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The presentation of art history artefacts on the Web: Current trends and a potential alternative

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Markus Siedler
Matrikelnummer 0625524

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Fakultät für Informatik der Technischen Universität Wien

Betreuung: Ao.Univ.Prof. Mag. Dr. Wolfdieter Merkl
(Univ.Prof. Dipl.-Ing. Dr.techn. Hannes Werthner)

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The presentation of art history artefacts on the Web: Current trends and a potential alternative

MASTER'S THESIS

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Markus Siedler
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at the Vienna University of Technology

Advisor: Ao.Univ.Prof. Mag. Dr. Wolfdieter Merkl
(Univ.Prof. Dipl.-Ing. Dr.techn. Hannes Werthner)

Vienna, 29.01.2013

(Signature of Author) (Signature of Advisor)

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Markus Siedler
Lacknergasse 73, 1180 Wien

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Danksagung

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Besonders danken möchte ich auch meinen Eltern, Waltraud und Michael Siedler, die mich auf meinem bisherigen Lebensweg mit allen erdenklichen Mitteln unterstützt haben.

Abstract

In the last years, information technology helped museums and cultural institutions in general to add complementary information to exhibitions that otherwise will not be visible for visitors in the buildings. Since art history artefacts are generally exhibited in display cases and walls, only a limited amount of information about them is visible. In virtual museum exhibitions, on the other side, artefacts can be visualized into a virtual interactive environment, where the physical limitations can be abandoned. Today, the cultural heritage sector shows a broad variety of initiatives like colorful websites, mobile applications and multimedia interactive compilations, which shows the motivation and the potential of museums and cultural institutions in general to extend their physical existence to an rewarding interactive Web experience.

The Master's thesis first provides a comprehensive overview about current trends of presentation forms of art history artefacts on the Web. These presentation methods are divided into the Web paradigms *Web 1.0*, *Web 2.0*, *Web 3D* and *Mobile Web*. In addition, several examples about Web presentations illustrate these theoretical descriptions. Furthermore, the role of the Semantic Web is described, since its popularity in the cultural sector gained significantly over the last years. Due to enhanced visibility of content, the exposure of metadata through aggregators, portals, and search engines led to an increased usage of those data.

Based on acquainted knowledge of the State-of-the-art analysis, an alternative approach of presenting cultural artefacts on the Web is found and implemented. Since textual descriptions of people from the scientific field of art history are generally written in a language hardly to understand for people who are new in the field of art history, the implemented prototype concentrates on the comparison of artwork images. The presentation of an alternative approach of user interaction tries to motivate lay persons as well as more experienced users to increase their interest in art history. Furthermore, the developed approach tries to give the virtual visitor the chance to discover something new and unexpected.

Finally, the developed prototype is demonstrated and tested by three users from different fields and knowledge in the field of art. A demonstration of a sample comparison process provides a first impression about the prototype's functions and its usability. Additional information of museum professionals illustrates how comparing images of artworks can complement the exploration of artworks. The subsequently performed proof-of-concept verifies the developed prototype's feasibility in a real environment. Furthermore it aims to receive initial feedback from users about the prototype's usability and the degree of interaction with the provided content. Finally, the evaluated results are discussed in this Master's thesis.

Kurzfassung

In den vergangenen Jahren wurde Informationstechnologie verstärkt von Museen und anderen kulturellen Institutionen angewendet um Ausstellungen mit komplementären und ergänzenden Informationen, welche im Normalfall für den Besucher nicht sichtbar sind, zu bereichern. Da Kunstobjekte im Normfall in Kästen oder an Wänden ausgestellt werden, ist der Raum für textuelle Informationen meist sehr limitiert. In virtuellen Ausstellungen können kulturelle Objekte jedoch in einer virtuellen, interaktiven Umgebung dargestellt werden, wo diese physischen Beschränkungen nicht berücksichtigt werden müssen. Heute zeigt der kulturelle Sektor eine große Bandbreite an Webpräsenzen wie bunte Webseiten, mobile Anwendungen sowie andere multimediale interaktive Anwendungen. Dies zeigt die Motivation sowie das Potential von Museen und anderen kulturellen Institutionen auf, deren physische Aktivitäten mit interaktiven Webinhalten zu erweitern.

Diese Master's Thesis beschreibt zunächst einen umfangreichen Überblick über aktuelle Trends von Präsentationsformen von Kunstobjekten im Web. Die Präsentationsformen werden dabei in die Webparadigmen *Web 1.0*, *Web 2.0*, *Web 3D* and *Mobiles Web* unterteilt. Zusätzlich sollen Beispiele von Webpräsenzen diese theoretischen Möglichkeiten weiter veranschaulichen. Außerdem wird die Rolle des Semantischen Web's beschrieben, dessen Popularität im kulturellen Sektor in den letzten Jahren signifikant zunahm. Aufgrund verstärktem Bereitstellen von Metadaten für Datenaggregatoren, Portale und Suchmaschinen steigen die Zugriffe auf semantische Inhalte im Web verstärkt an.

Basierend auf den Erkenntnissen der State-of-the-art Analyse wurde ein alternativer Ansatz gesucht und implementiert. Da textuelle Beschreibungen von Personen mit kunstgeschichtlichen Hintergrund meist schwer für Personen ohne entsprechenden Fachwissen zu verstehen sind, konzentriert sich der implementierte Prototyp auf den Vergleich von Bildinhalten. Die Präsentation dieses neuen Ansatzes soll Laien als auch erfahrene Benutzer motivieren das Interesse in Kunstgeschichte zu steigern. Außerdem soll der Prototyp dem virtuellen Benutzer die Chance geben etwas Neues und Unerwartetes zu entdecken.

Im letzten Teil dieser Master's Thesis wird die Durchführbarkeit des implementierten Prototyps gezeigt und von drei unabhängigen Personen mit unterschiedlichen Ausbildungen und Fachwissen getestet. Die Vorführung eines Beispielvergleichs unter der Benutzung des implementierten Prototyps soll zunächst die Funktionen und die Benutzbarkeit aufzeigen. Zusätzliche Informationen von Museumsexperten sollen veranschaulichen, wie der Vergleich von Bildern von Kunstgegenständen die Untersuchung desselben unterstützen kann. Das danach durchgeführte Proof-of-concept zielt darauf ab, erstes Feedback über die Durchführbarkeit, Benutzbar-

keit als auch die Interaktion mit den Inhalten zu erlangen. Am Ende dieser Master's Thesis werden die Ergebnisse diskutiert.

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CHAPTER 1

Introduction

1.1 Motivation

> *"The fact that twice as many people see our Web site as come through the museum doors, and that the online store rivals our most popular satellite store revenue, puts a whole other dynamic on what we are doing with the Web. It becomes another museum, in a sense, with that many complicated things to deal with."*

This statement from a museum professional, stated in Marty (2007*b*), perfectly reflects the current influence of Web technologies in the context of cultural institutions. In the last years information technology has offered museums and cultural institutions in general the tools to add information value to exhibitions and presenting complementary information that otherwise will not be able for users (Fuentetaja and Economou, 2008). Art history artefacts that are exhibited in the physical environment of a museum or any other cultural institution are usually shown in display cases, where only a limited amount of information about them is visible. In virtual museum exhibitions, art history artefacts can be visualized into a virtual interactive environment. Thus, museums and cultural institutions in general are given the opportunity to offer a more rewarding experience due to rich multimedia context information data about objects that are not possible on simple description cards in physical environments (Styliani et al., 2009).

As a result, many museum visitors see a complementation between the virtual and physical existence of museum resources. Online experiences help them to benefit when they "offer uniquely online features, such as interactive, online exhibit, as well as information resources that encourage a strong relationship with the physical museum, such as maps and driving directions" (Marty, 2007*a*). In Caffo et al. (2008), three advantages which are evolving with usage of digital collections are described:

1. **Educational learning:** When digital artefacts are embedded in an educational context, they may act as learning objects, serving to document and contextualize the physical collection in new kinds of learning scenarios.

2. **New interaction forms:** As the museum Web page acts as a pre or post-visit reference, this enables new kinds of hands-on, minds-on interactions with the collection that were not possible during the physical museum visit (i.e. rotating an object, collecting and comparing different artworks, magnifying a miniature work of art and others).

3. **New forms of art:** When works of art and new media expressions are born-digital, they represent new kinds of artistic practice (i.e. web art, net art, interactive art and others), art forms and interfaces, which cannot represented outside of the Web architecture.

Today, the cultural heritage sector shows a broad variety of initiatives like colorful websites, mobile applications and multimedia interactive compilations, which shows the willingness of museums or cultural institutions in general to use new media resources and take advantage of their improvements in accessibility these are offering (van Vliet and Hekman, 2012).

1.2 Problem statement

The main provider of cultural information in the Web are museums, who want to present and promote their cultural belongings to a broader audience. Besides other Web galleries are focused on specific regions, times, or artists. When visiting those sites, there is notably one main schema of presenting information about cultural artefacts: On one side lots of textual information, on the other side images, which can be displayed separately in higher resolution. Contrasting context related images in high quality is generally not possible. Textual descriptions of people from the scientific field of art history are generally written in a language hardly to understand for people who are new in the field of art history. To avoid a lack of interest, it becomes necessary to make the Web presence to an interacting experience by using new technologies and interaction methods. Thus the visitor's curiosity and interest about art and art history can be induced.

Starting from this point of view, alternative approaches of presenting art history artefacts on the Web can be found to raise visitor's further interest in historic art. In order to experiment with alternative approaches, it becomes crucial to get previously a holistic overview of current trends of Web presentations in the cultural sector.

1.3 Aim of the work

The aim of this master thesis is to describe current trends of galleries, libraries, archives and museums (GLAMs) presenting their cultural objects in the Web and subsequently find and develop an alternative approach to present and contrast images of art historic artefacts on the Web with the intention to raise user's further interest. Finding new interaction methods can help museums or cultural institutions in general to make people more interested in their cultural assets and bring people back to their buildings.

The experimentation and implementation of the prototype will be based on the previously performed State-of-the-art analysis. One approach can be a side by side comparison of context specific art pictures in higher resolution. Through the exploration of different levels of detail the

user is able to analyze and interpret differences or reveal particular characteristics. By including textual descriptions the analysis process of artworks is supported.

In the context of a museum this could be the presentation of different perspectives of a specific cultural artefact (e.g. infrared or X-ray images). In a broader context it could be a specific art topic, where various cultural assets are related to.

1.4 Methodological approach

The methodology of the master thesis comprises three parts:

- The first part is a literature survey, where several aspects of the topic will be searched and summarized: This includes current applied approaches of presenting visual and textual information about cultural artefacts on Web pages, as well as technical aspects to implement a Web platform with new presentation forms.

- The second part is the development of a prototype: On a website an alternative approach to present and contrast visual contents of art historic artefacts is implemented.

- The last part is an evaluation of the experimentation with the alternative approach. The evaluation is summarized in the Master's thesis.

1.5 Structure of the Master's Thesis

The master thesis comprises six main chapters:

- **Cultural Institutions:** In this master thesis relevant cultural institutions are described: Galleries, libraries, archives and museums (GLAM). Furthermore, the content on museum websites is analyzed.

- **Current Trends:** This chapter analyzes current trends of cultural institutions presenting cultural objects on the Web. The Web pages are divided into four Web paradigms: Web 1.0, Web 2.0, Web 3D and Mobile Web. The results reveal that contrasting images of artworks is generally not possible.

- **Semantic Web:** As Semantic Web's popularity in the cultural sector significantly gained in the last few years, this chapter analyzes Semantic Web technologies, relevant institutions and data models, as well as knowledge bases and thesauri. Furthermore, this chapter describes technical basics which are relevant for the development of an alternative approach.

- **A Potential Alternative:** This chapter describes the development of an alternative approach, based on the State-of-the-art analysis in the previous chapters.

- **Demonstration/Proof-of-concept:** In this chapter the developed prototype's feasibility is demonstrated: First, a demonstration of a sample comparison process shows the potential of the prototype. Next, a practical test reveals how people use this prototype and points out possible improvements. Finally these results are discussed.
- **Summary, Limitations and Future Work:** Finally, the master thesis is summarized. Moreover limitations and possible future work are pointed out.

CHAPTER 2

Cultural Institutions

In the 1980s, museums were influenced by the *New Museology* and began to change they conveyed the context information of the exhibits to the wider public. There was a shift in the museology concept towards considering that the context of a cultural artefact was more important than the object itself (Styliani et al., 2009).

The appearance and consolidation of the so-called *Knowledge Society* and the irruption of technologies in the cultural sector since the nineties has implied important changes in the practices of storage, conservation and preservation. Moreover, it resulted in important changes of larger accessibility to a broader public. In this context, cultural institutions tried to take advantage of the potential of the implementation of technological applications by creating their own websites, digital collections and virtual museums (Fuentetaja and Economou, 2008).

With the mass development of blogging and media sharing sites in the early 2000s, the Web had an important social impact (Oomen and Aroyo, 2011). Since then, users became active participants who were engaged in a cultural conversation with the institutions themselves (Arends, Goldfarb, Merkl and Weingartner, 2011). The ensuing Web 2.0 era allowed users to contribute information that was used to improve access to digital artefacts on the Web by simply complementing the cultural institutions' provided information.

Based on the principles of the Web 2.0 paradigm, a new term called *Crowdsourcing* emerged in the last few years: Oomen and Aroyo (2011) defines Crowdsourcing as "the act of a company or institution taking a function once performed by employees and outsourcing it to an undefined (and generally large) network of people in the form of an open call" . Currently, *Galleries*, *Libraries*, *Archives* and *Museums* (GLAM) around the globe are beginning to explore the potential of Crowdsourcing. Participation in the workflows of heritage institutions can help them to reduce operational costs by inviting users to assist in the selection, cataloguing, contextualizations, and curation of collections (Oomen and Aroyo, 2011). These works can be carried out by endless users remotely and can lead to a deeper level of involvement with the collections. The *Wikipedia:GLAM/BM* project, for example, is a pilot bringing active Wikipedia users and professionals from the *British Museum* together in order to find and evaluate strategies for

collaboration (Goldfarb, Arends, Froschauer, Merkl and Weingartner, 2011). Table 2.1 shows various categories of Crowdsourcing in cultural heritage sector.

Crowdsourcing type	Short definition
Correction and Transcription Tasks	Inviting users to corrects and/or transcribe outputs of digitisation processes.
Contextualisation	Adding contextual knowledge to objects, e.g. by telling stories or writing articles/wiki pages with contextual data.
Complementing Collection	Active pursuit of additional objects to be included in a (Web)exhibit or collection.
Classification	Gathering descriptive metadata related to objects in a collection e.g. Social tagging.
Co-curation	Using inspiration/expertise of non-professional curators to create (Web)exhibits.
Crowdfunding	Collective cooperation of people who pool their money and other resources together to support efforts initiated by others.

Table 2.1 – Classification of Crowdsourcing Initiatives (Oomen and Aroyo, 2011)

Nevertheless, the main provider of information about art history artefacts are still cultural institutions themselves, who aim to distribute information to a possible large user base. Thus, all examples of websites proposed in this master thesis are related to a certain type of institution: *Galleries*, *Libraries*, *Archives* or *Museums* (GLAM). Following, three types of institutions are described.

2.1 Libraries

Library institutions aim to collect and transmit knowledge to a possible large user base. *Digital Libraries*, in contrast to physical libraries, are libraries where collections are stored digitally. Both the digital library as well as the physical library offer search and retrieval systems to make their collections accessible to users. Information in the digital library is generally accessible remotely via computer networks.

Caffo et al. (2008) proposes three fundamental components in a digital library:

- **The collection:** The collection comprises information of all types (text, images, video, sound and metadata) and includes both a permanent collection and a temporary collection with a specific life span.
- **The access services:** Access services must enable the user fast and easy access to the collection and include the user interface, the research and identification systems and the systems for navigation and connection to the information desired.

- **The users:** Users act without intermediaries and are not limited by space and time.

Due to the fact, that user satisfactory is relevant for acquiring a broad user based, it is essential for libraries to identify and categorize their users and which type of requests they make. Focus groups with structured interviews as well as careful analysis of registrations can support the process of identifying relevant requests of users (Caffo et al., 2008).

In Caffo et al. (2008), users are categorized in levels of their expertise with the goal of achieving user satisfaction for all users by applying suitable mediation levels:

- **Traditionalist users:** Users who are deeply bound to traditional research tools who find it difficult to use the Internet generally.
- **Beginners:** Users who want to develop an expertise with regard to new technologies and only rarely use OPACs (Online Public Access Catalogue).
- **Skilled users:** Users who normally and preferably use OPACs for overcoming geographical barriers and make use of a strongly customized service.

2.2 Archives

Archives play an active role in the conservation and development of cultural heritage like libraries and museums. According to Caffo et al. (2008), archives differ from libraries in several ways and have traditionally the following characteristics:

1. Archives mainly preserve of primary sources of information (sources of information that was created at the time under study (Wikipedia, 2012*b*)) rather than the secondary sources found in a library (e.g. books).
2. Archives' contents are organized in series rather than as individual terms. Unlike in libraries where books are catalogued individually, libraries are typically grouped by provenance (i.e. the individual or organization who created them) and original order (i.e. the order in which the materials were kept by the creator).
3. Archives have unique content that cannot be found or consulted at any other location (e.g. books can be found in different libraries).

