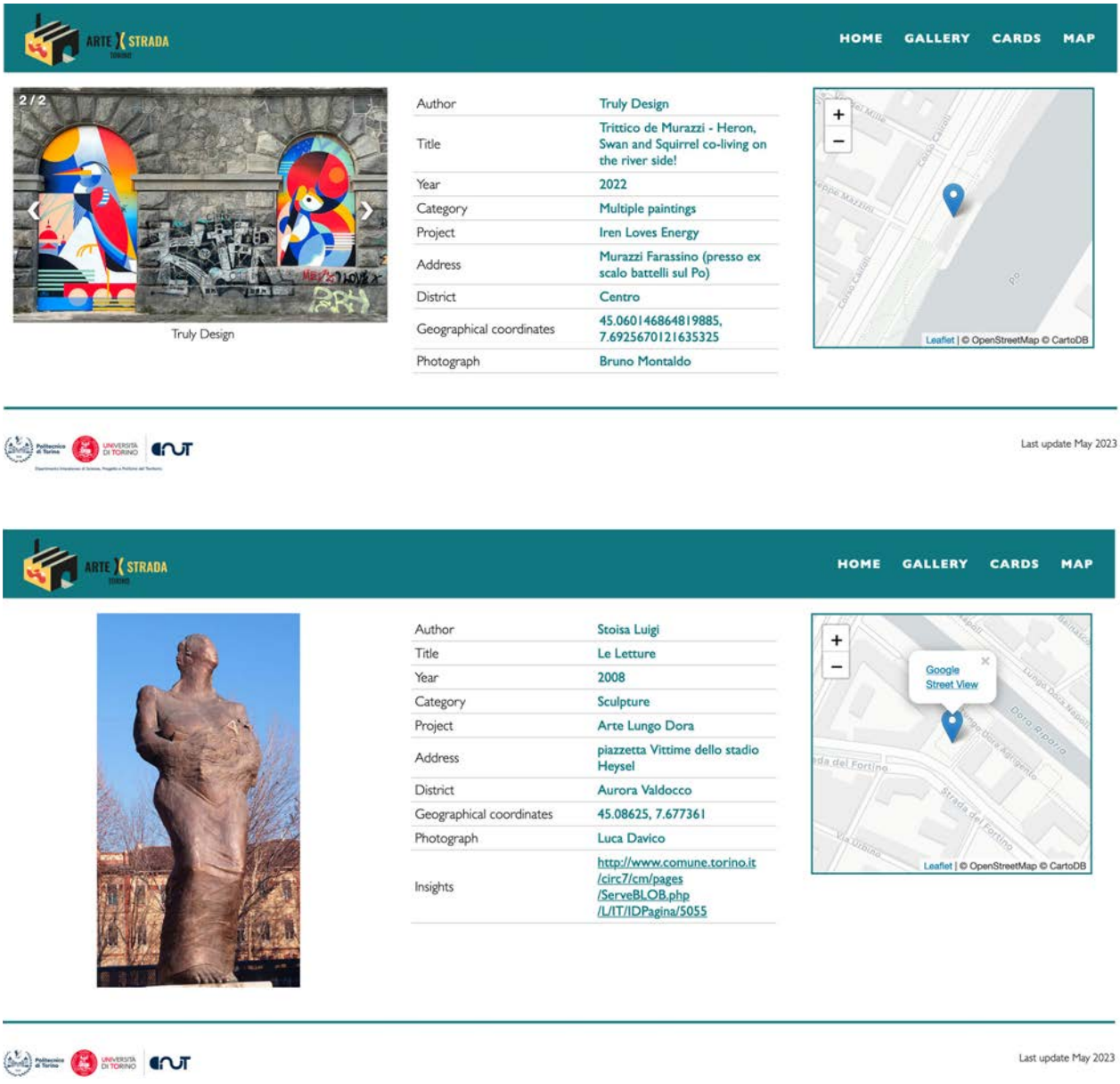

Figure 8. Examples of tabs about different types of works of art on the website of *Arte per strada Torino*.

were added to obtain the insertion of the photograph and the link to the card. The point elements were then selected according to the six categories of works, and six differently themed layers were created. The user then can act independently on the legend, enabling or disabling the information layers individually, in order to display the type of interest. A Web Map Service (WMS), CartoDB Positron© by OpenStreetMap© forms the base map. Finally, the map was exported, made interactive via the QGis2Web plug-in and inserted into the site. The user can select different zoom levels, search by address and measure distances over the territory. The position of each work is indicated by a triangular symbol, of a different colour depending on the type. By clicking on a symbol, a pop-up window appears. It contains a thumbnail of the photograph of the work (or a detail of it), the category, the street address and a link to access the card.

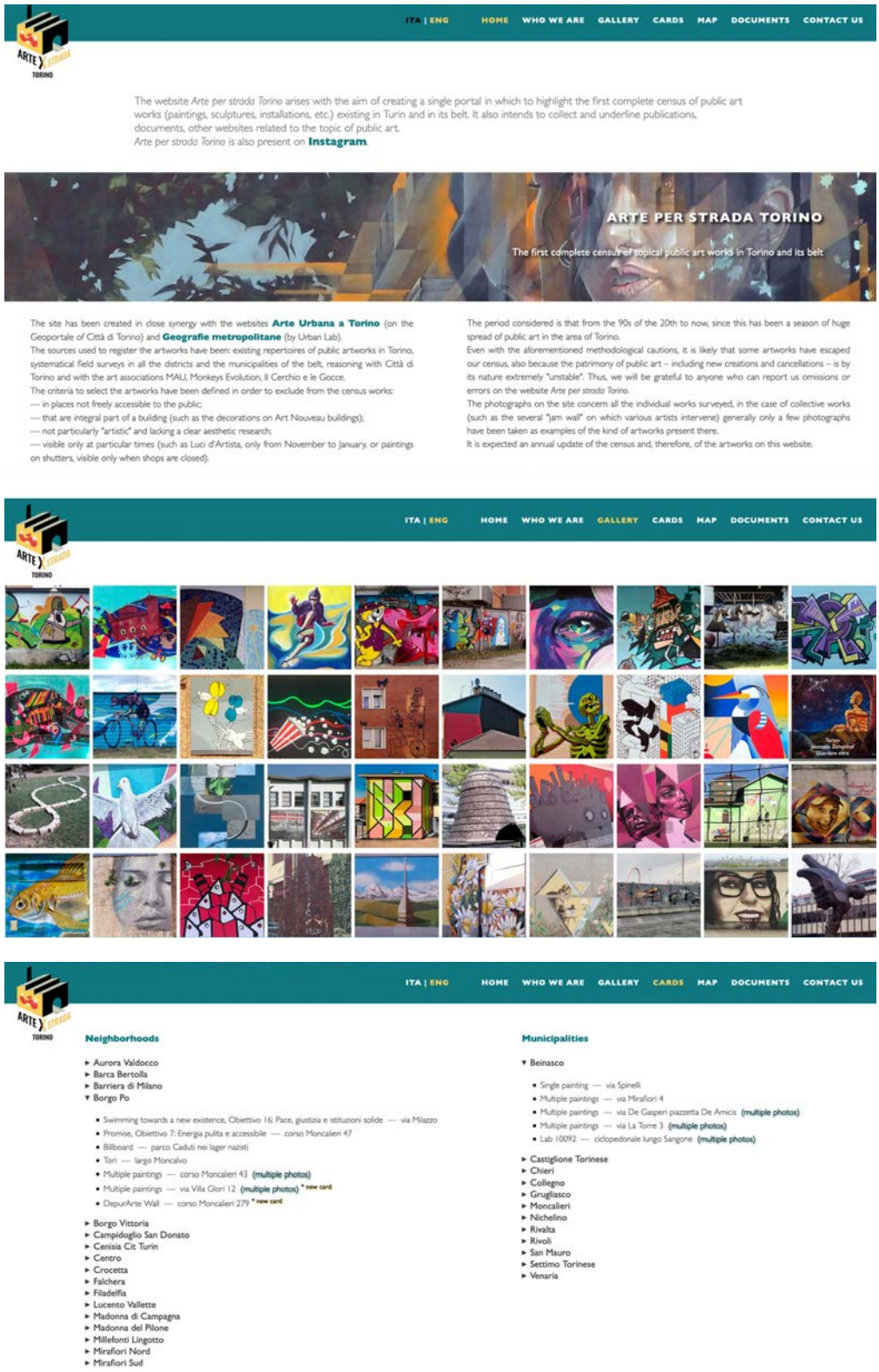

Figure 9. Some screenshots of the website of *Arte per strada Torino*: home page, gallery and textual list of the cards.

The pages of the site are in Italian or English. The homepage explains the history and purpose of the portal. The other pages contain the photo gallery, the textual list of cards and the interactive map (see Figure 9). There is also a page with the names of all the participants in various capacities in the project, a collection of bibliographical documents and links to sites on street art. The contact page contains a form for sending reports on new, modified or missing works, or any errors found on the site.

Recently, an Instagram page of the project has been created, where photographs of the works with their census data are posted.

The cataloguing of works is continually supplemented, and the site is updated approximately twice a year. On the occasion of the updates, the pages are enriched with content. In the future, it is planned to supplement the indexing with new entries on the works (such as size, technique used and state of preservation) and also to collect and index missing and deleted works. This last objective will be very challenging, especially to find out documentation on street art (in particular, graffiti that lasted only a short time on city walls). For three-dimensional works, the preparation of 3D models to supplement the static images is being considered.

3. First Research Outcomes: Contents and Objects of Public Art

About 1,500 works created between 1990 and March 2024 have so far been surveyed and documented on the *Arte per strada Torino* website. The majority of the works are wall paintings (singles, 46 % of the total, or multiples, 28 %), followed by installations (15 % of the total), sculptures (10 %) and mosaics (2 %).

The following graph (see Figure 10) shows the impressive growth in the number of public artworks in Torino, with a particular acceleration in the last decade. This impressive growth depends largely on an actual increase in the number of works, but also on the realisation of new paintings superimposed on others created in previous years. The growth effect shown in the graph (which only counts the works still visible in 2023) is therefore amplified by the disappearance of some works realised years ago.

Until the 1970s, only 30 % of the works were located outside the city centre. This share had already increased to 55 % in the 1990s, and today it reaches 80 %. This mainly depends on the strategies and projects for the redevelopment of working-class and peripheral neighbourhoods, in which the creation of artworks has often played an important role.

From a stylistic point of view, the research team of *Arte per strada Torino* attempted a (not easy) classification of the works, defining four macro-types (see Figure 11):

- abstract, characterised by geometric shapes, in which figures of people, animals, objects are not recognisable or are represented in highly stylised forms
- realistic, which, conversely, tends to represent the portrayed subjects as naturally as possible
- cartoony, in which caricature-like features and comic style prevail
- writing, a category that includes the various (already mentioned above) and more or less elaborate techniques: lettering, tags, etc.

Most of the works surveyed in Torino can be traced back to a comic style (41 %) or an abstract style (36 %). Realistic works are significantly less present (15 %) and even less so is writing (8 %). Obviously, the boundaries of the four categories are not so clear: there are hybrid works (e.g. writing with a cartoonish character), for which we opted to classify the prevailing style (with respect to the total surface area of the work). Ours is one of the first attempts to classify works, as hitherto very few (and very partial) classifications existed, which at most considered the type of work and/or the technique used.

The most represented subject category (see Figure 12) is that of living beings, primarily people, then animals (mainly wild, reptile and amphibian species, hence elephants, ungulates, lions and monkeys).

In the case of human beings, male figures predominate, accounting for 56 % of the people represented in the works, against 36 % females. The remaining 8 % consists of undefined figures, typical of the abstract style, for example, in which a human silhouette is represented, leaving its features undefined. As for the different age groups, young

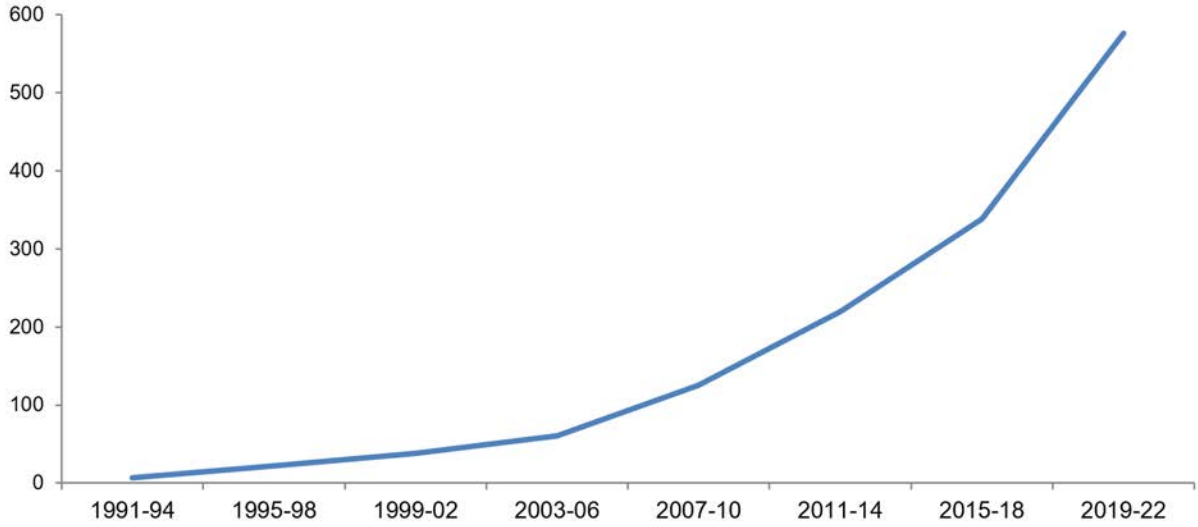

Figure 10. Number of existing public works of art in Torino and surrounding area, by construction period (update April 2023). Source: *Arte per strada Torino*.

Figure 11. Examples of the four stylistic categories in which the works are classified: abstract, realistic, cartoony, writing (1. Nevercrew, *Fade*, 2018; 2. Karim Cherif, *Piero Angela*, 2023; 3. Angelo Barile, *Il Cappellaio*, 2013; 4. Duke1 e Wave, *Street Attitude*, 2022). Source: *Arte per strada Torino*.

figures prevail (41 %). Adults account for 18 %, while a few works depict children (4 %) or the elderly (4 %); in the remaining cases, people of various age groups (11 %) or of indefinite age (23 %) appear.

From an ethnic perspective, signs of Torino's ongoing transition towards an increasingly multi-ethnic city are also emerging in the world of public art. The majority of people depicted in the works (51 %) are white-skinned, but the share of blacks (7 %) and people belonging to other ethnic macro-groups (Hispanics, Indians, Arabs, Orientals, together amounting to 3 %) is not insignificant. Eight per cent of the works depict, at the same time, people of more than one ethnicity and in the remaining 31 % of the cases the somatic features are not characterised to the point of distinguishing the ethnicity of the persons portrayed, thus referring to their generic belonging to the 'human race'.

Finally, 15 % of the total works represent well-known personalities, with a prevalence of political figures, iconic figures (fairy tales, mythological, etc.), comic strips and literature.

4. Public Art and the Urban Context

As pointed out above, one of the main reasons for the great expansion of public art in recent decades is the growing conviction that it can contribute to the redevelopment of urban public spaces.

However, it is appropriate to introduce some food for thought and critical analysis. The concept of urban regeneration appears pertinent in relation to artistic interventions planned and organised in concert between authors, administrators and other actors. It is less applicable in cases where interventions are stratified following more or less 'wild' logics of continuous overlapping, typical of traditional 'underground' cultures. The latter type of intervention is less widespread in Torino than it used to be, thanks to the strong growth of artistic projects channelled along more institutional tracks, and to the forms of self-regulation within the world of street artists (Montaldo, 2021).

The outcomes of urban regeneration of spaces are also rather differentiated in the case of artistic interventions planned

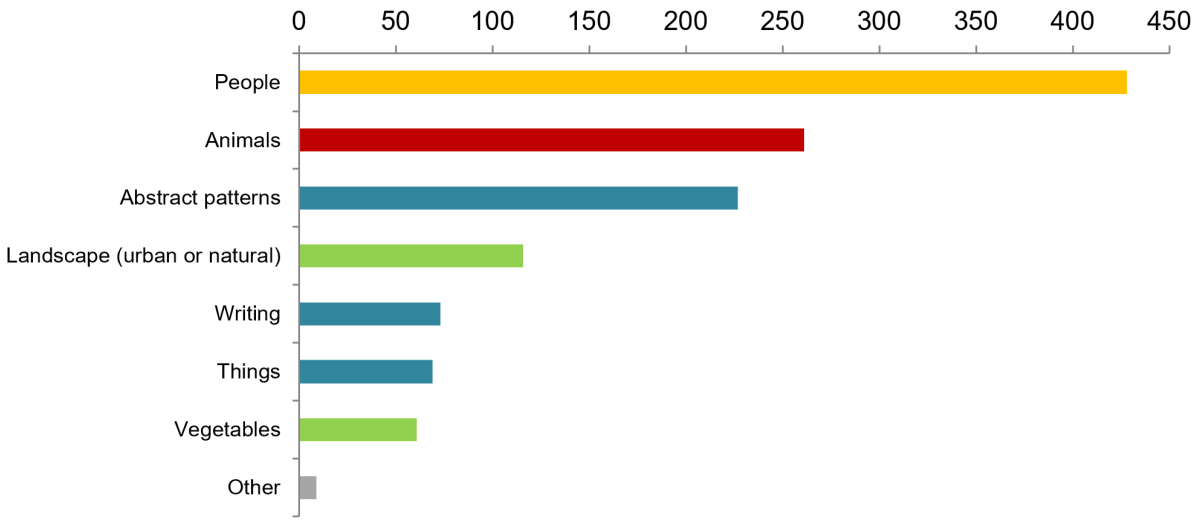

Figure 12. What public artworks depict (updated in April 2023). Source: *Arte per strada Torino*.

and agreed upon with public authorities. A relevant aspect in this respect concerns the size of the works. In the case of small- to medium-sized works, urban redevelopment seems to take forms that harken back to the concept of 'mending', coined a few years ago by architect Renzo Piano about micro-interventions that redevelop small urban spaces, such as refurbishment of little spaces, local gardens, urban design solutions and so on. Larger works (such as those on the blind side walls of large apartment blocks or on extensive boundary walls) probably produce the greatest effects both on the urban environment and on citizens' perceptions. In this regard, see the following images (Figure 13), in which shots (taken from Street View) of some urban views of Torino before the artistic interventions and corresponding current images of the same places have been juxtaposed.

The issue of the redevelopment of urban spaces has close connections with the theme of the dialectical relationship between the work of art and the public place where it is created or installed. This theme has played a central role throughout the history of public art, at least since the 1970s, especially with its dissemination in different neighbourhoods.

In this regard, a not infrequently controversial reflection has developed in the public art world on the importance of realising 'site-specific' works, that is to say designed

specifically for a peculiar territorial context. In the traditional conception, the artwork is designed or created in an atelier, and then realised or installed in a relatively indifferent spot in the territory. Instead, the site-specific conception starts from a preliminary knowledge of a place, studies its characteristics and historical roots by confronting those who inhabit that territory on a daily basis, because they live, study or work there. Following this knowledge phase, the artist synthesises the collected elements and develops them through his own creativity and technical skills in the realisation of the work.
In the world that explicitly refers to the 'site-specific' concept, however, there are very different ways of putting this general orientation into practice. At one end of an ideal continuum are artists who, in order to respectfully adapt to the context, produce works that are as 'assimilated' as possible, often almost mimetic, to the point that they are sometimes not even identified as works of art by many citizens. Others insert more or less explicit 'citations' of the territorial context in which the works are created, highlighting characteristic elements, territorial symbols of the neighbourhood or of the city. At another end of the continuum, however, are artists who follow a designedly 'intrusive' line. Having taken note of a specific context, they propose a work that is designedly 'breaking', in marked discontinuity, in order to radically innovate that specific territorial context.

In about two-thirds of the cases, the works surveyed do not explicitly reveal the artist's communicative objective. In the

1 2 3

Figure 13. Urban spaces in Torino, before and after the artistic interventions (1. Milla Bandiera, *Turtles*, 2019; 2. Millo, *Il re di Barriera*, 2014). Source: *Arte per strada Torino*.

remaining third, the works launch precise 'messages'. Among them, the reference to the local area (the neighbourhood, above all) is by far the most prevalent, followed at some distance by pacifist, environmentalist or cultural heritage messages (see Figure 14).

As already emphasised, the attitude of taking into account the context in which a work is to be inserted often goes hand in hand with a focus on those who live in that neighbourhood daily. This refers to the more general theme of citizen participation in a project, which also concerns other disciplines such as architecture or town planning.
This approach is stimulated by a couple of reflections. The first has to do with the observation that the inhabitants of a place, of a neighbourhood, are often the best experts of that place and therefore their skills and ideas are almost always instrumental in the realisation of a good quality project. The second concerns the central importance of public spaces for people's daily lives. Every day, citizens walk, look out of their windows and meet in public spaces whose quality influences perceptions, opinions, experiences and, consequently, also their sense of belonging or, vice versa, of estrangement or

repulsion from their neighbourhood.
On the subject of participatory planning, a rich body of literature has developed over the last decades, which makes it possible to distinguish between different participatory approaches, methods, and tools for involving citizens in planning choices (Ciaffi & Mela, 2006).

Limiting themselves to the field of public art, participatory processes can be traced back to a scale of different levels, which nevertheless have in common the desire to overcome the traditional conception of citizens as mere 'spectators' of a work of art. At a minimal participative level, project proponents and/or artists take care to consult the inhabitants of a territory through interviews, more or less structured surveys, meetings with local associations, etc. In other cases, citizens are also involved in the implementation phases of the artwork (Zukin, 1995). Sometimes the inhabitants are also given a voice so that they can express themselves and evaluate the outcomes of the artistic processes.

In truth, there are not many investigations in Torino that have explored citizens' opinions on public works of art: the

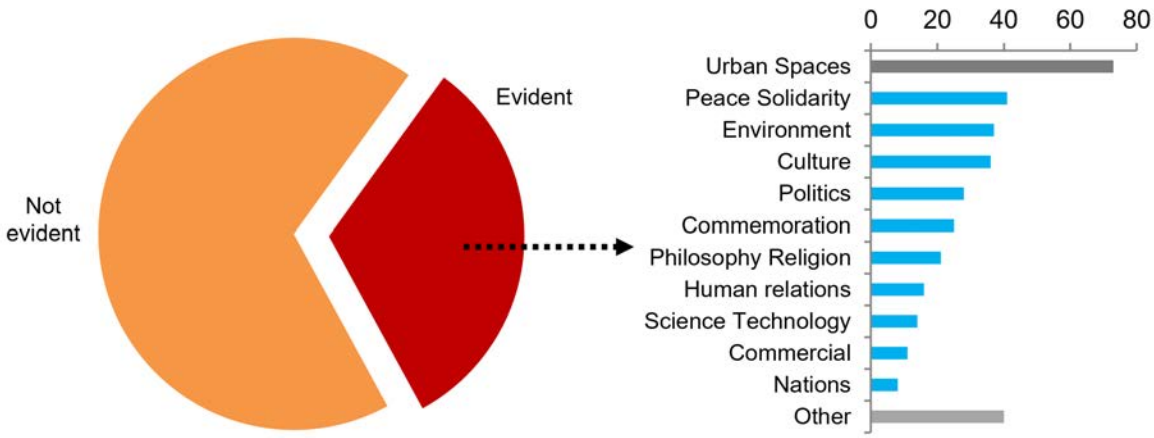

Figure 14. Themes and 'messages' of public works of art (updated in April 2023). Source: *Arte per strada Torino*.

surveys based on interviews with passers-by in four Torino neighbourhoods with a high concentration of works—Campidoglio, Barriera di Milano and San Salvario, carried out for two degree theses: Dellarossa, 2016; Milan, 2023—and in the case of the Borgo Po district (survey was carried out by the association of artists who have just created a new work of art, in the spring of 2023). These surveys revealed strongly differentiated levels of appreciation: in particular, to the question "Have the new public artworks improved the quality of the neighbourhood?" in Borgo Po 88 % of respondents answered positively, compared to only 49 % of respondents in the Barriera di Milano district. These differences may depend on the perceived quality of the individual works, and on the fact that in the first district they are more concentrated in a few blocks, and therefore more easily identified by the inhabitants. Furthermore, the repertoire of works is more heterogeneous, better able to intercept, at least in part, the tastes of the public. Conversely, in Barriera di Milano almost all the works can be traced back to two large blocks, one comprising 14 large walls created by the same artist (Millo), the other consisting mainly of sculptures and installations in an abstract style in Parco Peccei. The survey revealed that abstract works are more difficult to understand and, therefore, less appreciated by citizens.

With regard to the survey conducted in the Borgo Po district, it is interesting to underline that it polled opinions

both before and after the realisation of the works, finding that between the two rounds of interviews the levels of appreciation for the quality of the neighbourhood in terms of pleasantness, liveliness and orderliness on average increased. This would thus seem to confirm what has already emerged from previous similar surveys: not only does public art not go unnoticed, but it is predominantly perceived as improving a place (see Figure 15).

5. Conservation of Works

For the past couple of decades, a process of progressive transformation of public art (especially its street art variants, graffiti etc.) towards increasingly less ephemeral and extemporary interventions has been underway. This has contributed to the development of a debate on the documentation of works, their valorisation and conservation. With regard to the documentation phase, the *Arte per strada Torino* project had to deal with relatively new issues, such as the units of analysis to be considered when filing the works and the parameters to be used. In this regard, the research team of *Arte per strada Torino* established contacts with researchers from the Chemistry Department of the Università di Torino who, as part of the CAPuS project, analysed several street artworks from the point of view of their state of preservation (Ricci et al., 2023).

Similar unprecedented problems concern the valorisation of works. Whether one is addressing a local target (citizens wishing to discover the works of art in their city) or a more tourist-oriented target, it is not easy to propose

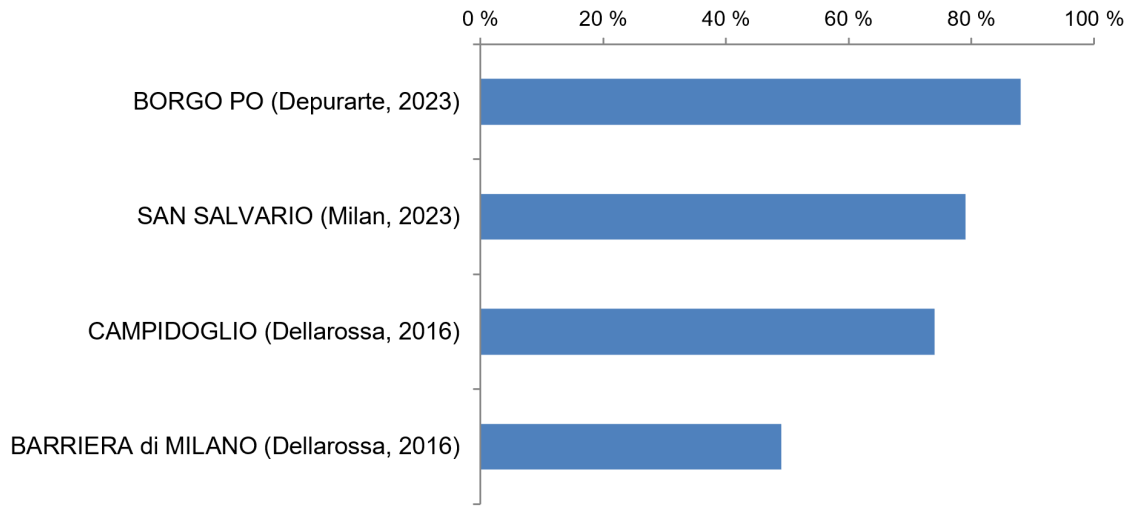

Figure 15. Levels of appreciation of public art by citizens in four districts of Torino ("Do you like works of public art? Do they improve the neighbourhood?"; percentages of positive responses). Data processed on following sources: Dellarossa (2016), Milan (2023), and project *Depurarte*.

tours to discover works spread over relatively large areas. It is no coincidence that in Torino, the works of the MAU in the Campidoglio district are more easily identified and appreciated by citizens because of their concentration in a relatively small area, which facilitates the organisation of visiting routes. At the MAU, in fact, the distances to be covered on foot are not much greater than those of a large indoor museum, with hundreds of works concentrated in a quadrangle of 160,000 square metres, about three times the size of the Louvre in Paris.

Finally, the issue of conservation of the works raises technical questions, regarding the choice of durable and less wearable materials during the construction phase of the works which,

due to their outdoor nature, are almost always exposed to atmospheric agents and thermal shocks, and the best way to intervene afterwards with restoration and rehabilitation actions.

There are a number of complex aspects that are being progressively defined, which concern the criteria for classifying works, so as to establish a sort of priority ranking between those more and less deserving of restoration work, also taking into account their cost. The problem of the lack of resources for conservation also emerged in Torino in recent years for works by artists of considerable renown. In the city, the case of a large sculpture by Arnaldo Pomodoro, inaugurated on the occasion of the 2006 Winter Olympics, at the centre of a busy and polluted road roundabout, caused quite a stir. It was removed after a few years and returned to its creator because neither public nor private entities invested the necessary financial resources for its restoration.

The problem of conservation arises for sculptures, and even more so for wall paintings, both because of their greater intrinsic fragility and because of the effects of the recent quantitative 'boom' in public wall art. Local administrations, especially in cities with the richest street art collections, are only recently starting to think over new methods and tools to manage the very rich heritage of works. These new tools must address both the administrative and the cultural dimensions: for example, who are the parties entitled to determine which works are more or less worthy of preservation? Who judges the artistic quality of works? With what criteria, logic and procedures? On the basis of which cultural references? Are there categories or styles more or less worthy of conservation? Should we or should we not rely on the criterion of the author's fame and therefore preserve the works of the most famous artists? These are all decidedly difficult questions, particularly if we take into account the extreme fragmentation of a world like public art, which is strongly segmented internally into very different currents, approaches and styles. Technicians and public decision-makers often still lack the cultural competences necessary to analyse the recent heritage of public art and thus to establish rules and parameters for its conservation.

To complicate this picture further, public art is still in a moment of transition between the phase in which it was predominantly conceived as ephemeral and the current phase in which works are designed with the perspective of lasting for a relatively long time. In urban policies dealing with public art, we often see a paradoxical situation today in which, on the one hand, criteria and methods for preserving works, that are degraded after many years, are discussed, and, on the other hand, in an excellent state of preservation, are cancelled only a few months after their creation, in order to cover them up with others (see Figure 16).

This latter attitude, in part, relates to a tendency still present in several specific contexts and areas of the public art world, which claim as their identity trait the tradition of urban 'graffiti artists' who, at night, created clandestine works destined to last only a short time. On the part of many public administrations, the tendency to indulge in—if not decisively promote in some urban locations—the practice of 'disposable' art is justified by an alleged lack of suitable spaces to accommodate new works. In the case of Torino, observing the abundance of walls and blind walls of buildings in a poor state of repair, the inconsistency of this argument is evident. Thus, this justification seems only a pretext to justify the laziness and delays of the offices and actors who should identify potentially suitable spaces to house new works and initiate the necessary negotiations and administrative procedures to make them usable for this purpose.

The practice of ephemeral public art is less and less justifiable, especially in an era characterised by an increasing focus on sustainability. Firstly, because the very idea of 'disposability' is structurally at odds with one of the very foundations of the concept of sustainability (favouring durability), as well as for various reasons of unsustainability:

- social (waste of resources—creative, planning, work, expectations—invested in the realisation of a work of art and thwarted shortly afterwards by its cancellation)
- economic (waste of public and/or private investment to buy materials, pay artists, etc.).
- environmental (CO2 and waste produced during the realisation phase of the work, aspects on which the art world is only recently beginning to think critically).

Figure 16. Examples of public artworks that survived in Torino for very short periods. Source: *Arte per strada Torino*.

Finally, the strongly negative subliminal message conveyed to citizens about the value of the works should not be overlooked. If the promoters and creators themselves remove the artworks after a short time, these are evidently artefacts of little value. So why should citizens appreciate them, identify them as positive territorial symbols and, consequently, take care of them and protect them from degradation and vandalism?

6. Conclusions

The public art movement has a relatively long history, but since the 1990s it has experienced a remarkable quantitative and qualitative growth, posing for the first time unprecedented problems concerning the documentation, protection and recovery of this heritage.

The *Arte per strada Torino* project was set up to create a complete and constantly updated census of public artworks in the metropolitan area of Torino. To date, documentation on approximately 1,500 works has been collected and published on a website. For the first time, a broad and comprehensive directory of all public artworks in a city is made available to the public, and can be used for tourist, administrative and research purposes. Useful insights can be gained into the most recurring themes and subjects, prevailing styles, relationships to the urban context and citizens. The analysis of the *Arte per strada Torino* database also makes it possible to develop critical reflections on aspects that have never been fully resolved, such as those relating to the criteria for safeguarding the works themselves.

Conflict of interest

The authors declare that they have no conflict of interest.

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References

Bolle, M., Davico, L., & Scira, R. (2017). *L'arte nelle strade di Torino: Guida alla scoperta dell'arte moderna e contemporanea in città*. Edizioni del Capricorno.

Ciaffi, D., & Mela, A. (2006). *La partecipazione: Dimensioni, spazi, strumenti. Università: Vol. 708*. Carocci.

Crivello, S. (2020). Città e politiche culturali. In D. Ciaffi, S. Crivello, & A. Mela (Eds.), *Manuali universitari Sociologia: Vol. 208. Le città contemporanee: Prospettive sociologiche* (pp. 161–176). Carocci.

Dellarossa, G. (2016). *L'arte pubblica come strumento di riqualificazione delle periferie di Torino?* [Master thesis, Politecnico di Torino, Torino].

Goffman, E. (1963). *Behavior in public places: Notes on the social organization of gatherings*. The Free Press.

Griffiths, R. (1995). Cultural strategies and new modes of urban intervention. *Cities*, *12*(4), 253–265. https://doi.org/10.1016/0264-2751(95)00042-K

Milan, A. (2023). *L'arte pubblica tra rigenerazione urbana e percezione dei cittadini* [Master thesis, Politecnico di Torino, Torino].

Montaldo, B. (2021). *Censimento dell'arte urbana torinese dal 1991 al 2021* [Master thesis, Politecnico di Torino, Torino].

Ricci, C., Croveri, P., Scarcella, A., Sunara, S. M., Tabak, T., Bertasa, M., & Scalarone, D. (2023). Tools to Document and Disseminate the Conservation of Urban Art: The Experience of the CAPuS Project. In G. J. Verhoeven, J. Schlegel, B. Wild, S. Wogrin, & M. Carloni (Eds.), *Document | archive | disseminate graffiti-scapes. Proceedings of the goINDIGO2022 international graffiti symposium* (pp. 188–202). Urban Creativity. https://doi.org/10.48619/indigo.v0i0.709

Rossi, L. E., & Nicolai, R. (2003). *Storia e testi della letteratura greca: L'età ellenistica e l'età imperiale romana.* Le Monnier.

Sennett, R. (1992). *The conscience of the eye: The design and social life of cities* (Revised edition). W.W. Norton & Company.

Zukin, S. (1995). *The cultures of cities.* Blackwell Publishers.

Additional Bibliography

Blanché, U. (2015). Street Art and related terms – discussion and working definition. *Street Art & Urban Creativity Scientific Journal*, *1*(1), 32–39. https://doi.org/10.25765/sauc.v1i1.14

Bofkin, L. (2014). *Concrete canvas: How street art is changing the way our cities look.* Cassell.

Davico, L., Guerreschi, P., & Montobbio, L. (2023). Censire l'arte pubblica, per ragionarci sopra: il progetto Arte per strada Torino. *Atti e rassegna tecnica della Società Ingegneri e Architetti in Torino*, LXXVII (1), 9-16.

Lossau, J., & Stevens, Q. (Eds.). (2015). *Routledge Advances in Art and Visual Studies. The uses of art in public space.* Routledge.

Mininno, A. (2021). *Graffiti writing in Italy 1989-2021*. Bruno.

Panta, P. (2019). *Italian street art: #90 best italian street artists*. HOW2 Edizioni.

Talking City: Voices of Hidden History in the Architecture and Urban Places of Rome

Giulia Flenghi [1,*], Elena Ippoliti [1], Alessandra Meschini [1], Michele Russo [1,*] and Noemi Tomasella [1]

[1] Department of History, Representation and Restoration of Architecture, Sapienza University of Rome, 00186 Rome, Italy;
E-Mails: giulia.flenghi/elena.ippoliti/alessandra.meschini/m.russo/noemi.tomasella@uniroma1.it
* Corresponding authors

Abstract

Our cities today represent a complex intersection of material and immaterial culture, which can be described and promoted through possible heritage itineraries. Among the various topics of these itineraries, a topic of great interest for us is the writings traced throughout history on the wall surfaces of the city's buildings to convey messages and opinions for the most diverse purposes. Their value is not only in the quality of the single artefact but also because they can serve as unique keys to understanding the society that produced them in depth, i.e., to comprehend the culture, customs, and ways of communication of a specific historical period. From this point of view, the inscriptions produced by the ruling classes, the secular and religious power are less exciting than those traced by single or common people. Therefore, these traces of the past are a fundamental historical resource since the people's voice resides in them; they are an intangible heritage transmitted through the materiality of the supports and architectures on which they were traced or placed. Unfortunately, many of these inscriptions are hidden or barely visible within cities. Besides, their decoding is related to the type of handwriting, the engraving technique, and the content conveyed. Finally, in today's society, there is a prevalent dominance of the image with clearly conveyed content, relegating these kinds of cultural products to an omitting background. The study presented in this paper, at an early stage of development, is developed within Rome, a city characterised by a complex and deep cultural stratification. The research aims to map some graffiti and 'minor' epigraphs (i.e., non-monumental or particularly solemn) and build narrative itineraries throughout the city, starting from a study of these particular traces within the architecture. By enhancing these historical sources through these routes, the architecture will become a narrative system capable of telling stories, giving voice to real-life stories and the immaterial culture condensed in those places, and rediscovering a stratified and hidden intangible heritage in the city.

Keywords

Graffiti; Image acquisition; Invisible traces; 'Minor' Epigraphs; Past voices; Storytelling

1. Introduction

Wall surfaces have always been an effective medium for communicating. Since ancient times, different people have traced sketches and writings on these surfaces to convey various types of content. The variety of cases is vast, even limiting the scope to ancient and, more generally, historical 'writings,' and therefore excluding figural elements. They can be authorised, official, clandestine, and transgressive. There are those signed and those anonymous. Some are an expression of secular or religious power, others of social or cultural movements, and still others of single individuals; some have celebratory and commemorative purposes of events or characters, and others are informal and extemporaneous writings made to leave a sign of one's presence in that

place and time. Men of culture trace some with particular executive care. Others are traced in a disordered and confused way by semi-alphabets. Sometimes, they are made in places open to the public to allow a collective reading (called 'exposed writings' (Petrucci, 1985)). However, they can also be created in places that are not easily accessible, with unusual writing codes, and are therefore difficult to understand (called 'introverted writings' (Felle, 2022, p. 8)).

These writings, whatever their forms, supports, executive techniques, and purposes, are a valuable source of information on the culture, customs, and modes of communication of the period in which they were produced. They express the society that produced them; therefore, they are a singular access key to its understanding. Moreover, as the essays by the paleographer Armando Petrucci already stated in the 1970s (Petrucci, 1978) and then more extensively demonstrated in the 1990s (Petrucci, 1996), the relationship between writing and society is very close. Therefore, the value expressed by all forms of writing on the wall surfaces is a fundamental document for reconstructing the history of society, not only that of the ruling classes but also that of the people.

In this context of great richness and complexity, our attention has been directed exclusively to those ancient and historical writings on the wall surfaces of the buildings in Rome that tell individual stories (Bianconi, 2014). From this point of view, we have therefore considered both the graffiti executed with any technique (scratched, engraved, painted or in charcoal) and the 'minor' epigraphs, meaning by this term, the epigraphs whose content concerns a single individual, not they are therefore neither monumental nor particularly solemn and neither an expression of secular or religious power.

Such written documents—graffiti or 'minor' epigraphs—are fundamental testimonies of intangible culture, because they tell individual stories that allow us to understand the society that produced them. However, they are also testimonies of material culture because of how they are made and the architectural and urban spaces in which they are located. In our opinion, another characteristic that these types of writings have in common is, in fact, that of the "spatial dimension" (Felle, 2022, p. 10), of the strong link they have with the context in which they are placed and, in the specific research, with the architectural and urban space. A powerful relationship in the case of graffiti which "derives their *raison d'être* from a given place, a spot that lifts them above the arbitrary and saves them from the status of random scribbles or mere elements of decoration" (van der Vliet, 2021, p. 91). However, it is the same for the epigraphs that "articulate space in its meaningful aspects and may reshape and overwrite it" (van der Vliet, 2021, p. 91). Therefore, these historical testimonies are a heritage of inestimable value, even if they are mainly known only by insiders, being unknown to a broad audience. It also happens in Rome, and the phenomenon is mainly present for different reasons. First, they are difficult to trace. Their location is almost unknown, hidden by a morphological complexity or limited accessibility. Furthermore, they need help understanding. Their decoding is linked to the type of handwriting, engraving technique, and content conveyed.

The rediscovery of these historical testimonies thus becomes a challenging theme, which led us to open a new research path without any funding. Enhancing this material heritage (artefacts and places) as well as the immaterial one (stories and values of individuals, communities, culture, society) and the network of related relationships can be an exciting action to carry on. Therefore, to identify a possible concrete action to enhance it, we started a preliminary study to evaluate the case study consistency and test a communication project of these written documents in Rome. The valorisation of cultural heritage continues after preserving its materiality. However, it is only fully realised on the condition that the cultural asset and the knowledge about it can be enjoyed and used by the community.

The Talking City study, presented in this paper in the first preliminary stage, aims to build narrative itineraries that accompany a broad and non-specialist audience through the city of Rome in the rediscovery of a stratified material and immaterial heritage, i.e., messages of these scriptures and the stories of those who wrote them. A perspective in which the buildings of the city of Rome become narrative

palimpsests[1], capable of telling and giving voice to lived life stories. The project, presented in the article in an early stage, aims to build knowledge itineraries within a certain number of case studies. We mapped their geographical distribution and location in this process, classifying the typologies and related themes. The first results allowed us to set up a first communication project, testing the possibility of scaling it in similar situations.

2. A Multidisciplinary Approach: Research Experiences

Several disciplines with different interests and objectives deal with such historical evidence. Among these are palaeography and epigraphy. The first concentrates its studies on writing forms (especially manuscript and non-monument) made on any material, thus also including painted, engraved, or scratched writing on walls. Epigraphy often deals with inscriptions made on 'hard' support materials and, therefore, durable materials. In particular, palaeography aims to reconstruct the history of the graphic forms of writing (decoding, interpreting, dating, and locating them) and to establish genres, types, and graphic styles of writing through executive techniques. The comparison among different examples allows investigating the socio-cultural contexts of their use (Istituto della Enciclopedia Italiana fondata da Giovanni Treccani S.p.A., 2023). Epigraphy, conversely, "deals with what is written to communicate a message or some simple information element to an audience theoretically as large as possible and for as long as possible" (Lambert, 2004, p. 13). Therefore, it studies both the texts of the epigraphs and the monuments or objects on which they are written and, above all, the society that produced both (Panciera, 1998).

These testimonies are generally studied in archaeology, philology, historical disciplines, and art history. For this reason, some scholars have made them their main subject of expertise (Susini, 1982). The heterogeneity of knowledge demonstrates the complexity of the subject and its multidisciplinary nature. As a result, the research projects are equally numerous and diverse.

First, these include those aimed at creating open-access online archives. In this context, a large-scale project launched in 1997 is represented by EAGLE – Electronic Archive of Greek and Latin Epigraphy (http://www.eagle-eagle.it), an international federation of epigraphic databases that aims to collect all the Greek and Latin inscriptions published up to the 7th century AD based on the best existing editions, attaching, when possible, further essential data. The Epigraphic Database Rome – EDR, the Epigraphische Datenbank Heidelberg – EDH, the Epigraphic Database Bari – EDB, and Hispania Epigraphica – HE are part of EAGLE. In particular, EDR (http://www.edr-edr.it) aims to collect the whole epigraphy of Rome and the Italian peninsula, including Sardinia and Sicily, except Christian inscriptions (under EDB jurisdiction).

The EAGLE Federation has initiated the EAGLE Europeana project (https://www.eagle-network.eu), co-funded by the European Commission (under its Information and Communication Technologies Policy Support Programme; Amato et al., 2014). The specific objective is to create a single user-friendly portal to collect and catalogue images and other digital objects, with various textual information, relating to hundreds of thousands of Greek and Roman inscriptions. The more general objective of the project is to disseminate, i.e., to make Latin and Greek epigraphy known, understood, and appreciated by a broad audience.

The Ancient Graffiti project – AGP (http://ancientgraffiti.org/Graffiti) also fits into this context, which, coordinated by Washington and Lee University with the collaboration of many universities and experts in digital humanities and ancient epigraphs, is a contributing member and works in collaboration with the Epigraphic Database Rome and EAGLE Europeana. The AGP is a collaborative and interdisciplinary research project that aims to create a digital resource (repository and search engine) for locating and studying handwritten inscriptions (messages and sketches) of the early Roman Empire, especially in Herculaneum and Pompeii. It offers a window into the daily life and interests of people

1 Here the use of the term palimpsest is in its metaphorical meaning, a very common use in the literature, architecture and history of cities. In this very important work, Gérard Genette (1982) examines the multiple relationships that a text can have with previous texts. A palimpsest is a parchment which contains two superimposed texts, and in which the original is not completely erased but remains visible in transparency. It is the hypertext relationship. Moreover, as in a palimpsest, it is not just a matter of writing, but also of reading.

who lived in the ancient world by providing information on the economy, religion, language spoken, literacy, and activities within the city (Benefiel & Sypniewski, 2020). The search engine allows for different types of searches. Indeed, it is possible to search for graffiti based on text (Latin terms, English translations, toponyms, bibliography), by their location (city map or city block), or by specific characteristics (for example, figural graffiti).

Therefore, the objective of sharing this cultural heritage has accelerated multidisciplinary collaboration, particularly between the humanities and computer science. In recent times, digital and interactive media have favoured its dissemination to a broad audience by creating narrative and multimedia paths and paying particular attention to the user experience. For example, the EAGLE Europeana Portal offers several resources in this direction. Among them is a storytelling platform (The Flagship Storytelling Application – FSA, https://www.eagle-network.eu/resources/flagship-storytelling-app), which is a web-based tool designed to allow users to create multimedia narratives on epigraphic content and share them on the web. Another resource is the EAGLE Mobile Application, which allows users to get information about one visible inscription by taking a picture with a mobile device and sending it to the EAGLE portal (https://www.eagle-network.eu/resources/flagship-mobile-app). This app, realised explicitly by CNR-ISTI-AIMH, is free, available on Google Play Store for Android smartphones, and can visually recognise approximately a million inscriptions collected by the EAGLE project (Bolettieri et al., 2015).

Another exciting project is the Venice Squeeze Project (https://mizar.unive.it/venicesqueeze/public/frontend/index), aimed at enhancing and disseminating the Ca' Foscari University collection of squeezes of Greek inscriptions preserved at the Laboratory of Greek Epigraphy. Within the project (made in collaboration with the E-stampages project of the École française d'Athènes and the HiSoMA Laboratory of Lyon, and the Digital Epigraphy and Archeology – DEA Project of the Florida University), the database was designed, the online archive created and 3D models of the squeezes made using the software designed by DEA based on the shape-from-shading method (Antonetti et al., 2017). DEA is an interdisciplinary project initiated by the Digital Worlds Institute and the Department of Classics at the University of Florida. The project aims to develop new open-access scientific tools to service and promote epigraphic and archaeological research by applying information technology and digital and interactive media (https://research.dwi.ufl.edu/projects/digitalepigraphy.org). In this context, the researchers have developed several open-source tools and applications. Initially the team worked on developing an online tool for the 3D reconstruction and analysis of epigraphic squeezes (https://www.digitalepigraphy.org/page/shape-from-shading-3d-reconstruction-tool), which can help scholars understand the structural characteristics of artefacts, based on the shape-from-shading method using two scanned images of the squeezed papers (Barmpoutis et al., 2010). They initiated the development of the Digital Epigraphy Toolbox (https://www.digitalepigraphy.org/legacy/toolbox/info.html), which integrates 3D reconstruction software with a dynamic online library of three-dimensional inscriptions for the practical study and comparative analysis of Greek and Latin inscriptions (Bozia et al., 2014). In the following years, they improved the Digital Epigraphy Toolbox by focusing on developing a graphical interface that includes user-friendly options for multi-modal visualisation of 3D model inscriptions (https://www.digitalepigraphy.org/page/digital-epigraphy-toolbox). They devised a new interface to allow users to browse through 3D databases of inscriptions and visualise the inscription within their actual physical space. Using head-mounted augmented reality displays (such as Microsoft's Hololens), users can browse 3D databases of inscriptions, select an inscription, place its hologram in physical space (e.g., on top of a desk), study the inscription by naturally walking around the hologram, zoom in on the hologram using natural hand gestures. In addition, users can rotate, scale, and move the hologram in real space and open multiple holograms simultaneously for a comparative study of inscriptions (Bozia & Barmpoutis, 2017). More recently, they have been improving interaction design by looking for solutions to use the sensors in popular portable devices, such as tablets and smartphones. The developed interface allows the users to naturally hold digitised inscriptions, interact with them in order to relight or manipulate them as if they were physical

objects and interact with metadata or other multi-modal data, such as text and images (Barmpoutis & Bozia, 2017).

Based on the projects reported, it is evident how the study, learning, and dissemination of artefacts such as ancient and historical epigraphs and graffiti passes through the balanced integration of communication and dissemination technologies. For this reason, the *Talking City* research presented here at an early stage aims to experiment with different technologies for acquiring, modelling, and visualising digital data to understand them better. These will define thematic and content-related inferences and relationships within the city, building knowledge paths aimed at giving voice to little-known but significant traces of the past for understanding the place's culture.

3. The Research Project and the Communication Project

The prototype of our communication project aims to propose an approach that favours access to information for non-expert users interested in knowledge of the cultural heritage and attracted by lesser-known and less frequented itineraries. This project focuses on ancient and historical graffiti and 'minor' epigraphs of the city of Rome, whose different characteristics are accurately described but always concerning the context in which they are located—the architectural space and the city. Through this heritage, visitors are guided to discover the architecture and the city of Rome from different points of view: people who inhabited or passed through those places at a particular time. Having clarified the target and the general objectives, we defined what content to disseminate, how to access it, and, consequently, the most effective tools and channels to adopt.

Considering the target, the communication models chosen are visual—maps, plans, photos, virtual tours, embedded with applications in AR—because they are more engaging and, therefore, can interest a broad audience. The visual content will then be coupled with textual information: from the meaning of the written document to contextual information to understand its cultural value. The primary way of accessing the content is thematic (geographical, historical, and typological). By choosing a theme (Figure 1), several unusual but reliable itineraries will be proposed to the user concerning the quality of the data processed and the content produced. Relevant maps will be displayed, highlighting thematic objects and, in some cases, suggesting proximity itineraries (proposing visits to a nearby place at a defined time).

Another way of accessing content will be through stories. This option allows the user to choose from several proposed

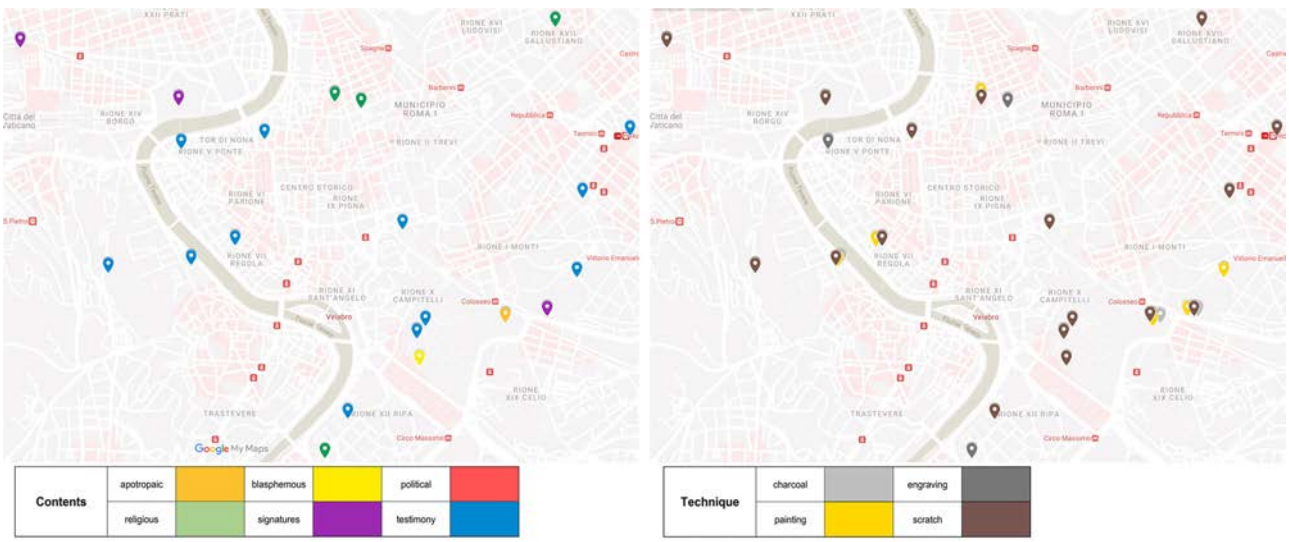

Figure 1. Examples of some thematic maps from which the thematic itineraries are derived.

stories constructed from graffiti and epigraphs. Stories of everyday life or excellence that aim to be deeply involved, establishing a profound relationship between content and audience, acting not only on cognitive-rational aspects but also on affective-emotional ones. Another access mode is exclusively geographical; the user can view points of interest distributed within a 1 km radius around his or her location. Finally, the last level of access is the classic searching instrument whereby it will be possible to find thematic objects in a building, a church, or a street.

After extensive research, it was decided that the most effective channel to convey this content is a Progressive Web App (PWA), a hybrid between a website and a mobile app (Figure 2). It can be used from a mobile device without downloading and can access the device's tools, such as a camera, microphone, GPS location, and push notifications. In addition, thanks to the PWA's responsive design, the user's perception of the app's interface (the so-called 'Look and Feel') is similar to that of a native app. Finally, AR technologies can also be integrated into a PWA so that mobile and web applications can be designed using the same source code base.

Among the advantages of PWA is the Service Worker, which is installed when the application is accessed for the first time, responds to events sent to it from the web page and saves and retrieves cached data. Thanks to this feature, PWA can also be used offline, data can be accessed much faster, and, above all, updates made on the website are

Figure 2. The prototype of the *Talking City* PWA.

always available on the mobile device. This last feature is the most relevant for the research project because although the objective is the dissemination of cultural content, in order for communication to be reliable, it must be based on an information system that can be implemented over time. It must be correctly structured, starting from the elementary units constituted by the written documents. Therefore, the project envisages that structured data collections organised in relational and geographic databases, metadata, and a set of links, will be related to each geographically contextualised elementary information unit. The data set will be made available by uploading it onto a platform (characterised by integration, interoperability, and scalability of data and technologies) precisely customised for the project, allowing access to and exploration of the entire heritage of resources.

In detail, the main challenges that need to be solved are summarised below:

- The definition of the information structure of relational databases: elementary information units (the writer documents) and related attributes—texts, 2D images (sketches, drawings and photographs), AR and Virtual tours; the geo-referencing on the map of the written documents—points of interest (POI)—and determining which cultural contents can be displayed according to the predisposed modalities;
- The configuration of the relationship system to interface by querying the database, the contents inserted in the Content Management System (CMS) with the browser;
- The design of the graphic interface, from the choice of visual language to layouts.

As mentioned, although the project envisages free navigation through textual and geographic queries, the preferred mode of use is guided to facilitate access to the objects, which will be from the icons on the map. Clicking on the icon will open a first page showing a synthetic plan of the architectural or urban space, with the locations of the historical writings highlighted (graffiti and 'minor' epigraphs) and for each scriptural document, a photographic image and a brief textual description. In addition, through links, it will be possible to explore the scriptural document in AR and, through a virtual tour, the architectural and urban space. In particular, AR is used to improve the legibility of inscriptions by superimposing images on the target object and incorporating historical information or written translations.

Another significant aspect is the introduction of audio files that would provide a voice to the people who created these inscriptions or to whom these inscriptions were made, making previously invisible and incomprehensible signs comprehensible to the public.

After defining the communication project prototype, we examined some of the main issues that will be described in the following paragraphs. In particular, they concern: the study and analysis of a significant number of examples of ancient and historical graffiti and 'minor' epigraphs found in Rome, the classification of these artefacts—the metadata, the recurring formal, material and dimensional characteristics—the correct methods of photographic shooting and the most effective forms of visualisation for the user-experience, also using AR applications.

4. Historical Writings in Rome: Graffiti and 'Minor' Epigraphs

The investigations first concentrated on identifying cases that could be considered relevant to the studies, proceeding methodologically in two ways. On the one hand, through the online application Google My Maps, a map was constructed to quantify the distribution of the places on Roman territory in which several examples have been found (Figure 3). It served as a helpful tool for consultation and progressive updating

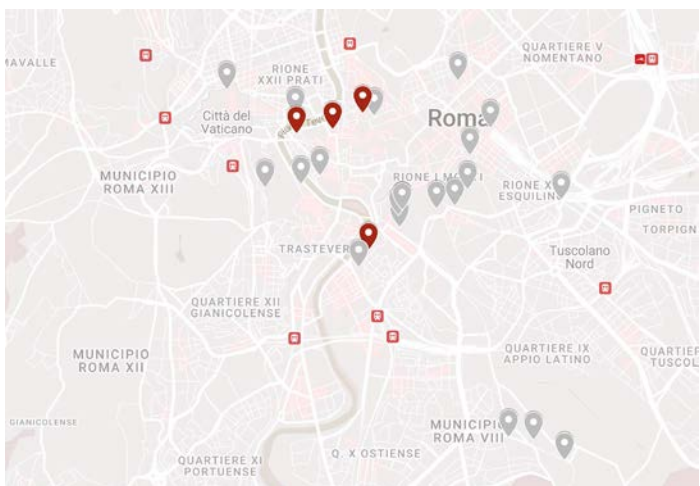

Figure 3. Multiple examples of ancient graffiti in Rome, showcased on a map created using My Maps, with the analysed samples highlighted in red.

among the authors. This aspect immediately highlighted the number and breadth of historical periods to which the examples refer and their typological variety in terms of creation and associated communication content. Besides, this process emphasised the complexity of identifying routes of access and appreciation for artefacts dispersed across distant locations and situated within diverse architectural contexts. Furthermore, some are found in inaccessible areas, presenting varying conditions for viewing and appreciation.
Therefore, on the other hand, and in parallel, it became necessary to identify typological-technical categories and content categories for classifying the cases. We considered 25 places where several examples are present for research purposes. All the cases are in diverse architectural-urban contexts: six churches/ecclesiastical complexes, three catacombs, five villas/historical palaces, two town gates and archways, one town monument, one private house, and seven archaeological areas. Most are examples of graffiti (21 places), and only in four locations are 'minor' epigraphs. The documentation showed that the religious and archaeological sites are those for which it was possible to find bibliographical references in the historical-archaeological or palaeographical and epigraphic domain. Conversely, information about the cases in historical villas, palaces, and catacombs is scarce, primarily traceable on online sites or framed in more general studies (Keegan, 2014; Solin, 2008).

The examples span from the first century to the first half of the seventeenth century. As a result, they present a range of characteristics influenced by the artistic sensitivity of the authors and the cultural context of their time. The content of these examples further contributes to their distinctiveness, showing glimpses into the life, beliefs, and concerns of the people who inhabited the city.

A comprehensive table (Table 1) was created to facilitate the analysis of the identified examples in the Roman area, categorising them on their type, technique, content, dating, and accessibility.

Three primary types were subsequently distinguished:

- Scratches: Scratches encompass etching surfaces such as walls, columns, or wood using pointed objects. This category comprises the most abundant examples of ancient graffiti, exhibiting a broad spectrum of content that ranges from simple personal names to more intricate and elaborate communications.
- Painted or charcoal signs: These graffiti were created using paint or charcoal to trace symbols, messages, or images on surfaces. These signs served various purposes, including political communication, religious expression, or simply leaving a mark to signify one's presence. While these signs were more prevalent in ancient times, fewer examples have survived due to the perishable nature of the materials used.
- Engraving: Typically found on marble or stone, these consist of concise texts in prose or verse covering many topics, from dedicatory messages to political statements. Many epigraphs are associated with funerary contexts, serving as memorials or epitaphs, while others express religious devotion, as exemplified by the case of San Lorenzo in Lucina (Brandt, 2012).

Once the main types were established, a further classification was applied based on the contents of these communications, resulting in the identification of five distinct subsets:

- Signatures: This type is prevalent and serves as evidence of an individual's presence in a specific location;
- Messages: Typically, these phrases are engraved or painted on walls. The topics can be diverse, ranging from messages directed at specific individuals to those of a more general nature. In many cases, ongoing exchanges or conversations have been found within graffiti.
- Politics: This category includes political slogans and satirical expressions. These types of graffiti offer insights into the political and social climate of the respective time (Morstein-Marx, 2012).
- Religion: Religious graffiti are abundant in Rome, showing the coexistence of different religious practices in the city. These inscriptions often depict symbols, prayers, and invocations. Within this category is a subcategory called Blasphemous graffiti. This particular graffiti mocks religious beliefs and is often accompanied by caricatures.
- Historical events: This group encompasses all graffiti that provide information related to historical events (of various kinds) or insights into the lifestyle of the society in question.

Sites	Type	Technique	Contents	Dating	Accessibility
Arco dei Banchi	graffiti	engraving	• testimony	1640	✓
Basilica Argentaria	graffiti	scratch	• testimony	1st – 3rd century AD	✓
Basilica di Santa Maria Maggiore	graffiti	scratch	• testimony	3rd – 4th century AD	X
Casa di Augusto	graffiti	scratch	• signatures • testimony	43 BC – AD 17	✓
Castel Sant'Angelo	graffiti	scratch	• testimony • political • signatures	6th – 7th century	✓
Catacombe di Santa Domitilla	graffiti	painting	• religious	4th century AD	✓
Catacombe di San Callisto	graffiti	painting	• religious	3rd century AD	✓
Catacombe di San Sebastiano	graffiti	scratch	• religious • testimony	3rd century AD	✓
Colosseo	graffiti	painting charcoal scratch	• testimony • signatures • apotropaic	3rd century AD	✓
Cryptoporticus degli Horti Sallustiani	graffiti	scratch	• religious	3rd century AD	✓
Domus Aurea	graffiti	painting charcoal scratch	• religious • testimony • signatures	2nd century AD 16th century	✓
Domus Tiberiana	graffiti	scratch	• testimony	2nd century AD	✓
Musei Vaticani	graffiti	scratch	• political • testimony • signatures	1527 17th - 19th century	✓
Palazzo Altemps	graffiti	scratch	• testimony	1496	✓
Palazzo Farnese	graffiti	painting scratch	• testimony	18th century	X

Pedagogium	graffiti	scratch	• blasphemous	2nd – 3rd century AD	✓
Pontificio Ateneo S. Anselmo	epigraph	engraving	• religious	3rd century AD	✓
Porta Maggiore	epigraph	engraving	• religious	AD 11 – AD 53	X
Privachaus graffiti at Stazione Termini	graffiti	scratch	• testimony	2nd century AD	X
San Lorenzo in Lucina	graffiti	painting scratch	• testimony	2nd century AD	✓
	epigraph	engraving	• religious	12th century	
San Silvestro in Capite	epigraph	engraving	• religious	9th century AD	X
Santa Sabina	graffiti	scratch	• religious	2nd century AD	X
Terme di Traiano	graffiti	painting	• testimony	2nd century AD	✓
Villa Farnesina	graffiti	painting charcoal scratch	• testimony	1527	✓
Villa Lante	graffiti	scratch	• religious	2nd century AD	✓
			• testimony	1527	

Table 1. Summary of the main examples in Rome.

Figure 4. Some accessible rooms in the basement of the Basilica.

4.1. Analysed Examples

The five case studies were selected according to several criteria. First, we considered two cases of each type (graffiti and epigraphs), differing in historical-temporal location and the wall surface (stone, fresco, and plaster). Therefore, we compared different digitisation methods, i.e., identifying the most appropriate ones for the types of artefacts identified by the research.

In San Lorenzo in Lucina, two cases were selected, which differ in type and location. In the underground Basilica, accessible according to specific visiting hours, there are parts of a building from the 2nd century AD on which walls fragmentary graffiti was found (Figure 4). Among the analysed cases, we present in section 5.2 some epigraphs in the rooms of the underground Basilica (Figure 4 A–B) and graffiti on the east wall (Figure 4 C–D). The latter, which is more extensive and partly damaged by several holes (Figure 4 C and 9), consists of four lines written 'in scratch' with letters varying in height between 10 mm and 30 mm, even slightly different in shape and depth of the inscription. Palaeographic readings have recognised the presence of

Figure 5. The main wall in the portico of San Lorenzo in Lucina.

some names (Victor, Agatemerus, and possibly Strenuus). The other graffiti is placed lower (about 15 cm) and next to a large hole in the plaster; it features a group of apparently disconnected figures (XV, IX, V, I, III, IIIXX) (Blennow, 2012).

The second case is a 12th-century epigraph, probably placed initially as a decoration inside the church, which is currently located in the entrance portico of the Basilica (Figure 5). It consists of a 0.68 m × 1.10 m marble slab, and the height of the letters is 25 mm to 35 mm high, regular with classical forms, sometimes with serifs. The inscription contains characteristic features of mediaeval orthography. It has no ornamentation except for an initial and final cross-placed between the Greek letters α and ω (Blennow, 2012).

The third case under consideration is a group of graffiti located in the Basilica of St. Sabina discovered following excavations carried out in the last century. These led to the discovery of an archaeological complex comprising a section of the Severian wall and a series of rooms that were used as a meeting place and place of worship for an Isiac community in the 2nd century AD. The series of graffiti (at least 8) is located on an *opus incertum*[2] wall in a connecting passage between these rooms. Traces of residual colour testify that they were traced on a plaster decorated at the time. They are partly overlapping and graphically different, written in Latin except for one in Greek, which is also executed with a relatively coarse tool (Volpe, 1982).

2 *Opus incerta* (opus incertum) is a Roman building technique that concerns the way in which the face of a concrete wall is built. Stones of unequal size were used, placed with their faces matching each other, resulting in an irregular and random pattern.

The fourth case is an epigraph under a vaulted passage called the Arco dei Banchi that connects via del Banco di Santo Spirito with Via Paola. Under the arch on the right is a tall and narrow stone slab, placed initially under the portico of the church of St. Celso and Giuliano, which, in semi-gothic characters and abbreviated words to save space, bears the oldest engraved inscription relating to the flooding of the Tiber on 7 November 1277. A horizontal line placed under a supporting iron bracket indicates the flood level. However, the most exciting aspect of this case is that in the upper part of the slab, a further inscription was engraved in 1640 that can be traced back to the typology of the testimonies.

The last case is located in Palazzo Altemps. Since 1997, it has been one of the four sites of the Museo Nazionale Romano and was named after Cardinal Marco Altemps, who bought it in 1568. However, its original core dates back to the 15th century when Girolamo Riario, nephew of Pope Sixtus IV, commissioned Melozzo da Forlì with its construction and decoration. Several frescoes remain visible from this older phase. They include the one painted on the *piano nobile* (1st floor) on a wall of the Sala dei Notabili, also known as the Sala della Piattaia, because of what the fresco depicts. Against a background simulating a colonnade set against a wall of coloured marble slabs and a tapestry with floral-vegetal motifs placed at mid-height, a sideboard or platter is depicted on which are arranged, on a tablecloth, candelabras, plates, cups, and another crockery, perhaps the tableware (or wedding gifts) used for the wedding of Girolamo Riario and Caterina Sforza in 1477. It is precisely on the Piattaia fresco that there are some graffiti dating between 1496 and 1498, probably made after the Riarios abandoned the palace, having fallen into disgrace after the death of Sixtus IV, i.e., before 1911, when Cardinal Francesco Soderini purchased the palace. Other graffiti can also be found on the wall jambs—also frescoed—of the two windows on either side of the Piattaia.

5. Methodology

5.1. Data Acquisition: General Considerations

The digital survey of the artefacts discussed in this research deserves general consideration before considering the specific case studies and specific activities in situ. The critical analysis allowed us to identify the best digitisation approach. Generally, there are two main variables to consider: the specific artefact (dimensional and material aspects) and the environment in which it is framed (Table 2). Both these elements lead to significant variations in a digital documentation campaign. As mentioned in the previous paragraphs, considerable distinctions between graffiti and epigraphs must be considered. These include dimensions—i.e., engraving depth, surface coverage, and character size—as well as material type and content intricacy, including text structure and meaning.

A difference, however, concerns the context in which the artefacts are placed. As will be inferred from the different characteristics of the two types, graffiti and epigraphs, their location and relationship to architecture also change. The important matter is represented by visibility. In Roman times, ancient graffiti in Rome are usually barely visible and often hidden within architecture, as they are defined by people's desire to leave a trace that does not necessarily need to be read by many people. Also, many of these scratches have been negatively affected by the passage of time, leading to their abrasion, removal, or being covered by other structures. In contrast, epigraphs are created to leave a trace that is evident and can be read by passers-by, so their visibility is more pronounced and highlighted by their larger size, different material, and location, often in observable areas (facades, narthex, or walls on passage areas within buildings). Furthermore, the different location of these artefacts within the architectures also implies a significant difference in their context and lighting conditions. The graffiti considered by the *Talking City* project are fleeting traces often in poorly visible (crypts, catacombs) or hidden parts (secondary walls, plinths), in which the absence or reduced amount of light or space for use makes them even less accessible. Epigraphs, on the other hand, precisely by their visible location, are often well-lit and have vast space that allows full fruition of the artefact.

A final distinction is the deterioration of these works over time. Graffiti is subject to the same conservation issues as the masonry in which it is embedded. Graffiti, having almost no thickness, is mostly subject to trace transformation.

Conversely, material deposits can more easily cover it. Finally, the fact that they are often in barely visible or inaccessible places sometimes preserves them from both anthropogenic and climatic conditions, even if the same external conditions prevent the visibility of artefacts. In contrast, epigraphs, especially those outside buildings, are subject to more significant deterioration due to weathering exposure and anthropic presence. The result is a progressive loss of detail in both the edges of the stems and the edges of individual letters, which change and lose their recognisability.

These characteristics open a critical overview of the possible documentation techniques that can be applied to the artefacts. Regarding graffiti, their two-dimensionality implies that no 3D acquisition methodology needs to be applied; a normal photo camera is sufficient. Instead, it may be helpful to superimpose images acquired with different cameras (visible light, near-infrared, multi-spectral) to investigate the characteristics of poorly visible artefacts better. In addition, graffiti is often placed in difficult acquisition conditions with low light and narrow spaces. Therefore, special attention should be paid during data acquisition, especially in the scene lighting and setup of the camera parameters. On the other hand, one must try to optimise the position of the camera with respect to the acquisition area, even in the absence of space.

Epigraphs may exhibit a three-dimensional shape, which implies the possibility of using 3D acquisition techniques consistent with the characteristics and level of detail of the artefacts, such as precision photogrammetry or active triangulation 3D laser scanner, preferably fringe projection, given the optical limitation of marble. The space for data capture is always guaranteed, as is the illumination of the artefacts. In the case of epigraphs, acquisition problems may be dictated by excessive grazing light, in case they are located outside the buildings, as well as by location, in case they have been placed in poorly accessible positions. Starting from this examination, only standard digital photo cameras are employed in the research, highlighting the specific problems and solutions adopted for each individual type.

Characteristics	Graffiti	Epigraph
Dimension	Small	Medium to large
Depth	None	Small
Material	Any surface	Marble/Granite
Visibility	Low/None	High
Illumination	Low	High

Table 2. Summary of the main characteristics of graffiti and epigraph which can affect the data acquisition process.

5.2. The Acquisition of the Graffiti and Epigraphs

In the present case, one of the four stems under the exonarthex of San Lorenzo in Lucina was considered. The shooting conditions are ideal since the light is diffuse. In addition, the space in front of it is very large, allowing for

optimal planning. The acquisition was divided into two different phases. The first one consisted of a single photograph at a distance of 3.5 metres and with a nadir optical axis more or less in the centre of the artefact to optimise the size of the acquisition area with the object shape. Next, the artefact's dimensions were measured, although some problems were encountered in precisely defining the boundaries, which were often poorly visible and blunt. In the second phase, we approached the distance of one metre, acquiring a mosaic of 24 photographs with an optical axis nadir to the cultural asset and covering the entire area with at least 60 % overlap in both directions and a vertical and horizontal baseline of around 20 cm. The single photograph was rectified and scaled according to a geometric rectification process (RDF program), resulting in a ground-sampling distance or GSD of 1 mm. The photogrammetric set was oriented within Metashape (Agisoft) until an orthoimage with a GSD of 0.3 mm was extracted (Figure 6).

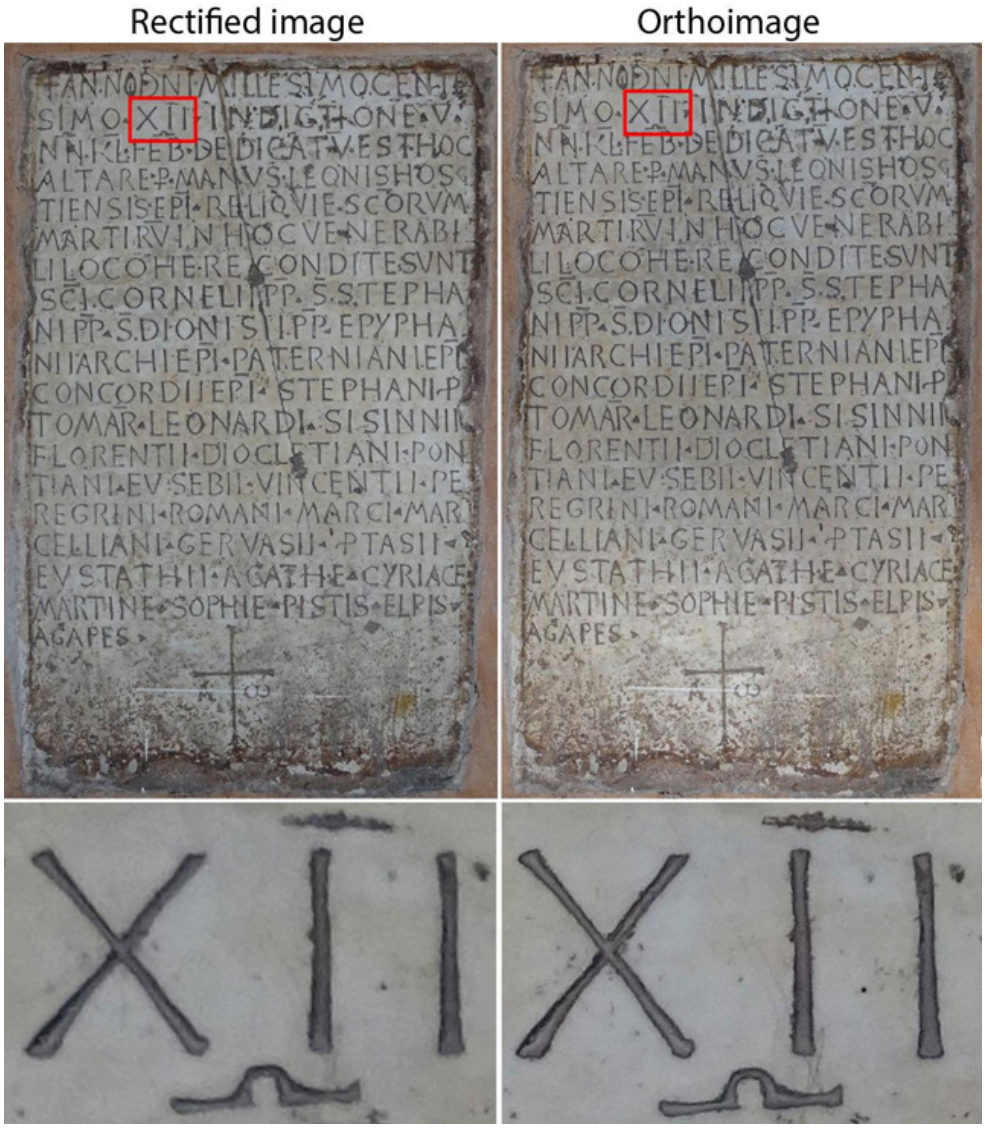

Figure 6. Comparison between rectified image and orthophoto with relative details.

The projection plane was easily identified on the plane of the stele. Evaluating the two results, the two products are comparable, dealing with a thin artefact, thus resulting in little significant topographic perspective distortion. On the other hand, having a smaller GSD, the orthoimage is more detailed, allowing for more meticulous product analysis (Figure 6). Thus, the choice of the two techniques is related to the purpose of the research: within a virtual itinerary, which does not involve interaction with the works, single photography is sufficient, perhaps using a ColorChecker to white balance the photographs. In contrast, the photogrammetric block allows for a datum to be analysed more thoroughly. One of the notable epigraphs we acquired is located on the papal throne at the centre of the apse wall (Figure 7). This epigraph pertains to the consecration of the church and the deposition of the relics of St. Lorenzo in 1112 (Brandt, 2012). To capture it, we opted for two separate photos, one focusing on the inscription on the backrest and the other on the base. We encountered some challenges due to the inadequate lighting of the space and a spotlight positioned at the top of the throne, resulting in uneven illumination of the object. However, these issues can be solved during the post-production process. In order to compensate for the poor lighting, we utilised high ISO settings, which resulted in some noise in the image. Alternatively, it is possible to use a tripod if the ground is stable, using longer exposure times while preserving the stability of the camera. In terms of the environment, the space in front of the throne allowed us to frame the full subject without any significant distortion, using a lens set at a focal length of 55 mm.

Figure 7. Epigraph on the backrest and base of the papal throne in San Lorenzo in Lucina.

Figure 8. Photos of epigraphs in the underground Basilica, showing the difference without and using grazing lights.