Due to the fact that archives are not easy accessible for non-experts, they are generally overseen by specialized personnel and rely on the use of special mediation tools (i.e. finding aids). Thus, archives were traditionally used by experts and users who are aware of the peculiarities of the archive order. This has been changed, as the archive audience has extended to non-specialized users, guided by practical and administrative interest or just curiosity (Caffo et al., 2008).

International descriptive standards and the digital treatment of research tools and documents lead to a increasingly common archive mediation over the Web. Thus, the educational value of the content is enhanced by its presentation via the user-friendly web environment. More recent trends like the Web 2.0 movement helps archives to enrich the research and use of the documents by using folksonomies (see chapter 3.2) (Caffo et al., 2008).

2.3 Museums

According to ICOM (2012), "a museum is a nonprofit making, permanent institution in the service of society and of its development, and open to the public, which acquires, conserves, researches, communicates and exhibits, for purposes of study, education and enjoyment, material evidence of people and their environment." Thus museums are locations of physical artefacts and mainly characterized by their authenticity, pecuniary value and their uniqueness (Caffo et al., 2008).

In contrast to their buildings, the World Wide Web allows museums to provide their potential visitors an unrestricted around-the-clock access to their cultural collections. Furthermore, it is a powerful communication tool for museum curators to deliver fast, user-friendly and low-cost information about the museum to their visitors (Styliani et al., 2009). To get an overview of the various goals of museums presenting their information on the Web, museum websites can be divided into four categories (Schweibenz, 2004):

- **The brochure museum:** This type of museum Web page informs potential visitors about the physical museum (e.g. museum context, museum history, exhibitions, opening hours and others)

- **The content museum:** This type of museum Web page presents the collection online to online users (e.g. text, images, audio, video). The goal is to provide a detailed portrayal of the collections of the museum.

- **The learning museum:** This type museum Web page offers different points of access to its virtual visitors, according to their age, background and knowledge. The website is didactically enhanced and linked to additional information that motivates the virtual visitor to learn more about a subject they are interested in and to revisit the Web page. The goal of the learning museum is to establish a personal and cyclical relationship with the online-collection and bring people to their buildings to visit the real objects.

- **The virtual museum:** This type of museum Web page aims to provide not only information about the institution's collection, but to link to digital collections of other providers. Thus digital collections are created which have no counterparts in the real world. Furthermore the virtual museum cannot be seen as a competitor to the real museum, as it offers no real objects to its visitors. Instead it can extend the ideas and concepts of collections into the digital space and in this way reveal the essential nature of the museum. Moreover it reaches virtual visitors who might never be able to visit a certain museum in person (Schweibenz, 2004).

As museum informatics has become increasingly important as advances in information science and technology offer new capabilities to meet changing user needs, a new type of museum professional has evolved: Museum information professionals (MIPs) specialize in the application of information science and technology and manage the unique information resources found in museums, including the museum's collections themselves, information about those objects,

and information about the contexts in which those objects are displayed, studied, or interpreted (Marty, 2007*b*).

Moreover, museum professionals have to increasingly consider user needs and ensuring that the right information resources are available at the right time and place, depending if users are inside or outside the museum. Therefore it is essential for museum professionals to learn about (Marty, 2007*b*):

1. Metadata schemas and controlled vocabularies for museum information resources.

2. Distributed collection building and data sharing initiatives

3. Information policy and digital rights management

Especially technological advances offer MIPs new ways to meet user needs: Instead of being limited to static text that presents the same information to all users, new capacities, for example, allow MIPs to provide personalized information to diverse users across multiple media. Resulting from this development, it is imperative to understand and disseminate the value of new technologies, recognize the importance of keeping the museum's technologies up-to-date and knows how to solve problems as they occur in the museum (Marty, 2007*b*).

Technological changes and the implementation of new capabilities because of evolving user needs result in further changes of user needs, which establishes a difficult feedback cycle. It is therefore crucial for MIPs to balance and integrate changing needs of different users of museum information resources, especially because those needs differ from user to user, both in the virtual and physical museum. Furthermore, resources need to be repurposed for multiple uses by different types of users, which requires information management and new abilities for understanding information access and usage (Marty, 2007*b*).

2.3.1 Content on Museum Websites

As surveys of cultural Web pages in past research were mostly done for museums, this chapter analyzes content on museum websites corresponding for all other cultural institutions. This assumption is underlined by the work of Marty (2007*b*), who notes that the traditional distinction between libraries, museums and archives is eroded due to the increased digitization. Today, "as users rely increasingly on online information, they will likely expect similar types of resources offered by different institutions."

"The past few decades have seen an important shift from the idea of museums as repositories of objects to museums as repositories of knowledge" (Marty, 2007*b*). According to Fuentetaja and Economou (2008), there are two main models of providing access to digital visitors:

- **Access to information:** This refers to making information available to everyone. The main processes are to offer multilingual content or the digitization of content. In this case, museums bring their physical information about their collection objects to the public (out of databases, catalogues, labels and others), without any further elaboration.

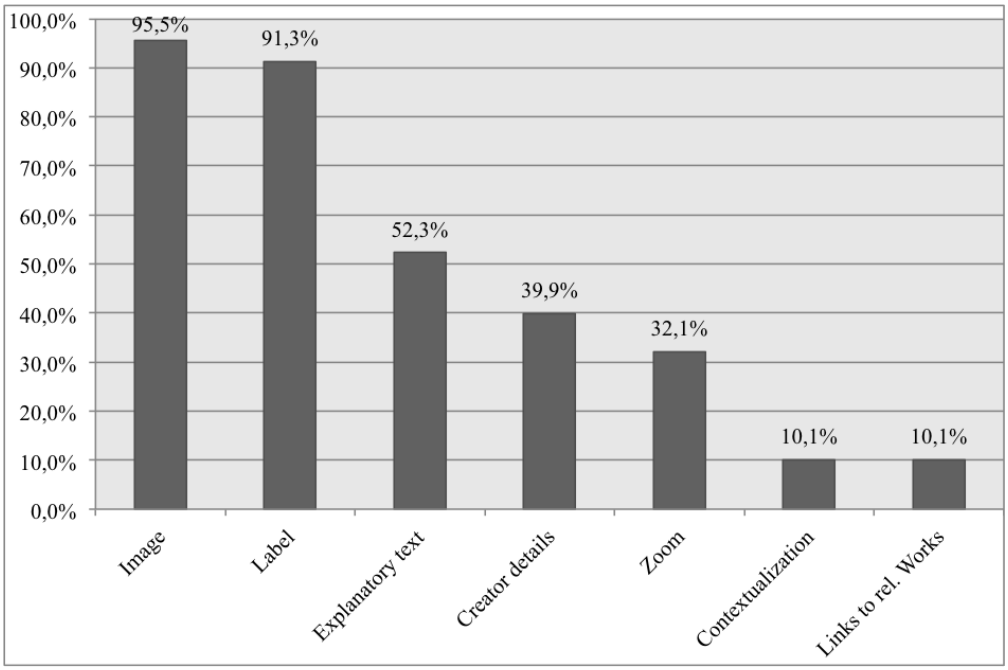


Figure 2.1 – Format of presentation of digital collections (Fuentetaja and Economou, 2008)

- **Access to knowledge:** Unlike to simple transport physical information to the public, this approach means to provide complementary 'information' and tools which help to reveal the meaning behind specific cultural content. Moreover, this model can be seen as an educational approach that provides learning activities for online visitors. Furthermore, unlike simply putting physical information about objects online, it can provide contextualization of contents (e.g. facts and information about the context in which the object was created or the meaning of the object) as well as links to related content. This leads to a more dynamic and participative process, where the user is supposed to acquire relevant knowledge by actively interacting with the content itself.

In Fuentetaja and Economou (2008), a survey of 219 websites with online collections was conducted. All containing websites are listed at the 'Virtual Library of Museums'[1] site. Figure 2.1 shows the percentages of various presentation forms used on the analyzed Web pages.

Interestingly, nearly all of the websites examined showed an image of the object (95.0%) or some sort of information label (91.3%). Furthermore, more than the half of the Web pages presented explanatory text (52.3%) and nearly four out of ten showed details of the artist or creator (39.9%). Only one third of websites allows their users zooming in on the images of the cultural objects (32.1%) and one out of ten offers contextualization of the objects or links to related works (both 10.1%).

[1] `http://archives.icom.museum/vlmp/` (accessed on July 10th, 2012)

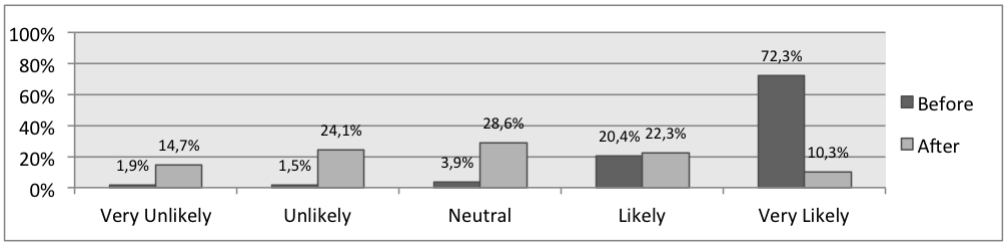
In Marty (2007*a*), a survey of museum visitors of nine different international museum websites and their usage of online resources can be found. The survey was divided into questions about the relevance of resources prior and after a real museum visit. The results are listed in Likert scales, which allowed survey respondents to distinct between 'Very Unlikey', 'Unlikely', 'Neutral', 'Likely' and 'Very Likely'.

According to the survey results in Figure 2.2a, Figure 2.2d and Figure 2.2b, online visitors who are visiting a museum's website prior to a corresponding museum visit are most likely to search for basic information like opening hours, locations and directions (92.7% likely or very likely), information about current and future exhibits (91.8% likely or very likely), and information about admission fees and pricing (87.2% likely or very likely).

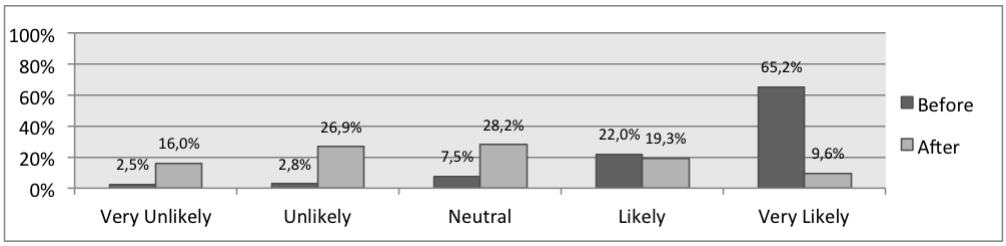
While information about current and future exhibits remained very interesting for online visitors after the corresponding museum visit (79.6% likely or very likely), information about admission fees and pricing (28.9% likely or very likely) as well as information about hours of opening, locations and directions (32.6% likely or very likely) became significantly less important.

Furthermore, Figure 2.2e and Figure 2.2c reveal that survey respondents were likely to use information about programs, tours, and special events (79.7% likely or very likely), as well as information about museum facilities, gift shops, and restaurants (64.2% likely or very likely) (Marty, 2007*a*).

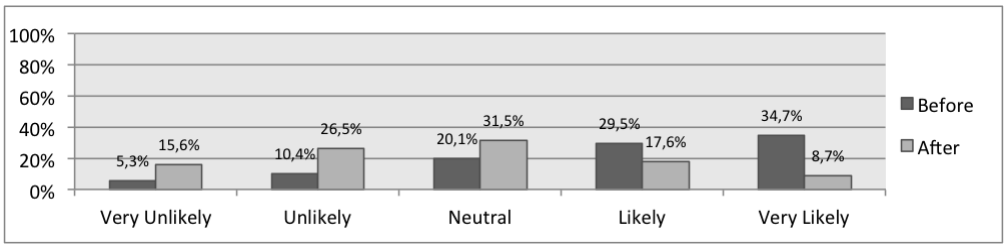
While after the museum visit information about programs, tours and special events remained nearly as likely as prior the visit (68.5% likely or very likely), information about museum facilities, gift shops and restaurants became very unlikely to use for online visitors (26.3% likely or very likely).



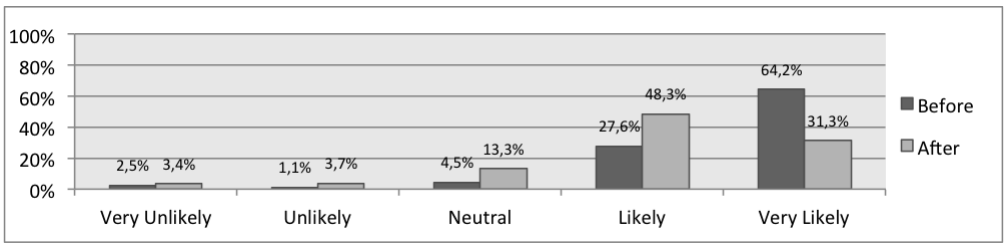
(a) Information about hours of operation / location / directions



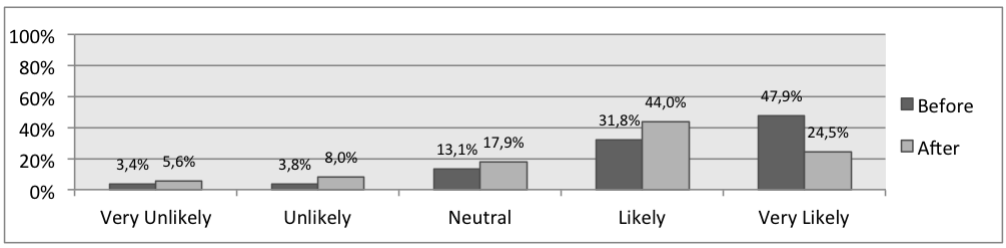
(b) Information about admission fees / pricing



(c) Information about museum facilities / gift shop / restaurants



(d) Information about current and future exhibits



(e) Information about programs / tours / special events

Figure 2.2 – Survey of online museum visitors and their usage of online resources (Part 1). (Marty, 2007*a*)

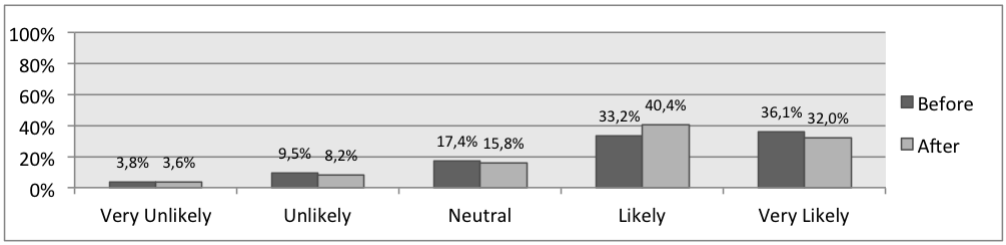
Surprisingly, prior the museum visit website visitors were only relatively likely to use online resources than the basic information stated above. Figure 2.3a, Figure 2.3, Figure 2.3d and Figure 2.3c show that online images of artefacts and collections data (69.3% likely or very likely) as well as online tours of galleries and interactive exhibits (61.0% likely or very likely) were more likely for survey respondents to use than online research materials and archives (53.9% likely or very likely) and online educational activities and learning resources (43.2% likely or very likely) (Marty, 2007*a*).

After the museum visit, survey respondents answered questions about the usage of online resources nearly identically than prior the corresponding visit: Online images of artefacts and collections data (72.4% likely or very likely), online research materials and archives (67.0% likely or very likely) as well as online tours of galleries and interactive exhibits (53.8% likely or very likely) and online educational activities and learning resources (53.8% likely or very likely) remained nearly as interesting as prior the visit.

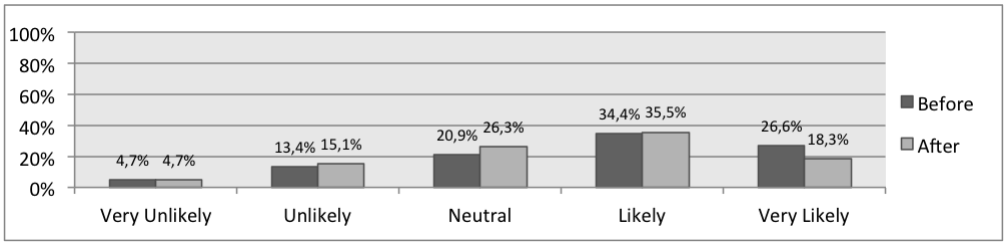
According to Figure 2.3e and Figure 2.3f, survey respondents were less likely to use information about employment and volunteer opportunities (24.4% likely or very likely) or information about donation and membership opportunities (27.1% likely or very likely) compared to the results above (Marty, 2007*a*) .

Finally, survey respondents remained very unlikely to use information about employment and volunteer opportunities (29.4% likely or very likely) and information about donation and membership opportunities (26.2% likely or very likely) after the museum visit.

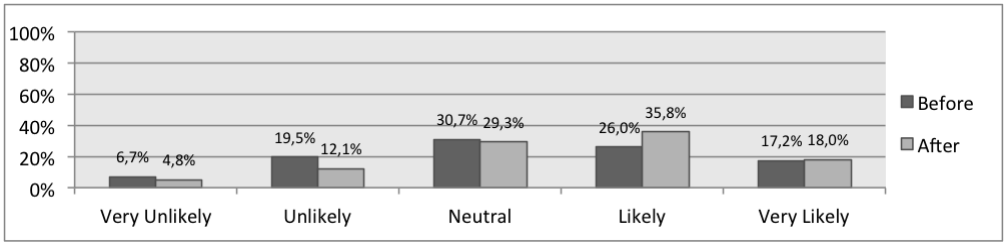
Summarizing, online users have clear expectations of what they want museum websites to provide, before and after visiting a museum: “Prior a visit, for example, online visitors are more likely to need information about opening hours or driving directions, while after the visit, they are more likely to want information about future exhibits and special events.” Another result of the survey was that “visitors are more likely to use online tours of galleries before visits than after visits, and more likely to use online images of artefacts after visits than before visits.’ (Marty, 2007*a*).