In other examples of epigraphs in San Lorenzo in Lucina, found in the underground Basilica (Figure 8), we conducted some experiments using grazing light. This technique proved effective in enhancing the relief via the creation of strong shadows and, consequently, increasing the contrast between the supporting surface and the writings. In this particular case, the epigraphs were relatively easy to identify compared to the graffiti, which we will describe below. Due to their small size, we acquired them with a single frame using multiple cameras (Canon EOS 1100D and Nikon D610). In Figure 8, it is evident how the utilisation of grazing lights during the acquisition stage allowed for an increase in contrast and, therefore, the legibility of the inscription. The first example was captured using a Nikon D610, equipped with a Nikkor AF-S lens with a focal length of 48 mm, while the second was captured using a Canon 1100D and an EF-S lens with a focal length of 45 mm.

Continuing within the context of San Lorenzo in Lucina, we encounter a particularly challenging case in terms of the legibility of the signs (Figure 9). Moreover, access to the underground Basilica is restricted to scheduled appointments, and locating the graffiti within it presents a difficulty. Additionally, the lack of natural light and the inability to descend to the level of the graffiti (as it is situated in an inaccessible area) posed some obstacles. However, due to the relatively small size of the graffiti area, it was possible to capture it within a single, good-quality photo.

Another interesting example of graffiti can be found in the crypt of the Church of Santa Sabina (Figure 10). The conditions here were quite different compared to the front portico of San Lorenzo in Lucina. In this case, the camera used was a Canon EOS 1100D. Due to the lack of natural light, we had to use high ISO settings (3200/6400) and relatively slow shutter speed (about 1/30 seconds). Furthermore, the

Figure 9. Overall photo and details of the graffiti in San Lorenzo in Lucina.

limited space made it impossible to capture the entire graffiti area without an ultra-wide-angle lens. However, this solution would have resulted in barrel distortions in the picture.
To overcome these challenges, we took photos in portions, ensuring that the optical axis remained approximately perpendicular to the wall's plane. We used a lens with a focal length of 23 mm. During the post-processing stage, we needed to combine the various partial shots.

Initially, we attempted photographic stitching, but it resulted in significant errors, particularly in the perimeter area of the graffito. Consequently, we conducted a second attempt using the Metashape software.

We obtained a textured mesh model by aligning all photos (via a structure from motion approach) and extracting a dense point cloud (using a multi-view stereo approach). We appropriately oriented the model to approximate the wall's plane on which the graffito was situated, resulting in a high-resolution orthomosaic (5713 x 6294 pixels).

However, it is worth noting that the conditions described

Figure 10. Orthomosaic of the graffiti-covered portion of the wall in Santa Sabina.

posed limitations, as neither the lighting nor the distance to the subject was optimal. While the Metashape workflow proved helpful in this particular case, it is not necessarily indispensable for studying graffiti and epigraphs since they are primarily two-dimensional objects with negligible depth.

The case at Arco dei Banchi presented relatively few challenges as it was located outside, beneath a vaulted surface, so it is accessible to anyone. However, due to the elongated rectangular shape of the object, it was not possible to capture it in its entirety while maintaining a good image resolution. Therefore, we decided to take a series of close-up shots, which were later stitched together during the processing phase. In this case, we combined photos taken by the previously described Canon 1100D and a Nikon D610. For the Nikon D610, we used a Nikon Nikkor AF-S 24–120mm f/4 G ED VR lens with a variable focal length. Different attempts were made, starting with a simple collage in Photoshop (Adobe) using the Photomerge tool, which was approximate from a metric standpoint but effectively gave back the image in its entirety with good definition. Subsequently, the frames were processed using Metashape. This involved aligning the frames through the identification of homologous points. Following this, a textured mesh model was constructed, appropriately oriented to approximate the wall's plane, which allowed us to create the orthophoto. In Figure 11, a discrepancy can be observed between the image processed in Photoshop and the orthophoto. In terms of the

Figure 11. From left: photo collage, orthophoto and comparison between the two methods.

metric aspect of the object, which is crucial for extracting measurements, numerous differences are noticeable, particularly at the bottom. However, while the first image is unreliable for measurements due to its inherent limitations, it remains equally effective for communicative purposes. Furthermore, it requires minimal resources for processing.

Regarding Palazzo Altemps, we captured both overall and detailed photographs (Figure 12). We encountered some challenges during the process. Firstly, the fresco was quite large, so we needed to acquire detailed images to capture its intricacies. Secondly, the lighting coming from the side windows posed an issue, but we were able to correct it during post-production. Lastly, access to the site was only permitted through museum visits. Again, we combined photos taken by both camera bodies.

Figure 12. Overall and detailed photos of the graffiti on the fresco *della Piattaia* (Palazzo Altemps).

5.3. Data Visualisation

Some procedures modified the image to extract significant information from the inscriptions. First, the image was contrasted to increase the readability of the letters. Next, a segmentation algorithm was applied to extract edges at which colour variation occurs. The instrument is called Trace Contour in Photoshop (Adobe) within the Stylize Filters. The Trace Contour filter finds the transitions between major brightness areas and thinly outlines them for an effect similar to the lines in a contour map. The user can set the level for evaluating colour values and specify whether to outline pixels that are below (Lower) or above (Upper) that level. The application of this filter made it possible to extract all the letters automatically. In the process, other incisions with similar texture as the letters have been extracted. In addition, it is shown in this extraction that the letters that have suffered edge deterioration have an unrecognisable edge geometry (Figure 13). Therefore, manual cleaning was carried out at this stage to increase the letters' readability. Engaging in this regard could be the application of AI algorithms capable of recognising and extracting known shapes beyond the edge variation undergone over time. The image with the lettering served as a starting point for further processing.

Tests were conducted for the different case studies, employing various image-processing techniques to enhance the legibility of inscriptions. As depicted in Figure 14, we

Figure 13. Image processing steps: contrasted image, features extracted and outliers cleaned.

Figure 14. Before and after processing of the graffiti photos in San Lorenzo in Lucina.

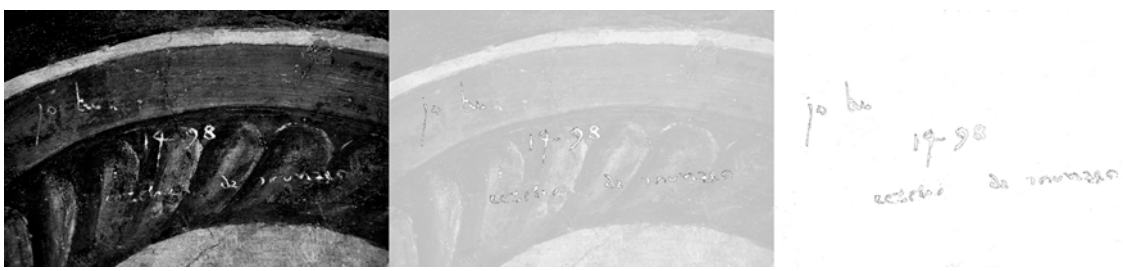

Figure 15. Some examples of the techniques applied to increase the legibility of the graffiti at Palazzo Altemps.

adjusted contrast and brightness via the tonal curves, employing layer masks to selectively enhance the visibility of the graffiti marks, which were comparatively less discernible and legible than the epigraphs.

These techniques involved isolating the inscriptions in post-production and overlaying them with transparency onto the photos (Figure 15). Additionally, we experimented with placing the inscriptions against a white background to improve their readability further. Again, image segmentation algorithms were applied, specifically operating with the colour data, and followed by a manual cleaning step to refine the extracted shapes.

In summary, the operational steps involved the creation of a suitable photographic shooting plan, considering the environmental conditions. Next, the selected images were rectified or extracted via orthorectification. Finally, adjustments were made to parameters such as brightness and contrast, followed by text extraction.

Besides, AR stands out as one of the most intriguing tools we have encountered. It offers possibilities for improving the legibility of inscriptions by overlaying images onto the target object, as well as incorporating historical information or written translations. Another significant aspect we consider is the introduction of audio files embedded in the AR application. This latter can help in making the previously

Figure 16. Some images with AR experimentation from two specific points of view.

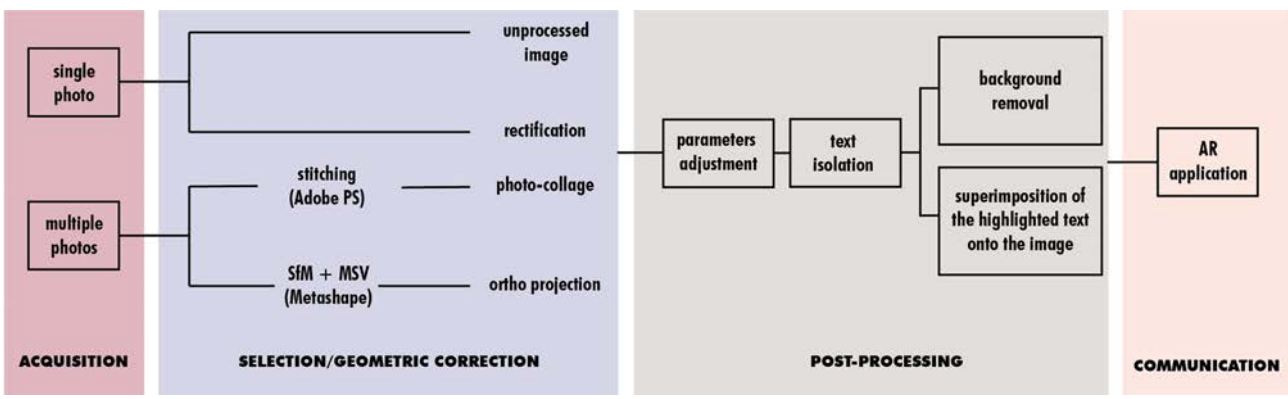

Figure 17. Workflow from the acquisition to the final image.

invisible and incomprehensible signs understandable to the broader public. Our goal is to further develop and explore the potential of AR applications, considering ways to enhance their capabilities (Figure 16).

The following is a workflow (Figure 17), the result of experimentation on a few examples, which can be replicated and scaled up in similar situations.

6. Conclusions

The research proposed here at the early stage covers the digital documentation and valorisation of ancient and historical graffiti and 'minor' epigraphs in Rome. These artefacts represent a valuable source of information about ancient society, as a thought, a voice, is frozen in them, with the desire or not to communicate it, depending on its private or public character. The presence of these traces on architecture is often faint and barely visible or known. The communication of an asset, to be such, cannot devote itself only to the material aspect but also to all the relationships and interrelationships that coexist between the assets, the people who live in them and the architectures that host them. For this reason, the current valorisation project first considers the elements of the project that are vital for the definition of a communication and valorisation system for these particular artefacts. Then, taking some significant sites as an example, it identifies and analyses some primary aspects related to the communication project: the acquisition of data, its processing and visualisation. It is why the research, once a few significant examples have been identified, focuses primarily on the problems of acquiring these elements, which present different bottlenecks. Constructing correctly rectified images with sufficient resolution for reading is difficult, as it comes up against difficult boundary shooting conditions. We then experiment with extracting certain features or elements that can facilitate their reading. Finally, through constructing some itineraries and using AR, some connections in the territory of Rome are suggested to highlight the importance of these artefacts, suggesting new knowledge itineraries, which gives a new voice to these often-hidden precious artefacts.

Conflict of Interest

The authors declare no conflict of interest.

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References

Amato, G., Casarosa, V., Martineau, P., Orlandi, S., Santucci, R., & Giberti, L. M. C. (2014). Eagle - Europeana Network of Ancient Greek and Latin Epigraphy, A Digital Bridge to the Ancient World. In P. Ronzino & F. Niccolucci (Chairs), *EPC 2014 Horizon2020 and Creative Europe vs Digital Heritage: A European Projects Crossover: Proceedings of the Workshop on Horizon2020 and Creative Europe vs Digital Heritage: A European Projects Crossover. Flash News co-located with the International Conference Museums and the Web Florence 2014 (MWF 2014)*, Florence, Italy.

Antonetti, C., Matijašić, I., Vido, S. de, & Mignosa, V. (2017). Digital Epigraphy at the Greek Epigraphy Laboratory, Ca' Foscari University of Venice. *Historika, 7 - Atti del V Seminario Avanzato di Epigrafia Greca*, 491–502.

Barmpoutis, A., & Bozia, E. (2017). Augmenting the Workspace of Epigraphists. An interaction design study. In S. Orlandi, R. Santucci, F. Mambrini, & P. M. Liuzzo (Eds.), *Collana Convegni: Vol. 36. Digital and Traditional Epigraphy in Context. Proceedings of the EAGLE 2016 International Conference* (209-220). Sapienza Università Editrice.

Barmpoutis, A., Bozia, E., & Wagman, R. S. (2010). A novel framework for 3D reconstruction and analysis of ancient inscriptions. *Machine Vision and Applications*, *21*(6), 989–998. https://doi.org/10.1007/s00138-009-0198-7

Benefiel, R., & Sypniewski, H. M. (2020). *Italia epigrafica digitale II: Volume 1.2.5: Regio I - Latium et Campania. Fascicolo V. Pompeii - Tituli scariphati.* EDR - Epigraphic Databse Roma, Dipartimento di Scienze dell'Antichità, Sapienza Università di Roma.

Bianconi, D. (2014). Paleografia: riflessioni su concetto e ruolo. In D. Bianconi (Ed.), *Bollettino dei Classici. Supplemento: Vol. 29. Storia della scrittura e altre storie* (pp. 7–29). Accademia Nazionale dei Lincei.

Blennow, A. (2012). Inscriptions and graffiti in San Lorenzo in Lucina. In O. Brandt (Ed.), *Skrifter utgivna av Svenska institutet i Rom. 4°: 61 = Acta Instituti Romani Regni Sueciae. 4°, 61. San Lorenzo in Lucina: The transformations of a Roman quarter* (pp. 207–233). Swedish Institute in Rome.

Bolettieri, P., Casarosa, V., Falchi, F., Vadicamo, L., Martineau, P., Orlandi, S., & Santucci, R. (2015). Searching the EAGLE Epigraphic Material Through Image Recognition via a Mobile Device. In G. Amato, R. Connor, F. Falchi, & C. Gennaro (Eds.), *LNCS Sublibrary: SL3 – Information Systems and Applications, incl. Internet/Web, and HCI: Vol. 9371. Similarity Search and Applications: Proceedings of the 8th International Conference, SISAP 2015, Glasgow, UK, October 12-14, 2015* (pp. 351–354). Springer International Publishing. https://doi.org/10.1007/978-3-319-25087-8_35

Bozia, E., & Barmpoutis, A. (2017). Augmented Reality for Epigraphy: How to bring holograms of inscriptions to your classrooms. In *Proceedings of CIEGL17: 15th International Congress of Greek and Latin Epigraphy, 2017*.

Bozia, E., Barmpoutis, A., & Wagman, R. S. (2014). Open-Access Epigraphy. Electronic Dissemination of 3D-digitized Archaeological Material. In S. Orlandi, R. Santucci, V. Casarosa, & P. M. Liuzzo (Eds.), *Collana Convegni: Vol. 26. Information Technologies for Epigraphy and Cultural Heritage: Proceedings of the First EAGLE International Conference* (421–435). Sapienza Università Editrice.

Brandt, O. (Ed.). (2012). *Skrifter utgivna av Svenska institutet i Rom. 4°: 61 = Acta Instituti Romani Regni Sueciae. 4°, 61. San Lorenzo in Lucina: The transformations of a Roman quarter.* Swedish Institute in Rome.

Felle, A. E. (2022). Scritture esposte e graffiti. Alcune note di riflessione. In G. Cavallo & A. E. Felle (Series Eds.) & D. Ferraiuolo (Vol. Ed.), Quaderni delle "Inscriptiones Medii Aevi Italiae": I. La dimensione spaziale della scrittura esposta in età medievale: Discipline a confronto. Atti del Convegno di studio, Napoli, 14-16 dicembre 2020 (pp. 1–14). Fondazione Centro italiano di studi sull'alto Medioevo.

Genette, G. (1982). *Palimpsestes: La littérature au second degré. collection Poétique.* Seuil.
Istituto della Enciclopedia Italiana fondata da Giovanni Treccani S.p.A. (2023, July 6). *paleografia nell'Enciclopedia Treccani.* https://www.treccani.it/enciclopedia/paleografia

Keegan, P. (2014). *Graffiti in antiquity.* Routledge.

Lambert, C. (2004). *Pagine di pietra: Manuale di epigrafia latino-campana tardoantica e medievale. Taccuini di Ippocrate: Vol. 2.* CUES.

Morstein-Marx, R. (2012). Political Graffiti in the Late Roman Republic: "Hidden Transcripts" and "Common Knowledge". In C. T. Kuhn (Ed.), *Alte Geschichte. Politische Kommunikation und öffentliche Meinung in der antiken Welt* (pp. 191–217). Franz Steiner.

Panciera, S. (1998). Epigrafia: una voce soppressa. *Archeologia Classica*, 50, 313–330.

Petrucci, A. (1978). Per la storia dell'alfabetismo e della cultura scritta: metodi – materiali – quesiti. In A. Petrucci & A. Bartoli Langeli (Eds.), *Pubblicazioni degli Istituti di Storia della Facoltà di Lettere e Filosofia (Perugia). Alfabetismo e cultura scritta nella storia della società italiana. Atti del Seminario tenutosi a Perugia il 29-30 marzo 1977* (pp. 33–47). Università degli Studi di Perugia.

Petrucci, A. (1985). Potere, spazi urbani, scritture esposte: proposte ed esempi. In *Collection de l'École française de Rome: Vol. 82. Culture et idéologie dans la genèse de l'Etat moderne: Actes de la table ronde organisée par le Centre national de la recherche scientifique et l'Ecole française*

de Rome Rome, 15-17 octobre 1984 (pp. 85–97). L'Ecole Française de Rome.

Petrucci, A. (1996). Au-delà de la paléographie: histoire de l'écriture, histoire de l'écrit, histoire de l'écrire. *Bulletin de la Classe des Lettres et des Sciences morales et politiques de l'Académie royale de Belgique*, 7(6), 123–135.

Solin, H. (2008). Introduzione allo studio dei graffiti parietali. In O. Brandt (Ed.), *Skrifter utgivna av Svenska institutet i Rom. 4°: Vol. 59. Unexpected voices: The graffiti in the cryptoporticus of the Horti Sallustiani and papers from a conference on graffiti at the Swedish Institute in Rome, 7 March 2003* (pp. 99–124). Svenska Institutet i Rom.

Susini, G. C. (1982). *Epigrafia romana. Guide: Vol. 9*. Jouvence.

van der Vliet, J. (2021). Inscribing Space in Christian Egypt. In R. Raja & E. Frood (Series Eds.) & A. E. Felle & B. Ward-Perkins (Vol. Eds.), *Contextualizing the Sacred: Vol. 2. Cultic graffiti in the Late Antique Mediterranean and beyond* (91-102). Brepols.

Volpe, R. (1982). I graffiti isiaci nell'area di S. Sabina a Roma. In U. Bianchi & M. J. Vermaseren (Eds.), *Études préliminaires aux religions orientales dans l'Empire romain: Vol. 92. La soteriologia dei culti orientali nell' Impero Romano: Atti del Colloquio Internazionale su La soteriologia dei culti orientali nell'Impero Romano. Roma 24-28 settembre 1979* (pp. 145–155). Brill.

Eternal Witnesses—Documentation and Analysis of Carved Historic Graffiti and Inscriptions on Stone Surfaces

Ruth Tenschert [1,*], Leander Pallas [1], Sebastian Kempgen [2] and Paul Bellendorf [1]

[1] Centre for Heritage Conservation Studies and Technologies (KDWT), Otto-Friedrich-Universität Bamberg, 96047 Bamberg, Germany; E-Mails: ruth.tenschert/leander.pallas/paul.bellendorf@uni-bamberg.de
[2] Slavic Linguistic, Otto-Friedrich-Universität Bamberg, 96047 Bamberg, Germany;
E-Mail: sebastian.kempgen@uni-bamberg.de
* Corresponding author

Abstract

High-resolution documentation of graffiti carved into stone surfaces can help read nearly illegible characters. They can fade out due to outdoor conditions like weathering or biological coating. Indoor, the illegibility can be caused by delicately carved graffiti on a hard stone with a polished or shiny surface. These witnesses of people from former times are nonetheless important to tell stories about the place or object and help to enrich its history. This research aims to show how 3D scanning, especially structured light scanning, can help adequately document and analyse carved graffiti. Therefore, two case studies are discussed in this paper, highlighting different challenges while recording: an abandoned quarry in Bavaria, Germany, illustrating the problems of deteriorated surfaces with biological colonisation outdoors, and a gravestone in North Macedonia illustrating challenges occurring indoors with shiny, polished stone surfaces. The advantage of 3D documentation is, in both cases, to facilitate analyses, help researchers from different scientific backgrounds, and visualise and disseminate the results in a suitable way.

Keywords

3D scanning; Deterioration; Graffiti; Multilevel documentation; Stone surfaces

1. Introduction

To document particularly hard-to-read inscriptions and carved graffiti at cultural heritage sites, 3D technologies offer many advantages (Tenschert et al., 2018). To illustrate both the challenges and potentials of these techniques, this paper discusses two case studies of graffiti and inscriptions on different stone surfaces. First of all, the so-called Fingalshöhle, situated near Illesheim in Bavaria, Germany, holds dual significance as both an archaeological and a historical cultural heritage site (Bayerisches Landesamt für Denkmalpflege, 2022a, 2022b; Bayerisches Landesamt für Umwelt [LfU], 2022). The location is an abandoned sandstone quarry that has been gradually reclaimed by nature and the surrounding woods over the course of several centuries (Figure 1). The stones quarried here were used to build the town walls of a nearby city in the early modern period. Historical research indicates that even after the cessation of stone mining, the site remained in use during the Thirty Years' War (1618–1648) and later, from 1806 during the Napoleonic Wars (1804–1815), as a field quarters for German and French troops. During their stay, the soldiers carved many inscriptions, characters and dates into the sandstone walls. In the later 18th and 19th centuries, the abandoned site became a popular destination for visitors from the nearby castle and villages, who found in this place an example of the wild landscape, aligning with the ideals of the Romanticism movement of that era (Schultheiß, 1986).

There are many challenges at the site; the quarry is gradually disappearing into the surrounding wood, and the characters are being erased by ongoing deterioration due to moisture and biological coatings (Figure 2). Therefore, the site was recorded with a multilevel documentation approach using a combination of terrestrial laser scanning (TLS) and high-resolution structured light scanning (SLS). This approach will help preserve this remarkable location, along with its 300 years of graffiti and inscriptions in at least a digital form (Tenschert et al., 2023).

The second case study is the gravestone of St. Kliment, in Ohrid, North Macedonia (Figure 3). Sveti Kliment (English: Clement of Ohrid, ca. 840–916) participated as a disciple of Saints Cyril and Methodius in the Christianisation of the Slavs in Bohemia. After their return to the Bulgarian Kingdom, he became the first bishop of the Bulgarian Orthodox Church with his seat in Ohrid, where he founded the "Ohrid Literary School", writing and translating many works and educating thousands of young priests. Many important Old Church Slavonic manuscripts stem from the region as a result of his educational efforts. Kliment was canonised shortly after his death and is regarded today as the patron saint of Northern Macedonia. He was buried in Ohrid in a grave prepared by himself. Later, his grave was marked by a gravestone with an inscription that today is the only extant inscription and

Figure 1. Areal view of the Fingalshöhle in March 2023.

Figure 2. Section of the sandstone wall, highlighting the issues of biological growth.

Figure 3. The gravestone of St. Kliment in the chapel of the Perivlepta church in Ohrid.

gravestone for any of the so-called "Seven Apostles of the Bulgarian Orthodox Church" in a Slavic country. Prochor, an important successor to Kliment as an Archbishop in Ohrid, was given the honour of being buried and commemorated alongside Saint Kliment with the same gravestone (Kempgen, 2017; Knoben, 1974; Schäfer, 2020).

The gravestone itself is a narrow, largely undecorated stone slab, which today can be found in a chapel of the Perivlepta church in Ohrid. The flat and shiny stone carries not only the inscription dedicated to the saint but also another line of characters above. These characters have already been discussed in relevant Slavic research (Kempgen, 2017), but the exact content varies throughout the different sources and is probably subject to similar errors as the reading of the inscription of St. Kliment itself (Kempgen, 2016, 2017). Therefore, high-resolution documentation was needed to analyse the characters further.

2. Historic Carved Graffiti and Their Documentation

Carved inscriptions and graffiti have been popular but also challenging objects of study, as they vary considerably in terms of size, form and location. Whereas inscriptions are usually located, for example, on buildings (with a specified date) or tombstones, graffiti can be spotted almost everywhere. Graffiti encompass marks that are scratched, drawn, painted, or otherwise applied to various surfaces and can include characters, sketches or meaningless lines (Woolfitt & Fairchild, 2021). Historic graffiti hold great value as a source of information for the history or use of a building or site at a certain time and are sometimes the only witnesses of visitors, or means by which interventions can be dated. Consequently, they hold significant importance alongside inscriptions in understanding the complex history of cultural heritage sites. Traditionally, the process of documenting inscriptions and graffiti involved manual tracing with paper and pencil (Valente & Barazzetti, 2020). This technique can be used for graffiti or inscriptions big enough to be traced by paper and pencil and only on surfaces that are not endangered to be damaged by physical contact. Valente et al. (2019) mention this problem regarding graffiti on fragile fresco surfaces where contact should be avoided for conservation reasons. Therefore, non-contact technologies are preferable for these cases.

Newer digital technologies for the 3D documentation of carved inscriptions and scratched graffiti still face a wide variety of challenges. These can include the size and depth of the letters or drawings (Tenschert et al., 2023; Tenschert et al., 2018; Valente et al., 2019), the fragility of the surfaces, and even the material they are scratched in, as mentioned above, frescos (Valente & Barazzetti, 2020; Valente et al., 2019) or shiny, polished marble (Abate & Trentin, 2019; Tenschert et al., 2018).

A relatively common research activity concerning graffiti and inscriptions is deciphering and dating the characters or drawings, sometimes to decide whether the currently understood content and date are correct (Tenschert, 2019). In many cases, however, the main aim of (3D) documentation and research on graffiti and inscriptions is to make faded or faintly discernible scripts readable again, ideally using non-contact methodologies (Greco & Flouda, 2017; Papadaki et al., 2015; Tenschert et al., 2023; Tenschert et al., 2018).

2.1. Multilevel Documentation of the Fingalshöhle

While there are various ways of documenting locations with graffiti and inscriptions, for this specific case study and the numerous challenges of this unique site, a multilevel documentation workflow as described in Tenschert et al. (2023) was applied, including terrestrial laser scanning and high-resolution structured light scans. First, a Faro Focus S350 was used for 20 scanning positions to obtain an initial terrestrial laser scan of the entire area. Due to the size of about 1225 square meters and the complex shape of the five quarry walls, laser scanning was considered the most efficient method for capturing and recording the entire site (Figure 4). Each scan was carried out using the device's parameters of 1/2 (resolution) and 2 (quality), resulting in approximately 174.8 million points per scan, with a 3D point distance of 3 mm at a distance of 10 m. The positions for scanning were selected to ensure coverage of all parts of the five main stone walls. Work was carried out in winter when the vegetation was less abundant to minimise the obstruction of the laser beam due to leaves and branches of the bushes and trees. The 20 individual scans were registered using the point cloud registration algorithm in Faro Scene software (Version 2020.0.7), and the recorded images taken by the scanner's built-in High Dynamic Range (HDR)-camera used to texture

the point cloud. Trees and bushes were manually removed from the 3D point cloud in areas next to the stone walls to increase the quality of the resulting point cloud. In addition, points recorded at a sharp angle to the walls were manually erased to reduce surface noise and improve the visibility and clarity of the graffiti and inscriptions (Tenschert et al., 2023).

In addition, high-resolution structured light scanning data of characters and writings that are barely readable or threatened due to their exposed location were recorded (Tenschert et al., 2023). An Artec EVA scanning device with Artec Studio 15 software was used to carry out the high-resolution scanning of these more delicate graffiti and inscriptions (Figure 5). The settings ensure a 3D point distance of up to 0.2 mm, though depending on the surface, a point distance of 0.5 mm to 1.0 mm was more likely (Artec3D, 2020). The device and resolution were chosen for this case study to ensure that the recording can be performed outdoors without a power supply and that even filigree scratchings are properly recorded. The approximately 30 most vulnerable graffiti and

Figure 4. Point cloud overview of the 1225 m² area of the abandoned quarry; the point could serve as a basis for a ground floor plan and as a general 3D documentation.

inscriptions were documented while the area of interest was in shadow, or using an umbrella to shield the surface from bright sunlight. The filigree organic structures (moss, algae and lichens) on parts of the inscriptions and graffiti covered with organic material, particularly in moist areas, were particularly difficult to capture. To enhance the quality of the surface model from the software's sharp fusion algorithm, the post-processing of each data set in Artec Studio 15 was carried out with a global registration followed by outlier removal (Tenschert et al., 2023).

Figure 5. Conducting the 3D scan in the Fingalshöhle with the Artec EVA.

2.2. High-resolution SLS of the Gravestone of St. Kliment

In May 2023, a Comet L3D 5M from Zeiss Optotechnik (formerly Steinbichler Optotechnik) was used for the three-dimensional measurement of the surfaces of the gravestone of St. Kliment. While not handheld, this SLS device is nevertheless portable and thus can be used on-site; it is particularly effective when used indoors (away from direct sunlight). The measurements are entirely contactless with only a projection of blue LED light, and are thus harmless to the stone surface. Although it is susceptible to the slightest vibrations and changes in light, the device scans the surface with exceptional accuracy and geometric detail. This method has proven to reveal even the finest details in the sub-millimetre range and measure tiny changes in cultural

Figure 6. Scanning the gravestone of St. Kliment in Ohrid using the Comet L3D 5M with two different resolutions and, therefore, different areas to capture, left: 260 mm x 215 mm at 0.1 mm point spacing, right: 74 mm x 62 mm at 0.03 mm point spacing.

heritage objects over time (Bellendorf et al., 2022; Degrigny et al., 2020; Rahrig et al., 2018).

The Comet L3D 5M was used because of its flexibility regarding the resolution; by changing the pair of lenses on the sensor, the measuring field of the scanner can be adapted to the desired surface resolution. The entire gravestone was recorded with the 250 mm lenses, which can record an area of 260 mm x 215 mm (with a depth of field of 140 mm), yielding a mean point spacing of 0.1 mm (Figure 6 left) (Steinbichler Optotechnik GmbH, 2014). In total, the recording consists of 46 individual scans, taken with an overlap of more than 50 %. This part of the gravestone was recorded in higher resolution to ensure that the delicate characters on the top of the stone could be analysed with the highest possible accuracy. These 21 scans were performed with a second set of lenses, ensuring a 3D point distance of 0.03 mm while covering an area of 74 mm x 62 mm (with a depth of field of 45 mm) per single acquisition (Figure 6 right) (Steinbichler Optotechnik GmbH, 2014). It was decided to use a structured light scanner that specialises in highly accurate acquisition of the stones' surface geometry, since the texture information is not needed to analyse the characters further (see also Tenschert et al. (2018)). Without the texture information, the surface structure is more obvious and can be virtually investigated in great detail using raking light generated with artificial light sources. Due to the high-resolution documentation of the surface topography in the sub-millimetre range, surface features of the strokes of the characters can be detected and analysed precisely to ensure a correct transcription.

The CometPLUS v.9.96 software processed the scans, performing a constrained matching calculating an iterative-closest point matching (ICP/'best-fit') and mesh building algorithm. The mesh resulting from the triangulation process was imported into Geomagic Wrap v.2021 to align the model orthogonally along a plane to simplify the export of views. After aligning the models, they were imported into the Aspect3D v 16.5 rev. 8586 (Arctron GmbH). Using this software, orthoimages were generated at a scale of 1:1 and 900 DPI under artificial raking light to highlight the surface structures.

3. Discussion and Results

As discussed by Valente et al. (2019), scratched graffiti can be extremely difficult to document, because of the main problems like the small size of the scratchings and the poor visibility due to unpleasant surface conditions, e.g. physical lacks, and unfavourable lighting conditions. Another main issue Valente et al. (2019) mention is the presence of different overlapping layers of graffiti, which makes it hard to separate the strokes. In the case of the quarry, these difficulties are caused not only by poor visibility due to outdoor lighting conditions (shade, sunshine) but also by bad stone surface conditions, moisture, minimal scratch depth, multiple layers of writing and, particularly in this case, the growth of lichen and moss and natural erosion. To use close-range photogrammetry (Samaan et al., 2016; Valente & Barazzetti, 2020; Valente et al., 2019) for the vulnerable graffiti and inscriptions was considered especially due to its flexibility regarding the camera used and the cost efficiency, but ultimately, it was decided to use SLS with the above-mentioned device and software. This ensures real-time feedback, and it could be verified on-site whether the recording was sufficient and successful. Using RTI (Reflectance Transformation Imaging), as suggested in previous research (DiBiasie Sammons, 2018), was considered but considered impractical due to the outdoor environment with uncontrolled lighting. DiBiase Sammons describes this single camera multiple light positions method as suitable for smaller graffiti that can help to decipher them (DiBiasie Sammons, 2018). As the method depends on controlled light settings, it is not so efficient outdoors. Valente et al. (2019) mentioned that even indoor conditions with ambient light can decrease the effectiveness of the RTI method. The position of the gravestone of St. Kliment was a determining factor as well, as the lack of space in the narrow corner where it is situated was deemed too impractical for RTI. The handheld SLS scanner mentioned above was also considered; however, the accuracy and precision of the Artec EVA scanner (as well as the more accurate device from the same manufacturer, the Artec Space Spider) were found to be insufficient to detect the delicate carvings on the gravestone.

3.1. The Graffiti and Inscriptions of the Fingalshöhle

The written testimonies to this site's diverse history are today threatened by the ever-increasing encroachment of the surrounding wood into the abandoned quarry and, above all, by unavoidable weathering processes affecting the unprotected stone, which will only be intensified by the effects of climate change in the future. Some photographs of the stone walls show that even over periods as short as the last 10–15 years, climatic effects have completely obliterated some of the graffiti and inscriptions. In addition, the growth of moss and lichen on stone exposed to an outdoor climate is a well-known problem for cultural heritage (Bertolin, 2019; Cozzolino et al., 2022; Daly, 2019; R. Drewello, 2004; R. Drewello & Drewello, 2009; U. Drewello & Drewello, 2013; Wilhelm et al., 2020). The main problems of the stone walls, as categorised in the ICOMOS glossary on stone

Figure 7. Area of the stone walls of the Fingalshöhle showcasing deterioration caused by weathering and the overgrowth with lichens, algae and moss.

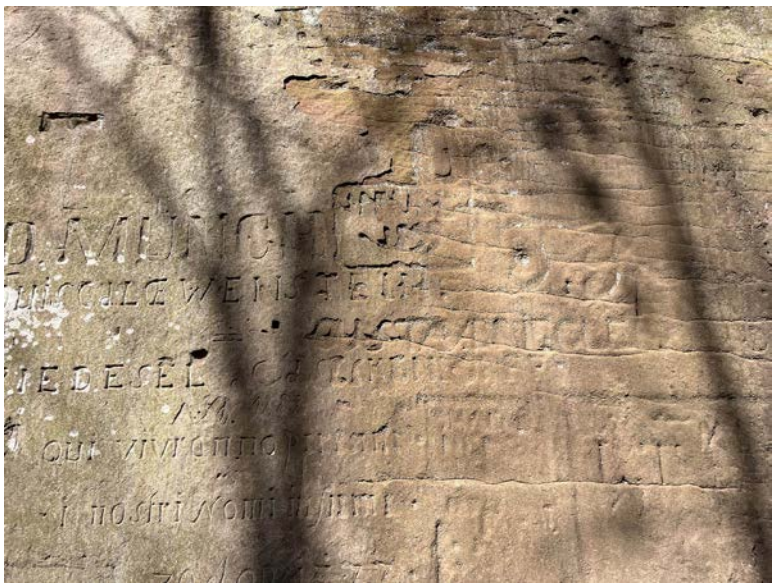

Figure 8. Area of the stone walls of the Fingalshöhle showcasing deterioration caused by weathering and water drainage.

Figure 9. Orthophoto of an area of the 107 meters of stone walls of the Fingalshöhle, showcasing graffiti readable in the TLS-data (left and right), also visible are the moist areas in darker grey.

deterioration patterns (ICOMOS - International Scientific Committee for Stone [ISCS], 2010), are erosion, mechanical damage and biological colonisation, as well as moist areas due to water drainage (Figures 7 and 8). Because of these ongoing deterioration processes, the graffiti and inscriptions in the former quarry are slowly but steadily being erased.

The aim of this work is, as already mentioned in Tenschert et al. (2023), to create a basic documentation which should preserve, at least in digital form, the current state of the cultural heritage site since the deterioration and decay could only be stopped with massive interventions to the quarry itself, for example, the construction of a roof. The documentation will enable further research and allow future generations to experience and explore this multi-layered site.

As mentioned in Tenschert et al. (2023), three stone walls show different kinds of inscriptions and graffiti: The size and arrangement differ widely, as well as the depth of the carvings. Whilst some of the characters and sketches are quite delicate and filigree and are therefore nearly invisible today, others are scratched very deeply into the sandstone

and can even be read in the TLS data (Figure 9). Some inscriptions are very well arranged with small sketches or drawings, for example, a group of writings with a military theme that serve as witnesses of the quarry's use as quarters for both German and French troops (also described in Schultheiß, 1986; Tenschert et al., 2023). Some of the graffiti and inscriptions are dated, and some just give a name. There are numerous inscriptions and graffiti, and one can also find traces of installations and many bullet holes in the area of the quarry, illustrating the site's usage and history in times of war. Some inscriptions and graffiti are clearly visible, but many are unreadable either in photographs (with raking light) or with the naked eye. The content of these examples of carved witnesses was only revealed using the high-resolution scanning data from the SLS. On the other hand, the larger and deeply scratched graffiti and inscriptions can be read using the orthophotos from the TLS point cloud. The inscriptions and graffiti on the stone walls have neither a specific order nor systematic arrangement, and some even overlap (Tenschert et al., 2023). Particularly interesting are the writings from visitors during the 19th century that can be addressed as graffiti: The visitors immortalised themselves with engravings in a great variety of ways. The writings often include a name and sometimes a place where the person came from, so one can begin to tell the story of the people visiting this place over time (Figure 10). There are also graffiti from the 20th century with mainly the name of the visitor and the year. The last group generally seems to take less

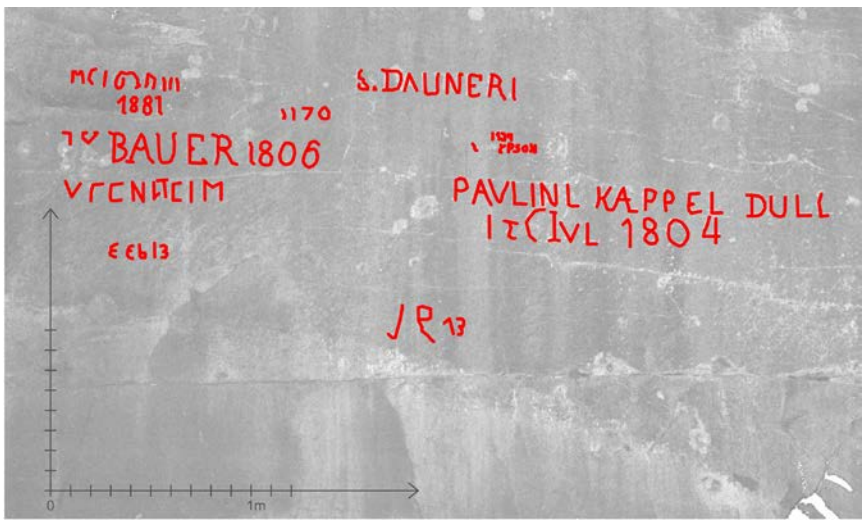

Figure 10. Orthogonal image of the TLS- data with transcription of the readable graffiti, showcasing on the left that a person called Bauer from Uffenheim (a village in Bavaria) visited the site in 1806 (see also Tenschert et al. (2023)).

Figure 11. Graffiti mentioning "H. v. Seckendorff" and the more delicately carved "G. Krahiser v. Sontheim" above, unreadable in photographs with different lighting and moisture conditions.

Figure 12. Graffiti quoting Johan F. Osterch. Comparison of the barely readable photo with the 3D model.

account of existing inscriptions than the others. They are sometimes even written over existing letters (Tenschert et al., 2023).

With the help of the 3D documentation, it was possible to rediscover some previously lost graffiti and inscriptions. An example of a nearly unreadable graffiti is shown in Figure 11: Above a deeply scratched graffiti, mentioning "H. v. Seckendorff", there is another with more delicately scratched characters mentioning "G. Krahiser v. Sontheim" (Sontheim is a nearby village) (Tenschert et al., 2023). The Seckendorff family is an old noble Franconian family and the

Figure 13. Graffiti quoting L. SchAUMAN. Comparison of the barely readable graffiti in a photo and in the orthophoto of the 3D model.

H. v. Sekkendorff mentioned might have been serving in the Bavarian army (Pierer, 1862).

Another example is a graffito with the words "Johan F: Osterch" (Figure 12). Due to the progressive erosion and the growth of lichen, especially in the lower half of the picture, it was difficult to decipher the letters. To the right and below this graffiti, the letters "K" and "H" could also be made out, as well as a curved line above, which, only recognisable in the 3D model, contains an "M".

Another example is letters that can be combined to form "L. SchAUMAN", but both moss and lichen combine to make the lower area barely legible (Figure 13). In the 3D surface model, however, further letters can be recognised, which could indicate the name of a place or of another person.

3.2. Gravestone of St. Kliment

The gravestone itself, a variety of marble or soapstone, was difficult to record due to its shiny surface, and the

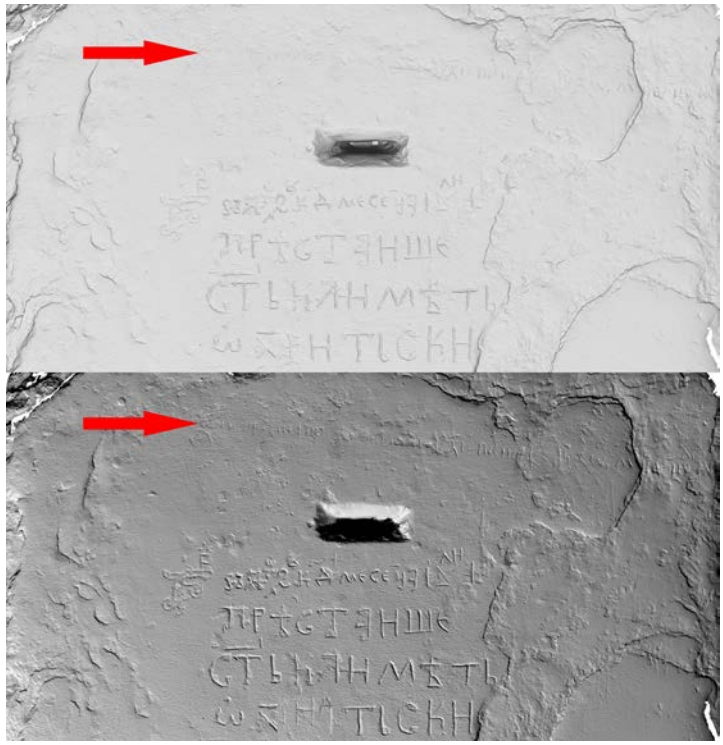

Figure 14. 3D model of the gravestone of St. Kliment. Above illustrated without artificial raking light with a mean point distance of 0.1 mm, below with raking light at the same resolution, the original inscription is clearly visible, the line of characters with the second epitaph starts at the red arrow.

Figure 15. 3D model of the line of characters with higher resolution (3D point distance of 0.03 mm) cut in the middle and illuminated artificial raking light to ensure the characters can be read. Red: Cyrillic characters and English translation.

various colours of the stone made reading the characters nearly impossible with the naked eye. The characters are not scratched deeply into the stone surface, and the single strokes are filigree. Similar to the Graffiti in St. Naum, this combination of shiny surface and delicate carving proved difficult to record (Tenschert et al., 2018). These challenges can lead to an insufficient or incorrect reading of the letters.

With the textureless high-resolution 3D models, it is now possible to investigate the characters in great detail without complications caused by the surface colour. The slight, wave-like noise in the 3D data cannot be avoided due to the stone structure and shiny surface, but it is negligible and does not affect the Slavists' evaluation and the readability of the characters. Therefore, this kind of documentation can contribute to clarifying the meaning of the characters.

On the gravestone of St. Kliment of Ohrid (840–916), whose epitaph (from the 14th century) was the primary focus of attention in the project, there is a second epitaph at the top of the stone dedicated to Archbishop Prochor of Ohrid (tenure 1528–1550), which was therefore engraved much later (and much smaller) (Figures 3, 14 and 15). Apparently, the archbishop was also buried here, because the Perivlepta Church was the city's main church at that time (during Ottoman rule) and thus Prochor's place of activity. The characters can be seen in a photograph with improvised lighting, but the problems are immediately apparent; reading the text properly is impossible. The exact contents of this line have been widely discussed in the relevant literature, but its reading in the various sources varies and is probably subject to similar errors as the reading of the inscription of St. Kliment itself (Kempgen, 2016, 2017).

The content is thus clear in principle, but the exact reading remains to be checked, corrected and completed if necessary, as indicated by the bracketed parts. For example, such a formulaic inscription usually includes the date of death, which should appear at the very end. So far, there is no indication in the literature as to whether this number is still present or legible (Figures 14 and 15).

4. Conclusions

The multilevel documentation approach for the abandoned quarry employing TLS and SLS was deliberately selected to achieve comprehensive documentation of the entire archaeological and cultural heritage site while also providing detailed records of the most vulnerable and delicate graffiti. The chosen methodology allows future investigations and interdisciplinary research, especially in the face of weathering effects and damages caused by moisture and natural erosion of the surveyed quarry, which will likely lead to further deterioration over time. It was not only possible to record and document this unique site, but it was also possible to make some of the most vulnerable and faded-out graffiti readable again. These analyses can serve as a basis for future research on the visitors and the use of the quarry itself. Furthermore, this dataset can serve as a basis to monitor the condition, enabling the measurement of weathering effects.

Along with the objective of documenting the current state of the site in digital form, ensuring its availability for future generations, new clarities could be found about the characters above the inscription for the saint himself on the gravestone of St. Kliment in Ohrid. The stone surface was challenging to record, but the chosen device and method did lead to satisfying results suitable for further research. With the help of the high-resolution 3D surface model of the stone and the ability to investigate the characters more accurately than in a photograph, it was possible to prove—due to the help of virtual raking light—that the reading previously suggested by the Slavic research is correct.

The two case studies highlight that stone surfaces can be challenging due to different factors when exposed outdoors or indoors. Nonetheless, the 3D documentations enable analyses and further research. For future work, it is planned to share the data with the local administrations, the public, and researchers, storing them in a digital repository to make it available.

Conflict of Interest

The authors declare no conflict of interest.

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References

Abate, D., & Trentin, M. G. (2019). Hidden graffiti identification on marble surfaces trough photogrammetry and remote sensing techniques. *ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, XLII-2/W15, 1–8. https://doi.org/10.5194/isprs-archives-XLII-2-W15-1-2019

Artec3D. (2020). *Eva. Tragbarer 3D-scanner für Schnelles und Genaues Scannen.* https://cdn.artec3d.com/pdf/Artec3D-Eva-de.pdf

Bayerisches Landesamt für Denkmalpflege. (2022a). *Aktennummer D-5-6528-0295*. https://geoportal.bayern.de/denkmalatlas/searchResult.html?objtyp=boden&koid=926037

Bayerisches Landesamt für Denkmalpflege. (2022b). *Aktennummer D-5-75-133-13*. https://geoportal.bayern.de/denkmalatlas/searchResult.html?objtyp=bau&koid=87320

Bayerisches Landesamt für Umwelt. (2022). *UmweltAtlas Bayern. Ehemaliger Steinbruch "Fingalshöhle" WNW von Obernzenn.* https://www.umweltatlas.bayern.de/standortauskunft/rest/reporting/sb_geotope/generate?additionallayerfieldvalue=575G001

Bellendorf, P., Holl, K., & Löther, T. (2022). Opto-technisches Monitoring am Hochaltar in Döbeln – klimainduzierte Bewegungen sichtbar machen. *Die Denkmalpflege*, *80*(1), 44–48. https://doi.org/10.1515/dkp-2022-1009

Bertolin, C. (2019). Preservation of Cultural Heritage and Resources Threatened by Climate Change. *Geosciences*, *9*(6), article 250. https://doi.org/10.3390/geosciences9060250

Cozzolino, A., Adamo, P., Bonanomi, G., & Motti, R. (2022). The Role of Lichens, Mosses, and Vascular Plants in the Biodeterioration of Historic Buildings: A Review. *Plants (Basel, Switzerland)*, *11*(24), Article 3429. https://doi.org/10.3390/plants11243429

Daly, C. (2019). Preliminary results from a legacy indicator tool for measuring climate change related impacts on built heritage. *Heritage Science*, *7*, Article 32. https://doi.org/10.1186/s40494-019-0274-x

Degrigny, C., Boochs, F., Raddatz, L., Veller, J., Justus, C., & Pinette, M. (2020). Use of Imaging Techniques as a Support for the Preventive Conservation Strategy of Wall Paintings: Application to the Medieval Decors of the Château de Germolles. In A. El Moataz, D. Mammass, A. Mansouri, & F. Nouboud (Eds.), *LNCS sublibrary: SL 6 - Image processing, computer vision, pattern recognition, and graphics: Vol. 12119. Image and Signal Processing: Proceedings of the 9th International Conference, ICISP 2020, Marrakesh, Morocco, June 4–6, 2020* (pp. 24–34). Springer International Publishing. https://doi.org/10.1007/978-3-030-51935-3_3

DiBiasie Sammons, J. F. (2018). Application of Reflectance Transformation Imaging (RTI) to the study of ancient graffiti from Herculaneum, Italy. Journal of Archaeological Science: Reports, 17, 184–194. https://doi.org/10.1016/j.jasrep.2017.08.011

Drewello, R. (2004). Denkmalpflege und Ökologie am Beispiel der Wallmauern der Festung Rosenberg in Kronach. In F. Brickwedde & A. Weinmann (Eds.), *Initiativen*

zum Umweltschutz: Vol. 59. Nachhaltiger Schutz des kulturellen Erbes - Umwelt und Naturgüter: 9. Internationale Sommerakademie St. Marienthal (pp. 191–204). Schmidt.

Drewello, R., & Drewello, U. (2009). Flechten auf Denkmälern: Indikatoren und Vermittler zwischen Denkmal- und Naturschutz. In A. Beck (Ed.), *Rundgespräche der Kommission für Ökologie: Vol. 36. Ökologische Rolle der Flechten: Rundgespräch am 13. Oktober 2008 in München* (pp. 161–180). Verlag Dr. Friedrich Pfeil.

Drewello, U., & Drewello, R. (2013). Mauervegetation: ein Gefährdungs- und Konservierungspotenzial für historisches Mauerwerk. In S. Siegesmund & R. Snethlage (Eds.), *Naturstein in der Kulturlandschaft* (pp. 108–117). Mitteldeutscher Verlag.

Greco, A., & Flouda, G. (2017). The Linear B *pa-i-to* Epigraphic Project. *Annvario Della Scuola Archeoligica Di Atene E Delle Missioni Italiane in Oriente*, *95*, 143–160.

ICOMOS - International Scientific Committee for Stone. (2010). *Illustrated glossary on stone deterioration patterns: English-German version; Englisch-Deutsche Fassung = Illustriertes Glossar der Verwitterungsformen von Naturstein. Monuments and sites: Vol. 15.* Michael Imhof Verlag GmbH & Co.

Kempgen, S. (2016). *Sv. Kliment Ohridski: His Tombstone and its Inscription.* Sv. Kliment Ohridski-University. Conference "1100 Years of Sv. Kliment Ohridski", Bitola. https://doi.org/10.20378/irb-50305

Kempgen, S. (2017). St Kliment Ohridski: His Tombstone and its Inscription (Summary). *Scripta & E-Scripta*, *16/17*, 9–13. https://doi.org/10.20378/irbo-53186

Knoben, U. (1974). Klemens von Ochrid. In E. Kirshbaum & W. Braunfels (Eds.), *Lexikon der christlichen Ikonographie: Band 7: Ikonographie der Heiligen: Innozenz bis Melchisedech* (pp. 324–325). Herder KG.

Papadaki, A. I., Agrafiotis, P., Georgopoulos, A., & Prignitz, S. (2015). Accurate 3D scanning of damaged ancient Greek inscriptions for revealing weathered letters. *ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, *XL-5/W4*, 237–243. https://doi.org/10.5194/isprsarchives-XL-5-W4-237-2015

Pierer, H. A. (1862). Seckendorff. In *Pierer's Universal-Lexikon der Vergangenheit und Gegenwart oder neuestes encyclopädisches Wörterbuch der Wissenschaften, Künste und Gewerbe. Fünfzehnter BAnd: Säugethiere - Sicilicus* (Vierte, umgearbeitete und stark vermehrte Auflage, pp. 724–727). Verlagsbuchhandlung H. A. Pierer.

Rahrig, M., Drewello, R., & Lazzeri, A. (2018). Opto-technical monitoring – a standardized methodology to assess the treatment of historical stone surfaces. *ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, *XLII-2*, 945–952. https://doi.org/10.5194/isprs-archives-XLII-2-945-2018

Samaan, M., Deseilligny, M. P., Heno, R., De La Vaissière, E., & Roger, J. (2016). Close-Range Photogrammetric Tools for Epigraphic Surveys. *Journal on Computing and Cultural Heritage*, *9*(3), Article 16, 1–18. https://doi.org/10.1145/2966985

Schäfer, J. (2020). *Klemens von Ohrid - Ökumenisches Heiligenlexikon.* https://www.heiligenlexikon.de/BiographienK/Klemens_von_Ochrid.html

Schultheiß, H. (1986). *Die Fingalshöhle im Sontheimer Holz.*

Steinbichler Optotechnik GmbH. (2014). *Comet®led. 3d digitizing. The new 3D sensor generation. Sensor overview / Technical data.*

Tenschert, R. (2019). Cathedral Notre Dame in Paris – the Inscription of the South Transepts Façade: Medieval Relict or 19th Century Recreation? ISPRS - *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, *XLII-2/W15*, 1141–1147. https://doi.org/10.5194/isprs-archives-XLII-2-W15-1141-2019

Tenschert, R., Pallas, L., & Bellendorf, P. (2023). Stone walls, characters, moos and trees – Multilevel documentation of inscriptions and graffiti from different centuries in a former sandstone quarry. *ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, *XLVIII-M-2-2023*, 1549–1555. https://doi.org/10.5194/isprs-archives-XLVIII-M-2-2023-1549-2023

Tenschert, R., Rahrig, M., Drewello, R., & Kempgen, S. (2018). Scratches? Scribbles? Scripture! Revealing the unseen – 3D scanning of Glagolitic graffiti of the 10th Century at the Monastery of St. Naum. In W. Börner (Ed.), *Proceedings of the 23rd International Conference on Cultural Heritage and New Technologies (CHNT 23)*. Museen der Stadt Wien – Stadtarchäologie. https://archiv.chnt.at/ebook_chnt23_tenschert

Valente, R., & Barazzetti, L. (2020). Methods for Ancient Wall Graffiti Documentation: Overview and Applications. *Journal of Archaeological Science: Reports*, *34*, *Part A*, 102616. https://doi.org/10.1016/j.jasrep.2020.102616

Valente, R., Barazzetti, L., Previtali, M., & Roncoroni, F. (2019). Considerations on the use of digital tools for documenting ancient wall graffiti. *ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, *XLII-2/W9*, 731–737. https://doi.org/10.5194/isprs-archives-XLII-2-W9-731-2019

Wilhelm, K., Gulotta, D., Leslie, A., Krus, M., Thome, V., Kilian, R., & Viles, H. A. (2020). Reviving 'Asterixe': A unique long-term archive for built heritage research. In S. Siegesmund & B. Middendorf (Eds.), *Monument future: Decay and conservation of stone: Proceedings of the 14th International Congress on the Deterioration and Conservation of Stone* (351-356). Mitteldeutscher Verlag.

Woolfitt, C., & Fairchild, J. (2021). *Graffiti on Historic Buildings: Removal and Prevention. Historic England Advice and Guidance: Vol. 288*. Historic England.

Each Graffito Deserves Its Polygon—It Is About Time

Geert J. Verhoeven [1,*], Jona Schlegel [2] and Benjamin Wild [3]

[1] University of Vienna - Department of Prehistoric and Historical Archaeology, 1190 Vienna, Austria;
E-Mails: geert@projectindigo.eu; geert.verhoeven@univie.ac.at
[2] Independent researcher, Vienna, Austria; E-Mail: jona.schlegel@gmail.com
[3] TU Wien - Department of Geodesy and Geoinformation, 1040 Vienna, Austria; E-mail: benjamin.wild@geo.tuwien.ac.at
* Corresponding author

Abstract

Time has remained one of the hardest-to-grasp properties of nature despite humans talking about time… all the time. However, even academic fields that are indifferent to the exact physical or philosophical characteristics of time must find ways to engage with the temporal dimension of their data. This applies to all of the Digital Humanities and maybe most to archaeology, a discipline focused on examining space- and time-bound anthropogenic activities. Like archaeological sites and landscapes, graffiti-scapes are spatially and temporally stratified. That is why the academic graffiti project INDIGO uses an archaeological lens to document, disseminate and investigate an urban graffiti-scape in space and time. However, since archaeologists still lack effective practical approaches to manage and visualise the temporal data dimension (besides a handful of data modelling standards and tools, both mainly created by geographers), INDIGO is currently developing graffiti-specific approaches to manage, visualise and analyse the uncertain spatio-temporal boundaries characterising these contemporary artefacts. After a general introduction to time and its relevance for archaeology and the study of graffiti, this paper explains why and how INDIGO uses polygons as digital representations for each real-world graffito. These polygons, stored in a human- and machine-readable file format and annotated with detailed temporal data, aim to provide a nuanced documentation of a graffiti-scape's spatio-temporal dimensions.

Keywords

GeoJSON; Graffito; Graffiti-scape; Polygon; Spatio-Temporal; Time

1. Introduction

1.1. Space, Time, Dimensions, and Spacetime

According to the classical Newtonian view of physics, one needs exactly three mutually perpendicular directions to define any possible position in physical space. The resulting geometrical space is called the three-dimensional (3D) Euclidian space. The adjective "Euclidean" distinguishes this 3D space from other spaces studied in physics and mathematics since the 19th century. However, these non-Euclidian spaces are irrelevant when describing spatial phenomena in the macro world around us; they only become important in certain parts of relativistic physics (Wheeler, 1990). In other words, the universe has three spatial degrees of freedom (Rucker, 2014). That is why an ambient space of three spatial dimensions (like *X*, *Y*, *Z* or latitude, longitude and altitude) will always be considered to define objects or events spatially.

Besides this generally accepted view on the spatial dimensions of the universe, it is possible to impose another mathematical dimension on the three spatial ones: time. Time gives static, rigid bodies a dynamical property. Since time is one-dimensional, the mathematical combination of these elements thus creates, in a technical sense, a geometry of four dimensions: a four-dimensional (4D) 'time plus space' or 'space plus time' reference frame. Therefore, any 'event' in the universe can be uniquely defined by its locational information (*x*, *y*, *z*) and a time of occurrence (*t*). These four numbers make an event a 4D entity (Muller, 2016).

This 4D space + time (or spatio-temporal) system with three dimensions of space and one of time is the accepted norm in almost all mathematical and physical theories. Other space + time systems would be unstable, inconsistent with predictability or too constraining. For instance, if there were a time dimension for every space dimension (i.e., a 3+3 dimensional space + time), it would be unpredictable as no cause-and-effect would exist. This led Tegmark to conclude that a 3+1 dimensional space + time is the only one with decent causal behaviour (Tegmark, 1997).

The well-accepted 4D space + time framework of our universe has led to the general assumption that wherever the abbreviation 3D is used, it invariably and implicitly relates to the three observable spatial/geometrical dimensions instead of, for instance, two spatial dimensions and a temporal dimension. Analogous to 3D, abbreviations such as 4D have come to denote systems or data that feature a temporal dimension in addition to three spatial dimensions. However, this does not mean a fixed numbering system for dimensions exists. Although we live in a universe of one time and three observable space dimensions, there is no inherent order in the space + time dimensional system. Many projected coordinate reference systems have Northing as their first axis, but Easting is also often used (Iliffe & Lott, 2008). Similarly, time can be considered the first or third dimension, like in Hägerstrand's space-time model (Hägerstrand, 1970). Thus, a statement such as 'time is the fourth dimension' is nonsensical "for the sufficient reason that 'the fourth dimension' is a collection of three words without meaning" (Bell, 1937, p. 95). Considering time as the fourth dimension is simply because of convenience, not because there is an inherent and fundamental dimensional order.

In addition, many other dimensions exist. The more general notion of dimension in both physical-mathematical and non-mathematical sense refers to any thinkable property, any measurable variable (Stewart, 1995). Following this logic, good examples of other dimensions are mass, electric potential, saltiness, temperature, humidity, colour or surface roughness.

Before tackling the relationship between archaeology and time, we must mention again that the above space + time interpretation is only correct for Newtonian physics. Until the 20th century, all significant scientists considered space and time separate and absolute dimensions without any intimate connection. However, Albert Einstein's 1905 special relativity paper (Einstein, 1905) made the world look differently at the concept of time, breaking the notion of an absolute universal time or time as a constant entity. Einstein's former Zürich professor Hermann Minkowski built upon his pupil's special theory of relativity to combine the space and time dimensions in one formulation (Minkowski, 1909), for which he coined the term spacetime or *Raum-Zeit* in German (Minkowski, 1908). In this 4D relativistic spacetime model of Minkowski (also known as Minkowski spacetime), time and space are no longer considered distinct aspects of nature; they are part of a single interwoven continuum and form a 4D union. When formulating his general theory of relativity (Einstein, 1916), this spacetime concept became indispensable to Einstein.

Although relativistic physics packs space and time into the unity of spacetime to deal with length contraction and time dilation, the remainder of this paper relies on the non-relativistic, classical approach to the universe with a 3D Euclidian space and a separate, constantly and universally forward-moving time dimension. This spatio-temporal approach of distinct dimensions is perfectly fine when studying objects that are not moving at speeds close to the vacuum speed of light relative to the observer.

1.2. Archaeology and Time

Archaeology is about space- and time-bound anthropogenic activities. However, whereas spatial dimensions are bidirectional, the temporal dimension is unidirectional. In other words, one can move back and forth along any spatial axis but only forward in time. In addition, an object can be stationary in the three spatial dimensions but never in time coordinates. Even though time always flows (Muller, 2016), archaeology has traditionally dealt with time via discrete temporal blocks. Monolithic temporal units like periods and phases, one followed by the next, thereby ontologising (pre) history "as a series of *replacements*" (Olsen et al., 2012, p. 42) in which time and archaeological materiality unambiguously pass from earlier phases to succeeding ones. However, an increasing number of archaeologists are challenging this oversimplified image of linear, unidirectional successions. In the past decades, the discipline has gradually realised that the temporality of objects can be messy, chaotic and complex. Medieval bridges are still in use, Roman graffiti get photographed two millennia after their production, and highways often deviate from their initial course if they risk crossing an important Celtic burial place. Many things of the past endure; they extend into the present, sometimes even totally forgotten somewhere along the way.

It is thus safe to state that barely anything around us shares the same temporality. Objects and phenomena all have different starting points, unique temporal lifespans, and they transform at different rates (Lucas, 2005). This observation lies at the core of Geoff Bailey's concept of time perspectivism. Formulated in the early 1980s (Bailey, 1981) and more recently summarised (Bailey, 2007, 2008), time perspectivism pivots on two ideas: different processes operate at various time scales, and the archaeological record's temporal resolution is variable but typically coarse. These ideas highlight that different explanatory variables and concepts are needed to understand different aspects of the archaeological record, and how they affect what we can or cannot know about the past.

Bailey attributes much of these issues to the palimpsest nature of the archaeological record (Bailey, 2007). Although there are many different conceptual 'archaeological records' (see Verhoeven (2017) for an overview) and palimpsests are, *stricto sensu*, manuscripts in which the earlier writing is scraped or washed off to make way for new text (Mollett, 1883), the expression 'palimpsest nature of the archaeological record' is often tossed colloquially (e.g., (Lucas, 2008)) when referring to the fact that humans have always reused, adapted and repurposed stuff. That is why archaeological landscapes and sites are such complex, cluttered, diffuse and messy entities (Mlekuž, 2012) in which the meaning and function of their constituents are often hard to separate (Gramsch, 2013). In that vast sense, one can indeed consider any archaeological record a cumulative palimpsest of different intermingling and intersecting temporalities (Mlekuž, 2013).

1.3. Graffiti-scapes and Time

The same temporal messiness holds for a graffiti-scape. They, too, form an archaeological record that is often created via palimpsesting (Myllylä, 2018) (but note again that 'palimpsest' must be understood in its more poetic sense, as the production of a graffito seldom starts with the entire physical or chemical removal of existing graffiti). A graffiti-scape is not just a mere historical layering. Graffitists often patch something new from the old; they modify existing graffiti through overspraying and erasing or even incorporate and reference elements of older works in the new creation. Producing new graffiti is an active, present- and future-orientated engagement with the existing graffiti-scape. And each graffito has its temporality. Some graffiti get covered or destroyed quickly and abruptly; other can live on for centuries. These complex temporalities can apply to the entire graffito or parts of it, thereby adding to the spatial and temporal messiness of graffiti-scapes. Many graffiti pro- and opponents contribute to the formation of graffiti-scapes, each creating and erasing in different rhythms at different locations with various speeds. And those speeds, locations and rhythms interact and combine in countless ways.

Similar to how landscapes are arrays of related features, so are graffiti-scapes. They are socially constructed spaces of human activity; like landscapes, they only possess spatial and temporal boundaries when imposed by analytical procedures and intellectual traditions. Graffiti-scapes are also more than a material backdrop to social life. They are

a temporal phenomenon intertwined with the occupation of its (non-)human inhabitants. In that sense, a graffiti-scape is a 'taskscape': "an array of related activities" (Ingold, 1993, p. 158). Social anthropologist Tim Ingold coined this term to express that landscapes develop through processes of temporality, and their study needs to go beyond purely symbolic or contemplative approaches.

Documenting and analysing such a diffuse and complex environment in a simple way typically only adds to the mess because plain and uncomplicated approaches break down if what they describe is messy. So, the only helpful way out of this seems to be the creation of descriptions that mirror the nature of graffiti-scapes: not a series of spatially discrete features in clear and distinct chronological succession, but a spatial continuum of multi-layered traces characterised by a mess of temporalities.

For this reason, one of project INDIGO's primary goals was to develop (meta)data structures and tools to capture and analyse a graffiti-scape's spatio-temporality. This paper presents the authors' initial thought exercises, considerations, challenges and implementations towards these goals.

2. Moments of Creation

Before tackling the development of concepts and tools to document, analyse and understand the spatio-temporal complexity of an individual graffito, it is helpful to consider the temporal meaning of a graffito's primary documentation step: capturing a digital photograph.

Consider Figure 1. Imagine a scholar of the Ancient Graffiti Project (http://ancientgraffiti.org/Graffiti) photographing a Roman wall painting with inscribed text in Pompeii, Italy (Figure 1, left). At the same time, someone from project INDIGO photographs a contemporary bird graffito in Vienna, Austria (see Figure 1, right). Both digital photographs feature the same creation date: 16th of June 2023, 10:25 Central European Time (CET). Whereas scholars of Roman graffiti would never consider this date and time a close proxy for the graffito's production, this would be standard practice in most contemporary graffiti research (with only a few scholars, like Levin (2019, p. 93), explicitly noting their potential separation). In both cases, the date and time mark a creation event: not of the graffito, but of the digital photograph. The following paragraphs will delve deeper into the consequences of this time lag between an artefact's production and its documentation.

Figure 1. Simultaneously photographing a Roman graffito (left) and a contemporary graffito (right) leads to different temporal distances and uncertainties between the photo and graffito productions. The Roman graffito photograph is by Dr. Sophie Hay.

Imagine that KUPER posted a video of his/her bird graffito on Instagram on the 6th of June 2023. The date of this Instagram post provides a *terminus ante quem* (Eng., a limit before which) for creating that graffito. In other words: KUPER must have created this graffito before the Instagram post. If somebody from project INDIGO was scouting new graffiti on the 2nd of June 2023 and KUPER's graffito was not visible on that wall at that time, the 2nd of June 2023

would be a *terminus post quem* (Eng., a limit after which) for the creation of KUPER's bird graffito. Ignoring hours and just focusing on the day, the production of the graffito must thus have happened 12 days ± 2 days before the digital photo.

The same reasoning can be applied to the left side of Figure 1. Pompeii, a thriving city south of ancient Rome, was covered by volcanic ash and pyroclastic surge deposits when Mount Vesuvius erupted in 79 Common Era (CE). This eruption provides a *terminus ante quem* for all Pompeian artefacts recovered by archaeological excavations. Imagine archaeologists could determine that the style of the Roman wall painting with the sitting bird only started to appear in 41 CE; this would date the wall painting between 41 CE and 79 CE. 41 CE would also be a *terminus post quem* for the inscription on the wall painting, as this scratching could only occur after the wall was painted. Between the wall painting's production and the digital photograph, 1963 years ± 19 years have passed. On a side note: most Roman archaeologists would only call the inscription a graffito, not the wall painting itself. However, what are the significant differences between the Roman wall painting and the contemporary KUPER graffito besides age and dominant colours? Similar and other considerations on using the term graffiti are covered by Schlegel et al. (2023).

Even though the date and time of the two photos—one depicting the Roman painting and the other the contemporary spraying of a bird—are identical, they are unrelated to the production of the graffito they represent, or the temporal fuzziness/uncertainty of dating that production event. Often, the older a recovered artefact is, the more extended the temporal uncertainty of its production. The same holds for the two graffiti illustrated in Figure 1. However, the production event is only one of many properties that can be temporally quantified. What about visibility?

Since its inception, the KUPER graffito had been entirely visible until at least the photo was acquired on the 16th of June 2023. In contrast, the Roman bird painting remained visible until volcanic ashes buried it in 79 CE, and a second visibility phase started when it was excavated. The temporal uncertainty characterising that second visibility phase is much narrower, as the exact excavation date is likely known. However, what about ancient graffiti inscribed on the walls of the Colosseum in Rome, Italy? Since its initial construction ended in 80 CE (Hopkins & Beard, 2011), this impressive amphitheatre has remained a visible, prominent symbol of the imperial Roman empire. Despite this extended visibility, the building has undergone many repurposing phases during its almost two millennia-long visibility. Can we treat its visibility and the visibility of graffiti on its walls as one long, extended phase with a relatively narrow temporal uncertainty? Or should we subdivide the entire Colosseum in chunks—some of which got destroyed when the amphitheatre functioned as a quarry, while others were covered with shops and houses—and track the visibility of the entire building and its graffiti in segments?

Examples like this illustrate three essential aspects concerning the temporality of archaeological objects and phenomena in general, and graffiti-scapes in particular:

1. Temporal idiosyncrasy: Temporality quickly becomes complex and messy. Different properties of the same object—like production and visibility—might come with unique temporalities, each of which can have a specific fuzziness (a topic Section 3 will tackle).
2. Temporal specificity: None of these properties and their temporality are related to a graffito's documentation via (digital) photography, even though the next section will explain how increasing the frequency of photo tours can reduce specific temporal uncertainties in a contemporary graffiti-scape. This temporal separation was already noticed in 1985 by Snodgrass and Ahn, when they distinguished between so-called "valid time" (when the event took place in the real world) and "transaction time" (when that event got stored in a database) (Snodgrass & Ahn, 1985). In other words, a physical graffito's metadata must always be clearly distinguished from the metadata of its analogue or digital approximations. Not only do a digital photo's temporal metadata differ from those of a real-world graffito, but standard metadata like copyright holder, creator, and location also differ for both resources. This divergence can vary enormously depending on the

graffito, even if the approximations are the same type, such as a digital photo. This dichotomy explains why project INDIGO developed metadata schemas for the real graffito on the one hand (i.e., a physical resource) and all its digital approximations on the other (i.e., digital resources), even though several well-known metadata schemas do not—or only partly—make this distinction explicit. However, having dissimilar metadata elements for physical and digital resources is essential to track their different aspects of temporality, amongst many other resource-specific metadata (see also the editorial introduction, Schlegel et al. or Trognitz et al. in this volume).

3. Temporal freeze: When looking at graffiti photos, it might be easy to forget that each photo compresses the entire history of that graffito up to the acquisition of that photo. While a digital photo always represents 'a moment' in the lifespan of the gafffito, that arbitrary moment becomes the graffito's 'definitive moment' as it will define all analytical and virtual viewing events. The former can be problematic as digital approximations decay differently than their physical counterparts (Burns, 2014). Physical resources like graffiti can suffer various slow or instant modifications: overpainting, paint flaking or the destruction of the carrier medium. The decay of digital approximations comes in accidental data overwriting, bit rot or technological obsolescence. Although a digital photo thus virtually arrests a graffito's colours (and maybe surface) in time, that photo stops serving as a surrogate for these real-world characteristics directly after its acquisition because of the different ways and rates of both deterioration processes. As soon as the photo camera's shutter button is pressed, the resulting digital approximation and physical graffito increasingly become more disparate. Project INDIGO tried to partly tackle this issue by tracking each graffito's various temporalities (like all its modification stages). Without these efforts, the graffito's unique lifetime is solidified in—and simplified to—one photograph; such an approach discards all unique chronological changes in a graffito's visibility and wear, thus making them meaningless.

3. Graffiti Observations

Several graffiti aficionados have been interested in the temporal aspects of graffiti and tried to document—either by inventorying existing photos or actively photographing—the dynamic, palimpsested nature of graffiti-scapes (Curtis & Rodenbeck, 2004; Hale, 2018; Hansen & Flynn, 2015; Levin, 2019). Project INDIGO monitored the graffiti-scape along the Viennese *Donaukanal* (Eng. Danube Canal) via follow-up photography tours. At least once per week, new graffiti that had appeared since the previous follow-up tour got photographed (see Verhoeven et al. (2023) for all details on this procedure). Figure 2 depicts how these observations allowed building a corpus of visibilityspans for each graffito.

Consider a scenario involving a graffito, denoted graffito 1. Upon being observed and photographed for the first time (Figure 2-A1), the visibility of graffito 1 stands at a 100 % certainty. That graffito is still there during the subsequent follow-up tour, so this second observation extends the temporal visibility of graffito 1 (Figure 2-A2). This pattern continues in two successive follow-up tours (Figure 2-A3), until there is a first observation of graffito 2 at the location where graffito 1 appeared before (Figure 2-B1). Although one cannot determine when graffito 2 was produced exactly, this first observation of graffito 2 implies that graffito 1 is now totally covered. In other words, graffito 1's invisibility is 100 % certain, indicated by the downward-sloping orange line reaching the "invisible" state at the moment of graffito 2's first observation (Figure 2-B2). Figure 2-C shows how the same reasoning can be applied to the start of graffito 2. Graffito 2 was invisible at the last observation of graffito 1. When the switch from visible to invisible happened for graffito 1 cannot be determined; the crossing orange and blue lines in Figure 2-C represent this uncertainty. Inset C also depicts a single observation for a third graffito. This observation also equals graffito 3's last observation, which could happen if the graffiti monitoring project stopped. Although the visibility start and end of, respectively, graffito 1 and graffito 3 are un-determinable, Figure 2-C represents them with a semi-transparent orange and pink line for completeness.

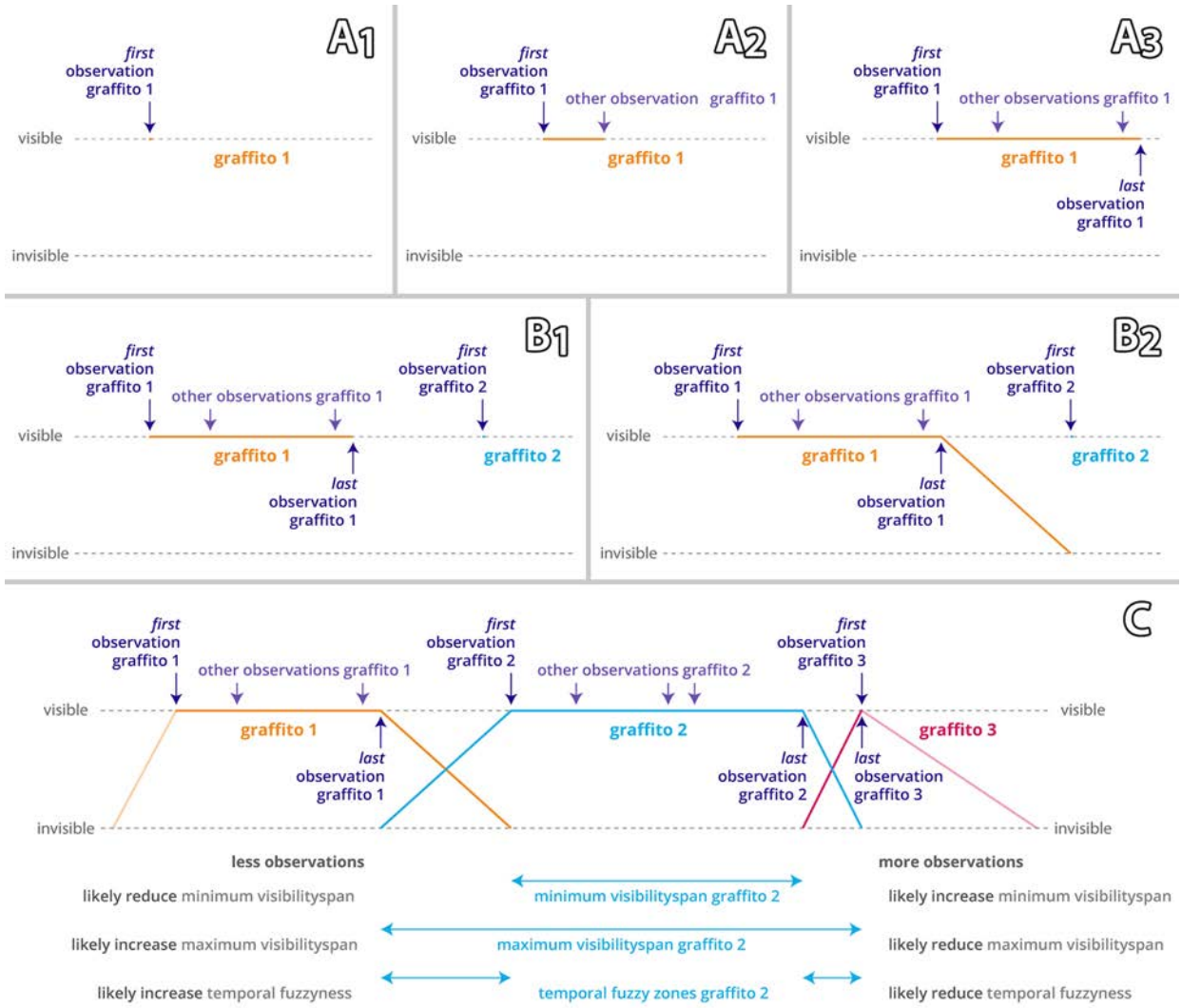

Figure 2. Extracting graffiti visibilityspans from observations.