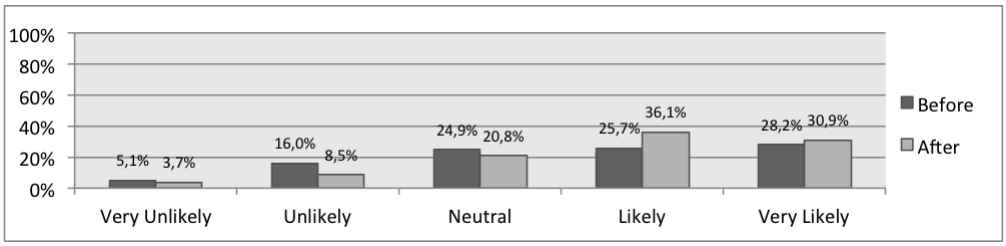
(a) Online images of artefacts / collections data



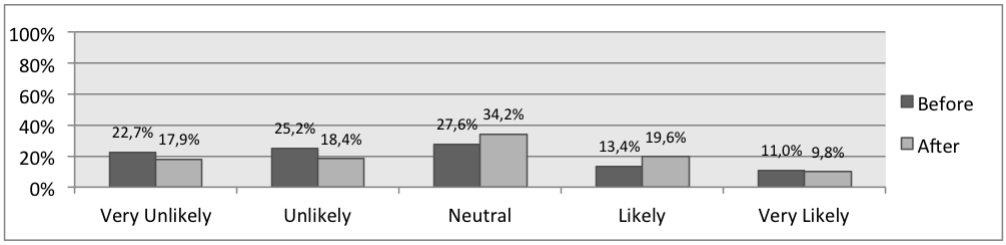
(b) Online tours of galleries / interactive exhibits



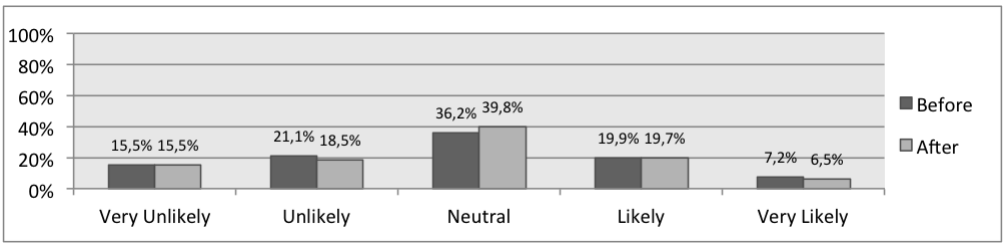
(c) Online educational activities / learning resources



(d) Online research materials / archives



(e) Information about employment / volunteer opportunities



(f) Information about donation / membership opportunities

Figure 2.3 – Survey of online museum visitors and their usage of online resources (Part 2). (Marty, 2007*a*)

CHAPTER 3

Current Trends

In the last years museums and cultural institutions in general increasingly used information technology tools to add information value to exhibitions and presenting complementary information that otherwise will not be able for users (Fuentetaja and Economou, 2008). Art history artefacts that are exhibited in the physical environment of a museum or any other cultural institution are usually shown in display cases, where only a limited amount of information about them is visible. In virtual museum exhibitions, art history artefacts can be visualized into a virtual interactive environment. Thus, museums and cultural institutions in general are given the opportunity to offer a more rewarding experience due to rich multimedia context information data about objects that are not possible on simple description cards in physical environments (Styliani et al., 2009).

As a result, many museum visitors see a complementation between the virtual and physical existence of museum resources. Online experiences help them to benefit when they "offer uniquely online features, such as interactive, online exhibit, as well as information resources that encourage a strong relationship with the physical museum, such as maps and driving directions" (Marty, 2007*a*).

Today, the cultural heritage sector shows a broad variety of initiatives like colorful websites, mobile applications and multimedia interactive compilations, which shows the willingness of museums or cultural institutions in general to use new media resources and take advantage of their improvements in accessibility these are offering (van Vliet and Hekman, 2012).

This chapter analyzes current trends of cultural institutions presenting cultural objects on the Web and illustrates them by showing relevant examples. Based on the work of Arends, Goldfarb, Merkl and Weingartner (2011), these interaction methods presented on cultural Web pages can be related to the following Web paradigms: *Web 1.0*, *Web 2.0*, *Web 3D* and *Mobile Web*. As the distinction of Web 1.0 and Web 2.0 is difficult in some cases, the assumption of Cormode and Krishnamurthy (2008) is used, who proposes the essential difference between Web 1.0 and Web 2.0 as: While in Web 1.0 the user acts as a simple consumer of content, in Web 2.0 the site visitor can also create content and various technological aids are created to maximize the potential of content creation.

3.1 Web 1.0

Web 1.0 is the simplest Web paradigm, where the user acts as a consumer of content (Cormode and Krishnamurthy, 2008). It can be further described as a one-way communication form from an art museum to a visitor (Arends, Goldfarb, Merkl and Weingartner, 2011). The museums or other cultural institutions, who are the provider of specific cultural content, present their information on Web pages. Even at this simple level of interaction, Arends, Goldfarb, Merkl and Weingartner (2011) see a broad spectrum of differences in presentation forms in their analysis of several museum websites: In some cases, museums just offer information about their physical existence, like address, opening hours and actual exhibitions. Other cultural institutions present their digital representations of cultural assets in Web galleries, so users all over the world are able to see this information online and get an impression of their cultural belongings. The different types of information presented on Web pages of cultural institutions is described in chapter 2.3.1.

To get an impression of the broad spectrum of differences in Web representations, some examples of cultural Web 1.0 pages and their interaction approaches are described: The *Cranach Digital Archive* presents various images of specific artworks (e.g. X-ray, infrared) from *Lucas Cranach the Elder*, which can be viewed separately in high-resolution. The *Timelines: Sources from History* website, on the other side, uses technological advanced presentation forms to present cultural artefacts on a timeline. Both Web pages were chosen as example for this chapter after discussions with my advisor.

Cranach Digital Archive

On the *Cranach Digital Archive*[1] website, an example of presenting artworks in a Web gallery is found.

The website is a digital archive, as described in chapter 2.2, where artworks from *Lucas Cranach the Elder*, a painter, printmaker and also an entrepreneur and politician are collected from different sources. Visiting this site, the user is able to search or filter for specific artworks, or simply explore artwork images which are presented in the main window. Filtering allows to distinct between *Attribution*, *Dating* and *Collection*. Attribution means to select the certain name attribute of the creator, like *Lucas Cranach the Elder* himself, *Follower of Lucas Cranach the Elder*, *Copy after Lucas Cranach the Elder*, *Lucas Cranach the Younger* or others. Dating allows to distinct between the decades, where the artworks were created. The Collection filter allows the user to select specific cultural institutions, who are the owners of the specific artworks contained in the archive. The filtering changes the presented artworks in the main window instantly.

If the user has selected a specific image, artwork information is shown on the main window: On the left side, information about the physical object is presented. This includes information about the year of creation, the creator, the owner and the dimension of the physical object. Below, specific images of this artwork can be selected. The extraordinary feature on this Web page is the possibility to see artworks from different perspectives: Besides the normal frontal angle, various artworks are uploaded with X-ray, infrared, backside as well as particular details of the art object.

[1] `www.lucascranach.org` (accessed on May 5th, 2012)

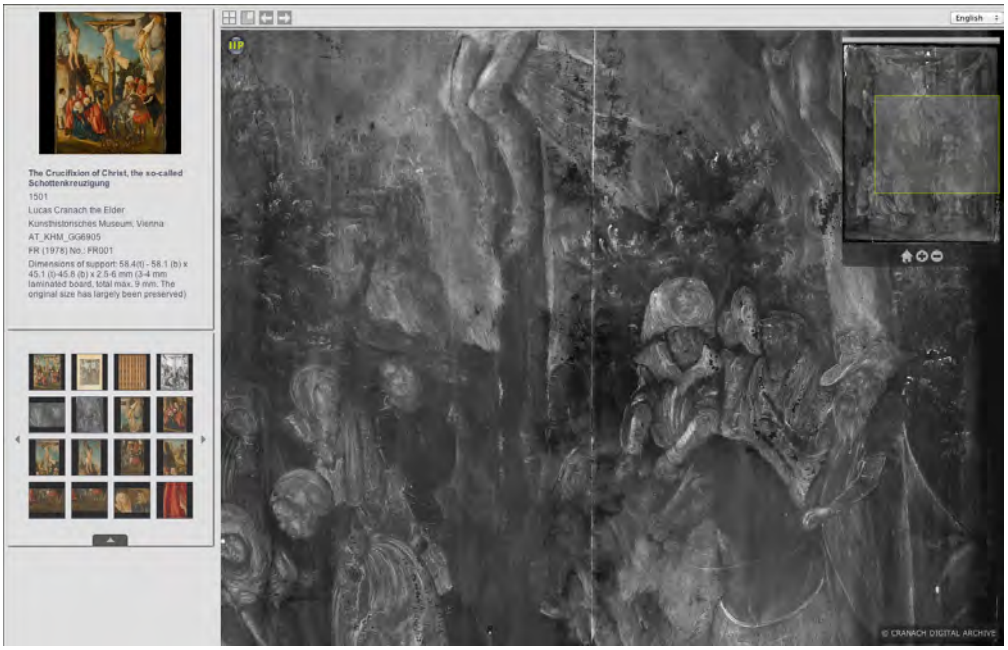


Figure 3.1 – X-ray image of the Crucifixion of Christ vom Lucas Cranach the Elder: Screenshot from the "Cranach Digital Archive"

In the main window, further textual information about the artwork is shown, including *provenance*, *exhibitions*, *interpretation*, *history*, *discussion* and *related works*. Furthermore, a *technical examination*, *condition reports* and a *history of restoration processes* is listed. On the right side of the main window, the digital image is described shortly: Beside the *filename*, *image description*, *image date*, *image creator*, *rights* and *credit owner* are mentioned.

By simply clicking on the image, it is viewed in full size in the main window. Figure 3.1, obtained from the Cranach Digital Archive on June 4th 2012, shows an X-ray image of the Crucifixion of Christ, the so-called *Schottenkreuzigung*, which is property of the Museum of Fine Arts in Vienna.

Furthermore, it is possible to view the images with a high level of detail, as the pictures are uploaded in high-resolution. Therefore a software called *IIPImage* is used.

The *Cranach Digital Archive* is a good example of presenting a Web gallery in the Web 1.0 paradigm, as it is strictly acting as a provider for information, whose users are able to consume the content while not generating and providing information themselves.

Timelines: Sources from History

The *Timelines: Sources from History*[2] project from the *British Library* presents cultural artefacts on a timeline, grouped in decades (van Erp et al, 2011). The overall objective of the project is

[2] `http://www.bl.uk/learning/timeline/index.html` (accessed on May 5th, 2012)

Figure 3.2 – Screenshot from the "Timelines: Sources from History" website

to ease the access for history students and teachers. In the work of The British Library (2010*a*), three goals of Timelines are described:

- Help students in their development process of understanding historical and chronological changes.
- Better access of original source material for students and teachers.
- Development of a cost-effective and sustainable interface to enable users to find and access content from the British Library collection.

The timeline starts in the beginning of the 13th century and ends in the present day. Users are able to compare different theme-based timelines: *Central Timeline*, *Key Events*, *Politics, Power and Rebellion*, *Literature, Music and Entertainment*, *Everyday Life*, *Sacred Texts*, *Medicine, Science and Technology* and *Asians in Britain*. Figure 3.2, obtained from the Timelines: Sources from History Web page[3], shows the standard setting with the *Central Timeline* and *Key Events*, where popular events in the past are related to the gallery objects in the main timeline. The timeline comparison allows users to compare various aspects of social, cultural and political life both within time periods, across time and against key events (The British Library, 2010*b*).

Timelines: Sources from History supports the principle of artwork exploration. Users, who have no art history knowledge can navigate through the timeline and explore new artworks and

[3] `http://www.bl.uk/learning/histcitizen/timeline/historytimeline.html` (accessed on June 13th, 2012)

their relationship to the century, decade and other time related works. Furthermore they can read descriptions by simply clicking on a specific artwork.

Moreover, users are able put specific artworks to a *My Favourites* timeline, which can be selected as a comparison timeline as well. Saving this user generated timeline is not supported.

The British Library offers additionally an orientation guide for the timeline, which allows students to explore the collection items chronologically from the last centuries to the present day and provides "background notes and suggested questions to use the interactive in the classroom". Moreover it supplies students with "the tools to develop independent historical enquiry and creative thinking skills." (The British Library, 2010*b*) The general aims of the orientation guide are described in The British Library (2010*b*).

The *Timelines: Sources from History* website is a good example of a Web 1.0 page with technological advanced presentation forms, as it uses Adobe Flash for the whole interface. The disadvantage is the lack of Flash support on various mobile platforms.

3.2 Web 2.0

Web 2.0 is strictly related to the term *Social Media* and refers therefore to a many-to-many communication model (Russo et al., 2006). As part of the Web 2.0 movement, museums and cultural institutions in general offered new opportunities to engage with museum processes through co-creation and participatory cultural experiences e.g. blogs, wikis, podcasts, photo and video sharing, virtual environments, tagging, annotation, and other authoring tools (Russo, 2011). Nevertheless, Oomen and Aroyo (2011) notes that despite the fact there is an explosion of user-generated content on the Web, "only a small number of people contribute the most of it. About 90% of the online users only consume content and from the 10% left only 1% actively and consistently contribute the majority of the user-generated content."

Web 2.0 pages can be distinguished by exploring the following features, which are described in the work of Cormode and Krishnamurthy (2008):

- Users act as first class entities in the system, including profile pages with properties like age, gender, location, testimonials, or comments by other users.
- The ability to build connections between users, group memberships, as well as subscriptions or RSS feeds of updates of other users.
- Encouragement of user-generating content like text, videos or photos as well as comments, tags and ratings. Furthermore the feature to control privacy and sharing.
- Inclusion of technical features, like public APIs to allow third-party enhancements and mashups, as well as embedding of rich content types like flash videos and communication with other users through internal mail or Instant Messaging systems.

Based on the classical communication model of Claude Shannon and Warren Weaver, the roles of the sender i.e. the curator and the receiver i.e. the visitor were fixed since the late 60s: The sender had to create the message, while the receiver had to learn to understand the

message. A feedback process was totally neglected. As a result, cultural institutions often do not realize which information visitors really want to see. According to Schweibenz (2011), the communication process is not only about delivering a message, "but also includes a certain perspective on a specific object or issue." Therefore effective museum communication has to consider the agenda of visitors and "their ways of interpreting things in order to support the visitors' meaning making as it is suggested by constructivist learning theory." Through the replacement of the traditional one-to-many broadcasting by a many-to-many communication model in the Web 2.0 movement, all senders are also receivers and vice versa (Schweibenz, 2011).

Thus, social media enables museums to maintain a cultural dialogue with its audiences in real-time (Russo et al., 2006). Furthermore it shifts the power from curators as creators and producers of knowledge to the users. So the users are no longer only passive consumers of information and become active participants and collaborators who start to play an eminent role as creators and producers of content. As a result, the traditional thinking of being in total control of the content and its interpretation has to be discarded by museums, as it becomes more important for them to decide how much control they want to lose and how much control they want to give to their visitors (Schweibenz, 2011).

A major problem with user participation is to ensure a specific quality of content. Through the contribution of information from a large group of users cultural institutions are unable to control the quality of the content efficiently and effectively, as quality control requires a lot of time and effort while resources are often scarce in many institutions. As a result, misplaced content might even threaten the reputation of the institutions as a whole. According to Schweibenz (2011), this predicament is solved by the paradigm of radical trust in the user community. The difficulty is to find a balance between a certain degree of trust in the users and a certain amount of control which still stimulates the user participation and allows the institution to maintain the responsibility for the quality of its content.

Museum learning is related to the process of co-participation within a social context, so it is made possible through involvement with, participation in, and acceptance into a community. Therefore learners should be contributing members of communities (Russo et al., 2008). Thus the term museum learning can be also called social learning.

The following subchapters will introduce several concepts of the Web 2.0 paradigm like *Personal Digital Collections*, *Social Tagging* and *Social Networks* in the context of museum websites and simultaneously describe various examples related Web experiences.

3.2.1 Personal Digital Collections

According to Marty (2011), personal digital collection tools have become increasingly common on museum websites since they were introduced in the mid-1990s. Many systems allow users to create multiple collections, annotate their collected artefacts with comments and share their collections via email or using social network platforms like *Facebook*, *Twitter* or others.

A study in 2008 showed, that the majority of online museum visitors "strongly agreed that museum websites should offer interfaces that can be customized to meet the needs of different online visitors (e.g. virtual tours that adapt to individual interests), as well as interfaces that

can record and store personalized information for different online visitors (e.g. personal digital collections of selected museum artefacts)" (Marty, 2011).

To fulfill this need, museums and cultural institutions in general began to develop approaches which allow users to create personalized collections with their favorite museum objects and moreover help them to get an overview to the museum's artefacts prior a visit and give them opportunities to plan their trip through the museum. The *J. Paul Getty Museum* website, for example, encourages visitors to select their favorite artefacts in an user collection, called *Getty Bookmarks*. Furthermore, users are able to create a printable, customized map showing the location of the selected artefacts in the museum. Thus visitors are able to plan their trip in advance by simply using it as a tour guide.

Moreover the current technology of mobile devices allows users to bookmark information during the museum visit, which can be retrieved online after the visit using personalized pages on the museum's website. Ideally, this can lead to a cyclical relationship between museums and their websites, encouraging users to visit their favorites in the museum building or online if this is not possible.

Due to the fact that repetition is an important factor in keeping memories, bookmarking can also play an important role in increasing visitors' knowledge about a collection or exhibition as well as "stimulating a positive response to their visit and the intrinsic desire to learn more" (Filippini-Fantoni and Bowen, 2007). Thus, if bookmarking of artefacts is "well-integrated into the visitor experience, it can be a powerful tool for supporting the learning experience in museums and creating a stronger relationship between the institution and the visitor" (Filippini-Fantoni and Bowen, 2007).

Taking more recent research into account, Marty (2011) proposes two different directions of the development of personal digital collections in the last few years:

Some museums decided to drop the idea of developing and maintaining their own systems and started to use external services like social networks (i.e. Facebook, Twitter, etc.). Social networks allow users to share information about artefacts with their friends and contribute information themselves. Furthermore many users prefer working with systems they are familiar with, instead of registering on several museum websites with different interfaces and functions. Social networks are further described in chapter 3.2.3 (Marty, 2011).

Other museums instead further developed their systems to more specialized personal collections to target more specific audiences. The *Museum of Fine Arts in Boston*[4], for example, focuses on teachers and students in their *Educators Online project*[5], which was developed in 2008. The system allows teachers and students to build personal digital collections, create customized virtual galleries, and develop personalized lesson plans that integrate directly with classroom curricula (Marty, 2011).

According to Marty (2011), the direction which will be dominant in the future "will likely depend on the needs of individual museums and the audiences they are trying to reach. Even if these approaches differ fundamentally in their principle, they "envision a world where all museums are encouraging their visitors to become active participants in the co-construction of digital knowledge."

[4] `http://www.mfa.org/` (accessed on July 2nd, 2012)

[5] `http://educators.mfa.org/` (accessed on July 2nd, 2012)

Personal digital collections are integrated in various museum websites. One of the most popular cultural experience in the Web is the *Google Art Project*, which is subsequently described in more detail. The Web page is an excellent example of summarizing various types of already tested functions and interfaces and combines them on a single page. The page was chosen as an example for this chapter after discussions with my advisor.

Google Art Project

The *Google Art Project*[6] is one of the most popular art collection initiatives in the last few years. It is a collaboration project with partnership agreements with 151 museums from 40 countries and with more than 30.000 objects from more than 6.000 artists.

The *Google Art Project* integrates the personal collection as a central aspect of the site. Users are able to access high-resolution images of artworks which are provided by partnership museums and, if registered, to discover and select specific artworks and relate them to a certain user gallery. Furthermore site visitors are able to share their personal collections with their friends on various social platforms like Facebook, Google+ and others. Moreover they can upload audio and video content from Google+ to personalize their user galleries and share them with others (Wikipedia, 2012*a*).

If users are more interested in specific artworks, they are able to view scholarly and contextual information to enhance their understanding of the work. This includes various descriptions about the physical object (i.e. size, material, artist) as well as *Artwork History*, *Artist Information* and *Viewing Notes*. Moreover, Google Art Project integrates various services like *Youtube* and *Google Scholar* to give the users further information on external platforms (Wikipedia, 2012*a*).

Another central aspect of the Web page is the possibility to take 360 degree tours of individual galleries using a *Street View* 'indoor' technology. Figure 3.3, obtained from *Google Art Project* website[7] shows a virtual tour through the Museum of Fine Arts in Vienna.

In the second generation of the *Google Art Project*, Google integrated three new features (Wikipedia, 2012*a*):

- **Exploration:** Users are able to find new artworks more intuitively by exploring artworks across all museums. The images of the artworks are shown in a slideshow format and can be filtered by various categories like artist, museum, type of work, date and country.

- **Audio and Video Content:** Guided tours and welcome videos help users to get introduced in the museums art objects. Museums can provide audio guides to certain artworks or a video tour as an experts guides users through the museum.

- **Education:** The Google Art Project integrates several educational tools and resources for teachers and students. This includes educational videos as well as two pages called *Look Like an Expert* and *DIY* which provide several activities for site users. An example for an activity is a quiz, which asks visitors to match paintings to a specific style. Finally, the

[6] `http://www.googleartproject.com/` (accessed on July 3rd, 2012)

[7] `http://www.googleartproject.com/de/collection/kunsthistorisches-museum-vienna-museum-of-museumview/` (accessed on July 4th, 2012)

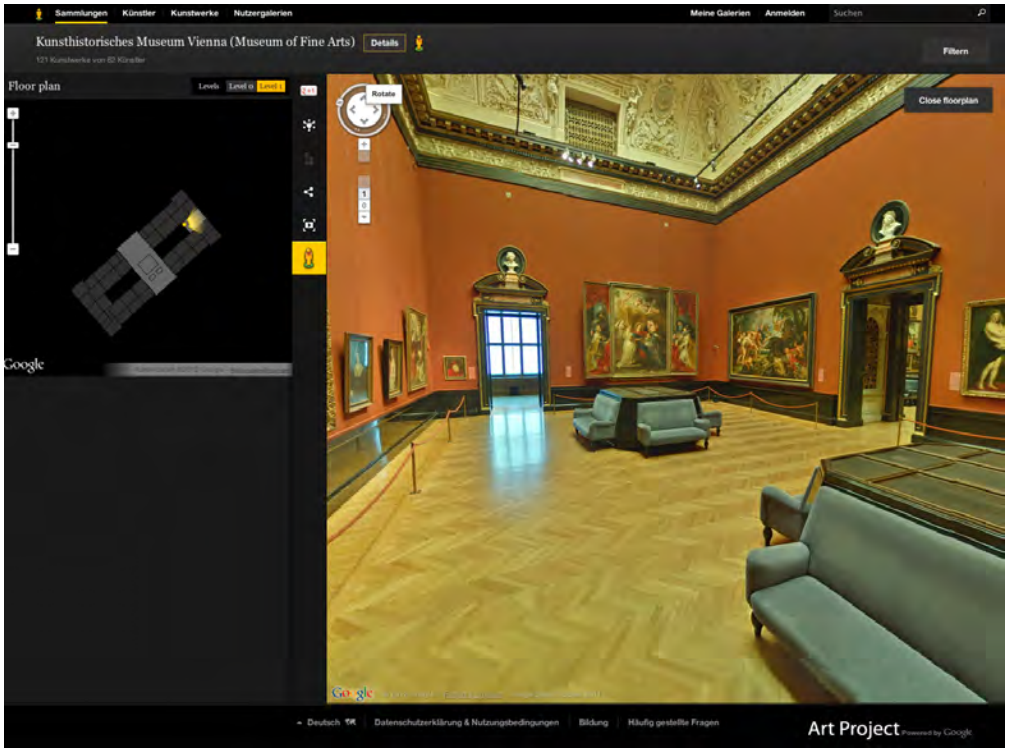


Figure 3.3 – Screenshot from the virtual tour through the Museum of Fine Arts in Vienna

What's Next page provides several resources and links to art history timelines, art toolkits, and comparative teaching resources.

3.2.2 Social Tagging

The concept of social tagging perfectly reflects the pros and cons of user participation and allows an democratic access of information by allowing users to give images specific text associations. As a result, it engages the public and makes object descriptions more generally comprehensible. The resulting aggregation of tags is called *folksonomy*, which was formed through a combination of the terms *folk* and *taxonomy* and refers to an "informal, organic assemblage of related terminology" (Trant, 2009). Furthermore, social tagging is a type of crowdsourcing, which is described in chapter 2.

As searchability is crucial for the accessibility of art collections, it is necessary to gather complete object descriptions to allow an efficient search process. In many cases, museums or cultural institutions in general use only a small amount of information, including a description of the art object, the date of acquisition, the reason for acquisition, the name of the museum employee responsible for the object, the name of the institute and the inventory number (van Vliet and Hekman, 2012). In most cases this data is created by art experts who are acquired by cultural institutions, allowing an "effective and precise information retrieval in an academic or business environment where professional searches are applied by subject specialists" (Schweibenz, 2011).

Due to the fact that in general the potential audience is very heterogeneous, the specialist terminology is a major barrier for accessing the database content, as laypersons do not have the knowledge of a specialist terminology allowing an effective search process . Therefore, in order to be found by users, it is indispensable for cultural institutions to replace or extend the specialist vocabulary by the users language and terminology which is comprehensible for the general public (Schweibenz, 2011).

van Vliet and Hekman (2012) supports this theory by proposing various studies which suggest that social tagging improves the value of art collections as well as the level of visitor involvement with the offered collection of artworks. Following, four benefits of social tags are described (van Vliet and Hekman, 2012):

- Tags provide users more closely related access points than formal artwork descriptions used by cultural institutions.
- Tags add new information to art collections, which is in some cases not available to cultural institutions themselves.
- Due to the people's involvement into the art collections, they contribute their personal meaning and experience with artworks to the museum and other users.
- Tags can be used for more personalized access to art collections by making suggestions, composing virtual exhibitions, providing route maps, or bringing users into contact with other users.

Nevertheless, Schweibenz (2011) suggests the importance of an unmistakably separation of social tags from terms attached by museum professionals, in order to resolve "the responsibilities and to document the origin of the descriptive terms." Furthermore, a set of metadata should indicate the origin of specific tags and the responsibilities of persons or organizations. This is also important for copyright and digital rights management, archiving and long-term preservation of both kinds of contents.

Social tagging is used by the *Your Paintings* project website, which was founded by the Public Catalogue Foundation, and the *explorARTorium* Web page from the Vienna University of Technology: The *My Paintings Tagger* project by the *Public Catalogue Foundation* is a pioneering and ambitious public tagging initiative to enhance the metadata for each oil painting in the *Your Paintings* project (Ellis et al., 2012). It underlines the aims of social tagging and shows the results and benefits in practice. The *explorARTorium* combines social tags with a contextualization of artworks. Both Web pages were chosen as examples for this chapter after discussions with my advisor.

Your Paintings

Your Paintings is a partnership project between the *BBC*[8], the *Public Catalogue Foundation*[9] and about 3.000 participating collections and museums from across the United Kingdom. As

[8] `http://www.bbc.co.uk/` (accessed on June 20th, 2012)

[9] `http://www.thepcf.org.uk/` (accessed on June 20th, 2012)

part of the *Your Paintings* project, the *Public Catalogue Foundation* started a project called the *Your Paintings Tagger*[10], where users can contribute by tagging paintings (Ellis et al., 2012).

The UK national collection contains estimated 200.000 oil paintings, out of which only 20 percent are visible to the public. Some of them might be being conserved or prepared, in storage or in a part of a building without any public access. The collection offers an insight into this country's history, topography, and culture through the eyes of world-famous and completely obscure artists from the past 700 years (Ellis et al., 2012). Since the digitisation of the paintings is still in progress, there are around 150.000 online in June 2012. The digitisation process will be finished by the end of 2012 (BBC, 2012).

The main idea of the *Your Paintings Tagger* is to get many people tag many paintings, repeatedly and redundantly to get fully descriptive classifications and keywords which help users to find specific artworks in the collection more efficiently (Bianchi, 2011). The *Public Catalogue Foundation* differentiates three types of users (Bianchi, 2011):

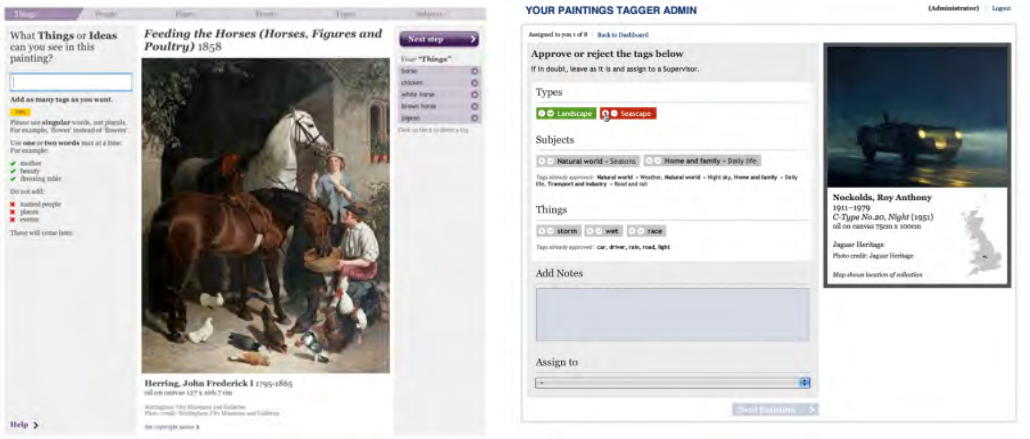
- **The general public:** Users who do not have specific knowledge or expertise in terms of art and technology are contributing through tagging *Things*, *Events*, *People* and *Places*. After a warming up with ten tagged paintings they are able to assign *Classifications* and *Categories*. The collected tags and descriptors are useful to virtually everyone.

- **Experts:** In the registering process users are able to disclose wether they have a particular expertise in the history of art by supplying their qualifications and credentials. If this data is verified users are given an expert status. Experts have two roles: First, they are given access to two additional workflows for each painting, *Dates and Styles* and *Movements*, and second they help to classify difficult paintings, after the general public failed to deal with them.

- **Supervisors:** Supervisors are hand picked academics, invited to take part in the project because of their specific fields of expertise in art history. (e.g. Baroque, Renaissance or Abstract Art). Their focus lays on classifying artworks which even experts are not able to, as well as uncertain tags.

The *Your Painting Tagger* shows paintings randomly to users with the goal to get a satisfactory number of contributors who completed each workflow. In this process, one particular picture is only presented once to the same user. When filling in terms into the tag field, specific terms from different vocabularies are suggested by the system (e.g. Oxford English Dictionary for *Things*, DBpedia for *Events*, *Places* and *Names*). If users do not want to use these terms, they can simply enter their own words. In the case, users do not have something to say about a painting, they can skip it. If a specific number of contributors is not reached within a given time frame through the general public, experts try to support the tagging process. If even experts do not know how to deal with difficult paintings, supervisors take action. Anything a supervisor tags is then automatically accepted (Bianchi, 2011). Figure 3.4a shows the tagging interface on the *Your Painting Tagger* Web page[11].

[10] `http://tagger.thepcf.org.uk/` (accessed on June 20th, 2012)
[11] `http://tagger.thepcf.org.uk/` (accessed on June 20th, 2012)



(a) Screenshot from the "Your Paintings Tagger"

(b) The "Your Paintings Tagger Admin" interface

Figure 3.4 – Screenshots from the "Your Paintings" project

When the tagging process is finished, the tags have to be reviewed before landing on the *Your Paintings* Web page. This review process comprises two parts (Bianchi, 2011):

- In the first run, a special software automatically decides wether a tag is accepted or discarded. Besides the number of agreeing tags, the reliability of taggers is relevant for this decision. Based on the assumption, that taggers get better by practice, novice taggers get a lower score than people who have already tagged hundreds of paintings. Moreover, the quality of their tags is taken into account (i.e. accepted tags among submitted tags).

- Although the automated analysis treats most of the tags correctly, some paintings have to be treated manually by supervisors. This might be the case if there are only a few tags, or tags which do not gather enough consensus, but are not weak enough to be discarded. Figure 3.4b shows the supervisor's interface[12], where tags can be approved or rejected.