The horizontal arrows at the bottom of Figure 2-C illustrate that the visibilityspan of each graffito has a minimum and a maximum. The difference between those two spans provides the temporal fuzzy zones, whereby fuzzy still relates to the visibility of that graffito. Reducing this temporal fuzziness can be achieved with more observations; a higher frequency of follow-up photo tours likely reduces the maximum visibilityspan and simultaneously increases the minimum visibilityspan. Even though increased observations do not guarantee the reduction of the temporal fuzzy zones—for example, when extra photo tours occur between the first and last observation of graffito 2—more observations will increase the likelihood of reducing them.

Simplifying and cleaning the graph in Figure 2C yields Figure 3. This multi-coloured line is a simple yet effective way to represent the visibility status of subsequent graffiti at a given location. Figure 3 shows that one can also infer a graffito's visibility status and corresponding certainty levels. For example, at time *t*, graffito 1 is visible with 100 % certainty, while the other two graffiti are invisible. Two days later (i.e., *t* + 2 days), graffito 3 is still invisible, but the exact visibility status of graffito 1 and 2 is unclear. However, given the observations, there is a 30 % chance for graffito 1 and a 70 % chance for graffito 2 to be visible. Another six days later (i.e., *t* + 8 days), graffito 1 is certainly invisible, while graffiti 2 and 3 are equally likely to be visible.

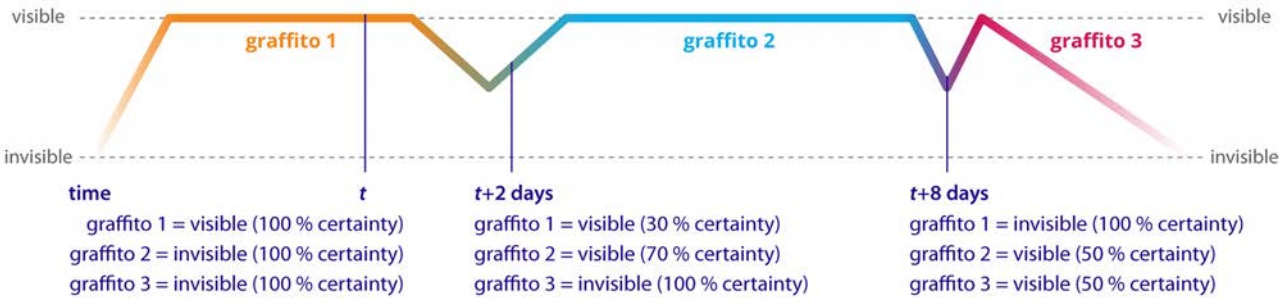

Figure 3. The visibility status of subsequent graffiti at one location, assuming that each new graffito entirely covers the previous one. The (in)visibility certainty of the three graffiti is derived at three moments.

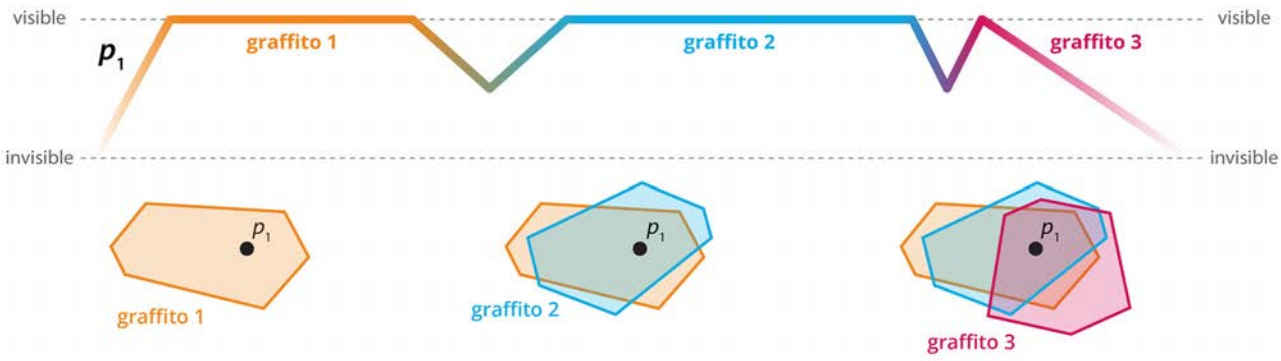

Figure 4. When polygons represent graffiti, it becomes clear that the time-dependent visibility line only applies to a few points of the initial graffito.

4. Towards Polygons

Figure 4 shows a critical limitation in the preceding analysis: the erroneous assumption that every new graffito entirely covers the previous one. Although that can be the case, it is not a given. Figure 4 represents the area covered by every graffito with a polygon. When all polygons are overlaid, it is clear that the multi-coloured and time-dependent line only represents the graffiti visibility at locations where all three polygons overlap, such as at position p_1. For most other points of graffito 1, 2 and 3, other temporally-dependent visibility lines must be constructed. For example, the upper left part of graffito 1 stays visible the entire time. Since it is impractical to divide a graffito into thousands or millions of points, each with its temporal history, we propose representing graffiti by polygons onto which temporal information gets attached as metadata.

Upon its first observation, an entire graffito is represented by a polygon (or a multi-polygon if the graffito consists of separate parts). If a second graffito partially covers the first one, the latter gets split into minimally two polygons, each with a different visibilityspan. Figure 5 clarifies this idea. On top, one finds the visibility lines presented before for location p_1. Every first and last observation of a graffito at p_1 is temporally stamped from t_1 to t_5.

In the grid that follows, there are three main sections. The first section contains one row with polygons, each representing the area covered by graffito 1, 2, and 3. The polygons also divide the table into columns. These resemble the three stages in the graffiti-scape, each corresponding to the observation of a newly produced graffito. The remaining

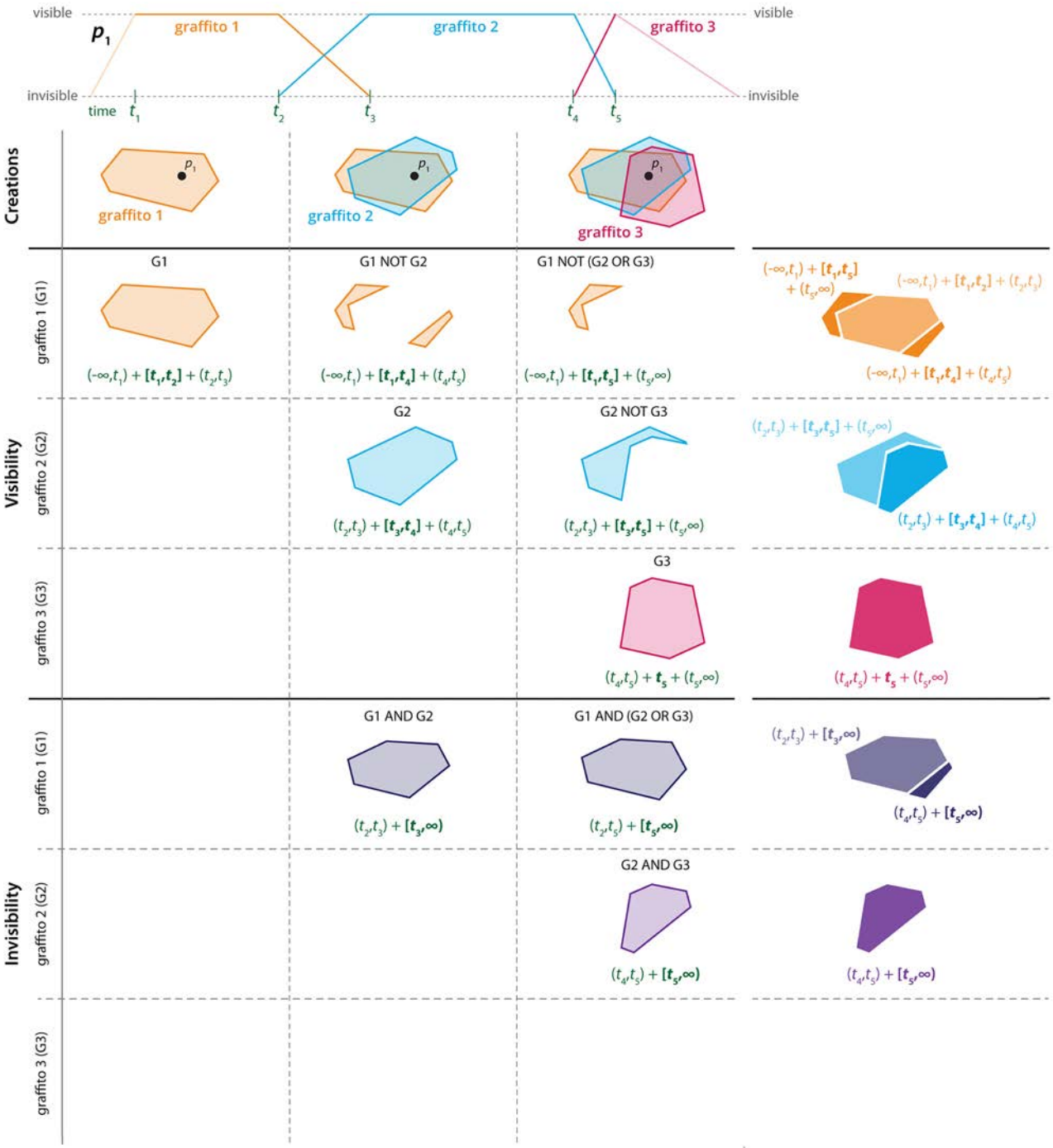

Figure 5. When polygons represent graffiti, tracking which part(s) of each graffito become(s) invisible over time becomes possible. Every derived polygon comes with two pieces of information. Above each polygon, one finds the boolean algebra used in its computation. The mathematical formulation below each polygon represents the certain and fuzzy portions of its visibilityspan.

second and third sections each consist of three rows. The second section indicates the initial polygons (or parts of them) that are visible at any of the three stages; the third and last section contains the (parts of the) initial polygons that are invisible at any of the three stages.

Let us focus on the row labelled "graffito 1 (G1)" of the table's Visibility section. When graffito 1 is observed for the first time, the entire polygon is undoubtedly visible from moment t_1 until, and including, moment t_2. Mathematically, this is written as $[t_1, t_2]$. Since there is no observation to infer the approximate production of this graffito, one can say that there is a fuzzy visibility zone ranging from minus infinity until, and excluding, t_1. Mathematically, this is written as $(-\infty, t_1)$. The uncertain visibilityspan ends with (but excludes) moment t_3, so the second fuzzy temporal zone equals (t_2, t_3). Upon combining these three pieces, the visibility of polygon G1 can be expressed mathematically as:

$$G1 = (-\infty, t_1) + [t_1, t_2] + (t_2, t_3).$$

When graffito 2 (G2) gets observed, the central portion of polygon G1 is definitely invisible, leaving only its two outer portions visible. Column 2 depicts the two polygons that represent these visible parts. With boolean algebra, both polygons would result from an operation G1 NOT G2. Temporally, the visibility of both polygons builds upon the visibility of the entire G1 polygon. The certain or minimum visibilityspan extends from t_1 until, and including, t_4. Its leading temporal fuzzy zone remains identical, but the trailing temporal fuzzy zone changes to (t_4, t_5). After the production and observation of graffito 3, only one part of the initial G1 polygon remains. G1 NOT (G2 OR G3) is the Boolean operator formulation that yields this polygon. The entire maximum visibilityspan of this polygon can be written as:

$$G1 \text{ NOT } (G2 \text{ OR } G3) = (-\infty, t_1) + [t_1, t_5] + (t_5, \infty).$$

As long as no new graffito gets recorded at this spot, the paint does not entirely weather or the wall is not destroyed, this small portion of graffito 1 will remain visible. Until then, the entire temporality of graffito 1's visibility can be represented by three polygons with their specific temporal metadata. Figure 5 depicts this in the last column of the table.

The same reasoning applies to the visibility of graffito 2 and 3. Figure 5 also displays these results, along with the polygons and mathematical specifications of the graffiti's invisibility. Here, it is essential to note that an invisibilityspan can be interrupted. For instance, a sprayed tag covered by a sticker becomes invisible; however, removing the sticker restores that tag's visibility.

The proposal to use polygons for managing spatio-temporal data is not new, of course. Polygons are fundamental geographical primitives, so they have been used to represent spatial extents for as long as vector-based Geographic(al) Information Systems (GIS) have been around. However, this does not make polygons the default optimal solution for managing temporal data. Space-time data come in so many variants that the field of Geographic(al) Information Science (GIScience) has put much research into representing and questioning the variety of spatio-temporal dynamics in a space-time GIS (Peuquet, 2002). Among all these techniques, temporal sequences of polygons—each with time-specific attributes—are considered one of the seven primary ways to deal with spatio-temporality (Goodchild, 2013). However, this does not imply there is a fixed recipe for polygon creation and reasoning. That is why project INDIGO had to develop bespoke software and workflows, some of which the next section details.

5. Polygon Tools

Project INDIGO relied on different software tools to create and store a graffito's temporal and spatial data. Section 5.2 first describes how a graffito's two- and three-dimensional locational data were created via GRAPHIS and AUTOGRAF, two software packages programmed within INDIGO. Afterwards, Section 5.3 explains why and how GeoJSON became the format of choice to save all these spatial data, and why the same format also stores the temporal data (Section 5.4). Since the process to automatically infer temporal data was only prototyped (as of September 2023), this paper can only provide an example in which the temporal GeoJSON data are derived manually (Section 5.5). However, before

delving into polygon creation, Section 5.1 introduces some necessary terminology.

5.1. Some Terminology

A polygon can represent any bordered planar surface. But what are polygons? Polygons are geometrical shapes bounded by a curve, but not just any curve. The curve must consist of connected line segments—called a polyline, polygonal chain, or polygonal curve—and be closed. Although these line segments or edges may intersect, the term 'polygon' often means 'simple polygon', simple being a qualifier denoting non-intersecting line segments (Preparata & Shamos, 1985; Schneider & Eberly, 2003). These line segments meet at corners or vertices (singular: vertex), whose spatial position is described by two coordinates: *x* and *y*. Polygons are thus always spatially two-dimensional or 2D (Berger, 2010). As a 2D object, 'polygon' refers to the polyline perimeter and the region it bounds (Gomes et al., 2012; Preparata & Shamos, 1985; Schneider & Eberly, 2003). Because all vertices of the polyline lie in a plane, a polygon's boundary is known as a plane curve. However, polygons are bounded by a particular kind of plane curve, as plane curves can also be open or feature curved and intersecting segments.

Some types of polygons are well known, like triangles (shapes formed by three line segments and three vertices) and rectangles, but polygons can have arbitrarily many edges *n*. These *n*-edged polygons are called *n*-gons (Preparata & Shamos, 1985). Since the number of edges and vertices are identical for polygons, the 13-gon polygon in Figure 6 features thirteen vertices and thirteen edges. Even though a disk is formed by a closed and non-intersecting plane curve (called the circle), this curve does not feature line segments, which disqualifies a disk from being a polygon.

5.2. Creating Location

5.2.1. In Two Spatial Dimensions: GRAPHIS

The spatial extent of each graffito is initially defined in GRAPHIS, an open-source and freely available Python-based software to create, annotate, visualise and store image regions. Users can load one or more photographs into GRAPHIS and draw disks or polygons—either a rectangle or any arbitrary *n*-gon—on them. Specific attribute data (like the creator of the region, the transcript of a text-based graffito or the unique identifier of that graffito) can be linked to each of such regions. Storage of the image region coordinates and related attribute data adheres to the Photo Metadata Standard (IPTC Photo Metadata Working Group, 2023) defined by the International Press Telecommunications Council (IPTC; https://iptc.org).

The backbones of GRAPHIS are two free and open-source software technologies: SQLite (https://sqlite.org/index.html) and ExifTool (https://exiftool.org). SQLite provides a self-contained, small and fast relational database engine. GRAPHIS' SQLite database stores links to the photos of interest and tracks every image region operation. This principle enables users to start/exit the software at will without the risk of losing work. It also enables collaboration on various photo collections, as each can have its own database. At any moment, the user can write the image regions back into the photo's metadata segment, an operation for which GRAPHIS utilises ExifTool, the Swiss army knife of file metadata manipulations. For more details on GRAPHIS, please consult the paper by Verhoeven, Wieser, & Carloni in this volume.

Delineating the entire region occupied by a graffito usually relies on arbitrary *n*-gons with more than four edges. The polygon's boundary (i.e., the closed polyline) equals the border of the graffito. The polygonal region (i.e., the area enclosed by the closed polyline) corresponds to all image pixels that digitally depict that graffito. If a graffito consists of multiple parts (such as separated letters in verbal graffiti), a grouping of polygons or a so-called multi-polygon is needed to indicate all image regions that graffito occupies.

Indicating the polygon(s) is based on the overview photos INDIGO acquired during its follow-up photo tours. As detailed in Verhoeven (2023), follow-up photo tours took place at least weekly to document new graffiti. Every graffito was documented via a collection of overlapping photographs, a photograph of a colour reference target (to achieve colour consistency) and an overview photo that captured the entire graffito. After finishing a follow-up photo tour and downloading the images, a MATLAB (https://nl.mathworks.com/products/matlab.html) script automatically finds all overview photos and copies them

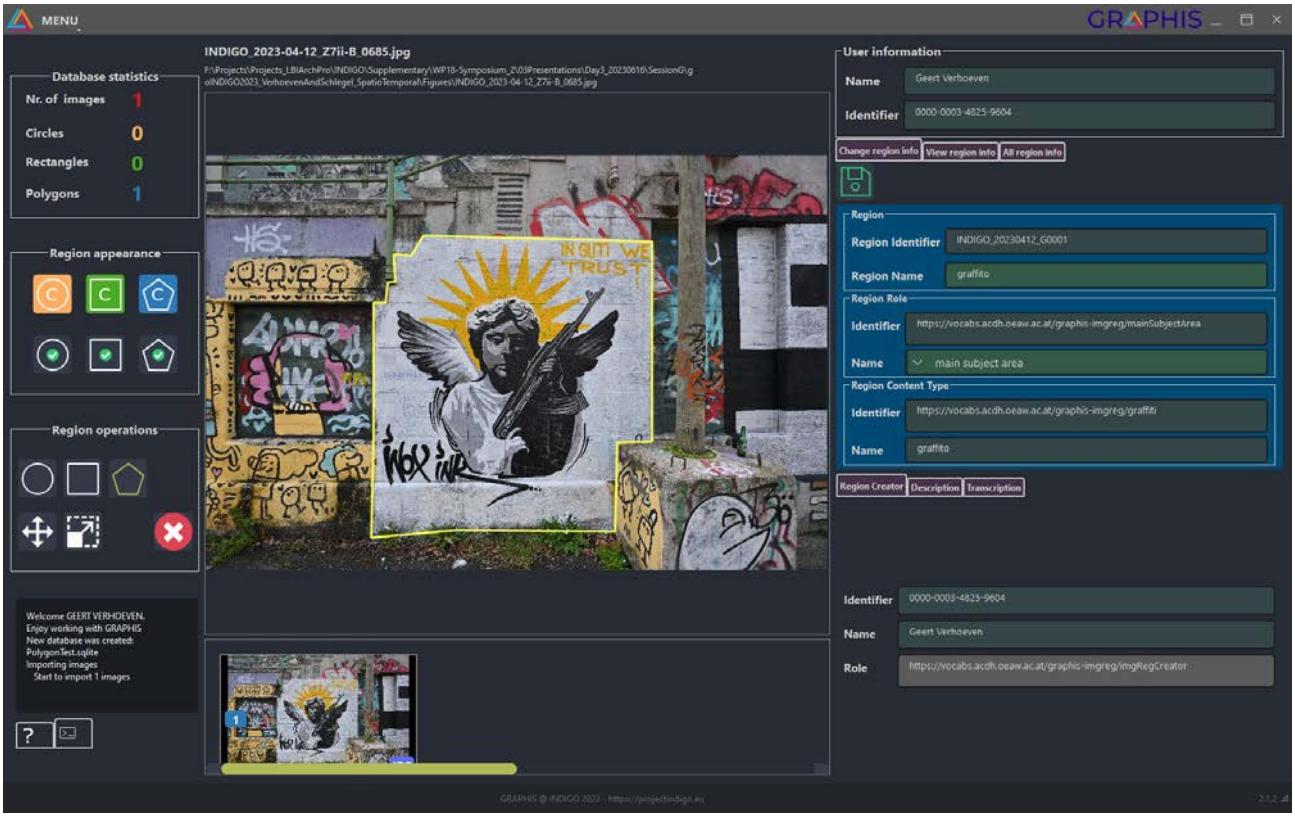

Figure 6. A database with one overview photo is opened in GRAPHIS' graphical user interface. A 13-gon indicates the graffito of interest. On the right, specific IPTC image region metadata get attached to this polygon: region identifier, region role, region content type and region creator.

into a specific subfolder. Afterwards, somebody from the INDIGO team creates an SQLite database in GRAPHIS for this subfolder and imports all overview photographs into this new database. As soon as the border of a graffito is indicated on an overview photograph (Figure 6), the coordinates of its vertices get stored in the GRAPHIS database. At the end of a GRAPHIS session, all newly indicated image regions and related metadata, like the region's creator and identifier, are saved according to the IPTC Photo Metadata Standard within the image file.

5.2.2. In Three Spatial Dimensions: AUTOGRAF

The GRAPHIS image region is a polygon with 2D pixel coordinates. For example, if the upper right vertex of the polygon in Figure 6 has coordinates (x, y) = (4080, 350), this corner is located 4080 pixels from the left side of the image and 350 pixels from its top. Since these coordinates are defined relative to the image, one cannot use them to compute the surface area of the physical graffito. That is why AUTOGRAF—INDIGO's bespoke software for orthorectifying graffiti photographs (Wild et al., 2022; Wild, Verhoeven, Wogrin, et al., 2023)—enters the workflow. AUTOGRAF reads the polygon vertex coordinates saved by GRAPHIS in the photo and projects those vertices onto a georeferenced triangle-based mesh that digitally represents the graffito surface in 3D (Figure 7-C). Using photogrammetric and computer vision principles, AUTOGRAF can extract this digital 3D surface mesh (see Figure 7-A) for every graffito from the series of overlapping photographs acquired during the follow-up photo tour. Since every point on this

Figure 7. AUTOGRAF can compute a 3D surface mesh (A) with texture (B) from the series of overlapping photos acquired per graffito. On this textured mesh, the image polygon can be projected (C) to yield a 3D closed polyline of which the vertices have real-world 3D coordinates.

meshed, digital 3D surface features accurate 3D coordinates expressed in a standard coordinate reference system for East Austria (MGI/Austria GK East, EPSG:31256; https://epsg.io/31256), it is possible to end up with exact real-world 3D coordinates (*x*, *y*, and *z*) for each projected polygon vertex.

AUTOGRAF thus turns the 2D image polygon into a new 3D shape bounded by a polyline with real-world 3D coordinates for every vertex. Although some GIS software calls this geometric entity a 3D polygon, the resulting shape or surface is no longer a polygon because the vertices of the bounding curve have *x*, *y*, and *z* coordinates. This curve is no longer a plane curve but a space curve (Agoston, 2005; Coolidge, 1959). However, not just any space curve; a closed one consisting of non-intersecting line segments. We shall refer to this curve as a 3D closed polyline.

5.2.3. Towards Surface Area and Overlap

The resulting area bounded by this closed 3D polyline could generically be called a 3D surface. The area of this 3D surface should approach the real-world area occupied by the graffito. However, two remarks must be made here. First, the resulting area will only closely approximate the real-world area if the entire polyline—not just its vertices—is projected onto the mesh. Second, computing the area at this stage is still impossible because the Euclidean geometry that allows for this needs planar shapes. Thus, one must break up this non-planar 3D surface into a collection of polygons glued along their edges. Known as tessellation, polygonisation or meshing (but see further for some comments), this breaking-up operation yields a polyhedral surface or polymesh (Kettner, 1998; Preparata & Shamos, 1985). The individual polygons—which can be of any sort—are known as the faces or facets of the polyhedral surface.

Often, the surface faces are triangles. Triangles are simple, easy-to-define polygons that are efficient for many calculation types. Because they are arguably the most helpful type of polygon, triangles are typically the elementary building blocks for complex 3D geometric structures (Botsch et al., 2010). A polyhedral surface consisting exclusively of triangular polygons results from a specific tesselation process known as triangulation (Gomes et al., 2012). Accordingly, the 3D polyhedral surface is then known as a triangulated surface or triangle/triangular/triangle-based mesh/polymesh, precisely like the triangle-based 3D surface mesh extracted from the overlapping graffito photographs.

How the area bounded by this closed 3D polyline gets triangulated is not established yet. One possible option

Figure 8. Creating and storing a graffito's location via GRAPHIS, AUTOGRAF and a hitherto undefined software package.

could be to use the existing triangle-based 3D mesh and cut out all facets encompassed by the 3D polyline. Although the graffito's surface area would be obtainable via the cumulative surface area of all extracted mesh facets, this operation would not allow computation of the graffito's potential spatial overlap with another graffito. To that end, the 3D facets must be flattened or 'unwrapped' to create a 2D surface and 2D polygon again, but now with 2D pseudo real-world coordinates. Any graffiti overlap in real-world space could be inferred from two such polygons, yielding a handful of new polygons that indicate the covered and still visible areas of the oldest graffito. However, all processing steps that trail the polygon's projection in AUTOGRAF are still in development (and indicated by "?" in Figure 8).

5.2.4. A Last Terminological Technicality

One extra technical subtlety can be mentioned before finalising this section. Please note that one can skip these two paragraphs without hampering the understanding of the remaining text. This information is provided here because it is typically hard to find. As the text above seems to imply, a polyhedral surface can be considered a 3D mesh. However, a 3D mesh might refer to a surface or a volumetric mesh. Depending on the industry, the term 'mesh' will almost exclusively mean one of the two. For instance, 'mesh' in the image-based modelling and cultural heritage fields—and in project INDIGO—typically implies surface mesh. Nevertheless, not every surface mesh is a polyhedral surface. Although both are not limited to triangles but can have any *n*-gon as their components, surface meshes can also consist of non-planar facets (i.e., not polygons). For instance, the computer graphics industry often deals with quadrilateral meshes whose four-edged facets are not necessarily flat. In other words, every polyhedral surface is a surface mesh, not vice versa; surface meshes can be polyhedral meshes (also known as polygonal meshes or polymeshes) as well as non-polyhedral meshes (Poranne et al., 2013).

Virtually every surface mesh created by image-based 3D modelling software is triangle-based. Because triangles are planar by definition, it is safe to remove the prefix "poly" when discussing triangle-based surface meshes. Furthermore, these meshes can only represent surfaces since triangles lack volume. What gets then reported in the image-based modelling literature is a 'mesh' generated by a 'meshing algorithm', even though both can technically refer to non-polyhedral or volumetric domains.

5.3. Storing Location

GRAPHIS stores the 2D pixel coordinates of the image polygon as IPTC image region metadata, either inside the image file or an accompanying sidecar file (but see Verhoeven, Wieser, & Carloni in this volume for more details). In contrast, AUTOGRAF stores the real-world 3D coordinates of the graffito outline in the GeoJSON format. JSON (JavaScript Object Notation) is a lightweight, text-based data format (Bray, 2017). Being text-based means that the file's content is easy to read and understand by humans (see Figure 9); at the same time, JSON uses specific syntax rules that make the content machine-readable. In other words, computers can automatically process or parse such data. Because it is a text-only format, code for generating and reading JSON files can be written in any programming language (Bassett, 2015).

Figure 9. This example shows a GeoJSON file; the white text on the upper right provides some basic info on the GeoJSON syntax. The file describes a GeoJSON object with "type" and "features" as top-level properties. The term 'member' refers to the object property name and its value(s). The first member has "type" as its field name and a string value "FeatureCollection". The "features" member has "features" as the field name and an array as its value. This array has three elements/items, of which "properties" and "geometry" are objects and the field "type" has the string value "Feature". Although the "properties" object is empty in this example, it can store temporal information (see Section 5.4). The "geometry" object has "type" and "coordinates" members. Field "type" has the string value "Polygon", while "coordinates" has an array of linear ring coordinate arrays as its value. The RFC 7946 (Butler et al., 2016) and RFC 8259 (Bray, 2017) standards provide the proper definitions for all these JSON and GeoJSON terms.

GeoJSON extends the JSON format to represent simple geographical features like points, lines, and polygons. The feature's coordinates are expressed in the WGS84 (World Geodetic System 1984) geographical coordinate reference system (EPSG:4979; https://epsg.io/4979) with longitude and latitude in decimal degrees and ellipsoidal height in meters (Butler et al., 2016). Figure 9 displays the contents of a GeoJSON file describing a polygon with five vertices. The polygon is a geometric object that can have additional properties (see the following section). Together, they form a "Feature". Sets of features are contained in a "FeatureCollection". Even though features in a GeoJSON file typically combine geometry and some attribute data, features can also exist without geometry. In that case, the feature's "geometry" member is empty or null (Butler et al., 2016). Finally, note that the geometric feature is called "polygon" instead of "closed polyline" even though every vertex features three coordinate values [longitude (°), latitude (°), and ellipsoidal height (m)]. Such misuse of the term polygon is prevalent in the GIS world.

5.4. Storing Time

Features in a GeoJSON file are typically a combination of geometry and some attribute data or properties. This "properties" object can hold a wide variety of information, so INDIGO used it to store the temporal attributes of a graffito (in contrast to the GeoJSON-T format, which stores temporal attributes in a "when" object; Grossner, 2020). Being a dimension, one could argue that time coordinates could be added to the spatial coordinates. However, the introduction of this paper illustrated that time is typically too complex to fit into one number. How many numbers, then, should one use to store all relevant temporal attributes of a graffito? This problem was given much thought in project INDIGO, resulting in various proposals which all tried to adhere to the following four principles:

- It must be possible to retrieve all temporal properties via *in situ* observation of the real graffito or mathematically derive them using its representative polygon(s). This does not mean that each property will always be filled out for every graffito, but the possibility should exist given enough observations.
- It must be possible to map these properties to the Conceptual Reference Model (CRM) of CIDOC (Bekiari et al., 2022). The CRM is a heritage-specific ontology that forms the semantic basis of INDIGO's graffiti database (see Richards et al. (2023), but also Schlegel et al. and Trognitz et al. in this volume).
- The properties and how they are grouped should make sense on several levels. They should facilitate various forms of temporal reasoning relevant to examining a graffiti-scape and be flexible enough to deal with edge cases.
- The properties are all *in situ* based, meaning they should only relate to the location a graffito was initially meant to be seen. For example, a sticker and stencil graffito need preparation at home, so the production process does not start *in situ*. However, the final graffito is only created at its intended location when that sticker gets pasted on a waste bin, or the stencil graffito is sprayed on a wall. Removing that sticker from the waste bin to paste it on a bridge or cutting out the stencil graffito for display in a museum alters the initial location of the graffito. Since this relocation implies the definition of a new polygon or closed 3D polyline with other spatial coordinates, tracking the temporal properties must also start anew. Conceptually, it means that the relocation event created a new graffito. Assigning a new unique identifier and polygon to this relocated graffito embodies this conceptual change. The metadata of the new graffito will record the unique identifier of the initial graffito it is based on, making it clear that both are related and temporal queries can account for this relationship. INDIGO thus treats graffiti as dynamic objects, but dynamic only because their shape/extent can change through time due to all kinds of modification processes. Following the classification by Goodchild et al. (2007), a graffito is thus an elastic, uniform and stationary geo-object: elastic means that its representing polygon can change in size and shape over time (e.g., when the graffito gets covered), while the graffito's internal structure is invariant (i.e., uniform) and its spatial position unaltered (i.e., stationary). Placing a mural in a museum means that its representing polygon is no longer stationary, hence the need for a new polygon and unique identifier.

Using these principles, INDIGO considered the following three graffito events:

- The production of the graffito. As described above, this only relates to the start and end of its *in situ* creation, which can vary between a second (i.e., pasting a sticker) to weeks for a large mural. A police intervention can abruptly end the production event. Depending on the situation, this interruption can mark the end of the production phase, or the production can continue a few hours or days later.
- One or more modifications to the graffito. This can be partial or total coverage by another graffito or a partial graffito removal, such as tearing down a part of a sticker.
- The destruction of the graffito. Destruction happens when the carrier medium of the entire graffito is no longer present at the location of graffito production. A good example is the cutting of a tree bearing an incised graffito, the chemical removal from spray paint on a window, the physical removal of a wall's paint layers or the demolition of a bridge covered with stickers.

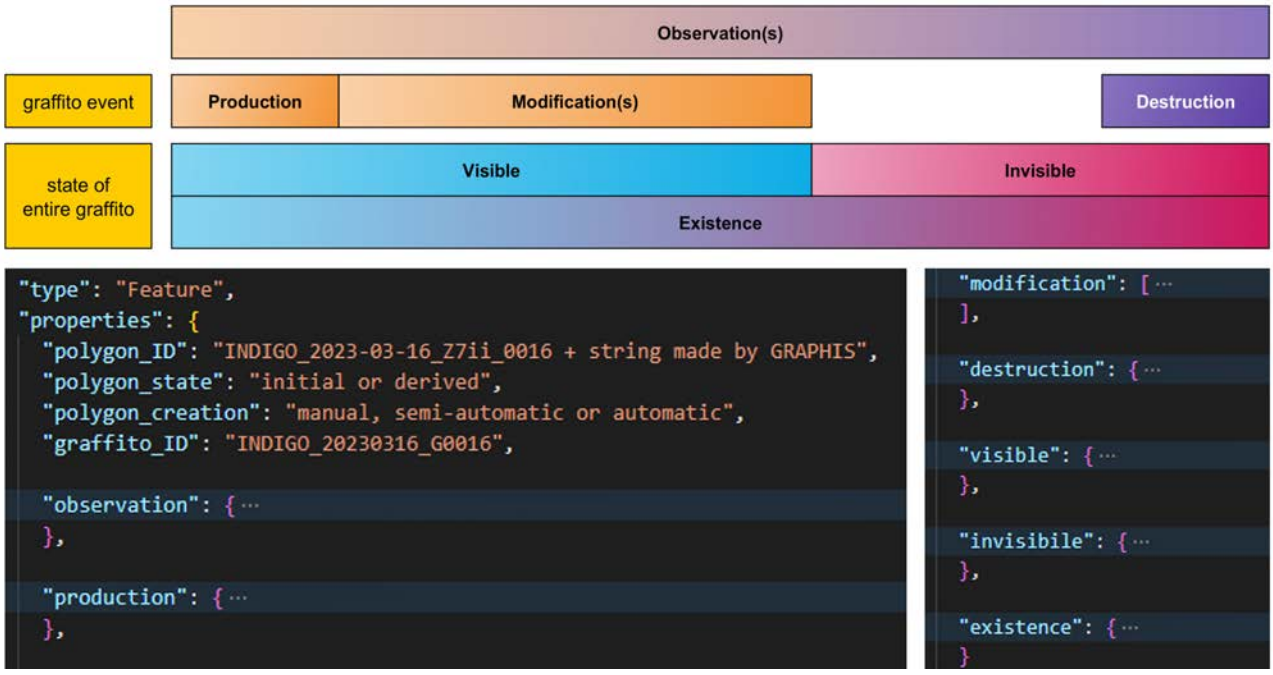

Figure 10. The temporal events and states which project INDIGO records per graffito in a GeoJSON file.

Destroying only a part of the graffito (for example, breaking down the upper part of a wall covered from top to bottom with a mural) is considered a modification event. Relocating a graffito in its entirety is also a destruction event.

Besides those three possible events, INDIGO also defined various states of the entire graffito:

- Visible or invisible: A graffito is considered visible as long as a small part is visible. At that stage, most of a graffito might be indicated by a polygon that carries the invisible attribute, while only a tiny polygon indicates the remaining visible part. Being invisible does not mean that the graffito is destroyed. Often, its last modification event was the creation of a new graffito covering the last remaining visible part. However, if that newly created graffito would be (partly) removed, the underlying graffito becomes visible again. This has happened with many Greek and Roman graffiti; they are characterised by a second visibilityspan from the moment an excavation unearths them.
- Existence: As long as a graffito is not destroyed, it keeps on existing—as already pointed out by MacDowall (2016). Any destruction event ends a graffito's existence.

The GeoJSON defining each graffito-specific polygon contains these six temporal objects (see Figure 10). All temporal objects feature an identical structure. Consider the "visible" member shown in Figure 11 as an example. It is an object with "start", "end", and "span" members. Although all three are objects, only the first two contain the same four field names: "earliest", "earliest_source", "latest", and "leatest_source". Each of those contains a string value, as do the "minimum" and "maximum" fields of the "span" object. Together, they define the different spans identified in Sections 3 and 4.

In addition to these temporal properties, there is also an "observation" object. Observations typically are INDIGO's follow-up photo tours, but could also be Instagram notifications. More observations typically mean less temporal fuzziness. Although Section 3 clarified that, the next section will illustrate this further using a real-world example.

5.5. Computing Time

The authors are currently (i.e., September 2023, one month after project INDIGO officially finished) still programming on POLYGRAF, the software to automate the spatio-temporal reasoning with the graffiti polygons. Similar to how a polygraph records several stress indicators during an interview, POLYGRAF should keep track of all relevant spatio-temporal polygon properties. More specifically, POLYGRAF must 1) check if polygons spatially overlap, 2) subdivide existing polygons into visible and invisible portions, and 3) fill out (or update) the temporal properties of all polygons involved. Figure 11 exemplifies how that might work for one specific polygon. Four photographs acquired during INDIGO's follow-up tours constitute the upper row. Each photograph also features its acquisition data and time (limited to minutes for clarity). The lower part of Figure 11 shows the "visible" element of the GeoJSON file that describes the entire Volodymyr Zelenskyy graffito, indicated with a pink polygon outline in the second photo from the left. Using the acquisition date and times of these four photographs, one can manually complete all temporal values of the indicated polygon (please note again that INDIGO's POLYGRAF should automate the following reasoning based on all graffiti polygons):

- "start" > "latest": The photograph acquired during the photo tour of 2022-09-12 establishes the latest possible start for the Zelenskyy graffito. This graffito could have been created ten minutes before acquiring the photo, but certainly not after that observation. The date and time format used to record this temporal information follows the ISO 8601 standard (International Organization for Standardization, 2019a, 2019b, 2022). The "photoTour" of 2022-09-12 is the source for this information (i.e., "latest_source" in the GeoJSON file).
- "start" > "earliest": Because the photographer did not record the Zelenskyy graffito during the follow-up photo tour of 2022-09-05, this is the earliest possible start because the graffito's production could have started one minute after passing that location.
- "end" > "earliest": The earliest ending of the graffito's visibility corresponds to the acquisition moment of the third photograph from the right, which is the last photo on which the graffito is still partially visible. A few moments afterwards, the graffito could have been covered entirely.
- "end" > "latest": This moment corresponds to creating the fourth photograph, as it no longer shows any trace of the Zelenskyy graffito.
- "span" > "minimum": This timespan—expressed in hours and minutes while following the ISO 8601 standard (International Organization for Standardization, 2019a,

Figure 11. Four photographs from the same portion of a legal graffiti wall, acquired by the INDIGO team during follow-up photo tours. With the photos' creation dates and times, one can fill out all temporal visibility attributes of the initial Zelenskyy graffito.