Moreover, *My Paintings* allows the users to select, comment and share paintings chosen from the national collection. User galleries and sharing is described in chapter 3.2.1 more detailed.

exploARTorium

The *explorARTorium*[13] is a Web platform, where users are able to explore new artworks by showing them in related contexts like artists, art topics, regions, types and time spans. Through the interpretation and contrasts of context related artworks the user "fosters the development of a

[12] `http://www.keepthinking.it/news/item/your-paintings-tagger-behind-the-scenes` (accessed on June 20th, 2012)

[13] `http://explorArtorium.info` (accessed on June 5th, 2012)

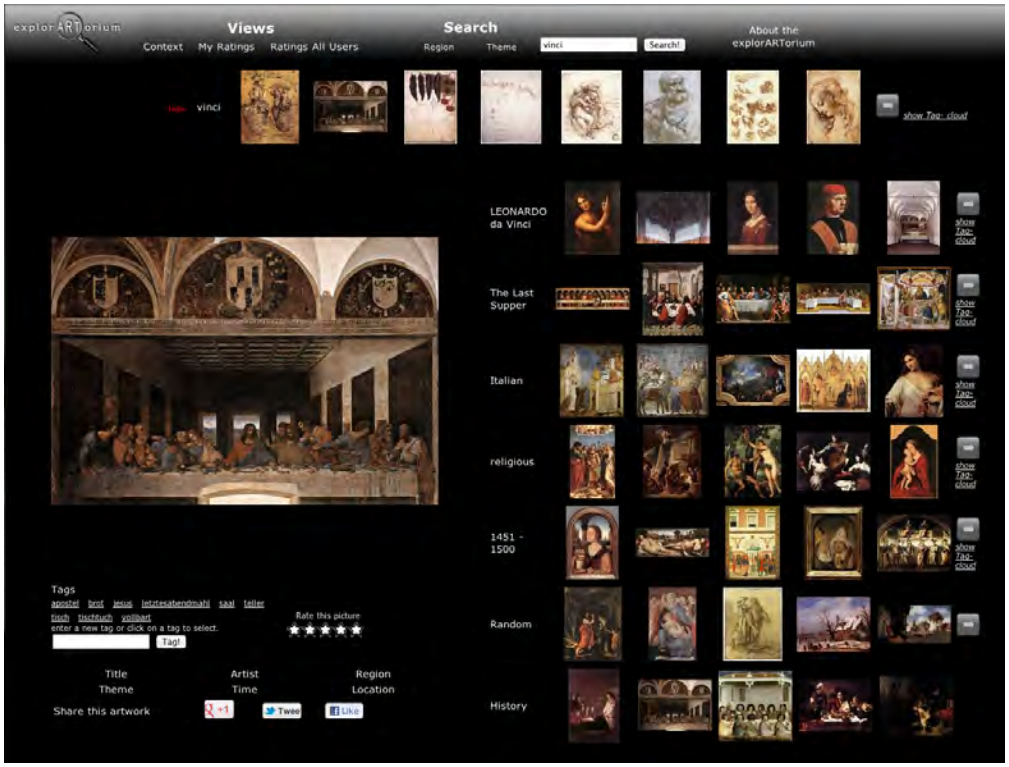


Figure 3.5 – The last supper by Leonardo da Vinci in the explorARTorium

feeling for art historic interrelation without resorting to textual information." Another key aspect is the possibility for users "to assign descriptive keywords (tags) for artworks" (VSEM, 2011).

The data was gathered from the *Web Gallery of Art* (WGA)[14], a free image database, which contains over 26.000 artworks from 3.200 different artists (Arends, Froschauer, Goldfarb, Merkl and Weingartner, 2011). The *explorARTorium* presents 12.741 artworks, which are mainly european origin and date back from 1100 until 1900.

In Figure 3.5 the structure of the *explorARTorium*[15] is shown. On the left side the main image of an artwork is presented, on the right side context related images of artworks are shown. The related contexts are (Arends, Froschauer, Goldfarb, Merkl and Weingartner, 2011):

1. **Artist:** This context relates further five artworks from the same artist to the current image. The intention is to give the user an impression of the general work of the artist.

2. **Topic/Title:** In general, an artwork is related to a specific topic, which is examined through the title of the image.

[14] `http://www.wga.hu/` (accessed on June, 5th 2012)
[15] `explorARTorium.info` (accessed on June 4th, 2012)

3. **Region:** The region describes where the artist created the artwork. In the example of *The last supper* of Leonardo da Vinci this region is *Italian*. It helps the user to find out the artwork tradition in this region.

4. **Theme:** This context helps to get an impression of the respective theme of the current shown artwork. This can be *religious*, *portrait* or others.

5. **Time:** The time is grouped in 50 year spans, which gives the user an understanding of the used themes and types of different artworks at this time period.

6. **Random:** This context relates five random artwork pictures to the current shown artwork. This helps the user to leave the current context and explore new paintings. If users select a specific tag to the current shown artwork, this context relates different paintings with the same tag.

7. **History:** The last context shows the history of the last five selected artwork pictures, so the user is able to return to a previously visited picture.

The context related images of artworks aim to give the user the possibility to explore and stimulate their interest in art history (Arends, Froschauer, Goldfarb, Merkl and Weingartner, 2011). To support this process of visual exploration, textual information is only visible by clicking on links. If users already know artworks they want to see, a search bar can be used to find specific information.

This generation of user content through social tagging is also the raison why the *explorARTorium* is assigned to the Web 2.0 paradigm. Today, there are 20.322 artworks, whereof 56 % are tagged with overall 97.823 tag associations.

3.2.3 Social Media Networks

Social Media Networks were getting increasingly popular over the last years and provide a significant and possibly more efficient way to publish audience responds to cultural content (Russo et al., 2006). They provide an useful addition to the museum's paper and other online publicity to inform people about upcoming events and exhibitions (Russo et al., 2008). It is therefore hoped to raise the institution's publicity amongst, between and around individuals and communities in social media spaces (Kidd, 2011).

Moreover, through the inclusion of communication between users and the institution, people feel more involved in the museum activity. Social networks establish a dialogue with and between users, build relationships with and between audiences and bring communities of interest together (Kelly and Russo, 2008). According to Russo et al. (2008), social networks give museums a recognizable "face", which is seen as an extension of their normal branding activity. Furthermore it facilitates "knowledge exchange by taking advantage of 'network effects' and creates a new forum through which diverse audiences can participate with museums to explore issues and voice these reflections" online (Kelly and Russo, 2008).

There are two ways to use social networks in context of a cultural institution: One approach is to use existing social media platforms like Facebook, Flickr or Twitter. Another approach is

to implement an individual social network on the website. The first idea does not need to bring people register in their own network, as social networks like Facebook already have a huge user stack. The benefit of the second approach is that only people who are interested in the topic will register, resulting a more intellectual quality of the conversation on the platform (Arends, Goldfarb, Merkl and Weingartner, 2011). In Russo et al. (2006), three difficulties implementing an individual social network are described:

- The museum is unable to predict the ways in which social media will be used.
- It is difficult to predict the number of people who will participate.
- It is difficult to plan for consistent length/duration of participation.

Therefore museums "need to weigh the relative merits of museums developing their own personal digital collections systems against the possibility of museums contributing their digital images and information resources to online social networking tools directly." While technical aspects can be neglected when using existing social platforms, questions of control, copyright, and intellectual property that may prove difficult to address, are raised.

Moreover, museums have to examine how the popularity of social media networking platforms has influenced user expectations about the features and capabilities of social networking platforms. Since the design of existing social platforms like *Facebook* has significant implications for the development of personal digital collection systems in museums, "visitors will increasingly expect museum-developed tools to function as smoothly, seamlessly, and effortlessly as the other tools they use online daily" (Marty, 2011).

The following examples were chosen after exploring several social media appearances of museums and cultural institutions in general. A promising social media presence regarding richness and up-to-dateness of the uploaded information is offered by the *National Gallery*, which is represented on Facebook, Twitter, and others. The *Powerhouse Museum*, on the other side, illustrates that simply referring to their institution's Web page does not stimulate any user participation.

National Gallery

The *National Gallery in London* offers their information on a broad spectrum of social media platforms.

The *Facebook* site[16] (Figure 3.6a) is online since July 2008 and has 94.000 followers, so called *Likes*, as of July 18th 2012. The museum offers basic information about their building like a description, opening hours, contact information, locations and directions to their visitors. Furthermore they announce current news (exhibitions and links to the official *National Gallery* website) and photos of artworks on their wall, the so called *Timeline*. Since they are very active on Facebook, there are several wall posts a day. Moreover, the museum show their visitors a *Word of the week*, which links to a specific artwork picture on their museum Web page.

[16] `http://www.facebook.com/thenationalgallery` (accessed on June 19th, 2012)

(a) Screenshot from the National Gallery's Facebook page

(b) Screenshot from the National Gallery's Twitter page

Figure 3.6 – The National Gallery'ssocial media presentations.

Users are able to contribute information by commenting wall posts or sharing information on the wall. This allows the museum to gather feedback for their current exhibitions and their general work.

Figure 3.6b shows the National Gallery's *Twitter* page, where they have 32.000 followers as of July 18th. Since the museum is very active on Twitter as well, they announce several posts, so called *Tweets* in the Twitter terminology, a day, where they offer information and links to current exhibitions and multimedia content.

Moreover, the museum offer a *Youtube* channel, where they offer videos to current exhibitions. The site has over 1.000 followers, as of July 18th,

Powerhouse Museum

The *Powerhouse Museum* offers a very contrary *Facebook* presentation[17] to the *National Gallery*'s. Instead of announcing current news about exhibitions, the museum post links to the *Facebook Wall*, which are directing to specific artworks on their Web page. Notably this type of simply posting links is not stimulating user participation as there are hardly any comments and *Likes*.

[17] `https://www.facebook.com/powerhousemuseum` (accessed on July 19th, 2012)

3.3 Web 3D

The improvements of graphics hardware and the growing availability of broadband internet connections in the last years led to the increased use of 3D in the Web. 3D creates a platform for people "to experiment new methodologies to classify and share cultural resources, and to enable everyone everywhere to freely access information" (Carrozzino et al., 2012).

The creation of realistic visualization of 3D models from cultural assets allows users to access and exploit object details difficult or impossible to notice in the real asset. Web3D therefore allows to virtually touch, experiment and restore virtual copies without damaging them. Furthermore researchers and scientists can reconstruct damaged art and historical works, sites or environments in order to maintain their preservation (Carrozzino et al., 2012).

Despite the technology is very promising, Web3D still is not massively spread among Internet users. On the one side Carrozzino et al. (2012) sees possible difficulties of "setting up effective interaction metaphors taking advantage of the third dimension as an added value, rather than as stylish gadget." On the other side it is more challenging for users to control within a 3D space. Untrained users need to pay attention to navigate rather then focusing on the content itself (Goldfarb et al., 2012). As a result the used technology might become even more central than the message the Web page should convey.

The *London Charter*[18] therefore provides guidelines for 3D visualization of cultural content on Web pages "seeks to establish what is required for 3D visualization to be, and to be seen to be, as intellectually rigorous and robust as any other research method" (Beacham et al., 2009).

The 3D visualization tools, so called three dimensional viewers, allow the visualization over the Web and can be stand-alone or plugins for Web browsers. While stand-alone viewers have to be downloaded and installed on the computer, viewers for Web browsers generally require only the installation of plugins which can be done in the browser itself. A challenging task for 3D viewers is to provide an intuitive interface with a high level of interactivity even when a large number of data is shown. Mendes et al. (2010) notes that "in order to ensure a high degree of interactivity with the user, the visualization systems of 3D models need to provide fast and practical access, with usability features adequate to as many as possibly and, more importantly, effectively perform its functions." The frames per second (fps) rate can be a measure to evaluate the efficiency since the higher the rate the smoother the objects can be turned and moved (Mendes et al., 2010).

Currently, various languages and technologies are used to create, display and interact with Web3D scenarios. Despite *HTML5* and *WebGL*[19] is very promising, there is no established standard for presenting 3D applications in browsers. As as result, Web users have to install different plugins, which might be an obstacle for inexperienced users.

In Carrozzino et al. (2012), 50 feedbacks of volunteer internet users on 16 sample Web3D cultural applications were taken in order to answer questions about the usage of the platforms. Twenty-two percent of all interviewed users answered that they abandoned the application before completing the navigation. Table 3.2 shows that the main reason are compatibility problems with plugins, followed by too long navigation times and navigation problems.

[18] `http://www.londoncharter.org/` (accessed on October 10th, 2012)
[19] `http://khronos.org/webgl/` (accessed on October 11th, 2012)

My browser is not compatible with the plugin	25.0%
The navigation time was too long	18.7%
I could not move in the virtual environment	12.5%
I have not figured out how to interact	12.5%
The application download times were too long	12.5%
I could not install the plugin	12.5%
I could not properly see models	6.3%

Table 3.1 – Interview result after questioning internet users "Why have you abandoned the application before completing the navigation?" (Carrozzino et al., 2012)

The *Virtual Reality Modeling Language* (VRML) is used by most Web pages to present 3D models and describes interactive 3D objects and 3D environments in a text format (Mendes et al., 2010). Nevertheless, Mendes et al. (2010) depicts various problems related with the use of VRML plugins, since there are "different behaviors in the visualization of 3D models when computers with different hardware configuration or operating system are used." Furthermore, there can be a sudden inoperability of the system without error messages, intermittent delay in visualization even with simple 3D models and a high memory and processing consumption.

A further widely used technology for Web3D applications is Flash, which also needs a browser plugin.

Subsequently, two examples of Web3D experiences on the Web are described: The virtual museum *Museo Virtual de Artes El Pais* (MUVA) is a virtual museum for uruguayan art, where users are able to navigate through a virtual 3D exhibition. *ThIATRO* is a treasure hunt game about art history, which aims to teach users to examine and understand paintings. Both examples were chosen as examples for this chapter after discussions with my advisor.

MUVA - Museo Virtual de Artes

MUVA, Museo Virtual de Artes El Pais[20] is a virtual museum for uruguayan art, which only exists on the Web and was launched on May 20th, 1997 (Haber, 1998).

Haber (1998) describes in her work the origin and the incentives of the project, which are related to the economic and political problems in the late 90s. Since there were only few private efforts and no incentives to support the income and revenues of museums, the creation of *MUVA* is "in part related to the frustrations and limitations stemming from certain socio-economic realities and to the constraints of the Uruguayan society."

The museum is located in a special building which was designed by architects. According to Haber (1998), "the progress in virtual reality and development of Internet has made a great adventure possible: the design of what today is an impossible museum for Uruguay and at least have it in a virtual form."

Instead of being confronted with plugin problems for Web browsers, the first version of *MUVA* was created entirely in HTML, which made the site more accessible. The second version

[20] `http://muva.elpais.com.uy/` (accessed on October 11th, 2012)

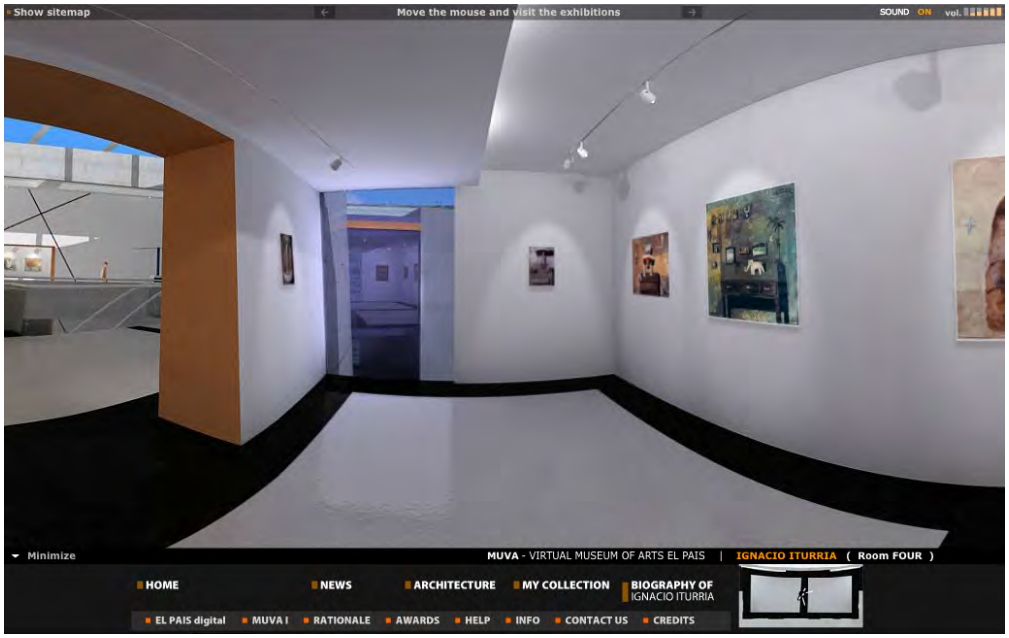


Figure 3.7 – Screenshot of MUVA

of *MUVA*, shown in Figure 3.7, was entirely developed in Flash. Virtual museum visitors are allowed to navigate through the building and watch artworks more detailed by clicking on them. Moreover various textual information about the specific artworks can be viewed additionally.

ThIATRO

ThIATRO is a treasure hunt game about art history that can be played online in the Web browser. It is related to the term serious heritage games, which means to link virtual heritage applications with challenging and motivating game elements. Users are allowed to navigate through a virtual 3D exhibition and thus aims to teach users to examine and understand paintings instead of learning them hard facts (see Figure 3.8, obtained from the *ThIATRO* page[21]). Furthermore it provides tools for classroom use and general tools for users who want to gain knowledge in art history (Goldfarb et al., 2012).

According to Goldfarb et al. (2012), *ThIATRO* aims to follow three goals:

- Combination of learning and fun in an immersive 3D environment to make the communication of art-historical facts more entertaining.
- Creation of a game-like environment that fosters a lively learning experience as an incidental consequence of the game activity.
- Raise of interest in art history, culture and cultural heritage.

[21] `http://www.thiatro.info` (accessed on October 22nd, 2012)

(a) Screenshot from an outside view of ThIATRO

(b) Screenshot from an exhibition inside a virtual museum in ThIATRO

Figure 3.8 – Screenshots from the ThIATRO Web game.

The core functions can be summarized as movement in the virtual world, investigation and comparison of artworks and the recall of knowledge from previous levels to fulfill the tasks. The game story is divided into seven levels, which can be finished by collecting five paintings that fulfill the assigned task. For a correct choice, 10 points are assigned, for a wrong choice, 5 points are subtracted. When the task is fulfilled, the player returns to her own museum and enters the next level.

In order to show images of artworks in the virtual exhibitions, the *Web Gallery of Art*[22] was used as a data source. For *ThIATRO*, 40 classical paintings, that in their entirety incorporate typical characteristics of the important art historical ages from Middle Age to Baroque, were chosen.