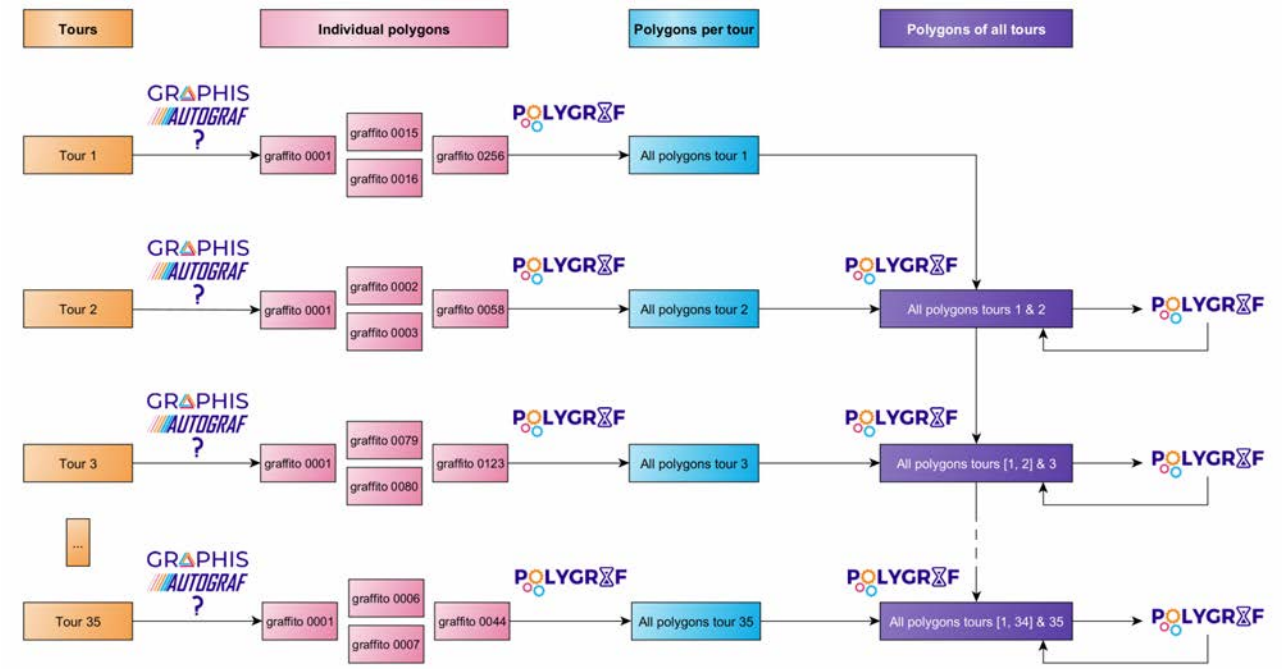

Figure 12. This flowchart presents INDIGO's envisioned pipeline for creating graffiti polygons and attributing them with temporal information.

2019b, 2022)—is computed between the latest start and the earliest end. It is the only visibilityspan one can be sure about and corresponds to the minimum visibilityspan in Figure 2C.

- "span" > "maximum": Computed between the earliest start and latest end, it is a graffito's maximum visibilityspan (see Figure 2C). Only increased observations can reduce the temporal fuzzy zones defined by the "earliest" and "latest" timestamps.

This example disentangles the idea that each graffito has a single, well-defined, continuous visibility. Many of a graffito's temporal properties can only be defined weeks (or even months and years) after that graffito's production, and the only reasonable way to document these temporal aspects of graffiti-scape formation seems to be repetitive photo tours.

The photos from 2022-09-12 and 2022-19-14 in Figure 11 also illustrate the large quantity of new graffiti that might be created over only a few days. Although new graffiti appear daily along Vienna's *Donaukanal*, this exceptional density is due to this wall's legal status; it is part of Vienna's *Wienerwand* (Eng. Viennese wall), a joint label given to the 22 legal graffiti zones in the city (see https://www.wienerwand.at). The photo from 2022-09-14 also shows why it can quickly become time-consuming to indicate every new graffito with a polygon in GRAPHIS: many graffiti can only be adequately defined by complex multi-polygons rather than a single simple polygon like the one used to delineate the Zelenskyy graffito.

Figure 12 shows the workflow that INDIGO envisions as soon as all processing pipeline parts are complete. Ideally, all polygons are created via GRAPHIS, AUTOGRAF and a hitherto undefined software (indicated with "?") directly after the follow-up tour. POLYGRAF fills out the first temporal properties and combines these individual polygons into one large tour-specific GeoJSON file. Afterwards, POLYGRAF appends this file to previous tours' polygons. At that moment, the automated spatial and temporal reasoning can subdivide overlapping polygons and fill out or update temporal properties.

6. Still Puzzling

A graffiti-scape is usually a very dynamic environment with various changes at different locations over time. This paper has covered the approaches—some still in development—that INDIGO used to track and manage a graffiti-scape's spatio-temporality in combination with its frequent photography tours. All pieces of the puzzle were slowly connected. However, some aspects are still puzzling, not in the least because much of this work is trial-and-error based. The GeoJSON data structure that stores the temporal data only came into existence after many iterations, and the INDIGO team still has to map it to the CRM ontology (even though the authors accounted for CRM concepts during the design phase of the temporal structure). The 3D polyline to 2D polygon construction is still in the works, as is the POLYGRAF software to automate polygon splitting and temporal attribute completion. It is unsure if the completion of POLYGRAF will necessitate changes to the current temporal structure. Finally, polygonising each graffito becomes time-consuming for an extended graffiti-scape, so more automated methods—maybe based on the change-detection algorithms INDIGO has developed (Wild, Verhoeven, & Pfeifer, 2023)—would be welcome. Automation would also decrease the subjectiveness in polygon creation. Five people will likely create five slightly different polygons for most graffiti, meaning polygons represent relatively subjective thresholds as long as they result from a manual process.

Despite the need for more understanding, additional developments and never-ending finetuning, the authors believe that the proposed polygon-based approach allows for the sufficient and straightforward management of a graffiti-scape's spatial-temporal aspects. Polygons are digital but nuanced approximations of real-world graffiti, which INDIGO leverages to infer spatial and temporal information about the latter. Once it becomes routine to atomise large quantities of new graffiti into temporally attributed polygons, one can start thinking about ways to visualise and analyse them. In other words, the spatio-temporal reasoning covered in this paper is but one aspect of the entire story, solely needed to create digital entities that can represent graffiti in space and time. A second spatio-temporal engine is needed to visualise and query those entities via INDIGO's online Urban Chameleon platform (see Schlegel et al. in this volume), thereby hopefully revealing various explicit or implicit spatial and temporal relationships among the thousands of documented graffiti. Although it is not unimaginable that some graph-based tools could be of help here, this second can of worms will only be opened upon finishing the entire polygon creation pipeline, likely in a follow-up project to INDIGO.

Conflict of Interest

The authors declare no conflict of interest.

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References

Agoston, M. K. (2005). *Computer graphics and geometric modeling: Mathematics.* Springer. https://doi.org/10.1007/b138805

Bailey, G. (1981). Concepts, time-scales and explanations in economic prehistory. In Tempus Reparatum (Series Ed.) & A. Sheridan & G. Bailey (Vol. Eds.), *BAR International Series: Vol. 96. Economic Archaeology: Towards an integration of Ecological and Social Approaches* (pp. 97–117). BAR.

Bailey, G. (2007). Time perspectives, palimpsests and the archaeology of time. *Journal of Anthropological Archaeology*, 26(2), 198–223. https://doi.org/10.1016/j.jaa.2006.08.002

Bailey, G. (2008). Time perspectivism: Origins and consequences. In S. Holdaway & L. Wandsnider (Eds.), *Time in archaeology: Time perspectivism revisited* (pp. 13–30). University of Utah Press.

Bassett, L. (2015). *Introduction to JavaScript Object Notation: A to-the-point guide to JSON.* O'Reilly.

Bekiari, C., Bruseker, G., Canning, E., Doerr, M., Michon, P., Ore, C.-E., Stead, S., & Velios, A. (June 2022). *Volume A: Definition of the CIDOC Conceptual Reference Model: Version*

7.1.2. CIDOC CRM Special Interest Group. https://www.cidoc-crm.org/sites/default/files/cidoc_crm_v7.1.2.pdf

Bell, E. T. (1937). *The Handmaiden of the Sciences*. The Williams & Wilkins company.

Berger, M. (2010). *Geometry Revealed: A Jacob's Ladder to Modern Higher Geometry*. Springer. https://doi.org/10.1007/978-3-540-70997-8
Botsch, M., Kobbelt, L., Pauly, M., Alliez, P., & Lévy, B. (2010). *Polygon Mesh Processing*. A K Peters.

Bray, T. (December 2017). *The JavaScript Object Notation (JSON) Data Interchange Format* (Request for Comments No. 8259). Internet Engineering Task Force. https://doi.org/10.17487/RFC8259

Burns, J. E. (2014). Digital Facsimiles and the Modern Viewer: Medieval Manuscripts and Archival Practice in the Age of New Media. *Art Documentation: Journal of the Art Libraries Society of North America*, *33*(2), 148–167. https://doi.org/10.1086/678515

Butler, H., Daly, M., Doyle, A., Gillies, S., Hagen, S., & Schaub, T. (August 2016). *The GeoJSON Format* (Request for Comments No. 7946). Internet Engineering Task Force. http://www.rfc-editor.org/info/rfc7946

Coolidge, J. L. (1959). *Treatise on Algebraic Plane Curves*. Dover Publications Inc.

Curtis, C., & Rodenbeck, E. (2004). Graffiti archaeology. In *Proceedings of SIGGRAPH 2004* (p. 1). ACM SIGGRAPH. https://doi.org/10.1145/1186194.1186196

Einstein, A. (1905). Zur Elektrodynamik bewegter Körper. *Annalen der Physik*, *322*(10), 891–921. https://doi.org/10.1002/andp.19053221004

Einstein, A. (1916). Die Grundlage der allgemeinen Relativitätstheorie. *Annalen Der Physik*, *354*(7), 769–822. https://doi.org/10.1002/andp.19163540702

Gomes, J., Velho, L., & Costa Sousa, M. (2012). *Computer Graphics: Theory and Practice*. CRC Press.

Goodchild, M. F. (2013). Prospects for a Space–Time GIS. *Annals of the Association of American Geographers*, *103*(5), 1072–1077. https://doi.org/10.1080/00045608.2013.792175

Goodchild, M. F., Yuan, M., & Cova, T. J. (2007). Towards a general theory of geographic representation in GIS. *International Journal of Geographical Information Science*, *21*(3), 239–260. https://doi.org/10.1080/13658810600965271

Gramsch, A. (2013). Landscape Archaeology: Of Making and Seeing. *Journal of European Archaeology*, *4*(1), 19–38. https://doi.org/10.1179/096576696800688060

Grossner, K. E. (2020). *Geojson-T: Adding time to GeoJSON*. http://kgeographer.org/geojson-t-adding-time-to-geojson

Hägerstrand, T. (1970). What about people in regional science? *Papers in Regional Science*, *24*(1), 7–21. https://doi.org/10.1111/j.1435-5597.1970.tb01464.x

Hale, A. (2018). *Is 52 weeks enough? Unsettling archaeology with graffiti recording*. the GRAFFITI REVIEW. https://graffitireview.com/is-52-weeks-enough-unsettling-archaeology-with-graffiti-recording#more-1152

Hansen, S., & Flynn, D. (2015). Longitudinal photo-documentation: Recording living walls. *Street Art & Urban Creativity Scientific Journal*, *1*(1), 26–31. https://doi.org/10.25765/sauc.v1i1.13

Hopkins, K., & Beard, M. (2011). *The Colosseum. Wonders of the world*. Profile Books.

Iliffe, J., & Lott, R. (2008). *Datums and map projections for remote sensing, GIS, and surveying* (Second edition). Whittles Publishing; CRC Press.

Ingold, T. (1993). The temporality of the landscape. *World Archaeology*, *25*(2), 152–174. https://doi.org/10.1080/00438243.1993.9980235

International Organization for Standardization (2019a, February 25). *Date and time — Representations for information interchange — Part 1: Basic rules* (ISO/TC 154 ISO 8601-1:2019). International Organization for Standardization. https://www.iso.org/standard/70907.html

International Organization for Standardization (2019b, February 25). *Date and time — Representations for information interchange — Part 2: Extensions* (ISO/TC 154 ISO 8601-2:2019). International Organization for Standardization. https://www.iso.org/standard/70908.html

International Organization for Standardization (2022, October 25). *Date and time — Representations for information interchange — Part 1: Basic rules — Amendment 1: Technical corrections* (ISO/TC 154 ISO 8601-1:2019/Amd 1:2022). International Organization for Standardization. https://www.iso.org/standard/81801.html

IPTC Photo Metadata Working Group. (2023). *Iptc Photo Metadata Standard 2022.1*. https://iptc.org/std/photometadata/specification/IPTC-PhotoMetadata-2022.1.html

Kettner, L. (1998). Designing a data structure for polyhedral surfaces. In R. Janardan (Ed.), *Proceedings of the fourteenth annual Symposium on Computational geometry - SCG '98* (pp. 146–154). ACM Press. https://doi.org/10.1145/276884.276901

Levin, J. (2019). Roman Graffiti: A Study of Deterioration and Stratification on Subway Trains (1992–2019). *Nuart Journal*, *2*(1), 89–97.

Lucas, G. (2005). *The archaeology of time. Themes in archaeology.* Routledge.

Lucas, G. (2008). Time and Archaeological Event. *Cambridge Archaeological Journal*, *18*(1), 59–65. https://doi.org/10.1017/S095977430800005X

MacDowall, L. J. (2016). A Boneyard of Data: Graffiti and Street Art's Temporalities. *Street Art & Urban Creativity Scientific Journal*, *2*(2), 48–59. https://doi.org/10.25765/sauc.v2i2.53

Minkowski, H. (1908). Die Grundgleichungen für die elektromagnetischen Vorgänge in bewegten Körpern. *Nachrichten von der Königlichen Gesellschaft der Wissenschaften zu Göttingen, Mathematisch-Physikalische Klasse, 1908*, 53–111.

Minkowski, H. (1909). Raum und Zeit. *Jahresbericht der Deutschen Mathematiker-Vereinigung, 18*, 75-88.

Mlekuž, D. (2012). Messy landscapes manifesto. *AARGnews, 44*, 22–23.

Mlekuž, D. (2013). Messy landscapes: Lidar and the practices of landscaping. In R. S. Opitz & D. C. Cowley (Eds.), Occasional Publication of the Aerial Archaeology Research Group: Vol. 5. Interpreting Archaeological Topography: 3d data, Visualisation and Observation (pp. 88–99). Oxbow Books.

Mollett, J. W. (1883). *An illustrated dictionary of words used in art and archaeology: Explaining terms frequently used in works on architecture, arms, bronzes, Christian art, colour, costume, decoration, devices, emblems, heraldry, lace, personal ornaments, pottery, painting, sculpture, &c., with their derivations.* Sampson Low, Marston, Searle, and Rivington.

Muller, R. A. (2016). *Now: The physics of time* (First edition). W.W. Norton & Company.

Myllylä, M. (2018). Graffiti as a Palimpsest. *Street Art & Urban Creativity Scientific Journal*, *4*(2), 25-35. https://doi.org/10.25765/sauc.v4i2.141

Olsen, B., Shanks, M., Webmoor, T., & Witmore, C. L. (2012). *Archaeology: The discipline of things.* University of California Press.

Peuquet, D. J. (2002). *Representations of Space and Time.* The Guilford Press.

Poranne, R., Ovreiu, E., & Gotsman, C. (2013). Interactive Planarization and Optimization of 3D Meshes. *Computer Graphics Forum, 32*(1), 152–163. https://doi.org/10.1111/cgf.12005

Preparata, F. P., & Shamos, M. I. (1985). *Computational Geometry: An Introduction. Texts and Monographs in Computer Science.* Springer. https://doi.org/10.1007/978-1-4612-1098-6

Richards, N., Eichert, S., & Watzinger, A. (2023). One Ontology to Rule Them All—CIDOC CRM in the Humanities and Its Use in OpenAtlas. In G. J. Verhoeven, J. Schlegel, B. Wild, S. Wogrin, & M. Carloni (Eds.), *Document | archive | disseminate graffiti-scapes. Proceedings of the goINDIGO2022 international graffiti symposium* (pp. 220–230). Urban Creativity. https://doi.org/10.48619/indigo.v0i0.711

Rucker, R. v. B. (2014). *The fourth dimension: Toward a geometry of higher reality.* Dover Publications Inc.

Schlegel, J., Carloni, M., Wogrin, S., Graff, A. M., & Verhoeven, G. J. (2023). Making a mark—Towards a graffiti thesaurus. In G. J. Verhoeven, J. Schlegel, B. Wild, S. Wogrin, & M. Carloni (Eds.), *Document | archive | disseminate graffiti-scapes. Proceedings of the goINDIGO2022 international graffiti symposium* (pp. 203–219). Urban Creativity. https://doi.org/10.48619/indigo.v0i0.710

Schneider, P. J., & Eberly, D. H. (2003). *Geometric tools for computer graphics. The Morgan Kaufmann series in computer graphics and geometric modeling.* Morgan Kaufmann Publishers.

Snodgrass, R., & Ahn, I. (1985). A taxonomy of time in databases. In S. B. Navathe & A. Dale (Eds.), *Proceedings of the 1985 ACM SIGMOD international conference on Management of data* (pp. 236–246). ACM. https://doi.org/10.1145/318898.318921

Stewart, I. (1995). One hundred and one dimensions. *New Scientist, 148*(1999), 28–31.

Tegmark, M. (1997). On the dimensionality of spacetime. *Classical and Quantum Gravity, 14*(4), L69-L75. https://doi.org/10.1088/0264-9381/14/4/002

Verhoeven, G. J. (2017). Are We There Yet? A Review and Assessment of Archaeological Passive Airborne Optical Imaging Approaches in the Light of Landscape Archaeology. *Geosciences, 7*(3), 86. https://doi.org/10.3390/geosciences7030086

Verhoeven, G. J., Wogrin, S., Schlegel, J., Wieser, M., & Wild, B. (2023). Facing a chameleon—How project INDIGO discovers and records new graffiti. In G. J. Verhoeven, J. Schlegel, B. Wild, S. Wogrin, & M. Carloni (Eds.), *Document | archive | disseminate graffiti-scapes. Proceedings of the goINDIGO2022 international graffiti symposium* (pp. 63–85). Urban Creativity. https://doi.org/10.48619/indigo.v0i0.703

Wheeler, J. A. (1990). *A journey into gravity and spacetime.* Scientific American Library.

Wild, B., Verhoeven, G. J., & Pfeifer, N. (2023). Tracking the urban chameleon – Towards a hybrid change detection of graffiti. *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, X-M-1-2023*, 285–29. https://doi.org/10.5194/isprs-annals-X-M-1-2023-285-2023

Wild, B., Verhoeven, G. J., Wieser, M., Ressl, C., Schlegel, J., Wogrin, S., Otepka-Schremmer, J., & Pfeifer, N. (2022). AUTOGRAF—Automated Orthorectification of GRAFfiti Photos. *Heritage, 5*(4), 2987–3009. https://doi.org/10.3390/heritage5040155

Wild, B., Verhoeven, G. J., Wogrin, S., Wieser, M., Ressl, C., Otepka-Schremmer, J., & Pfeifer, N. (2023). Urban creativity meets engineering. Automated graffiti mapping along Vienna's Donaukanal. In G. J. Verhoeven, J. Schlegel, B. Wild, S. Wogrin, & M. Carloni (Eds.), *Document | archive | disseminate graffiti-scapes. Proceedings of the goINDIGO2022 international graffiti symposium* (pp. 131–145). Urban Creativity. https://doi.org/10.48619/indigo.v0i0.705

Outer Space, Inner Time. Political Graffiti and Street Art's Audience Research

Francisca Fernandez Merino

School of Politics and International Relations, Queen Mary University of London, E1 4NS London, United Kingdom; E-Mail: f.a.fernandezmerino@qmul.ac.uk

Abstract

According to Velikonja (2020), there are three starting points of Graffiti and Street Art Research (GSAR): the contextualisation, the intentionality of the producer, and the reception, which is related to the audience/viewer/observant, where the audience is one of the starting points less approached in the literature. Consequently, I pretend to explore the potential level of analysis from time and space and its relationship with Graffiti and street art audiences. Time and space will not be considered in linear or geographic terms but in relational terms. Therefore, literature on the social construction of space, the historicity of phenomena from oral history, and audience studies will be considered. In this exploration, I intend to argue that to find the meaning and role of both Graffiti and its audience, it is necessary to consider literature that points to their relationship and how this develops. In this article, I delve into the ways scholars study Graffiti and Street Art audiences, highlighting their methodologies, techniques, and results. Then, I provide a fresh approach to Context in Graffiti and Street Art Research that integrates renewed emotional, temporal, and spatial elements. Lastly, drawing from both scholar's experiences and my own, I propose embodiment as an innovative tool that has yet to be fully explored in this field. By utilising this means, we may be able to bridge some of the gaps that currently exist.

Keywords

Audience; Embodiment; Graffiti; Social Space; Time

1. Introduction. Graffiti and Street Art, Social Movements, and Audiences

From October 2019 to March 2020, Chile witnessed massive social protests with over 3.7 million people participating in the marches (Cooperativa.cl, 2019). The Human Rights Institute report revealed that as of 19 February 2020, there were 3,765 wounded, 445 eye injuries, and 951 complaints of torture (CNN, 2020). The demonstrations led to explosions in metro stations, looting, damage to public and private property, barricades, and fires. However, amidst the chaos, there was also an extensive display of aesthetic and artistic expressions. Graffiti, murals, and stencils adorned every wall, bus, metro station, and building during this period (Le Bert & Soto, 2021; Ribeiro Cavalcanti & Barbosa de Oliveira, 2021). These events grabbed national and international public attention. Local and international electronic media indicated several causes for the outbreak, such as dissatisfaction with the neoliberal socioeconomic model, the increase in the price of public transportation in Santiago (Rehbein Caerols, 2019), social and economic inequality and the high cost of living (Zúñiga, 2019), abuses of power and cases of corruption, cases of collusion in basic goods and medicines, increase in unemployment and business closures, and few guaranteed social rights (Paúl, 2019). Additionally, they reported on the marches, the encounters between protesters and police forces, the reasons for the outbreak, and the artistic expressions. For instance, a Euronews article/video featured an interview with a passer-by woman who commented on

the impressive display of expressions by the people. Similarly, a young man remarked that the walls scream history (Castro, 2019).

These events are not unique, as social movements, strikes, riots, and other collective actions happen frequently. In fact, since 2017, over 400 significant anti-government protests have erupted worldwide (Carnegie Endowment for International Peace, 2023). They are usually accompanied by artistic expressions that resonate with their audience and hold great significance.

Consequently, one may ask whether politics (and contentious politics) could exist without a form of aesthetics or art. From Rousseau and Schiller to more contemporary scholars (Kompridis, 2014; Rancière, 2004, 2013; Ryan, 2017, 2020; Waldner & Dobratz, 2013), there has been an ever-growing exploration of political life from an aesthetic perspective (Kompridis, 2014). Recent books and articles linked to non-routine politics and social movement studies address aesthetics from different approaches, such as cultural studies and democracy (Dabène, 2020), visual culture and communication (McGarry et al., 2020), or urban space and visual protest (Campos et al., 2021), to mention some. Despite this progress, there is more to explore, particularly regarding the role of the audience and their impact on the (re)constitution of time and space.

In this article, I delve into the ways scholars study Graffiti and Street Art's (GSA) audiences, highlighting their methodologies, techniques, and results. Then, I provide a fresh approach to context in Graffiti and Street Art Research (GSAR) that integrates renewed emotional, temporal, and spatial elements. Lastly, drawing from both scholar's experiences and my own, I propose embodiment as an innovative tool that has yet to be fully explored in this field. By utilising this means, we may be able to bridge some of the gaps that currently exist.

2. Audience's Approach

The field of GSAR has traditionally focused on the context, the artist and their work, neglecting the audience's reception and how audiences shape production (Velikonja, 2020; Waldner & Dobratz, 2013). While some scholars have emphasised the importance of social dynamics in GSA, research in this area remains limited (Ryan, 2020; Velikonja, 2020; Waldner & Dobratz, 2013).

Despite the lack of research on audiences' interpretation of Graffiti, Joswig-Mehnert and Yule (1996) provide a starting point for examining viewers' perspectives. In their study, participants responded to a simple written questionnaire attached to each Graffiti image. The survey results show that, on average, 53 % of the responses offered an interpretation of Graffiti, while 47 % offered no interpretations because participants did not respond to the question or expressed individual opinions. The authors did not consider these responses as having definitive meaning. Overall, the study highlights that viewers have a variety of interpretations, and analysts' interpretations may not coincide with those of other viewers. This finding challenges the previous assumption that viewers have a homogeneous understanding of Graffiti. Velikonja (2020) agrees with this conclusion, stating that there is no straightforward interpretative consensus in society, and every text is a battlefield of different interpretations.

Similarly, Lynn (1999) concluded that audience interpretation of Graffiti meaning reveals more about the reader than it does about the writer. To clarify, there is a strong connection between the interpretations and the audience's experience and knowledge. Unlike Joswig-Mehnert and Yule's survey (1996), Lynn employed interviews with Graffiti Writers and created multiple interpretations of selected works. Additionally, Lynn considers the expression of opinions, emotions, and the idea of social space, but they do not play an important role in her results. Joswig-Mehnert & Yule (1996), as well as Lynn (1999), researched uncategorised Graffiti. In other words, they made no distinction between political Graffiti, subcultural Graffiti, or aesthetic Graffiti.

In contrast, Olberg's research (2013, pp. 17–19) focused on political Graffiti from the viewers' perspective. He argues that political Graffiti can motivate an audience to change, unite a population toward a common goal, shape popular consciousness, inform people of important events, persuade

the audience toward action, and/or document a source of popular history and remembrance (Chaffee, 1990, 1993; Salole, 2004). Olberg conducted interviews where the participants observed Graffiti photographs while answering the questions. Three interesting observations emerged from the results: participants tend to overlook Graffiti details, interpret Graffiti ambiguously, and tell personal stories (Olberg, 2013, pp. 111–118). Additionally, Olberg recognises that material space and linear time are important factors in political Graffiti production and meaning. Like Lynn, emotions were observed but were not considered a significant factor in building meaning.

In my Master's thesis (Fernández Merino, 2023), I focused on the audience's perception of Graffiti during the Social Explosion in Chile (2019–2020). Following Olberg's steps, I conducted interviews while showing a selected number of GSA pictures (see Figures 1, 2 and 3). Some of the responses were similar as well, including the participants' tendency

Figure 1. Researcher collection. *Justicia para el Anthony* (Eng. Justice for Anthony).

to story-telling, but others differed. To clarify, around 70 % of the respondents described in detail what they saw in the photograph and what each of these details meant to them. Additionally, I observed varying levels of ambiguity in the responses, both individually and collectively. While some Graffiti had a clear and agreed-upon meaning, others remained entirely open to interpretation. My analysis revealed that, regardless of the interpretation, some participants found the meaning either obvious or ambiguous.

Unlike previous research, I considered emotions a substantial factor in my interviews. After asking about the meaning of Graffiti, I asked how participants felt while looking at the picture. Their responses were sometimes expressed through words and other times through silence, hesitation, or body language. Additionally, it was apparent that Graffiti perception was not only highly emotional but also transformed the audience's understanding of space and drove them back to memories of the past. These three factors play an important role in meaning-building and potentially could affect people's conduct, self- and other's perceptions, and their political position in contentious scenarios. Furthermore, in a social movement context, these factors have the potential to affect the outcome of the movement; and therefore, play

Figure 2. Researcher collection. *No los perdones, saben perfecto lo que hacen* (Eng. Do not forgive them, for they know perfectly well what they are doing).

a role in (un)successful overturns of the status quo. Chaffee describes this as the "psychopolitical explanation of Graffiti" (Chaffee, 1993, p. 17).

My research produced results that aligned with previous findings on interpretation and the role of prior knowledge in shaping meaning. However, I identified a more complex interaction between Graffiti and its audience, with the process of building meaning being attached to more components than just knowledge. I identified five stages of interaction and meaning building: observation and description, identification of core or symbolic meaning, construction of profound meaning, identification of self and others, and reaction to reidentification. Participants' behaviour and understanding of public space changed because of this process.

- First, participants observed, recognised, and described the image; meanwhile, they expressed an aesthetic or political opinion. They also used to interact with the image itself. In other words, these opinions were given to the image and not to me.
- Second, participants identified the core or symbolic meaning of the image. The participants usually shared this meaning, so there was a reduced range of interpretations.
- Third, participants constructed, developed and described a profound meaning. At this stage, the meaning was attached to personal memories, emotions, and previous knowledge; therefore, the range of interpretation was larger than in the previous stage.
- Fourth, participants (re)identified themselves and their political position and the "other's" identity and political position. Hence, they were not only in favour or against but also insiders or outsiders of the meaning they previously built.
- Finally, participants reacted in consequence to their reidentification. They expressed that when they see these Graffiti on the streets during a contentious time, the streets are not the same, and they are not used in the same way. Their understanding of public space changes, and their behaviour changes with it.

In essence, scholars employ a similar methodology when conducting research—they engage in interviews with people and collect both written and spoken data. Consequently, this technique solely enables researchers to interpret

Figure 3. Researcher collection. Rebellious cartoons.

meaning through language and narratives, assuming that the communication between the object and the people is unidirectional. As a result, there is a tendency to disregard the stages of the process, bidirectional communication, and other substantial forms of communication (verbal and non-verbal) and meaning building that is related to aesthetic/political opinions, emotional and sensorial factors, temporal association, and spatial change.

3. Using Embodiment to Extend the Concept of Context

Context is a crucial aspect of GSAR literature. In Valikonja's terms (2020), context is not only a possible starting point for GSAR, but contextualisation is compulsory for finding meaning. Moreover, the context where Graffiti is placed can affect the emotional reactions of its perceiver (Gartus & Leder, 2014). Thus, to understand GSA's place in the world, researchers need to examine where and when GSA is placed and how this place and time conforms to an emotional setting.

In GSAR there are at least three elements of context to consider: (1) Where and when? Space and time and its active relationship with them. (2) What or which elements surround it? Graffiti's message begins and ends with its environment. What matters is not only the Graffiti but also whatever surrounds it since Graffiti without its wall (or whatever surface it is situated on) is not Graffiti. Moreover, (3) Who is (or are) behind it? Graffiti cannot be understood isolated from other Graffiti by the same author, crew, or political group. From a semiotic point of view, Graffiti is, like any other sign, always a part of a wider Graffiti oeuvre and connected to others in the same system of meaning. One can understand it only by understanding its entire symbolic frame. (cf. Velikonja, 2020, pp. 6–7).

However, "Outer Space and Inner Time" aims to delve into a fresh viewpoint on how we comprehend context, time, and space, with particular attention paid to an individual's internal realm. This methodology acknowledges the significance of the social construction of space and the part that memory

plays in our perception of time. Conventional practices may not be adequate to fully understand the intricacy of this interplay, and embodied research may be a promising avenue to gain more profound insights into GSAR.

Embodied research design puts the focus on the body and particularly considers the interaction between the mind, brain, and body, as well as how systems behave and interact (Changaris, 2020; Spatz, 2017). This approach shifts the focus from just the effect A has on B to the contexts and circumstances in which it occurs. By incorporating context into the research process, embodied research design develops more accurate theories of biological, social, and mental phenomena (Changaris, 2020). The embodiment has three core principles that can be used as guides for a method of embodied study construction and research design (after Changaris (2020, p. 3)):

- "The first of these three principles is that embodiment is "situated," i.e., there is a specific time, place, memory, working model, and history (Barsalou, 2008; Wilson, 2002). Rather than attempting to separate out history and location, embodiment recognizes that history and location are core aspects of understanding a process.
- The second core aspect of embodiment is that bodily/system states change outcomes. States often act like a filter on the behaviour of the system, e.g. stress changes memory test outcomes.
- The third aspect of embodiment is simulation. The brain is fundamentally developed for actions and predicting outcomes of actions, which requires a model (i.e., simulation) of the self, one's ability, and the world. Embodied simulation creates working models of the environment and the available responses to the world (i.e., affordances) (Barsalou, 2008; Gallese, 2011; Wilson, 2002)."

In an embodied research design, and particularly through the idea of situated embodiment (Changaris, 2020), the three elements of the context might experience few changes. Embodied methodology emphasises the importance of the physical and socio-temporal contexts and the interactions with all people involved in the study (Fransberg, Myllylä, & Tolonen, 2021). In situated embodiment, this is framed into three core questions about the phenomenon: when, in what context, and what other factors must be present for an outcome to occur (Anderson, 2003). These situated systemic factors have two core components – structures (defined parts of a system that interact) and dynamics (how the parts interact and create emergent properties and system behaviours).

Then, this physical-socio-temporal context involves relational elements in the space in addition to the "when, where, and who" of GSA process. For the interaction between all these elements or part of them, I propose to consider the concept of the social construction of space through its triad, that is the space that is conceived, perceived, and lived (Lefebvre, 1991). The perception of space is related to the perception through our bodies, which are not only things but also 'interspaces between things' (Maurice Merleau-Ponty in Löw (2006, pp. 120–121)). This means that in perceiving through our bodies, we form syntheses in our everyday activities–our lived space–as a means of linking together a great multiplicity of objects to form–or conceived–spaces. In so doing, the body leads to a noteworthy double existence. It is not only the medium of perception but is itself a placed object. As such, it is staged, styled, genderised, and permeated by ethnic constructions. Thus, it is becoming a highly precarious 'building block' of spaces (Löw, 2006, pp. 120–121). As Lin (Lin, 2019, p. 872) notes, the body creates space and becomes the space itself.

Consequently, the context in GSAR should include two more elements: (4) Who is (are) the one(s) interacting with it? GSA are made to be watched, which kind, type, or genre of people is the audience, how they lived, conceived, and perceived the space and how they remember this experience. In other words, how does Graffiti build the context of the audience and vice-versa? Finally, (5) How do these four elements bodily interact with each other, and what are the practices and techniques performed by the bodies in question?

These five elements of context understand the interaction around GSA as an indivisible process between all the bodies involved, including the artist, artwork, audience, and both internal and external context. To address this complex web

of interactions, I turn to the 'Model of Embodied Aesthetics' (Lange et al., 2020, p. 215).

4. Model of Embodied Aesthetics

The Model of Embodied Aesthetics was developed by Koch (2017) for the study of Creative Art Therapies, aiming to define the effects of art. This model focuses on both art perception and active artmaking and argues that there is a continuous process between the active and receptive aspects of the aesthetic experience. Additionally, taking the idea of 'the ambiguity of the body' by Merleau-Ponty (1962), this model understands the body as the only object in the world that can perceived from the inside and outside. Therefore, when people create art, they express something related to their thoughts and emotions, and this expression feeds back into their thinking and feelings. In other words, the artmaking process is circular, with a constant interchange of expression and impression (Lange et al., 2020, p. 215).

Adapting this model may enable scholars to understand GSA interaction as a simultaneous experience of expression and impression as active and receptive bodies. Additionally, it enables scholars to observe participants' embodied experience and aesthetic response, data that goes beyond perception and invites scholars to observe and analyse more than words.

For instance, a 'felt sense' is a bodily experience that occurs before we use words or symbols to describe a situation or object, such as art, theories, or relationships. By delving into these felt senses, we can gain new perspectives that can alter our outlook on past events. It is crucial to understand that felt senses are distinct from emotions or thoughts and are not mere physical sensations. Rather, they hold inherent significance and can guide us in determining our future actions. As Gendlin (1992, p. 343) points out, a felt sense is a constantly evolving, present experience.

An aesthetic response is a distinct and bodily response to an occurrence in the imagination, an artistic act, or an artwork's perception. This term has been developed and extended into the concept of aesthetic answering that can be used as a research method to generate knowledge around an epistemological question (Weiser Cornell & McGavin, 2020). According to Weiser Cornell & McGavin (2020), creating and perceiving art can offer insights that cannot be fully expressed in words. This nonverbal material provides valuable knowledge and meaning that traditional research methods, both qualitative and quantitative, cannot capture.

Therefore, by paying attention to the aesthetic responses and felt sense of either the artist or the audience, it is possible to identify both the internal and external (inside and outside the body) interaction process. Additionally, through their active or receptive behaviour, it is possible to identify impressions and expressions that are shaped before words, emotions, or thoughts. At this point, it is important to concentrate on silence, sounds, body movements or gestures.

To obtain this data in GSAR, a variety of methods can be used, ranging from observation, interview, embodied narrative, photography, video, and others (Bresler, 2006; Fransberg et al., 2023; Hannula et al., 2022). The possibility of laboratories, spaces prepared to investigate performing arts, has also been argued (Scialom, 2021). This will depend on the focus that researchers want to give their study.

5. Conclusions

The purpose of this article was to delve into how Graffiti and Street Art (GSA) and its audience interact in a social movement context. By using embodied research design, this article introduces a fresh perspective on the meaning of context, time, and space.

On this journey through outer space and inner time, two specific findings are worth emphasising. First, the possibility of extending the conceptualisation of the GSA context by incorporating two important elements: the context of the audience, including their construction of space and their memories, and the interaction between the context's elements. Second, the introduction of embodied research design and the model of embodied aesthetics as a promising means for studying the interaction between GSA and the artist/audience. Hopefully, this proposed literature can help with further research on GSA.

Conflict of Interest
The author declares no conflict of interest.

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References

Anderson, M. L. (2003). Embodied Cognition: A field guide. *Artificial Intelligence*, *149*(1), 91–130. https://doi.org/10.1016/S0004-3702(03)00054-7

Barsalou, L. W. (2008). Grounded cognition. *Annual Review of Psychology*, *59*, 617–645. https://doi.org/10.1146/annurev.psych.59.103006.093639

Bresler, L. (2006). Embodied Narrative Inquiry: A Methodology of Connection. *Research Studies in Music Education*, *27*(1), 21–43. https://doi.org/10.1177/1321103X060270010201

Campos, R., Pavoni, A., & Zaimakis, Y. (Eds.). (2021). *Protest, culture & society: Vol. 28. Political graffiti in critical times: The aesthetics of street politics.* Berghahn Books.