3.4 Mobile Web

In the last years, mobile media has successfully found its way in the cultural heritage domain, thanks to its characteristics of portability, handiness, ubiquity, and social networking. The innovative character is not the technology itself rather than communication and interaction models, which help to enrich the communication strategies at disposal of museums and other cultural institutions. Thus it is becoming more and more important to consider the visitor's needs and expectations as well as museum objectives, physical space, digital content and information flows (Mason, 2011). According to Calvi and Cassella (2011), there are four important objectives identified by museums and cultural institutions in general to offer mobile experience:

- Provision of supplementary information to visitors.
- Diversification of the museum's offering to visitors.

[22] `http://www.wga.hu` (accessed on October 22nd, 2012)

- Engagement of visitors as part of the museum's experimentation.
- Creation of interactive experiences.

The latest development has shown that mobile media for museums and other cultural institutions with physical exhibitions is moving from typical audio-tour guides to more complex mobile systems which can engage users to new ways of experiencing their visit. Mason (2011) describes the standard architectural approach of these systems: *pieces of information (nodes)*, *structure and organization*, *navigation*, and *language*. While nodes are simply pieces of information and the structure the way they are connected with each other, the navigation modality is more complex.

The structure of information architecture can be divided into *sequential*, *hierarchical*, *matrix* and *organic* (see Figure 3.9, obtained from Mason (2011)). While sequential information structure mainly corresponds to a linear tour navigation at the basis of the traditional audio tour guide, hierarchical structures generally let the users to choose from general categories to more specific ones. According to Mason (2011), this is one of the best method of structuring museum contents, since "the structure is conducive for going into greater and greater detail." While the matrix structure let users to filter and select content according to their needs and demands (e.g. artist, historical period, and others), organic structured information architectures do not follow any consistent pattern. Nodes are connected together on a case-by-case basis and the architecture has no strong concept of sections. Mason (2011) sees organic structures as good for exploring a set of topics whose relationship is unclear or evolving, but generally uncommon for museum-specific mobile apps.

As mobile devices offer persons at her disposal a portable technology and a potentially continuous access to information, navigation has to be different than on non-mobile systems. According to Mason (2011), "this implies that the navigation happens no more only in a virtual world (amongst virtual contents) but also in a physical space." Furthermore visitor collaboration and content sharing may also affect the way of navigation is used on mobile devices. In Mason (2011), the type of navigation modality during a museum visit is divided into *spatial*, *semantic* and *social* aspects. While spatial navigation means to leave the visitor the choice of orientation in the museum (by showing interactive or still image maps of the museum and its objects), semantic navigation connects the semantic information of objects and guides the visitor through the museum by linking specific artworks. Finally, social navigation is an extension of semantic navigation and uses social aspects to affect the dynamics of navigation. Therefore technologies like social tagging (see chapter 3.2.2), social network sharing and visitor comments are used to find out possible similarities of understanding artworks among visitors with different interests and background and thereby enhancing socialization.

In February 2012, the third *Museums and Mobile* annual survey with about 615 participated museums was published. The survey was conducted between late-November 2011 and early-January 2012 and aimed to show the objectives of museums going mobile, and the "main challenges in delivering mobile applications and the future perspectives of mobile technology in museums." The result showed that around thirty percent of the museums surveyed offered mobile interpretation tools to visitors, while 27% planned to do so (Mobile, 2012)(Calvi and Cassella, 2011).

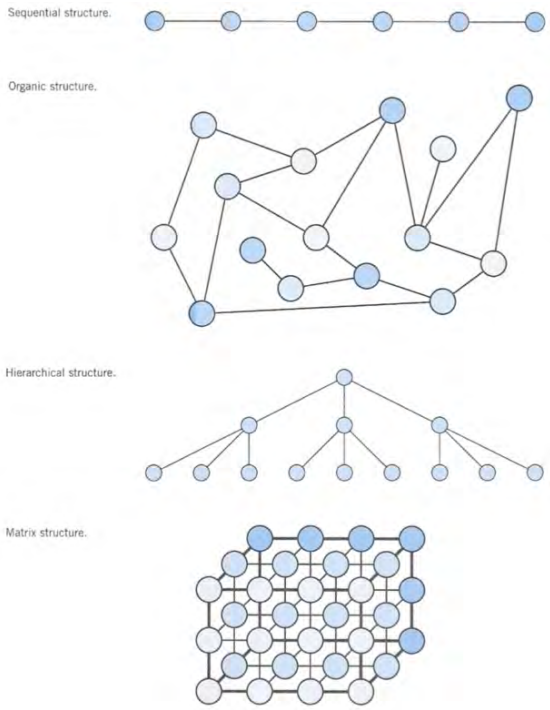


Figure 3.9 – Structure types of information architecture.

In 2010, the *Indianapolis Museum of Art* (IMA) conducted a short survey on visitor's mobile preferences: The results showed that the majority of visitors prefer to access mobile content from their own devices, followed by a smaller number of visitors who would rather rent a mobile device from the museum. Only a small amount of people prefer to sit and watch a museum video at home (Calvi and Cassella, 2011).

In Calvi and Cassella (2011), a survey asking 20 respondents about the use of mobile technology in their museums, is described:

A mobile website of the museum	33.0%
Mobile video tours of the museum	25.0%
Mobile video tours of the special exhibitions	17.0%
Mobile audio tours (podcasts)	33.0%
E-books and catalogues on permanent and special collections	8.0%
Multimedia guides and instructions	42.0%

Table 3.2 – Interview result after questioning internet users "What kind of services, plug-ins, etc. are you offering via mobile platform?" (Carrozzino et al., 2012)

Subsequently, two examples of mobile Web technology are presented: The *Museum of Fine Arts Vienna*'s mobile app called *KHM Wien*, where visitors are able to get various information about the museum and its exhibitions. The *Powerhouse Museum*'s mobile Web page illustrates

(a) Screenshot from the iPhone App *KHM Wien* showing the museum's floor plan

(b) Screenshot from the iPhone App *KHM Wien* showing the room's exhibited artworks

Figure 3.10 – Screenshots from the iPhone App "KHM Wien".

an excellent example of presenting information on mobile platforms. Furthermore the museum introduced QR codes in order to link to mobile Web pages with information about specific artworks when visiting the building. Finally *QRpedia* is described, where QR codes are used to reference to corresponding Wikipedia Web pages in users' preferred language. These Web pages where chosen as examples for this chapter after discussions with my advisor.

Museum of Fine Arts Vienna

The *Museum of Fine Arts in Vienna* offers Smartphone users a mobile app, called *KHM Wien*, where visitors are able to watch a floor plan for the museum (see Figure 3.10a). Moreover, users are able to see the exhibited artworks in specific rooms by clicking the room number on the map and thus are able to plan their visit prior the visit or helps them to find their way through the museum (see Figure 3.10b).

In the main menu, the museum offer their mobile app users a *Highlight-Tour*, where picked out artworks are presented in a slide view. Additionally textual information can be viewed. Moreover, short films and biographies of artists can be viewed. Users are also able to get contact information about the museum, like address, opening hours, telephone numbers.

The mobile app of the *Museum of Fine Arts in Vienna* has a hierarchical structure, as described in chapter 3.4, because there are several ways to find and display artworks. One approach is to display the Highlight-Tour, a second way to search for specific artworks. The last approach to find and display artworks is to examine the museum's rooms as described above.

This type of preparing visitors for future museum visits is a very simple approach of mobile applications.

Powerhouse Museum

The mobile Web page of the *Powerhouse Museum*[23] illustrates an excellent example of presenting information on mobile platforms.

The menu is clear designed and adapted to small screens. Additionally, the menu is ordered by the relevance of information needed for an upcoming visit. The first menu entries are about *Planning your visit*, including *Location & hours*, *Admission & ticketing*, and *Contact & Connect*. Further information can be displayed about exhibitions, WIFI-connection, mobile apps and blogs. Moreover if users want to search the collection, the *Powerhouse Museum* additionally offers a search engine, which is optimized for mobile platforms.

Seb Chan writes in his blog[24] about the implementation of *QR (Quick-Response)* codes in the Powerhouse Museum in Sydney, Australia. A QR code is a two-dimensional matrix (see Figure 3.11a) which can embed more data than a simple barcode. Thus, QR codes can be used to redirect to specific Web pages by embedding URLs. These Web pages can either contain textual information, images, videos, or other multimedia content (Simon, 2011).

Chan (2009) sees the high potential of QR codes. By using these two-dimensional matrices in museums, visitors are able to scan the codes with their mobile phone (see Figure 3.11a) and thus are automatically directed to a mobile website representing information about the observed artwork (see Figure 3.11b). Thus it is not necessary to type in the whole URL into the address field of a browser, which is very time intensive on a mobile phone (Chan, 2009).

Due to the fact that every QR code reader can be used to encode URLs, the implementation of the technology for museums and other cultural institutions seems to be very simple and easy: For each artwork a QR code has to be generated and the corresponding mobile website has to be generated. Nevertheless Seb Chan describes in his blog several problems evolving with the implementation of QR codes.

A major problem evolving with creating own mobile websites for cultural objects is the cost- and time-intensity when descriptions are used in multiple languages. The subsequently described *QRpedia* therefore provides a simple solution.

QRpedia

QRpedia[25] is a similar approach of using QR codes in museums. Instead of referencing to own museum websites, *QRpedia* links to corresponding Wikipedia Web pages in their users' preferred language.

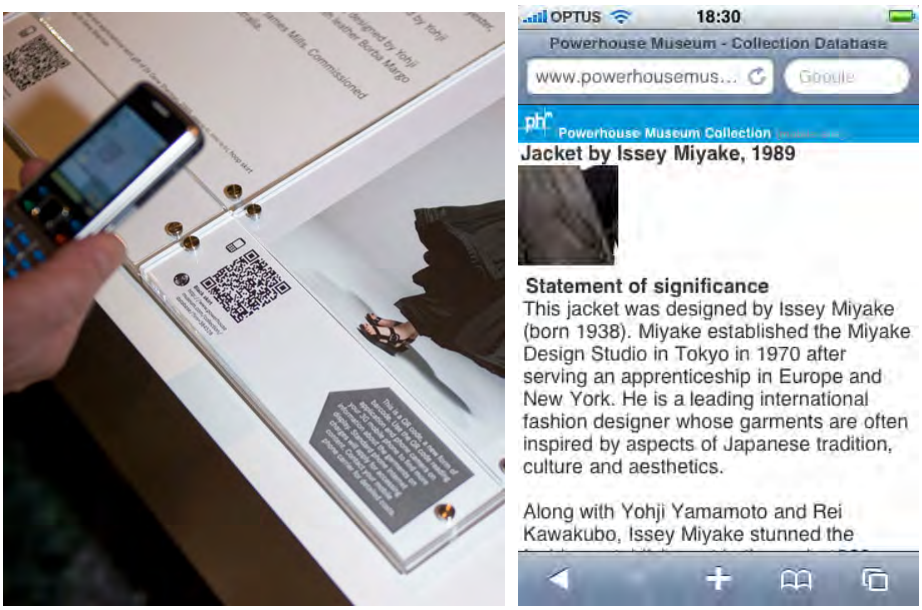
By detecting the mobile phone's language, *QRpedia* is able to link to the corresponding Wikipedia page. Thus, museums are not forced to create multiple language pages for cultural objects, which is very cost- and time-intensive (Phillips, 2011).

A disadvantage of *QRpedia* is the fact, that Wikipedia can not always be seen as a reliable source. In some cases, incorrect data may be included, either in textual form or image files.

[23] urlhttp://www.powerhousemuseum.com/m/ (accessed on November 7th, 2012)

[24] `http://www.freshandnew.org/2009/03/qr-codes-in-the-museum-problems-and-opportunities-w` (accessed on October 31st, 2012)

[25] `http://qrpedia.org` (accessed on October 31st, 2012)



(a) Mobile phone scanning a QR code related to a specific artwork.

(b) Screenshot from the iPhone browser showing the mobile Web page redirected from a QR code

Figure 3.11 – QR codes in the Powerhouse Museum (Chan, 2009).

Taking the example of *Palma Vecchio* on Wikipedia[26], mistakenly an image of Titian's *Violante* is shown on the right side.

As of September 2012, the *Derby Museum and Art Gallery*[27] in England, the *Children's Museum of Indianapolis*[28] in the United States, and many others are using *QRpedia* (Wikipedia, 2012*c*).

[26] `http://en.wikipedia.org/wiki/Palma_Vecchio` (accessed on November 7th, 2012)
[27] `http://www.derbymuseums.org` (accessed on October 31st, 2012)
[28] `http://www.childrensmuseum.org` (accessed on October 31st, 2012)

CHAPTER 4

Semantic Web

In the last few years, the term Semantic Web became more and more attention. It reflects the idea of a global knowledge base, connected by data already available in the Web. Instead of human-readable free-text currently mainly available, Semantic Web uses machine-readable data for connecting online resources (Goldfarb, Arends, Froschauer, Merkl and Weingartner, 2011). Currently, there is establishing a main standard called *Resource Description Framework* (RDF), described in chapter 4.1.1.

Semantic Web techniques are aiming to improve the understanding of machines of different knowledge domains, aid their reasoning and discover serendipitous links between items in the collections (Oomen and Aroyo, 2011). Furthermore Semantic Web refers also to the term *Linked Open Data*, whose goal is to enable the sharing of structured data on the Web. According to Oomen et al. (2012), there are several motivations to make cultural resources such as metadata and objects more open:

- Open access leads to an increased usage of collections through enhanced visibility of content. This helps to drive users to online content and it enables new scholarships that can only be done with open data, which makes collections more meaningful and relevant for end-users. The usage also helps institutions fulfill their public mission to open up access to the collective heritage." This enhanced visibility through aggregators, portals, and search engines by exposing metadata is visualized in Figure 4.1[1].

- Linked Open Data stimulates collaboration of cultural institutions and beyond. This allows the creation of new services and supports creative reuse of material in new productions. Moreover, encouraging external parties to develop services based on publicly available sources stimulates innovation.

[1] `http://www.icbl.hw.ac.uk/perx/advocacy/exposingmetadata.htm` (accessed on November 14th, 2012)

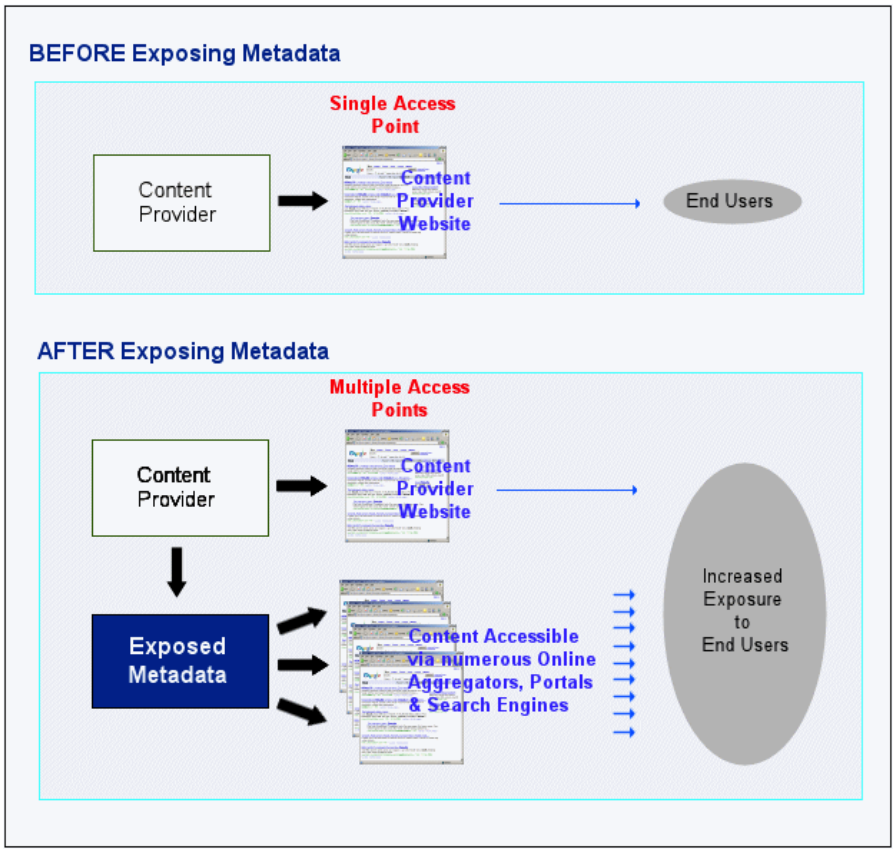


Figure 4.1 – Exposing metadata can enhance the visibility of content.

Subsequently this chapter will describe semantic technologies (cf. Chapter 4.1), organizations and their established data models (cf. Chapter 4.2), as well as relevant thesauri (cf. Chapter 4.3).

4.1 Technologies

To enable the representation and sharing of machine-accessible, structured data over the Web, the *World Wide Web Consortium* (W3C)[2] has introduced several standards like the *Resource Description Framework* (RDF), as well as ontologies like *RDF Schema* (RDFS) and the *Web Ontology Language* (OWL) (Doerr et al., 2010). First, these standards will be described in the subsequent chapters. Finally the established query language for Semantic Web techniques, *SPARQL*, will be introduced.

[2] `http://www.w3.org/` (accessed on October 30th, 2012)

4.1.1 RDF

The *Resource Description Framework* (RDF)[3] was introduced by the W3C and is a standard model for data interchange on the Web. RDF extends the linking structure of the Web and uses URIs to describe two resources and their relationship to each other.