Carnegie Endowment for International Peace. (2023). *Global Protest Tracker.* Carnegie Endowment for International Peace. https://carnegieendowment.org/publications/interactive/protest-tracker

Castro, B. (2019, November 26). El estallido social de Chile contado a través de los grafitis de la capital. *Euronews.* https://es.euronews.com/2019/11/26/el-estallido-social-de-chile-contado-a-traves-de-los-grafitis-de-la-capital

Chaffee, L. G. (1990). The popular culture political persuasion in Paraguay: Communication and public art. *Studies in Latin American Popular Culture*, *9*, 127-148.

Chaffee, L. G. (1993). *Political protest and street art: Popular tools for democratization in Hispanic countries. Contributions to the study of mass media and communications:* Vol. 40. Greenwood Press.

Changaris, M. (2020). Embodied research design – a transformational paradigm in scientific discovery. In J. F. Tantia (Ed.), *The art and science of embodied research design: Concepts, methods and cases* (pp. 3–18). Routledge.

CNN (2020, February 19). Reporte del INDH a cuatro meses del estallido: 3.765 heridos, 445 heridos oculares y 951 querellas por tortura. *CNN Chile.* https://www.cnnchile.com/pais/reporte-indh-estallido-social-heridos-oculares-querellas_20200219

Cooperativa.cl (2019, November 12). Más de 3,7 millones de personas han asistido a manifestaciones durante la crisis, según Carabineros. *cooperativa.cl.* https://www.cooperativa.cl/noticias/pais/manifestaciones/mas-de-3-7-millones-de-personas-han-asistido-a-manifestaciones-durante/2019-11-12/071637.html

Dabène, O. (2020). *Street Art and Democracy in Latin America. Studies of the Americas.* Palgrave Macmillan. https://doi.org/10.1007/978-3-030-26913-5

Fernández Merino, F. (2023). *Graffiti in a social movement context. A battle of interpretations* [Master's thesis]. University of Passau, Passau.

Fransberg, M., Myllylä, M., & Tolonen, J. (2023). Embodied graffiti and street art research. *Qualitative Research*, *23*(2), 362-379. https://doi.org/10.1177/14687941211028795

Gallese, V. (2011). Embodied Simulation Theory: Imagination and Narrative. *Neuropsychoanalysis*, *13*(2), 196–200. https://doi.org/10.1080/15294145.2011.10773675

Gartus, A., & Leder, H. (2014). The white cube of the museum versus the gray cube of the street: The role of context in aesthetic evaluations. *Psychology of Aesthetics, Creativity, and the Arts*, *8*(3), 311–320. https://doi.org/10.1037/a0036847

Gendlin, E. T. (1992). The primacy of the body, not the primacy of perception. *Man and World*, *25*(3-4), 341–353. https://doi.org/10.1007/BF01252424

Hannula, M. S., Haataja, E., Löfström, E., Garcia Moreno-Esteva, E., Salminen-Saari, J. F. A., & Laine, A. (2022). Advancing video research methodology to capture the processes of social interaction and multimodality. *ZDM – Mathematics Education*, *54*(2), 433–443. https://doi.org/10.1007/s11858-021-01323-5

Joswig-Mehnert, D., & Yule, G. (1996). The Trouble with Graffiti. *Journal of English Linguistics*, *24*(2), 123–130. https://doi.org/10.1177/007542429602400205

Koch, S. C. (2017). Arts and health: Active factors and a theory framework of embodied aesthetics. *The Arts in Psychotherapy*, *54*, 85–91. https://doi.org/10.1016/j.aip.2017.02.002

Kompridis, N. (Ed.). (2014). *The aesthetic turn in political thought*. Bloomsbury Academic.

Lange, G., Hartmann, N., Eberhard-Kaechele, M., & Koch, S. C. (2020). Aesthetic answering. A method of embodied analysis and arts-based research in creative arts therapies. In J. F. Tantia (Ed.), *The art and science of embodied research design: Concepts, methods and cases* (pp. 212–228). Routledge.

Le Bert, J., & Soto, M. (2021). Inscripciones callejeras en tiempo de malestar: un análisis etno-semiótico de imágenes del estallido social en Chile. *Sur y Tiempo: Revista de Historia de América*, *2*(3), 66–85. https://doi.org/10.22370/syt.2021.3.2686

Lefebvre, H. (1991). *The production of space* (D. Nicholson-Smith, Trans.). Basil Blackwell.

Lin, Z. (2019). Mediating embodied protest: Performative body in social protests in the Internet age in China. *Media, Culture & Society*, *41*(6), 863–877. https://doi.org/10.1177/0163443718818356

Löw, M. (2006). The Social Construction of Space and Gender. *European Journal of Women's Studies*, *13*(2), 119–133. https://doi.org/10.1177/1350506806062751

Lynn, N. (1999). Graffiti. *What you know is what you get* [Master's thesis]. Mount Saint Vincent University, Mount Saint Vincent.

McGarry, A., Erhart, I., Eslen-Ziya, H., Jenzen, O., & Korkut, U. (2020). Introduction: The Aesthetics of Global Protest: Visual Culture and Communication. In J. W. Duyvendak & J. M. Jasper (Series Eds.) & A. McGarry, I. Erhart, H. Eslen-Ziya, O. Jenzen & U. Korkut (Vol. Eds.), *Protest and social movements. The aesthetics of global protest: Visual culture and communication* (pp. 15–35). Amsterdam University Press. https://doi.org/10.1515/9789048544509-004

Merleau-Ponty, M. (1962). *Phenomenology of perception* [Phénoménologie de la perception]. Routledge; Kegan Paul Ltd.

Olberg, S. T. (2013). *Political graffiti on the West Bank wall in Israel / Palestine.* Edwin Mellen Press.

Paúl, F. (2019, October 20). Protestas en Chile: 4 claves para entender la furia y el estallido social en el país sudamericano. *BBC News Mundo.* https://www.bbc.com/mundo/noticias-america-latina-50115798

Rancière, J. (2004). *Disagreement: Politics and philosophy*. University Of Minnesota Press.

Rancière, J. (2013). *The politics of aesthetics: The distribution of the sensible. Bloomsbury revelations.* Bloomsbury Academic.

Rehbein Caerols, C. (2019, October 20). El petitorio de la primavera de Chile: La voz de distintos representantes sociales. https://www.publimetro.cl/cl/noticias/2019/10/23/petitorio-medidas-sociales.html

Ribeiro Cavalcanti, R., & Barbosa de Oliveira, T. M. (2021). Museo de la Dignidad: Entre la polémica y la memoria. Una

mirada sobre las acciones artístico-políticas en el octubre chileno de 2019. *ESCENA. Revista De Las Artes*, *80*(2), 253–296. https://doi.org/10.15517/es.v80i2.45332

Ryan, H. E. (2017). *Political street art: Communication, culture and resistance in Latin America. Routledge research in place, space and politics*. Routledge.

Ryan, H. E. (2020). Political Street Art in Social Mobilization: A Tale of Two Protests in Argentina. In J. W. Duyvendak & J. M. Jasper (Series Eds.) & A. McGarry, I. Erhart, H. Eslen-Ziya, O. Jenzen & U. Korkut (Vol. Eds.), *Protest and social movements. The aesthetics of global protest: Visual culture and communication* (pp. 99–120). Amsterdam University Press. https://doi.org/10.1515/9789048544509-008

Salole, G. (2004). Letter from Johannesburg: A Lesson in Remembrance and Forgiveness. *Ford Foundation Report*, *35*(3), 39.

Scialom, M. (2021). Research Laboratories: Embodied research methodology in perfoming arts. *Revista Brasileira De Estudos Da Presença*, *11*(4), Article e111236. https://doi.org/10.1590/2237-2660111236

Spatz, B. (2017). Embodied research: A Methodology. *Liminalities: A Journal for Performance Studies*, *13*(2).

Velikonja, M. (2020). *Post-Socialist political graffiti in the Balkans and Central Europe. Southeast European Studies*. Routledge.

Waldner, L. K., & Dobratz, B. A. (2013). Graffiti as a Form of Contentious Political Participation. *Sociology Compass*, *7*(5), 377–389. https://doi.org/10.1111/soc4.12036

Weiser Cornell, A., & McGavin, B. (2020). The concept of “felt sense” in embodied knowing and action. In J. F. Tantia (Ed.), *The art and science of embodied research design: Concepts, methods and cases* (pp. 29–39). Routledge.

Wilson, M. (2002). Six views of embodied cognition. *Psychonomic Bulletin & Review*, *9*(4), 625–636. https://doi.org/10.3758/BF03196322

Zúñiga, D. (2019, October 20). Chile: ¿Por qué explotó el país tranquilo de Sudamérica? *Deutsche Welle*. https://www.dw.com/es/chile-por-qu%C3%A9-explot%C3%B3-el-pa%C3%ADs-tranquilo-de-sudam%C3%A9rica/a-50908967

Attitudes and Gazes from Graffiti

Valentina Tretti-Beckles [1,*] and Adrián Vergara-Heidke [2]

[1] Faculty of Human Sciences, University Potsdam, 14476, Germany; E-Mail: tretti@uni-potsdam.de
[2] Faculty of Letters, University of Costa Rica, 11501-2060, Costa Rica; E-Mail: adrian.vergara@ucr.ac.cr
* Corresponding author

Abstract

Place-making is the process of building a 'place' through relationships, practices, and representations of meanings of a varied nature and with the participation of different actors. These actors play different roles as neighbours, producers, recipients, passersby and visitors. Place-making includes all these actors in their relationship with that 'place' and in their interrelationships, practices and in the processes of construction of meaning. Within the stimuli from which people build a sense of a place are the semiotic products that are on the street, for example, commercial signs, advertising, graffiti and urban art. In 2018, we began a project to archive and analyse the semiotic landscape of neighbourhoods in Costa Rica and Chile. Based on this work, two specific aspects caught our attention: people's attitudes and semiotic competence regarding graffiti and street art. We understand semiotic attitudes as an evaluative mental disposition towards the representation of a semiotic object, particularly tags, throw-ups and pieces. This evaluative mental disposition can guide the acts and reactions of people towards those objects and spaces. Semiotic competence is conceptualised as the ability to produce and understand different semiotic products. In the case of this work, we focus on the gaze of throw-ups and the recognition of graphemes. For this paper, we present the preliminary results of two specific objectives of the research that we are developing: first, determining the semiotic attitudes of international and Costa Rican people regarding tags and throw-ups; second, identifying the reading routes and the recognition of graphemes in pieces in people outside the environment of graffiti and hip-hop culture. For the first objective, focus groups were held in Costa Rica with Costa Ricans and Germany with individuals of different nationalities. These focus groups were transcribed and analysed using the appraisal theory of linguistics. For the second objective, an eye tracker experiment was designed to record eye movements and responses regarding the graphemes of the graffiti. The partial results show people's negative attitudes towards tags and throw-ups, as well as different reading patterns in the eye tracker between those who identified graphemes and those who did not.

Keywords

Appraisal; Attitudes; Eye tracking; Gazes; Graffiti

1. Introduction

The semiotic landscape of cities is composed of different texts, such as commercial or institutional signage, shop windows, and graffiti. The latter are stimuli perceived by people who live, work, or walk through the city. They activate and generate representations in their minds, which determine people's attitudes, evaluations, and practices. Precisely, our objectives are: first, identifying how individuals react to tags and throw-ups, which we call here semiotic attitudes, and second, determining, through eye tracking, whether there are different reading patterns in the process of identifying graphemes in pieces[1].

1 Part of this study is inserted in the project Development of Reading Comprehension of Multimodal and Multimedia Texts in Highschool in Costa Rica, financed by the *Espacio de Estudios Avanzados* of the University of Costa Rica.

In the project *Linguistic landscape of urban neighborhood and its perception in people*[2], after photographing commercial signage and graffiti in public spaces in neighbourhoods of San José, Costa Rica, and Santiago, Chile, we noted that there was a higher amount of graffiti in a wealthy neighbourhood in San José (Escalante) compared to a less wealthy (Desamparados). Based on this observation, we created an online questionnaire with images from the neighbourhoods, asking participants to indicate their level of agreement or disagreement with statements about the public spaces where the graffiti and commercial signage were located.

After analysing the results obtained from the questionnaire, we executed focus groups in Costa Rica (with Costa Rican participants) and Germany (with international participants) to identify the semiotic attitudes and evaluations of the individuals (for more details, see Section 3). The relevance lies in understanding the attitudes that are components of the place-making process in urban spaces. Furthermore, they reveal the evaluations and representations, including stereotypes, that individuals hold about the urban space, graffiti artists, and the graffiti itself. Within the results of these focus groups, there were aesthetic appreciations of the graffiti and assessments of the capabilities of graffiti artists. This led us to question whether there was a multimodal literacy (skills to produce and comprehend multimodal texts) among individuals, specifically regarding the perception and understanding of graffiti.

To answer that question, we developed an experiment that was implemented using an eye tracker, with the purpose of exploratively observing reading patterns when tasked with recognising graphemes (letters) in graffiti pieces of varying levels of difficulty (see Section 3). Reading patterns were determined by the number and duration of fixations, as well as the frequency of regressions (backward eye movements) for each grapheme. Informants were recruited from two groups: art students and students from other disciplines.

In the following sections, we first present the results regarding the semiotic attitudes towards the tags and throw-ups from the online questionnaire and the focus groups. Second, we provide partial results obtained from the reading patterns of art students and students from other disciplines, as well as those who correctly identified the graphemes and those who did not.

2. Theoretical Brushstroke

2.1. Urban Linguistics, Attitudes and Appraisal Theory

Urban linguistics is a research approach that investigates the linguistic expressions (e.g., road signs, street names, place names, advertising billboards, commercial shop signs, public signs on government buildings and language variations in the city), which have traditionally been their main focus, in the urban landscape (e.g., Franco Rodriguez, 2013; Gorter, 2006; Landry & Bourhis, 1997; Pickenhayn, 2007; Pons Rodríguez, 2012; Shohamy et al., 2010). However, for this investigation, we consider the multimodality[3] (Bateman, 2008; Kress & van Leeuwen, 2001) of the semiotic landscape, which we define as any communicative or artistic expression (produced by individuals or public or private entities) arranged in public areas, intended to be perceived by passersby. An important concept within urban linguistics is *place-making* (Busse & Warnke, 2015): the process of constructing a place through relationships, practices and representations of meaning, which are varied in nature and serve as a space for the interaction of different actors.

From the above, we are interested in the construction of meaning and attitudes of people outside a neighbourhood based on specific semiotic expressions: graffiti. We understand the attitudes as an evaluative mental disposition towards a psychological object (Ajzen, 2001; Oskamp & Schultz, 2005). In other words, attitudes are evaluations that can determine our actions and reactions towards *attitude objects* (i.e., groups of people, spaces, situations, ideas, and actions) (Oskamp & Schultz, 2005). For this research, we propose using a broader concept than linguistic attitudes (McKenzie & McNeill, 2023), *semiotic attitudes* (Klinkenberg, 2006), which encompasses all evaluative dispositions generated from a semiotic realisation. We focus on the attitudes generated when observing the public space, from

2 This project is coordinated by Adrián Vergara-Heidke and the participants are: Valentina Tretti-Beckles and Héctor Morales-Gutiérrez.

3 The multimodal approach differentiates from traditional urban linguistic works because we do not focus exclusively on the verbal.

which we hypothesise that the attitudes generated by these multimodal texts will be triggered by the graffiti, the sector of the city where it is located and the people who produced it.

For studying the attitudes, in this research, we used a digital valuative questionnaire (Trochim & Donnelly, 2006) and focus groups. The transcriptions of what was expressed by the people who participated in the focus groups were analysed through the *appraisal theory* (Martin & White, 2005; Molina Valverde & Tretti-Beckles, 2021; Oteíza & Pinuer, 2019; White, 2015). This theory proposes a systematisation of the evaluative expressions generated and implied in the texts according to three domains: attitude, engagement and graduation. From attitude, we consider three subdomains (see also Table 1): affect, express sensations or feelings of the speaker; judgement, those that evaluate persons, groups of people or institutions or objects with agentive characteristics; appreciation, those that evaluate processes and objects. Engagement is the expression from which the evaluations are constructed, whether they are the sender's own or are taken from other sources or voices. The graduation domain refers to the intensity and salience of the evaluations. For this research, we only considered the attitude domain. From its subdomains, we applied affection and judgement (categories considered by Molina Valverde and Tretti-Beckles (2021)). The following new categories: integrity, quality, complexity and social impact, were established for the appreciation subdomain because the original ones (Martin & White, 2005; Oteíza & Pinuer,

Subdomain	Category	Explanation	Example
Affect	In/security	Expression of a feeling of security or insecurity of the speaker about himself/herself.	*I feel **insecure.***
	Dis/inclination	Expression of attraction or not to an object, process or person.	***I like it*** very much.
Judgement	Integrity (social sanction)	Evaluative expression of a person or group of people based on moral or legal sanction criteria.	*They are **vandals.***
	Capacity (social esteem)	Valuative expression on the intellectual, physical, social, political, professional, and technical capabilities of a person or group of people.	*He does his job like a **true professional.***

Appreciation	Integrity	Valuative expression of an object or process from the moral or legal sanction.	*That state of the object is **vandalism.***
	Quality	Valuative expression about qualities, characteristics or properties of an object or process. This includes aesthetic appraisals.	*This place is **dirty** and **ugly.***
	Complexity	Valuative expression about the composition and production process of an object or the difficulty of a process.	*That is **complicated.***
	Social impact	Valuative expression about an object or process based on the consequences it may have for people and society. These consequences can be direct or associated with these objects or processes.	*That place is **dangerous.***

Table 1. Attitude domain and categories used in the study.

2019; White, 2015) did not allow for a clear classification and display of graffiti and urban space assessments[4].

2.2. Graffiti

Graffiti, along with other texts, make up the semiotic landscape of (almost) every city in the world. They contribute to the process of constructing the identities of zones, neighbourhoods, and cities. Graffiti is a semiotic expression of graffiti artists and a manifestation of public space, thus contributing to place-making (Busse & Warnke, 2015). In most cases, graffiti is produced and funded by individuals or private institutions (bottom-up), and sometimes, it is created illegally or confrontationally. This has historically led to the persecution and punishment of graffiti artists and graffiti itself (Castleman, 2013; Touborg, 2021). The global expansion of contemporary graffiti in different areas of cities (Castleman, 2013; Chang, 2014; Figueroa Saavedra, 2006) has led to a less negative perception and a diminished association with secrecy, transgression, or illegality. Different classifications of graffiti can be found in the literature (Gottlieb, 2008); however, the most common criterion is the style. Based on Castleman (2013) and Touborg (2021), considering the style, the following distinctions are made:

- *Tag:* Small-sized text with few graphemes, usually representing the author's alias. It is typically created with a single colour and line, using spray paint or markers.
- *Throw-up:* Text that, like the tag, features the author's alias, but with larger letters, a combination of colours, and a filled-in appearance. The graphemes are easily identifiable.

4 The *appraisal theory* is not a closed list of categories, instead it allows the construction of new emerging categories from what is identified in the analysis material.

- *Piece:* Text with large-sized graphemes that have more details than throw-ups. Pieces often have low legibility.
- *Wildstyle:* Text with large-sized graphemes that are nearly impossible to recognise or decipher due to their intricate and complex style.
- *Street art:* Text accompanied by illustrations or abstract/iconic drawings made on walls. Different materials such as paint, spray paint, and stencils can be used for its creation.
- *Message:* Text conveying a social, political, or personal message (often related to love) and created using various materials.

For this research, we are only interested in tags, throw-ups, and pieces due to a methodological decision in which not all types of graffiti that were found could be approached, and the most representative and less complex ones were chosen from a multimodal perspective (without illustrations or abstracts).

2.3. Multimodality and Multimodal Literacy

The concept of multimodality refers to the presence of different modes (words, images, colours, supports) in texts, where semiotic resources serve as stimuli for the construction of meaning by the receiver (Bateman, 2008; Kress, 2010; Kress & van Leeuwen, 2001). This concept draws attention to the complexity of texts and the relevance of all their components. It avoids reductionism by not focusing exclusively, for example, on words or images alone. Graffiti is a multimodal form of text that combines graphemes, words, colours, typography, styles, illustrations, materials, and supports to convey semantic, political, and aesthetic content. For example, Figure 3 shows the multimodality of graffiti in the use of background colour (yellow, red and black), words with ornaments (e.g., s), symbols (e.g., asterisks at the beginning and the end), different types of graphemes and colours (compare with Figures 1 and 2).

Furthermore, we understand multimodal literacy as the ability to produce and comprehend multimodal texts.

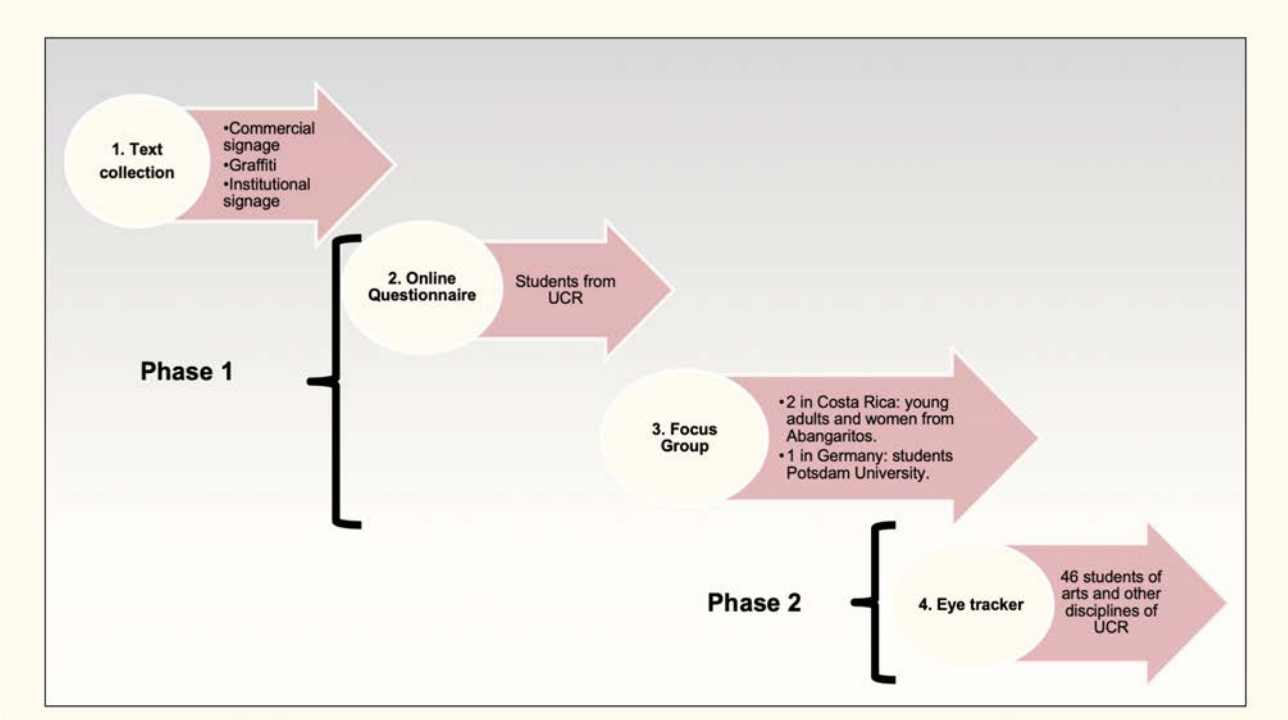


Figure 1. Method phases flowchart.

Multimodal literacy goes beyond the skills of using different semiotic resources to create a multimodal text; it also includes the processing and understanding of these texts. These skills are developed through socialisation and formal and informal education processes (Kress, 2010). We believe that both producing, reading, and understanding (including evaluations) graffiti require that individuals develop specific skills (multimodal literacy for graffiti). One method to approach the study of these skills is through instruments that allow us to explore semiotic attitudes and the process of reading graffiti, such as eye tracking to track eye movements.

2.4. Tracking the Gaze

Eye tracking is a method that allows for direct tracking of gaze while individuals perceive a stimulus (text). This method involves recording, using a device (sensor technology), where the gaze stops (fixations) and moves (saccades) in real-time. This approach eliminates the need for individuals to process the texts and provide their opinions about what they did while reading them, thus avoiding the risk of bias or social desirability influencing their responses (Sülflow et al., 2019). Behind studies using eye trackers and texts lies the eye-mind hypothesis: when the gaze stops on a word or image, the person is processing the information of what they are seeing (Just & Carpenter, 1980). Accordingly, it is said that the longer the duration of the fixation, the higher the processing cost of the visual stimulus (words or images).

3. Methods

The results presented in this text were extracted from two phases, each with its own methodology: first, semiotic attitudes and appraisal, and second, eye tracking. These two phases will be presented separately.

3.1. Phase 1: Semiotic Attitudes and Appraisal

This study explores the semiotic attitudes that different types of graffiti generate in Costa Rican people. Attitudes are approached through an indirect method, as we used an online questionnaire and conducted three focus groups. In these instruments, images of graffiti and commercial signage are combined so that the participants did not know which responses to the stimuli we were interested in. The images used are part of a photo collection that was acquired between July and December 2018 in two neighbourhoods in the city of San José, Costa Rica (Escalante and Desamparados), and two neighbourhoods in the city of Santiago, Chile (Italia and Franklin)[5,6].

In December 2018, the online questionnaire was "digitally circulated" among university students in Costa Rica. In this way, a total of 56 anonymous responses were obtained. Of those participating in the online questionnaire, none of the respondents lived in the neighbourhoods where the images were collected. The items had the following structure: a photograph of a graffiti or sign accompanied by six statements (see below), which were rated according to the degree of agreement or disagreement on a Likert scale (Trochim & Donnelly, 2006).

After a review of the results obtained, we observed more negative associations towards urban space based on graffiti stimuli, which surprised us, given that there were more graffiti in wealthy neighbourhoods in Costa Rica. In order to better understand the causes of these negative associations, we conducted two focus groups in Costa Rica in 2022 and one in Germany in 2023.

The first focus group was examined with seven university students between 24 and 37 years from the University of Costa Rica, Rodrigo Facio Campus, San José; the second with four women between 40 and 58 years from the town of Abangaritos, Puntarenas; and the third with four students between 22 and 31 years[7] from the University of Potsdam, Germany. In all three cases, the persons signed an informed consent, allowing the audio recording of the meeting, and we committed to maintaining their anonymity. We

5 Barrio Escalante and Barrio Italia are wealthy and commercial (restaurants, design shops, pubs) neighbourhoods, their growth occurred over the last 15 years. Desamparados and Franklin less wealthy and commercial (shops, small restaurants and beauty salons) neighbourhoods, which have been in existence for more than 70 years.

6 See Vergara-Heidke and Morales-Gutiérrez (2020) for more details about the neighbourhoods.

7 From Taiwan, Argentina and India.

hypothesised that different attitudes might occur among people from different origins, which is why the focus groups have a different composition; however, this was not the case because the difference was not significant between these groups. Therefore, we present the results together below. The focus groups were audio recorded, and then the responses and comments motivated by graffiti images were transcribed.

Applying the *appraisal theory* (see Table 1), the transcripts of the focus groups were analysed and systematised, in which the manifestations of semiotic attitudes and their evaluative segments were identified. Excel software was used for this purpose.

3.2. Phase 2: Gaze Movement

We created an experiment with 14 different images: 3 stimuli of interest and 11 fillers (distracting images, such as fake news, collages and commercial signs). Additionally, the

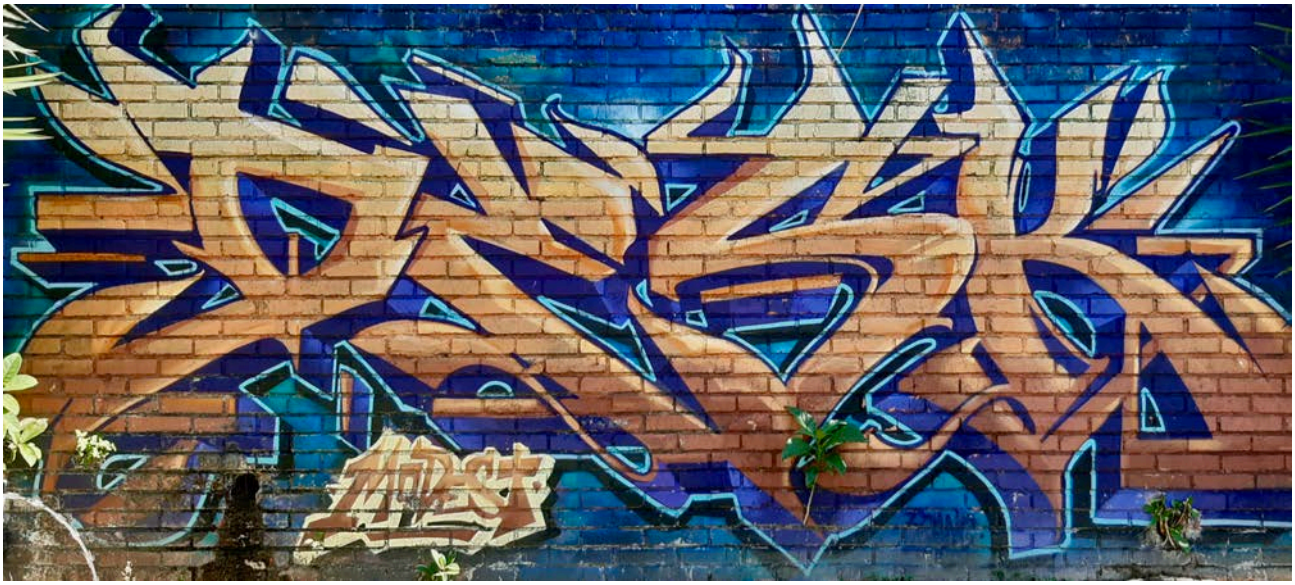


Figure 2. Piece which reads "DESK". Photograph taken by Adrián Vergara-Heidke in Escalante, Costa Rica, March 2023.

Figure 3. Piece which reads "MUSH". Photograph taken by Adrián Vergara-Heidke in Escalante, Costa Rica, April 2023.

Figure 4. Piece which reads “RUSTE”. Photograph taken by Adrián Vergara-Heidke in Escalante, Costa Rica, April 2023.

Figure 5. Eye Tracker SMI RED500 (image taken from the IMOTIONS website.)

stimuli of interest were photographs of real graffiti pieces from San José, Costa Rica. The pieces have varying degrees of difficulty in identifying the graphemes.
Some of the images were followed by questions about the content of the image. In the case of the three pieces (see Figures 2, 3 and 4), the questions were about "what you read" in the graffiti, specifically focusing on the larger letters. The non-graffiti images appeared on the screen for 5 seconds, while the pieces were displayed for 8 seconds. This difference in the times is due to the fact that if they were all 8 seconds, the experiment would be very long.

The equipment used was the RED500 by SMI company (https://imotions.com/products/hardware/smi-red), with an applied instrument sensitivity of 500 Hz (see Figure 4).

Data were collected at the Faculty of Letters and the Faculty of Arts of the University of Costa Rica. The volunteer participants were divided into two groups: Group 1 consisted of 23 students from the Faculty of Letters, which incorporates various disciplines with a focus on humanities, while Group 2 consisted of 23 students from the Faculty of Arts who were at least in their third year of the arts program with any of its emphases. The selection of these locations was based on the hypothesis that individuals with an arts literacy, and therefore a more developed visual literacy compared to other disciplines, might be better at identifying the graphemes of the graffiti pieces and would have particular reading patterns of graffiti[8].

The data were collected between April and May 2023. The experiment involved participants viewing the images on a computer screen while their eye movements and responses to the questions were recorded. The duration of each session was between 5 and 8 minutes, depending on the time needed to answer each question. All participants signed an informed consent form authorising the use of the collected data.
The data analysis was divided into several steps: first, the correct responses (all graphemes must be correctly classified) regarding the identification of the graphemes were observed and compared between the two participant

8 It has been proven that there are different reading patterns depending on the motivations and previous knowledge of the person (Vergara et al., 2021; Villalobos Fernández et al., 2020).

Figure 6. Graffiti graphemes—"DESK".

Figure 7. Graffiti graphemes—"MUSH".

Figure 8. Graffiti graphemes—"RUSTE".

groups. Second, the data on fixations, fixation durations, and regressions of participants from both groups were cleaned. In this step, individuals with a tracking ratio (percentage of detected gazes) below 80 % and those who did not stop at all graphemes were excluded. It is important to note that individuals who did not stop at all graphemes were excluded because it was required to have at least one fixation on each letter to ensure that the entire graffiti was read. Third, the results were compared between the students from the arts group and the other students. Fourth, the results were compared between the students who correctly identified the graphemes and those who did not, regardless of their academic field.

Each step aimed to provide insights and comparisons related to the participants' performance, considering both their identification of graphemes and their eye-tracking data. We have only conducted a descriptive statistical analysis of the results, as they are still considered to be partial results.

4. Analysis and Results

In this section, we present the results obtained after applying the questionnaire and conducting the focus groups, as well as the instrument with the eye tracker.

4.1. Attitudes and Appraisal

These results are organised based on the degree of negativity in attitudes towards different types of graffiti, as depicted in the images used in the questionnaire and focus groups.

4.1.1. Tags

In this section, we will show the results obtained, with respect to the tags, in the questionnaire and the focus groups. Figure 7 displays an example used in the two instruments used.

Table 2 shows that 67 % of the participants of the questionnaire think that the place where the tag is located is unsafe, and 74 % consider it not to be a good place to live. Additionally, 66 % of the participants contemplate that this is not a place to go for a walk, eat or drink; additionally, 65 % appraise it as a sector of the city without stores for shopping. Moreover, 53 % believe this is not a cosmopolitan (multicultural) neighbourhood, and 64 % agree that it does not have a lot of cultural or artistic activities.

Regarding linguistic expressions, Table 3 reveals that Costa Rican participants do not like tags, and they believe that the urban space is unsafe and insecure. In the international group, participants did not express any dis/inclination over the tags; however, they also appraised the place

Figure 9. Example of a tag: Photograph taken by Adrián Vergara-Heidke in Escalante, Costa Rica, August 2018.

When I see this, I think:	Agree	Neutral	Disagree
"This must be an unsafe part of the city".	67 %	19 %	14 %
"It must be good to live here with the family"	5 %	21 %	74 %
"To this neighbourhood I would go for a walk, eat or drink."	9 %	25 %	66 %
"This must be a cosmopolitan (multicultural) neighbourhood"	13 %	34 %	53 %
" It must be a sector of the city plenty of stores for shopping."	11 %	24 %	65 %
"In this neighbourhood there should be a lot of cultural and artistic activities (museums, theatres, art galleries, cultural centres…)."	12 %	24 %	64 %

Table 2. Results of online questionnaire on tags.

Subdomain	Category	Linguistic Expressions in Costa Rica	Linguistic Expressions in Germany	Valued object or person
Affect	Dis/inclination	"I wouldn't like it" (–)	––	graffiti
Judgement	Moral integrity	"*vandals*"(–)	––	graffiti artists
Appreciation	Integrity	––	"vandalism"(–)	graffiti
	Quality	"abandoned area"(–), "place of passage"(–), "dirty"(–), "it smells very bad"(–), "they smell like homeless people's poop"(–), "where homeless people are"(–), "those who can live there are thieves, drug addicts or something like that"(–)	"imagine this place dirtier than the previous ones" (–), "place dirty" (–), "pretty busy area" (+–)	urban space
		"less aesthetic"(–)	"art" (+), "not so tidy or so decent" (–), "messiness" (–), "not so good" (–)	graffiti
	Social Impact	"insecure"(–), "dangerous"(–)	"most unsafe (–)"	urban space

Table 3. Valuative words according to categories and objects valuated from tags.

as unsafe. No judgmental expressions regarding graffiti artists were made by international participants, which was not the case with Costa Ricans, who considered them negatively as "vandals". Nonetheless, the international group contemplated as vandalism the integrity of the graffiti, which was not observed in the Costa Rican group. Moreover, in both groups, participants made positive and negative linguistic assessments regarding urban space and graffiti. Furthermore, Costa Rican participants produce more negative appreciations regarding the social impact of the urban space than the internationals.

From the responses obtained in the questionnaire, it is confirmed that insecurity is negatively valued, and it is striking that the tags are not related to residential, commercial, cultural or gastronomic areas. Then, it is worth asking in what urban spaces one would expect to find this type of graffiti, taking into account, as noted above, that in the collection of graffiti in San José, Costa Rica, it was found that in Escalante, a neighbourhood characterised by its offer of restaurants and bars and by its security, there was much more graffiti than in more popular and commercial areas such as the downtown of Desamparados.

Moreover, there is evidence of the negative attitude that the tags generate through the association with citizen insecurity. In other words, the presence of these multimodal semiotic expressions activates a representation related to unsafe urban spaces in the minds of the participants. This type of negative attitude is also present in the focus groups, in which 72 % of the evaluations expressed were negative in the Costa Rican group and 80 % in the international group.

Neutral evaluations were made in both groups, Costa Rican 28 % and international 10 %; the Costa Rican group made no positive evaluations in contrast with the international 10 %. Thus, it is evident that tags generate mainly negative attitudes. However, these attitudes vary with respect to the object evaluated. In the focus groups, three elements were observed when people gave their opinions based on an image of a tag: the graffiti, the urban space and the people who created it (graffiti artists). An example of the focus groups is presented below.

1. "The truth is that I see it **all dirty,** it's like **there's a lot of garbage on the sidewalk,** so I see it as **a little dangerous too,** but during the night, during the day, **I would walk around a little more carefully,** but I do feel that it **smells pretty bad"**[9] (P1G1 [10]). [11]

In this fragment, after seeing the image of a tag, a participant evaluates the urban space as "dirty", with garbage ("there is a lot of garbage there on the sidewalk") and that "it smells pretty bad", in other words, they evaluate the hygiene of the place negatively. Likewise, reference is made to insecurity with expressions such as "a little dangerous" and "yes, I would walk around a little more carefully". All these evaluations are consistent with a negative representation of the area in which a tag could be located. On the other hand, it is evident that these attitudes determine the actions of these people since the person affirms that "yes, I would walk more carefully", that is, I would walk according to these representations. These attitudes correspond to the category of quality and social impact within the appraisal subdomain of the appraisal system.

In addition, in the Costa Rican and international groups, participants produced linguistic expressions as "a place of passage or to pass by" to refer to the urban space. This construction of the urban space as a "passing by place", perhaps, explains the results obtained in the questionnaire regarding the fact that the space was neither residential, commercial, cultural, nor gastronomic, since it was not a place to stop, but a 'passing-by place'. These places where people circulate, where they do not stop, are the places they represent in their minds when they see a tag.

9 The bold font is used in the fragments of the focus groups to emphazise the valuative elements.

10 The code identifies the participant (PX) and the focus group (GX).

11 Translated from original: "yo la verdad es que lo veo todo sucio es como ui que de fijo hay como un montón de basura ahí en la acera entonces si lo veo como medio peligrosillo también, pero durante la noche en el día sí andaría como más como con un poco más de cuidado pero ahí sí siento que huele bastante mal" (P1G1).

Figure 10. Example of a throw-up. Photograph taken by Adrián Vergara Heidke in Escalante, Costa Rica, August 2018.

When I see this, I think:	Agree	Neutral	Disagree
"This must be an unsafe part of the city".	55 %	29 %	15 %
"It must be good to live here with the family"	6 %	26 %	68 %
"To this neighbourhood I would go for a walk, eat or drink."	16 %	27 %	57 %
"This must be a cosmopolitan (multicultural) neighbourhood"	24 %	35 %	41 %
" It must be a sector of the city plenty of stores for shopping."	12 %	30 %	58 %
"In this neighbourhood there should be a lot of cultural and artistic activities (museums, theatres, art galleries, cultural centres…)."	24 %	33 %	43 %

Table 4. Results of questions about throw-ups.