The RDF data model is based on three types of objects: *resources*, *properties*, and *statements* (Caffo et al., 2008):

- **Resources:** Resources are defined as everything that is described by RDF expressions. like Web pages, XML elements, collections of Web pages, or objects that are not directly accessible through the Web.
- **Properties:** Properties are used to describe resources (e.g. aspects, characteristics, attributes, relations) and defines admissible values, the types of resource that it can describe, and its relations with other properties.
- **Statements:** Resources, identified by names, and values of properties for specific resources form an RDF statement. A statement therefore forms a triple, which is composed of a *subject* (resource), a *predicate* (property), and an *object* (value). Objects of statements (property value) can be either an expression (sequence of characters or a primitive type defined by XML) or a reference to another resource. Furthermore, these so called triples allow structured and semi-structured data to be mixed, exposed, and shared across different applications (W3C, 2012).

In Caffo et al. (2008), an easy example of an RDF description about *William Shakespeare* is published:

```
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-
ns#" xmlns:dc="http://purl.org/dc/elements/1.1">
<rdf:Description rdf:about="http://en.wikipedia.org/wiki/
William_Shakespeare">
        <dc:publisher>Wikipedia</dc:publisher>
        <dc:title>William_Shakespeare</dc:title>
</rdf:Description>
</rdf:RDF>
```

In contrast to the relational schema, RDF is more extendable because new information can be added without to change the whole data schema. In Arends et al. (2010) an example of extending existing data is shown: The name of a specific artist, *Raffaello Sanzio*, is linked with the corresponding dataset in the *ULAN* (Getty Union List of Artist Names)(cf. Chapter 4.3.2) database. The birth date of Rafaello Sanzio, *Urbino*, is linked with the *TGN* (Thesaurus of Geographic Names) (cf. Chapter 4.3.4), where information about the geographical location and a short description can be found. Finally, the type of the artwork, *painting* in this particular case, is linked with the *AAT* (Art and Architecture Thesaurus)(cf. Chapter 4.3.5).

[3] `http://www.w3.org/RDF/` (accessed on October 30th, 2012)

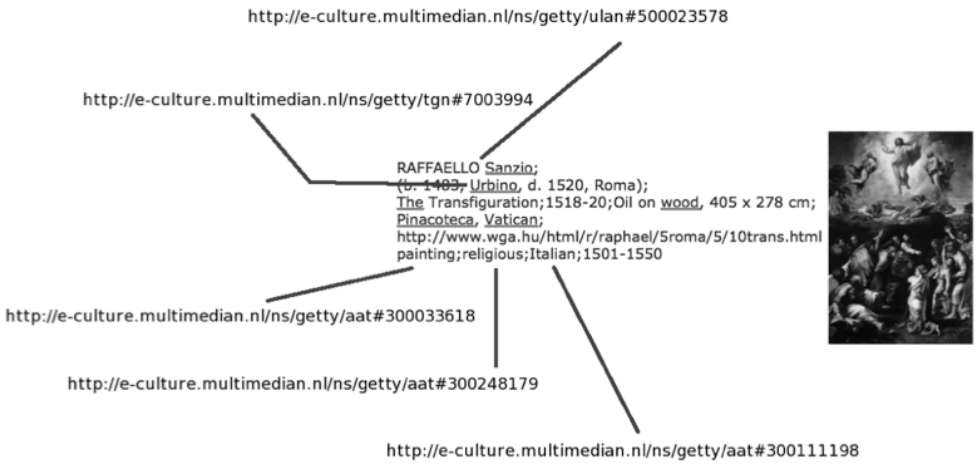


Figure 4.2 – Extending a RDF structure by several thesauri.

4.1.2 RDFS

RDF Schema (RDFS)[4] is a vocabulary description language for describing properties and classes of RDF-based resources, with semantics for generalized hierarchies of these properties and classes. Furthermore, it provides basic elements for describing ontologies (RDF vocabularies) (W3C, 2004) (Caffo et al., 2008).

As RDF provides no mechanism for describing RDF properties or any mechanisms for describing the relationships between properties and other resources, RDFS therefore defines classes and properties that may be used to describe classes, properties and other resources.

4.1.3 OWL

The *Web Ontology Language* (OWL)[5] was specified by the W3C to create, publish and distribute ontologies. OWL has more facilities for expressing meaning and semantics than XML, RDF and RDFS and is therefore more descriptive.

According to W3C (2009), "ontologies are formalized vocabularies of terms, often covering a specific domain and shared by a community of users. The specify the definitions of terms by describing their relationships with other terms in the ontology." The current version of OWL is *OWL 2 Web Ontology Language*[6] and is an extension and revision of the *OWL Web Ontology Language*[7], developed by the *W3C Web Ontology Working Group*[8], which was published in 2004. OWL 2 was developed by a follow-on group, the *W3C OWL Working Group*[9].

[4] `http://www.w3.org/TR/rdf-schema/` (accessed on November 8th, 2012)

[5] `http://www.w3.org/2004/OWL/` (accessed on November 8th, 2012)

[6] `http://www.w3.org/TR/owl-overview/` (accessed on November 8th, 2012)

[7] `http://www.w3.org/TR/2004/REC-owl-features-20040210/` (accessed on November 8th, 2012)

[8] `http://www.w3.org/2001/sw/WebOnt/` (accessed on November 8th, 2012)

[9] `http://www.w3.org/2007/OWL/` (accessed on November 8th, 2012)

The OWL specification includes the definition of three increasingly expressive sublanguages designed for the use by specific communities of implementers and users: *OWL Lite*, *OWL DL* and *OWL Full* (W3C, 2009),:

- **OWL Lite:** OWL Lite supports users primarily needing a classification hierarchy and simple constraints
- **OWL DL:** OWL DL supports users who want the maximum expressiveness while retaining computational completeness (all conclusions are computable) and decidability (all computations will finish in finite time).
- **OWL Full:** OWL Full supports users who want maximum expressiveness and the syntactic freedom of RDF with no computational guarantees.

Each of them is an extension of its simpler predecessor in what can be legally expressed and validly concluded.

4.1.4 SPARQL

SPARQL[10] is the query language for RDF. It can be used to express queries across diverse data sources, whether the data is stored natively as RDF or views as RDF via middleware. Furthermore, SPARQL contains capabilities for querying required and optional graph patterns along with their conjunctions and disjunctions. It also supports extensible value testing and constraining queries by source RDF graph. The result of SPARQL queries can be results sets or RDF graphs.

4.2 Organisations and Data Models

This chapter describes important organizations and their established data models and interchange schemas in the cultural heritage sector.

4.2.1 ICOM

International Council of Museums (ICOM)[11] is an international organization for museums and museum professionals is committed to the preservation, maintenance, and communication of cultural and natural world heritage. The organization was created in 1946 and comprises an network of almost 30.000 members and museum professionals in about 137 countries and territories (ICOM Deutschland, 2012).

According to ICOM Deutschland (2012), ICOM follows the subsequent duties:

- Dissemination and development of professional standards and ethical guidelines for museums.

[10] `http://www.w3.org/TR/rdf-sparql-query/` (accessed on November 14th, 2012)
[11] `http://cidoc.mediahost.org` (accessed on November 6th, 2012)

- Protection of world heritage and its cultural diversity.
- Prevention of illicit trafficking of cultural objects.
- Raising of public awareness of the needs of museums.
- Professional exchange at a international level
- Knowledge transfer and

Under the ICOM umbrella, two standards have been established to support the goals of preserving, maintaining and communicating cultural heritage, CIDOC CRM and LIDO.

CIDOC CRM

CIDOC Conceptional Reference Model (CRM)[12] is a formal ontology for the cultural heritage sector and was established by the *International Council of Museums* (ICOM) to encourage GLAMs to improve their interoperability (Goldfarb, Arends, Froschauer, Merkl and Weingartner, 2011).

In 1996, CIDOC[13], and the *CIDOC Documentation Standards Working Group* (DSWG) started to create an object oriented data model, which should replace the already established *CIDOC Relational Data Model*. With intensive voluntary work of various contributors the first complete edition of the CIDOC Conceptual Reference Model resulted in 1999. In the same year, CIDOC decided to submit the CRM to *ISO* for standardization in order to fully exploit the potential of enabling information interchange and integration in the museum community. Since 2006, in the version 3.2.1 it is officially approved as an international standard (ISO 21127). The current version of CIDOC CRM is 5.0.1, as of November 2012 (Lampe et al., 2010).

CIDOC Conceptional Reference Model (CRM) is a formal ontology, which encourages the integration, access, and interchange of a variety of different information in the cultural heritage sector. It aims to provide semantic definitions and disambiguations to transform different types information sources to a global connected information resource (Lampe et al., 2010). In Lampe et al. (2010), the main functions of the CRM are described:

- Providing developers a guideline for effective data modeling. CRM aims to help structuring data from different data sources and bring them in relation.
- Providing a common language between experts of a scientific field and developers of information systems in order to formulate requirements and agreements of system functions (i.e. using cultural information content).
- Provide a formal language to identify mutual information content in a variety of data formats (e.g. to support the implementation of algorithms

[12] `http://www.cidoc-crm.org/` (accessed on November 7th, 2012)
[13] `http://cidoc.mediahost.org` (accessed on November 6th, 2012)

- Supporting associative search requests on integrated information resources by providing a global model of basic classes and associations to formulate these requests.
- Supporting advanced speech processing algorithms and case-specific heuristics by bringing unstructured textual information in a formal and logical form, in order to identify specific content and their relations.

LIDO

Lightweight Information Describing Objects (LIDO) is a XML Schema and combines the schema of *CDWA Lite* and *museumdat*[14], and is informed by *SPECTRUM*[15] concepts. Furthermore, it is CIDOC CRM compliant and can describe information about all kinds of cultural heritage objects (Coburn et al., 2010).

LIDO is not thought as a basis for a collection management system. Instead, it is intended to deliver metadata from organization's online collection databases to portals of aggregated resources, as well exposing, sharing and connecting data on the Web. It fully supports the full range of descriptive information about museum objects and can be used for all kind of objects (e.g. art, cultural, technology, and natural science). Moreover, it supports multilingual portal environments (Coburn et al., 2010).

In Coburn et al. (2010), the information of a LIDO record is organized in seven areas. Four out of seven have descriptive character:

- **Object Classification:** Information about the type of the object.
- **Object Identification:** Basic information about the object.
- **Event:** Events that the object has taken part in.
- **Relation:** Relations of the objects.

The three further areas are of administrative type:

- **Rights Work:** Information about the rights associated with the object.
- **Record:** Basic information about the record.
- **Resource:** Information about digital resource being supplied to the service environment.

4.2.2 Europeana

To the general public, *Europeana*[16] is mainly perceived as a portal giving access to millions of objects from all kinds of cultural heritage communities.

[14] `http://www.museumdat.org` (accessed on November 7th, 2012)

[15] `http://www.collectionslink.org.uk/programmes/spectrum` (accessed on November 7th, 2012)

[16] `http://www.europeana.eu/` (accessed on July 27th, 2012)

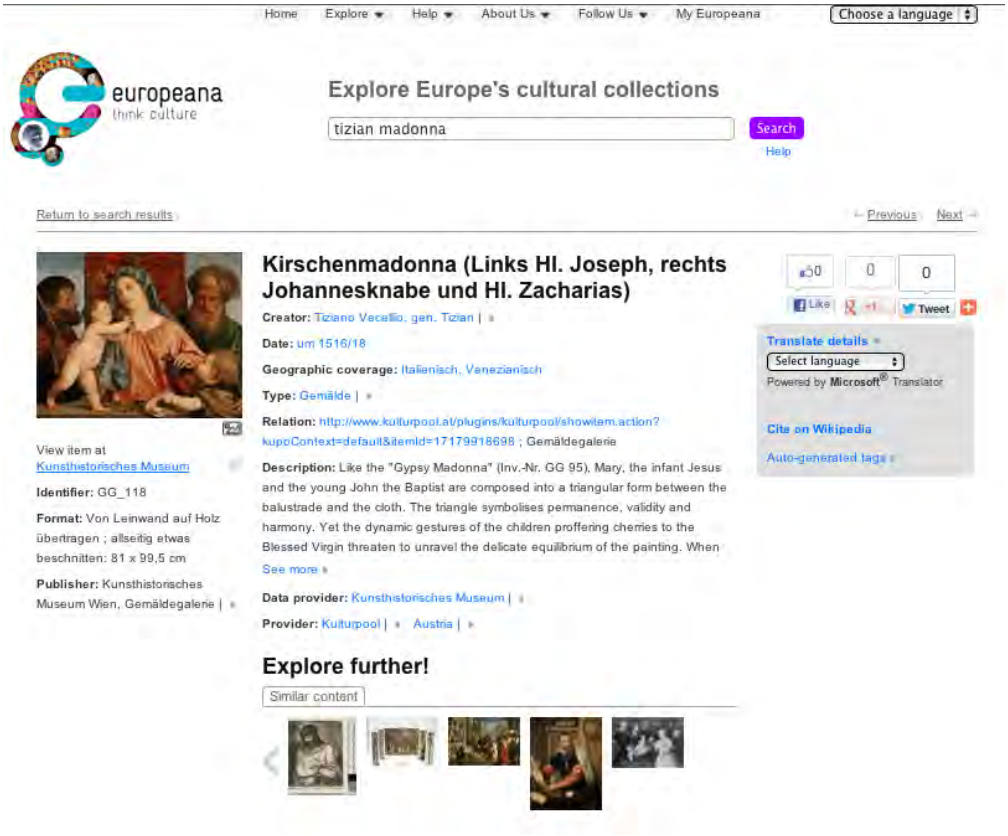


Figure 4.3 – Screenshot from the Europeana portal showing the Kirschenmadonna of Tiziano Vecellio

Since the data remains outside the Europeana data space, Europeana needs to receive this data only once for processing and producing surrogate representations. The surrogates are linked to each other and additionally contextualized with links to nodes of a semantic network (Concordia et al., 2010).

Leaving this very abstract view on Europeana, Concordia et al. (2010) describes the primary vision of a public Application Program Interface (API), which allows users to make use of rich data and functionality.

Europeana Data Model

The *Europeana Data Model* (EDM) is a semantic data model and is the successor of the *Europeana Semantic Elements* (ESE) data model, Europeana's first data model. Since Europe's cultural institutions mostly use different metadata standards, it aims to build up a bridge between them and Europeana, where data appears in a cross-cultural, multilingual context (Europeana, 2012). Moreover, EDM can show multiple views on an object, including information on the physical and digitised representation.

EDM reuses several reference ontologies like the *Simple Knowledge Organization System* (SKOS). SKOS defines a model to represent the elements of Knowledge Organization System such as thesauri and classification schemes. It includes a main class to describe concepts, which are labelled through various properties (e.g. skos:prefLabel for the preferred label, skos:altLabel for the alternative label). Semantic relationships are described through the properties *skos:narrower*, *skos:broader* and *skos:related*. Moreover, SKOS allows to linking concepts from different thesauri which are semantically equivalent using the property *skos:exactMatch* (Doerr et al., 2010).

Furthermore, EDM includes other ontologies like *Dublin Core* (DC) and *Friend-of-a-Friend* (FOAF). Dublin Core gives a compact vocabulary to describe the core features of culture objects (e.g. creators, relations to other resources, subject indexing and others). FOAF is used to describe persons and their connections to each other in RDF (Doerr et al., 2010).

"The EDM uses RDF(S) as its meta-model and URIs to identify structured information about cultural heritage objects. The structural modelling framework for the EDM ontology is provided by the OAI Object Reuse & Exchange (OAI-ORE) specifications." Thus, the EDM makes the Europeana compatible with the Semantic Web paradigm and allows cultural institutions to change their information architectures to open, linked environments.

4.3 Knowledge Bases and Thesauri

This chapter describes various knowledge bases and vocabularies which are relevant in the cultural sector: *DBpedia*, *Getty Union List of Artist Names* (ULAN), *Art and Architecture Thesaurus* (AAT), *The Getty Thesaurus of Geographic Names* (TGN), and *Cultural Objects Name Authority* (CONA).

4.3.1 DBpedia

DBpedia[17] is a knowledge bases offering structured information from Wikipedia and making it available on the Web. Furthermore, DBpedia allows to query against Wikipedia, and link other data sets on the Web to Wikipedia data. The English version of the DBpedia knowledge base describes 3.77 million things, out of which 2.35 million are classified in a consistent ontology, including 764.000 persons, 573.000 places, 333.000 creative works, 192.000 organizations, 202.000 species and 5.500 diseases, as of November 2012. Moreover, DBpedia is offered in 111 languages (DBpedia.org, 2012).

Among others file formats, records in DBpedia can be exported as RDF files with N-Triples, N3/Turtle, JSON or XML notation. Besides, DBpedia offers an online access via a public SPARQL endpoint[18] .

[17] `http://wiki.dbpedia.org/` (accessed on November 15th, 2012)
[18] `http://dbpedia.org/sparql` (accessed on November 16th, 2012)

4.3.2 ULAN

The *Getty Union List of Artist Names* (ULAN)[19] is a structured vocabulary, which contains around 293.000 names and other information about artists. Names in ULAN may include given names, pseudonyms, variant spellings, names in multiple languages, and names that have changed over time (e.g., married names). Among these names, one is flagged as the preferred name (J. Paul Getty Trust, 2010*c*).