4.1.2 Throw-ups

The results obtained in the questionnaire and focus groups regarding throw-ups are presented in this section.

In Table 4, we can observe that 56 % of the participants of the questionnaire agree that the place where the throw-ups are located is unsafe, and 68 % consider it not a good place to live. In addition, 57 % believe that they would not go to this neighbourhood to walk, eat or drink. In addition, 58 % think that this location must be in a sector of the city that does not have stores. Further, most of the participants are neutral (35 %) or agree (21 %) with the fact that this place is a cosmopolitan or multicultural neighbourhood. Similarly, participants believe that this is a neighbourhood with cultural and artistic activities (24 % agree, and 33 % are neutral).

Subdomain	Category	Linguistic Expressions in Costa Rica	Linguistic Expressions in Germany	Valued object or person
Affect	Dis/inclination	"I don't like it"(–), " I don't dislike it"(+–), "I certainly prefer the graffiti to the grey wall"(+), "I like it"(+), " I do like it "(+), "for someone to paint it for me in a T-Shirt "(+)	"not as strong emotions" (–), "I don't like it that much" (–), "I appreciate it as a whole" but it doesn't give me a very strong emotion of like or dislike(+–), "I quite like it" (+), "I don't dislike it" (+–), "in terms of style I like this piece" (+), "I don't like how the yellow looks" (–), "I like it, I like that it dives out a feel of movement of speed" (+)	graffiti
	In/security	"I have been afraid"(–), "insecurity"(–)	"it's not necessarily safer or less safe; it makes me feel like there are fewer people around" (–+), "I feel safe" (+), "I would not necessarily feel unsafe here" (+–)	urban space
Judgement	Moral integrity	"*sketchy person* there is a sketchy" (–), "vandals that are painting walls"(–), "vandals"(–), "it doesn't necessarily have to be vandalism"(+), "it belongs to a gang or a clique"(–), "who was there"(–)	––	graffiti artists
	Capacity	"this is their art"(+), "very amateurish and it is like from school"(–)	––	graffiti artists

Appreciation	Integrity	"vandalism"(–)	––	graffiti
	Quality	"smell of urine"(–), "abandoned places"(–), "cleanliness"(–), " abandoned building"(–), "poop and urine"(–), "under the bridges where there are homeless people and those walls are there"(–)	"transit place" (+–), "not a nicer place" (–), "somewhere around the office space" (+–), "very busy place"(+–), "pretty old like it's been washed away with time"(–)	urban space
	Complexity	"not planned"(–), "very amateurish and yes it's like from school"(–), "this is art is their art"(+), "yes it was thought"(+)	"art"(+), "illustration"(+), "fancy" (+), "Bold"(+), "pretty elaborate"(+), "it's better than the previous one" (+)	graffiti
	Social Impact	"and I say people are rushing by"(+–), "insecure"(–), "I pass running"(–)	"fewer people will pass" (–), "people go around but not stay for long they just pass by" (+–), "very isolated place" (–)	urban space

Table 5. Valuative words according to categories and valued objects from throw-ups.

Table 5 shows that participants of the focus groups demonstrate either positive or negative affection, dis/inclination regarding the throw-ups, they either like or dislike them. In this case, international participants produce more neutral or positive expressions regarding urban space insecurity than Costa Ricans, which are only negative. Moreover, Costa Ricans make judgments regarding the moral integrity and capacity of graffiti artists, which are mostly negative. In contrast, the international group did not produce any of these valuations. Participants show appreciation for the quality of the urban space; in the case of Costa Ricans, they do it with negative expressions and internationals with both neutral and negative. Additionally, they refer to the quality of the graffiti with positive, negative or neutral expressions. Further, Costa Rican participants evaluate the complexity of the graffiti either negatively or positively; in contrast, internationals rate them positively. Finally, both groups refer to the social impact of urban space negatively or neutrally, mostly considering that these throw-ups are located in places where people pass by.

The answers of the focus groups show that there is a majority of negative evaluations (52 %), compared to neutral (30 %) and 18 % of positive evaluations in the Costa Rican group; however, in the international group, the majority are positive 52 %, 26 % are neutral and 21 % negative.

Thus, unlike the tags, the people participating in the focus groups expressed negative attitudes, but in a lower percentage than with respect to the tags. In both groups, but especially in the international group, participants made positive evaluations, which was not seen with the tags. Below is an example of what was said in the focus groups.

2. "But it's not that there are many people who dedicate themselves to drawing on walls, so it doesn't necessarily have to be **vandalism**" (P1G2).[12]

This example presents a positive evaluation of graffiti and, at the same time, in an implicit (evoked) way of graffiti artists: "it does not necessarily have to be **vandalism**". These positive

12 Translated from original: "pero no es que hay muchas personas que se dedican a andar dibujando paredes entonces no no necesariamente tiene que ser vandalismo" (P1G2).

attitudes generated by throw-ups are observed, not only but now towards other elements such as graffiti and graffiti artists. Nonetheless, there are also negative evaluations of the urban space, see Table 5, with expressions regarding the cleanliness of the public space. This shows that even though participants value graffiti artists and throw-ups positively (compared to tags), the spaces where they are located are still unsafe, dirty, and "passing by places".

In addition, from Table 5, we would like to draw attention to the evaluations of the complexity of the throw-ups. Among them, they refer to "not planned", "very amateur and yes, it is like school", "this art is, art of them [graffiti artists]", and "yes, it was thought". It is observed that planning is an element that is considered to value the complexity of these graffiti ("not planned", "yes, it was thought out"). It can be argued that the more semiotic resources such as colours, brightness, filling, among others, the greater the planning and, therefore, the better the quality. On the one hand, this greater planning involves the need for the graffiti artist to have made a previous sketch (design), as well as to have foreseen the colours and space required to make the throw-up. Moreover, it is considered that expressions such as "very amateur and yes, it is like school", "this is art is their art", "pretty elaborate", and "too basic" refer to complexity, since they are associated with the technique and the ability that the graffiti artist manifested in his work. On the other hand, these evaluations could indicate specialised knowledge or skills (multimodal literacy) of the individuals who made those statements. We will address this in the following section.

4.2. Gazes and Fixations

In this section, we present the partial results obtained from the data recorded with the eye tracker while applying an experiment with pieces. The aim is to evaluate the recognition of graphemes and observe reading patterns, comparing art students and students from other disciplines, as well as between those who identified the graphemes and those who did not.

	Participants	***RUSTE***		***DESK***		***MUSH***	
		Correct	Incorrect	Correct	Incorrect	Correct	Incorrect
Arts	23	48 % (11)	52 % (12)	13 % (3)	87 % (20)	4 % (1)*	96 % (22)
Other disciplines	23	61 % (14)*	39 % (9)	22 % (5)*	78 % (18)	0 % (0)	23 (100%)

Table 6. Identification of graphemes according to disciplines of study.

4.2.1. Comparison Between Students of Arts and Other Disciplines

The first review of results involved comparing the responses and eye movements of art students and students from other disciplines. First, the correct or incorrect identification of each graffiti was observed. Subsequently, the means of the number of fixations, fixation durations, and number of regressions were compared among those students from both groups who made at least one fixation on all graphemes of each piece.

Table 6 shows that more individuals identified the graphemes in the graffiti "RUSTE" (a total of 25 people), followed by "DESK" (8 people), and finally, "MUSH" (only one person). It is also evident that more students from other disciplines correctly identified all the graphemes in "RUSTE" (61% vs. 48%) and "DESK" (22% vs. 13%), while only one art student identified "MUSH". Excluding the exception of the student who recognised all four graphemes in "MUSH," students from non-art disciplines had a higher accuracy in identifying the graphemes.

On the other hand, we compared the mean number of fixations, fixation durations, and regressions between

art students and students from other disciplines who had fixations on all the graphemes of each graffiti, in order to observe if there was any pattern that distinguished the reading process between the two groups. However, we did not find any significant differences in these data. Therefore, we can conclude that art students and students from other disciplines do not differ in these three aspects.

Based on the previous results, we can conclude that, first, in the field of arts, it appears that the multimodal skills for identifying graphemes in graffiti are not developed. Second, if there is a different multimodal literacy among students from different disciplines, it is not evident in the recognition of graphemes or in eye movements (fixations, fixation durations, and regressions) when presented with pieces stimuli.

4.2.2. Comparison Between Those Who Identified the Graphemes and Those Who Did Not

In the second review of results, we compared the means of the number of fixations, fixation duration, and number of regressions between those who correctly identified the graphemes and those who did not. We only considered those individuals who had made at least one fixation on all the graphemes of each graffiti. Additionally, we excluded the piece "MUSH" since only one person managed to identify all the graphemes. Out of all the analysed data so far, only the mean fixation duration shows a clear behavioural pattern that distinguishes individuals who identified all the graphemes from those who did not.

	Participants	R	U	S	T	E
		Time fixation average	Time fixation average	Time fixation average	Time fixation average	Time fixation average
Incorrect	9	108.88 ms	129.57 ms	126.82 ms	161.30 ms	134.52 ms
Correct	9	211.80 ms*	148.24 ms*	180.08 ms*	183.06 ms*	210.07 ms*

Table 7. Fixations and time according to correct and incorrect answers of "RUSTE".

	Participants	D	E	S	K
		Time fixation average	Time fixation average	Time fixation average	Time fixation average
Incorrect	**20**	218.21 ms	219.34 ms	196.26 ms	188.27 ms
Correct	**5**	310.28 ms*	230.97 ms*	240.21 ms*	200.23 ms*

Table 8. Fixations and time according to correct and incorrect answers of "DESK".

When examining Tables 7 and 8, a trend becomes evident among individuals who successfully identify the graphemes: they spend more time per fixation on each grapheme. In other words, individuals who recognise the graphemes do not make more fixations or regressions, but their fixations last longer. This can be explained by a higher cognitive effort (Just & Carpenter, 1980) to achieve grapheme identification. This could reinforce the idea that participants in the experiment did not possess multimodal literacy for graffiti, as even those who recognised the graphemes had to exert cognitive effort to do so.

5. Conclusions

After analysing the semiotic attitudes and appraisals of Costa Ricans in focus groups conducted with both Costa Ricans and an international group living in Berlin (but of students of Potsdam University), it was observed that in Costa Rica people have negative attitudes and appraisals towards graffiti, particularly tags and throw-ups, graffiti artists, and the public spaces where these texts can be found. On the other hand, participants in the focus group conducted in Berlin showed fewer negative semiotic attitudes and explicit negative appraisals towards the same stimuli. This difference may be because graffiti is more widespread and easily seen in any neighbourhood in the city of Berlin. This would make people more accustomed to these texts, so neither the graffiti nor the public spaces generate semiotic attitudes or many negative appraisals. We cannot rule out the possibility that the fact that the international group did not share some cultural elements made them more cautious when making appraisals.

The results obtained through eye tracking did not show any difference in the identification of graphemes or reading patterns between individuals with a visual or multimodal literacy in the field of arts and students from other disciplines. This could be explained by the fact that the arts program does not specifically develop skills for recognising graffiti but rather focuses on other forms of visual artistic and cultural expressions. Therefore, we reject the hypothesis that students in the arts program would have developed skills that would enable them to identify graphemes better and exhibit their own reading patterns.

The difference in partial results regarding reading patterns between those who correctly identified the graphemes and those who did not showed a longer duration of fixations. This longer fixation time may indicate a higher cognitive effort from individuals to identify each grapheme. It suggests that these individuals do not possess a multimodal literacy for graffiti, as they required more cognitive effort. This assumption is based on the idea that individuals with the skills to perceive something (the literacy for it) require less time in their fixations when observing the text. The relationship between fixation time and cognitive effort in multimodal texts should be addressed in future research.

One of the limitations of this work is that by filtering the data to include only individuals who fixated on all the graphemes, the number of partial results obtained was significantly reduced. Furthermore, very few of these individuals correctly identified the graphemes, so we cannot make statistical generalisations based on these data. Finally, the stimuli were presented on a screen, which is a laboratory setup that does not correspond to the real-world perception of graffiti in a public space.

We still have pending tasks to review the data obtained using other criteria. For example, we need to subdivide the graphemes internally to observe if a specific part is more frequently observed. We also need to analyse the sequences of fixations to identify any reading patterns and apply more complex statistical formulas. Additionally, we have plans to conduct the same experiment with graffiti artists from outside the country, as those in Costa Rica are familiar with each other and may recognise the graphemes. Furthermore, we intend to conduct a new experiment using graffiti pieces from another city and apply it to Costa Rican graffiti artists.

In future studies, on the one hand, we would like to use eye-tracking glasses to directly record gaze patterns on graffiti in the public space. Additionally, we plan to conduct graffiti workshops to assess and measure grapheme identification using an eye tracker before and after the workshop. This will allow us to observe if there is a development of multimodal literacy specific to graffiti. On the other hand, we should research semiotic attitudes in which the stimuli (in questionnaires or focus groups) show more elements of the spatial contexts in which graffiti appear and that delves into assessments and constructions of other related topics (youth, music, violence, crime, pollution), in order to address more factors that determine the social perception of graffiti.

Conflict of Interest

The authors declare no conflict of interest.

References

Ajzen, I. (2001). Nature and operation of attitudes. *Annual Review of Psychology, 52*, 27–58. https://doi.org/10.1146/annurev.psych.52.1.27

Bateman, J. A. (2008). *Multimodality and Genere: A foundation for the systematic Analysis of Multimodal Documents.* Palgrave Macmillan.

Busse, B., & Warnke, I. H. (2015). Sprache im urbanen Raum. In E. Felder & A. Gardt (Eds.), *Handbücher Sprachwissen: Band 1. Handbuch Sprache und Wissen* (pp. 519–538). De Gruyter.

Castleman, C. (2013). *Getting up / Hacerse ver: el grafiti metropolitano en Nueva York.* Capitán Swing.

Chang, J. (2014). *Generación Hip-Hop: De la guerra de pandillas y el graffiti al gangsta rap* (M. Battistón, Trans.). Caja Negra.

Figueroa Saavedra, F. (2006). *Graphitfragen: Una mirada reflexiva sobre el graffiti. Anejos de Cuadernos del Minotauro: Vol. 1.* Minotauro Digital.

Franco Rodriguez, J. M. (2013). An Alternative Reading of the Linguistic Landscape: The Case of Almería. *Revista Internacional De Lingüística Iberoamericana*, *11*(1(21)), 109–134.

Gorter, D. (2006). Further Possibilities for Linguistic Landscape Research. In D. Gorter (Ed.), *Linguistic Landscape: A New Approach to Multilingualism* (pp. 81–89). Multilingual Matters Ltd. https://doi.org/10.21832/9781853599170-006

Gottlieb, L. (2008). *Graffiti art styles: A classification system and theoretical analysis.* McFarland & Company, Inc.

Just, M. A., & Carpenter, P. A. (1980). A theory of reading: From eye fixations to comprehension. *Psychological Review*, *87*(4), 329–354. https://doi.org/10.1037/0033-295X.87.4.329

Klinkenberg, J.-M. (2006). Manual de semiótica general [Précis de sémiutujue genérale]. *Colección Humanidades.* Universidad de Bogotá Jorge Tadeo Lozano.

Kress, G. R. (2010). *Multimodality: A social semiotic approach to contemporary communication.* Routledge.

Kress, G. R., & van Leeuwen, T. (2001). *Multimodal discourse: The modes and media of contemporary communication.* Arnold Publishers.

Landry, R., & Bourhis, R. Y. (1997). Linguistic Landscape and Ethnolinguistic Vitality: An Empirical Study. *Journal of Language and Social Psychology*, *16*(1), 23–49. https://doi.org/10.1177/0261927X970161002

Martin, J. R., & White, P. R. R. (2005). *The Language of Evaluation: Appraisal in English.* Palgrave Macmillan UK. https://doi.org/10.1057/9780230511910

McKenzie, R. M., & McNeill, A. (2023). *Implicit and explicit language attitudes: Mapping linguistic prejudice and attitude change in England. Routledge Studies in Sociolinguistics.* Routledge.

Molina Valverde, N., & Tretti-Beckles, V. (2021). Evaluación en tiempos electorales: un acercamiento al proceso electoral desde el sistema de valoración. In L. Álvarez Garro (Ed.), *Imaginarios, subjetividades y democracia: estudios sobre el proceso electoral del 2018 en Costa Rica* (pp. 101–145). Universidad de Costa Ricaa, Centro de Investigación y Estudios Políticos.

Oskamp, S., & Schultz, P. W. (2005). *Attitudes and opinions* (Third edition). Lawrence Erlbaum Associates.

Oteíza, T., & Pinuer, C. (2019). El sistema de valoración como herramienta teórico-metodológica para el estudio social e ideológico del discurso. *Logos: Revista de Lingüística, Filosofía y Literatura*, *29*(2), 207–229. https://doi.org/10.15443/RL2918

Pickenhayn, J. (2007). Semiótica del paisaje, *Revista Geográfica*(141), 7–22.

Pons Rodríguez, L. (2012). *El paisaje lingüístico de Sevilla: Lenguas y variedades en el escenario urbano hispalense. Ciencias sociales: Vol. 25*. Diputación de Sevilla.

Shohamy, E. G., Ben-Rafael, E., & Barni, M. (2010). *Linguistic landscape in the city*. Multilingual Matters.

Sülflow, M., Schäfer, S., & Winter, S. (2019). Selective attention in the news feed: An eye-tracking study on the perception and selection of political news posts on Facebook. *New Media & Society*, *21*(1), 168–190. https://doi.org/10.1177/1461444818791520

Touborg, E. (2021). *Graffiti Bible: A complete guide on how to do graffiti.* Publikat Publishing.

Trochim, W. M. K., & Donnelly, J. P. (2006). *The research methods knowledge base* (Third edition). Atomic Dog Publishing.

Vergara, A., Siles, I., Castro, A. C., & Chaves, A. (2021). The Mechanisms of "Incidental News Consumption": An Eye Tracking Study of News Interaction on Facebook. Digital Journalism, 9(2), 215–234. https://doi.org/10.1080/21670811.2020.1813047

Vergara-Heidke, A., & Morales-Gutiérrez, H. (2020). Globalización y lenguas en contacto: paisaje lingüístico en barrios de Costa Rica y Chile. In M. Drescher, I. Neumann-Holzschuh, S. Segler-Meßner & R. Spiller (Series Eds.) & C. Gabriel, A. Pešková & M. Selig (Vol. Eds.), *Studienreihe Romania: Vol. 35. Contact, variation and change in Romance and beyond = Kontakt, Variation und Wandel in und jenseits der Romania: Studies in honor of Trudel Meisenburg = Festschrift für Trudel Meisenburg* (pp. 497–511). Erich Schmidt Verlag.

Villalobos Fernández, L. A., de La Ossa Osegueda, Á., Rodríguez-Villagra, O. A., & Vergara-Heidke, A. E. (2020). Resolución de diagramas de flujo y pseudocódigo por parte de estudiantes de Ciencias de la Computación de la Universidad de Costa Rica. *Revista Tecnología, Ciencia y Educación*, 129–146. https://doi.org/10.51302/tce.2020.491

White, P. R. R. (2015). Appraisal Theory. In K. Tracy, C. Ilie, & T. L. Sandel (Eds.), *The Wiley Blackwell-ICA international encyclopedias of communication. The International Encyclopedia of Language and Social Interaction.* Wiley Blackwell. https://doi.org/10.1002/9781118611463.wbielsi041

OSKAR BAUMANN

Oskar Baumann (°1995) is a research associate at the Research Center for Energy Economics (FfE) in Munich. He is a recent graduate of the international Erasmus Mundus Master program in Cartography, earning his joint Master's degree in 2023 from the four cooperating universities: Technical University of Munich (TUM, Germany), Vienna University of Technology (TU Wien, Austria), Dresden University of Technology (TU Dresden, Germany), and the University of Twente (The Netherlands). Beyond his enthusiasm for graffiti and street art, Oskar's research interests include cartography, web mapping, and geoinformatics.

PAUL BELLENDORF

Paul Bellendorf studied Materials Science in Erlangen and Heritage Conservation in Bamberg. There, he also completed his dissertation in building preservation science. Paul worked for three years at the Fraunhofer Institute for Silicate Research in Würzburg, Bronnbach branch, as head of the Environmental Monitoring and Protection of Cultural Heritage department. He then spent six years as head of the Environment and Cultural Heritage department at the Deutsche Bundesstiftung Umwelt. Since October 2018, he has been a Materials and Preservation Science Professor at the Otto Friedrich University of Bamberg.

MASSIMILIANO CARLONI

Massimiliano Carloni (°1990) is currently employed at the Austrian Centre for Digital Humanities and Cultural Heritage (Austrian Academy of Sciences) in Vienna. He completed his PhD in Classical Philology at the Scuola Normale Superiore, Pisa (Italy) in 2019 with a thesis on ancient Greek literature. His primary research interest lies in exploring the use of semantic technologies and metadata standards to describe and render accessible vast collections of diverse materials. In particular, he is interested in graph-based data models and linked open data. This led him to join the academic graffiti project INDIGO in November 2021 and take up the challenge of developing technical solutions for the description and long-term digital preservation of the collected data. His research output can be found at https://www.researchgate.net/profile/Massimiliano-Carloni.

LUCA DAVICO

Luca Davico (°1964) is an assistant professor at the department DIST of Politecnico and Università di Torino; he teaches Urban Sociology, Sociology of Innovation and Social Research Methodology. Luca carried out research on the following topics: sustainability, social sciences in urban plans, policies, transformation and redevelopment, public art, transports, training, tourism, and toponymy. From 1999 to 2023, he was the scientific director of Rapporto Rota (which analyses policies and data on Italian metropolitan cities); since 2014 he has coordinated the project Immagini del cambiamento (documentation and analysis on urban transformations in the area of Torino: http://www.immaginidelcambiamento.it) and from 2016 the project Arte per strada Torino (with the first complete census of public art in Turin and its surroundings: https://www.arteperstradatorino.it).

FRANCISCA FERNANDEZ MERINO

Francisca Fernandez Merino (°1993) is currently a PhD Student in Politics and International Relations at Queen Mary University of London, Great Britain and holds a scholarship from the London Art and Humanities Partnership (LAHP). In 2022, she completed her Master's degree at the University of Passau, Germany and in 2017, she earned her Bachelor's degree from Universidad de Santiago in Chile. Her research interests lie in semi-ephemeral public art expression and performances during contentious episodes. She aims to gain a better understanding of the relational aspects between public art expressions, particularly, political graffiti and street art and its participants and spectators. She undertakes this aim with special attention to affect theory and the social construction of space.

GIULIA FLENGHI

Giulia Flenghi (°1988) is a PhD student in the Department of History, Representation, and Restoration of Architecture at Sapienza University of Rome. Giulia graduated in History of Art at Roma Tre University in 2017 with a thesis exploring Medieval urban and architectural depiction in Rome. She obtained a second Master's in Cultural Heritage Communication in 2021. Between 2021 and 2023, she was

an adjunct professor in the Design, Multimedia, and Visual Communication master's program. Her research focuses on the hybridisation of AR and AI systems applied to the Cultural Heritage study. Her academic profile can be found at https://research.uniroma1.it/persone?search=giulia+flenghi.

PAOLA GUERRESCHI

Paola Guerreschi (°1968) is a research technician at the Interuniversity Department of Regional and Urban Studies and Planning at the Politecnico e Università di Torino (DIST). She has worked for years in the geomatics field using GIS software to process geographic datasets for spatial analysis and photogrammetric software to produce 3D models and orthoimages. She has a degree in architecture. She promotes and coordinates the Arte per Strada Torino project, dealing with creating the interactive map for the website (https://www.arteperstradatorino.it).

ELENA IPPOLITI

Elena Ippoliti (°1962), Architect (1989), PhD (1995), is a Full Professor at Sapienza University of Rome, Vice Dean of Architecture Faculty and Director of the Master's in Communication of Cultural Heritage. She teaches Architecture and Design courses and in the PhD of History, Representation and Restoration of Architecture. In recent years, Elena has oriented her research towards critical reflection and experimental investigation of digital technologies to enhance cultural heritage. In particular, she has dealt with defining visual languages for the knowledge, communication and use of cultural heritage values. Her academic profile can be found at https://research.uniroma1.it/persone?search=elena+ippoliti.

SEBASTIAN KEMPGEN

Sebastian Kempgen is a professor emeritus of Slavic Linguistics at the University of Bamberg (Germany). He is a professor honoris causa of the St. Clemens of Ohrid-University in Bitola, North Macedonia. His broad interests include Slavic palaeography, inscriptions, and the history of Slavic scripts. He is also known for creating the most widely used Old Church Slavonic fonts for Slavic philology. He was the main editor of the largest handbook on Slavic Linguistics (Berlin 2009 and 2014), as well as three volumes containing the German contributions to the International Congress of Slavists (2008, 2013, 2018). For his achievements in the field and also for his services as vice-president of the University of Bamberg (2008–2017), he was awarded the Order of Merit of the Federal Republic of Germany (2016). All of his publications are available online at https://www.uni-bamberg.de/slavling/personal/prof-em-dr-sebastian-kempgen.

BERNHARD KOSCHIČEK-KROMBHOLZ

Bernhard Koschiček-Krombholz (°1987) is a software developer specialising in OpenAtlas (https://openatlas.eu) at the Austrian Centre for Digital Humanities and Cultural Heritage within the Austrian Academy of Sciences. He earned his BSc in Computer Sciences from the University of Applied Sciences Technikum Wien, Vienna, in 2010, followed by a BA in History from the University of Vienna in 2018. His primary academic interests lie in mediaeval history and archaeology, with a particular focus on the effective management of spatial-temporal, object, and written data. Bernhard's involvement with graffiti emerged through project INDIGO, where he found himself captivated by the artful expressions and intriguing community dynamics associated with this form of urban art.

ALESSANDRA MESCHINI

Alessandra Meschini (°1966), Architect (1993), PhD (1998), is an Associate Professor at Sapienza University of Rome. She currently teaches Architecture courses, but she has also taught Design courses. She has been working on many representation, survey and documentation topics consistent with the development of digital technologies and the main issues of architectural and urban heritage sites. In recent years, she has oriented her research towards digital media, communication and applications for promoting, enhancing and enjoying cultural heritage. Her research output can be found at https://www.researchgate.net/profile/Alessandra-Meschini.

GUNTHER MICHELS

Gunther Michels (°1982) is a journalist and reporter located in Frankfurt, Germany. After earning a diploma in social science at the University of Frankfurt and studies in

politology, philosophy and psychology, Gunther entered the world of journalism. He now works as an independent reporter but is also the head of a newspaper resort of the local monthly newspaper called 'Journal Lokal'. He runs a radio show at the independent station Radio X, and he is the founder of the noncommercial online urban art archive Vagabundler, which provides photos, interviews and maps. One of his fundamental aims is to preserve human creations in a documented way accessible to everybody. https://vagabundler.com; http://radiox.de.

LUISA MONTOBBIO

Luisa Montobbio (°1968) is a technician at the Interuniversity Department of Regional and Urban Studies and Planning at the Politecnico e Università di Torino (DIST). She works in graphic design and publishing. She has a degree in literature with a focus on art history and archaeology. She promotes and coordinates the Arte per Strada Torino project, which aims to classify all public artworks in the metropolitan area of Turin. She manages the website https://www.arteperstradatorino.it.

LEANDER PALLAS

Leander Pallas is a research associate at the Chair of Materials and Preservation Science at the University of Bamberg (Germany). He received his Master's degree in Heritage Conservation in 2021 and is now researching the monitoring of sensitive cultural heritage with non-destructive methods. The optimisation of the experience gained by combining different methods, as well as overcoming individual challenges on the object on site, are central to this. The visualisation of historical, partially weathered graffiti in particular, is a frequent topic of investigation.

MICHELE RUSSO

Michele Russo (°1977) is an Associate Professor in Representation at the Sapienza University of Rome. He received his Master's degree in architecture from Ferrara University and his PhD from Politecnico di Milano in 2002 and 2007, respectively. Since 2008, Michele has been working on many 3D acquisition, modelling, and data visualisation topics at Politecnico di Milano and Sapienza, where he moved to in 2016. He is involved in much research about 3D imaging, virtual reconstructions, Augmented Reality, and Artificial Intelligence applied to the cultural heritage, architecture, and design domains. His research output can be found at https://www.researchgate.net/profile/Michele-Russo-5.

JONA SCHLEGEL

Jona Schlegel (°1988) is a PhD student at the University of Vienna, focusing on archaeological stratigraphy and spatio-temporal reasoning in the context of graffiti. She completed her MSc in Landscape Archaeology in 2018 at the University of Applied Science and the Free University, Berlin. At the Ludwig Boltzmann Institute for Archaeological Prospection and Virtual Archaeology (2018–2023) Jona worked on geophysical prospection and 3D documentation. During project INDIGO, Jona has contributed to developing the INDIGO graffiti thesaurus, organised symposia, and played a pivotal role in web development and spatio-temporal data structuring. Her work and research can be explored at https://www.researchgate.net/profile/Jona-Schlegel.

RUTH TENSCHERT

Ruth Tenschert is a postdoc researcher at the KDWT (University of Bamberg). She studied Art History and Heritage Conservation and received her Master's degrees in 2011 and 2014. In 2021, she completed her doctorate in Building Preservation Sciences. Since 2014, she has been a research associate at the University of Bamberg and, since 2018, at the KDWT in various projects. She is especially interested in cultural heritage, its materials and its changes over time, as well as documenting it for future generations. Since 2015, she has also been working on documenting and analysing historic graffiti on stone surfaces.

NOEMI TOMASELLA

Noemi Tomasella (°1996) is a PhD student in History, Representation and Restoration of Architecture at the Sapienza University of Rome. She holds a master's degree in architecture, received in 2021 with honours from the Sapienza University of Rome with a thesis on form-finding and optimisation of double-curved structures. Her doctoral thesis focuses on the role of visual models in the sensory-cognitive enjoyment of cultural heritage. Her research

interests mainly concern the study, documentation and enhancement of cultural heritage and topics related to visual communication and visual culture. She is also interested in generative modelling across various applications. Her academic profile can be found at https://research.uniroma1.it/persone?search=noemi+tomasella.

VALENTINA TRETTI-BECKLES

Valentina Tretti-Beckles is currently a student in the Master's Cognitive Systems: Language, Learning and Reasoning at Potsdam University. She received her Bachelor's degree in Spanish Philology with an emphasis in Linguistics from the University of Costa Rica in 2020. She is also interested in other disciplines of study; for this reason, she has studied anthropology, computer engineering, and teaching. She has collaborated in research projects on indigenous languages, electoral processes, cognitive processes and perception of the semiotic landscape. Valentina is interested in pragmatics, discourse studies, natural language processing, and embodiment, among others. She has published on discourtesy and valuation in electoral processes. In the past years, she has participated in the project "Linguistic landscape of urban neighbourhoods and its perception in people", which focuses on studying people's perception of urban neighbourhoods, including graffiti.

MARTINA TROGNITZ

Martina Trognitz is a senior repository manager of the digital archive ARCHE at the Austrian Centre for Digital Humanities and Cultural Heritage (ACDH-CH) of the Austrian Academy of Sciences in Vienna (Austria). She studied Computational Linguistics and Classical Archaeology at the University of Heidelberg. Martina has accumulated over ten years of experience in long-term preservation and data management, including coverage of data formats suitable for long-term preservation, data management, FAIR data, metadata, metadata schemas, and controlled vocabularies. As a former fellow of the Open Science Fellows Program of Wikimedia Deutschland, Martina is an advocate for Open Science in all its facets. Current research interests include the application of statistical and machine learning methods in archaeology, Wikidata, network analysis, and Linked Open Data. She joined project INDIGO in September 2021 to guide through the process of preserving the digitised graffiti in ARCHE.

ADRIÁN VERGARA-HEIDKE

Adrián Vergara-Heidke is a full Professor in the School of Philology, Linguistics and Literature at the University of Costa Rica. He received his Master's and PhD in Linguistics from the Pontificia Catholic University of Chile and the University of Bremen (Germany), respectively. He has developed collaborative research projects at two Research Institutes from the University of Costa Rica (CIEP and CICOM). Adrián has held different administrative positions at the University of Costa Rica; currently, he is the director of the PhD in Society and Cultural Studies and the representative of the Arts and Literature Area in the SEP Council. His areas of expertise are text linguistics, pragmatics, discourse studies (i.e., multimodal texts, media, political and digital communication) and forensic linguistics. In the past years, he has participated in the project "Linguistic landscape of urban neighbourhoods and its perception in people", which focuses on studying people's perception of urban neighbourhoods, including graffiti.

GEERT J. VERHOEVEN

Geert J. Verhoeven (°1978) is a senior scientist in archaeology at the University of Vienna (Austria). He received his Master's and PhD degrees from Ghent University (Belgium) in 2002 and 2009, respectively. Geert is passionately curious about photography, image-based 3D surface modelling, metadata and semantic technologies, spatio-temporal reasoning, colour science, image processing, data visualisation and statistics. His endeavours in these fields aim to improve and standardise data acquisition, data management and information extraction procedures to benefit archaeology and the broader cultural heritage field. From September 2021 to August 2023, Geert took a deep dive into the colourful graffiti world by coordinating project INDIGO. His research output can be found at https://beyondconventionalboundaries.com.

BRETT WEBB

Brett Webb (°1972) is a creative technologist actively participating in the graffiti scene since 1988. He has painted walls and given talks across North America, Europe and Asia.

While attending the University of Southern California in 1993, Brett became one-half of the first website dedicated to graffiti and street art, Art Crimes (http://www.graffiti.org). Through the experience he gained working on Art Crimes, Brett has led tech projects for many well-known brands, media companies, and cultural institutions. Brett resides in the San Francisco Bay Area and is currently creating a photo-sharing social media app built explicitly for the graffiti and street art communities. He has been posting his photos on Instagram @spraystreetdotcom.

MARTIN WIESER

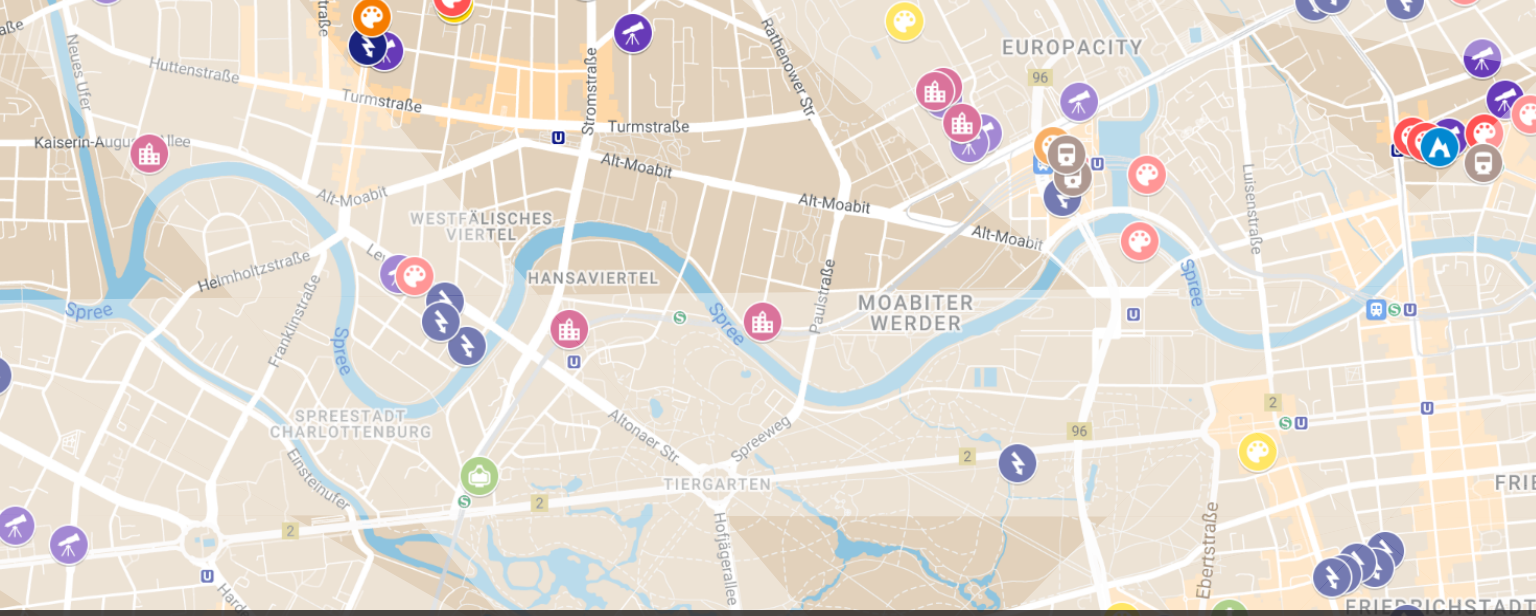
Martin Wieser (°1986) is an independent researcher in photogrammetry and remote sensing. He received his Master's degree from the Technical University of Vienna (TU Wien, Austria) in 2012. From 2010–2019, Martin worked on many photogrammetry, 3D modelling, remote sensing and data visualisation topics at the TU Wien as a project and university assistant. Since 2016, Martin has also been developing geospatial soft and hardware prototypes for researchers worldwide (Historic England, University of Vienna, Murdoch University Perth).

BENJAMIN WILD

Benjamin Wild (°1996) is a PhD student and university assistant at the Photogrammetry unit at the Department for Geodesy and Geoinformation at Technische Universität Wien (TU Wien). He received his Master's degree from TU Wien in Geodesy and Geoinformation in 2021. Since then, he has been part of the graffiti-centred academic project INDIGO. Before investigating photogrammetric solutions in the context of graffiti research, Benjamin worked in the same department but in the field of environmental microwave remote sensing. What connects both experiences is the interest in understanding our environment better, be it the Amazon rainforest or the graffiti along Donaukanal. Benjamin's research output can be found at https://www.researchgate.net/profile/Benjamin-Wild-5.

STEFAN WOGRIN

Stefan Wogrin (°1989) is an art historian and graffiti documenter. He received his Bachelor of Arts in Art History and European Ethnology from the University of Vienna in 2017. Stefan has been an active graffiti writer since 2001, when he also founded the Vienna-based Spraycity graffiti writing archive (https://spraycity.at), an online platform where 100,000 graffiti photos are accessible. Stefan takes photos of graffiti from all different public surfaces in Vienna and has been researching Vienna's graffiti history. He also curated several exhibitions about graffiti and is the editor of the Offline Graffiti Magazine. His graffiti research can be found at https://spraycity.at/research.



In the year of Hip-Hop's 50th anniversary and the 40th birthday of Wild Style, goINDIGO 2023 managed to bring various disciplines together to discuss the various ways of dissipating and understanding bits of graffiti bytes. The proceedings of this symposium pick up and reiterate where the previous proceedings left off: with the contemporary ways of disseminating old or new graffiti. Afterwards, several papers discuss practical and theoretical ways to unravel graffiti-scapes and develop new insights.

In summation, tackling graffiti as sociocultural artefacts demands multidisciplinary frameworks. The editors hope the interconnected graffiti themes covered here and in the goINDIGO 2022 proceedings provide inspiration and an up-to-date overview of various framework components to deal with ancient and contemporary graffiti-scapes.

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