Although ULAN is displayed as a list, it is structured as a thesaurus, compliant with ISO and NISO standards for thesaurus construction. Moreover it contains hierarchical, equivalence, and associative relationships.

The focus of each ULAN record is an artist. There are around 120,000 artists in the database, as of July 2010. Each artist record is identified by a unique numeric ID and contains information about names, related artists, sources for the data, and notes. The temporal coverage of the ULAN ranges from Antiquity to the present (J. Paul Getty Trust, 2010*c*).

4.3.3 AAT

The *Art and Architecture Thesaurus* (AAT)[20] is a structured vocabulary containing around 131.000 terms and other information about concepts, as of April 2011. Furthermore, it can be defined as thesaurus in compliance with ISO and NISO standards. Terms in AAT can be used to describe art, architecture, decorative arts, material, culture, and archival materials. The target audience includes museums, libraries, visual resource collections, archives, conservation projects, cataloging projects, and bibliographic projects (J. Paul Getty Trust, 2011).

The focus of each AAT record is a concept, which is identified by a numeric ID. There are around 34.000 concepts in the AAT, as of April 2011. A concept contains terms, related concepts, a parent (position in the hierarchy), sources for the data, and notes. The temporals coverage of the AAT ranges from Antiquity to the present and the scope is global (J. Paul Getty Trust, 2011).

4.3.4 TGN

The *Getty Thesaurus of Geographic Names* (TGN)[21] is a structured vocabulary containing around 1.105.000 names and other information about places, as of November 2012. TGN is a thesaurus, compliant with ISO and NISO standards for thesaurus construction and contains hierarchical, equivalence, and associative relationships (J. Paul Getty Trust, 2010*b*).

The focus of each TGN record is a place, which is identified by a unique numeric ID. There are around 912.000 places in the TGN. A place contains names, the place's parent or position in the hierarchy, other relationships, geographic coordinates, notes, sources for the data, and place

[19] `http://www.getty.edu/research/tools/vocabularies/ulan/` (accessed on November 14th, 2012)

[20] `http://www.getty.edu/research/tools/vocabularies/aat/` (accessed on November 15th, 2012)

[21] `http://www.getty.edu/research/tools/vocabularies/tgn/` (accessed on November 16th, 2012)

types, which are terms describing the role of the place (e.g. inhabited place or state capital). The temporals coverage of the TGN ranges from prehistory to the present and the scope is global (J. Paul Getty Trust, 2010*b*).

4.3.5 CONA

The *Cultural Objects Name Authority* (CONA)[22] is a structured vocabulary containing authority records for cultural works, including architecture and movable works such as paintings, sculpture, rints, drawings, manuscripts, photographs, textiles, ceramics, furniture, other visual media such as frescoes and architectural sculpture, performance art, archaeological artefacts, and various functional objects that are from the realm of material culture and of the type collected by museums. The focus of CONA is works cataloged in scholarly literature, museum collections, visual resources collections, archives, libraries, and indexing projects with a primary emphasis on art, architecture, or archaeology (J. Paul Getty Trust, 2010*a*).

[22] `http://www.getty.edu/research/tools/vocabularies/cona/` (accessed on November 15th, 2012)

CHAPTER 5

A Potential Alternative

"When an art expert describes a painting, she uses a language that differs a lot from common everyday speech or the language of lay persons. Only people, who are acquainted with the scientific field of art history (people who are "socialized" with the field), are able to understand their language with all its subtleties."

This citation from Goldfarb et al. (2012) reflects the situation of lay persons confronted with art. Textual descriptions of people from the scientific field of art history are generally written in a language hardly to understand for people who are new in the field of art history. To avoid a lack of interest, more and more museums and cultural institutions in general try to make their Web presence to an interacting experience by using new technologies and interaction methods, as described in Chapter 3. As a result, the visitor's curiosity and interest about art and art history can be induced.

As the State-of-the-art analysis in Chapter 3 shows, current approaches of interaction forms on the Web generally show images of artworks and textual information. Contrasting artwork images of specific types (e.g. X-ray, infrared, replicas) side-by-side is not supported. Based on this finding the developed prototype uses the principle of image comparison. The images are presented side-by-side on the Web platform.

The developed prototype aims to make the visit to an experience where the virtual visitor gets the chance to discover something new and unexpected. By introducing a new approach of user interaction that mainly concentrates on visual aspects, this prototype tries to motivate lay persons as well as more experienced users to increase their interest in art history.

This chapter represents a summary of the practical part of this Master's thesis and describes various aspects relevant for the development of the prototype. The data was provided by the Museum of Fine Arts in Vienna and comprises images and textual descriptions about Titian's[1] painting *Madonna with child and saints*. Images used for other works of Titian were taken from

[1] `http://en.wikipedia.org/wiki/Titian` (accessed on November 3rd, 2012)

the Web Gallery of Art[2] and the Museum of Fine Arts Vienna's image database[3]. The textual descriptions were completely used from the Museum of Fine Art Vienna's image database.

Chapter 5.1 will introduce several features of the prototype, Chapter 5.2 will describe relevant technologies.

5.1 Interaction Capabilities

The implemented prototype comprises four main features: First, a *search and selection* page to find and select specific artworks. Second, an *image comparison* to discover, analyze and interpret specific artworks. Third, the ability to display *paint layer samples*, which supports the analysis and interpretation of artworks. And finally, the possibility to display *textual information*, which further supports the analysis and interpretation and gives the user the ability to see the results of museum professionals.

5.1.1 Search and Selection of Artworks

In the last years an increasing number of institutions offer different Web based query front-ends to their collection databases. Taking in consideration that databases become very large, effective search interfaces are mandatory to find relevant information. This chapter will first analyze different search strategies, and finally describe the implemented approach in the prototype.

According to Hildebrand et al. (2007), search interfaces in the semantic field can be summarized as:

- **Free text input:** Free text input is supported in existing systems in three ways: First, full text search allows the user to find all resources with matching textual content or metadata. In many semantic search engines, full text search is the main entry point into the system. Second, free text input can be restricted to match a value of a specific property. In faceted browsers, this is the case when users are searching for a value within a particular facet. Third, systems which support free text input in the form of natural language (Hildebrand et al., 2007).

- **Property-specific search fields:** Property-specific search fields support query construction guided by a specific set of possible search values. The value sets are typically defined by the range of the corresponding RDF property (Hildebrand et al., 2007).

- **Faceted browsing/Query refinement:** Advanced search techniques like faceted browsing or query refinement "allow users to narrow down the results returned from initial queries that often contain only simple terms". Moreover, they "provide helpful means of acquiring overview on the contents of huge information spaces, especially for people who are not acquainted with the field" (Goldfarb, Arends, Froschauer and Merkl, 2011). Constraining results happens within particular facets, which are typically directly mapped

[2] `http://www.wga.hu` (accessed on November 3rd, 2012)
[3] `http://bilddatenbank.khm.at` (accessed on November 3rd, 2012)

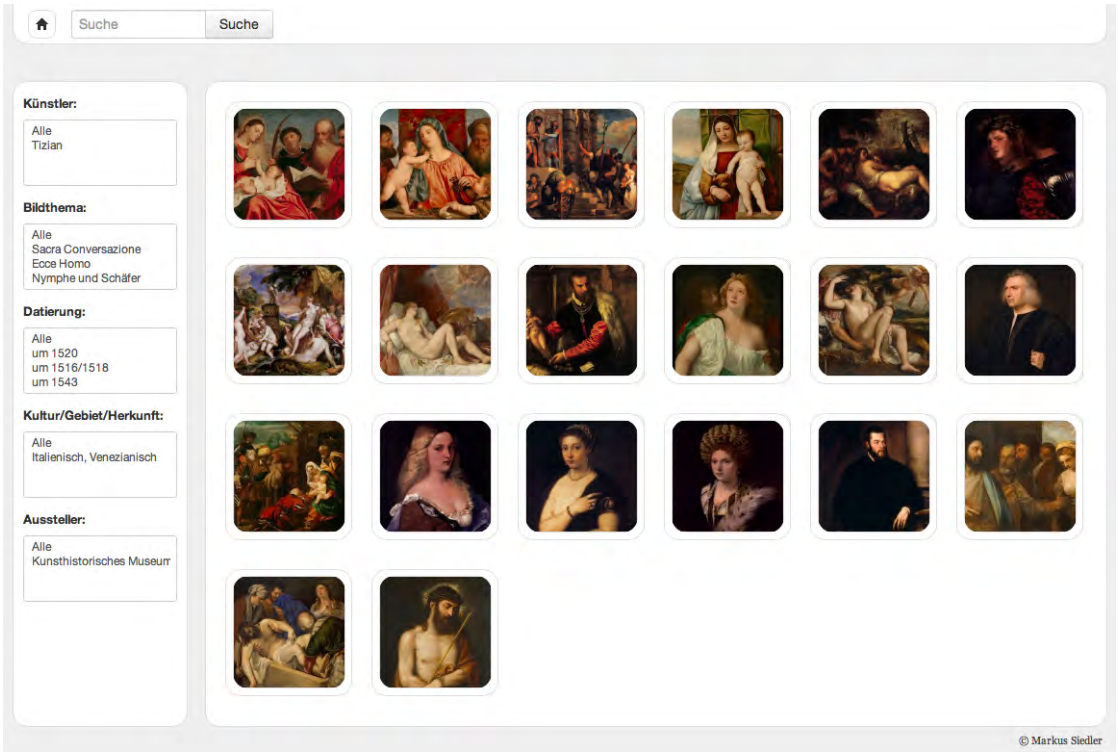


Figure 5.1 – Search interface of the prototype.

to properties in RDF. Alternatively, the mapping is made by projection rules, whose indirect mapping allows the developer to define facets that match the user's needs while keeping the data structure unchanged. These methods can be summarized under the term *exploratory search*, which aims to help people finding information which they are not explicitly looking for, respectively people who do not have the relevant knowledge of the domain and the used terminology (Goldfarb, Arends, Froschauer and Merkl, 2011) (Hildebrand et al., 2007).

- **User feedback:** User feedback is typically provided after the query has been entered, or dynamically during the construction of the query as a form of semantic autocompletion. In semantic autocompletion the system suggests controlled terms with a label prefix that matches the text typed in already. In faceted interfaces autocompletion is often used within a single facet (Hildebrand et al., 2007).

When users enter the Web site, they face a search mask and a window with artwork images (cf. Figure 5.1). By clicking into the search field, entering a specific term and pressing the *Suche* button, the database is searched for matching artist names or titles. The results are shown as images in the right window below. By moving the cursor over the image, a small window

with the artist's name and artwork title is displayed on the right hand side. A click on the image forwards the user to the main interface of the artwork.

Additionally, the prototype supports exploratory search by enabling users to filter the results for specific attributes by using the lists in the left column. The attributes users are able to select are:

- Artist (e.g. Titian).
- Artwork Topic (e.g. Sacra Conversazione).
- Date of creation.
- Culture and provenance (e.g. Italian, Venetian)
- Exhibition place (e.g. Museum of Fine Arts, Gemäldegallerie)

If the user clicks a specific entry in the list, the selection of artworks in the main window is automatically filtered and displayed. The selected entry is marked with grey color. Moreover, the filter lists allow multi choices by using the *Shift* key. The selection of filters can be changed by clicking the entries in the list. A filter can be deselected by clicking on selected entries. By selecting the entry *Alle*, all selected filtered entries of this specific filter are deselected.

5.1.2 Image Comparison

The main feature of this prototype is the ability for the user to compare and contrast several views of artworks and artwork replicas. The virtual visitor is therefore able to explore similarities as well as diversities of artwork images, which can induce new and unexpected insights. As a result, this exploration process should raise the user's curiosity about artworks. Furthermore it gives lay persons the chance to understand and gain interest in art history by being confronted with a new approach of user interaction.

In the main window, the prototype displays three views side-by-side (cf. Figure 5.2). The user can change the images displayed in the view window by drag-and-drop a new image from the selection window below. Moreover, users are able to see artworks in a high level of detail. By using the navigation window on the right top of each image window, the user is able to zoom in and out by clicking the buttons + and -. The home button can be used to reset the initial zoom factor. By clicking into the image and moving the cursor, the viewpoint c changed to analyze different regions of the image.

With synchronized views, users are able to zoom in specific regions of a picture on one single view and the application automatically sets the viewport of the other images. Thus the comparison of specific views of same artworks, like X-ray or infrared images is effective and user-friendly. If synchronized views are not needed, users are able to switch them of manually by clicking on the right top buttons of the view window.

Comparing images at different levels of detail allows users to discover certain characteristics of paintings. Therefore, the implemented prototype gives the user the possibility to compare different types of images:

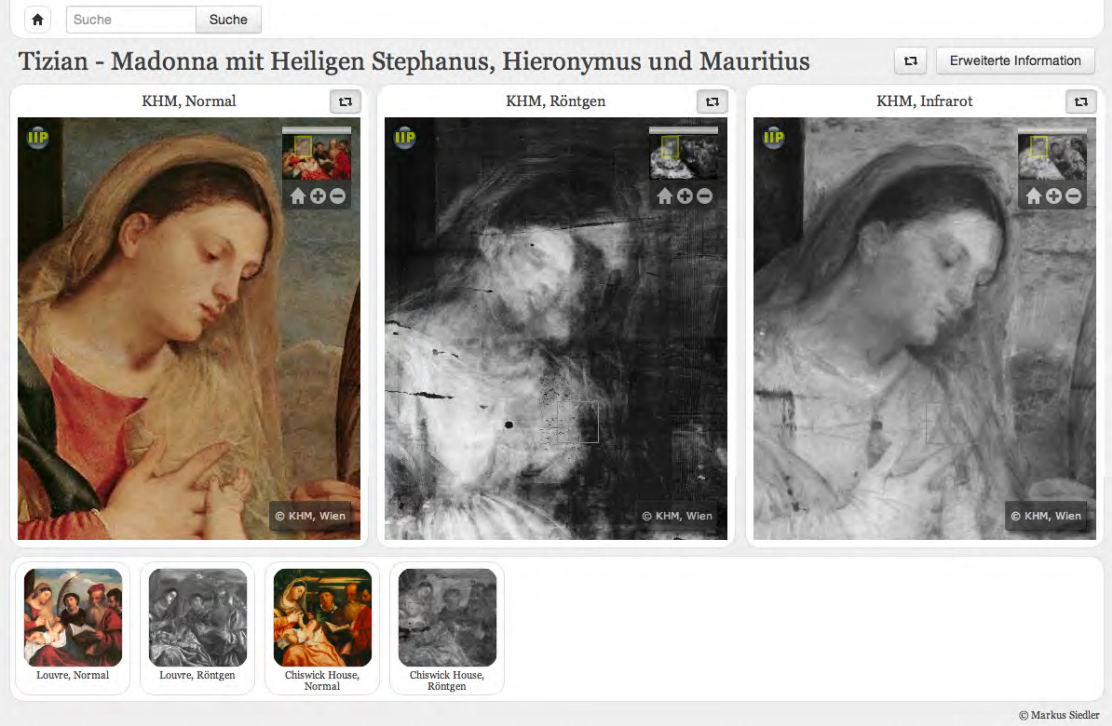
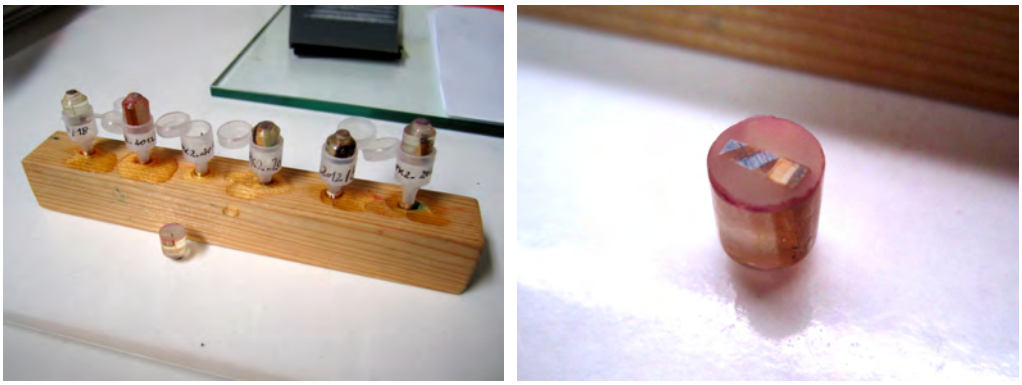


Figure 5.2 – Image comparison

- Comparison of artworks with X-ray and infrared images: Artworks are analyzed by X-ray or infrared techniques, which allows to determine and analyze pigments and other traditional materials. By displaying an image of a specific artwork and comparing it with X-ray and infrared images, earlier painting layers, as well as impurities and damages can be detected and analyzed.

- Comparison of replicas of a specific artwork: According to Alexander (1989), replicas are copies that imply a great accuracy and are likely to be "the same size as the object copied." Titian's *Madonna with child and saints*, for example, exists in three different versions, exhibited in three locations: Museum of Fine Arts Vienna, Louvre in Paris and Chiswick House in London. By comparing different replicas of a specific artwork, several aspects of specific changes can be determined and interpreted.

- Comparison of X-ray and infrared images of different versions of a specific artwork: Besides comparing images of different versions of specific artworks, the user is allowed to compare specific X-ray and infrared images of replicas of a specific artwork. Thus, users are allowed to compare earlier pigments of different versions of artworks with each other, allowing them to detect changes of used pigments and other materials, as well as comparing impurities and damages.



(a) Paint layer samples.

(b) Paint layer sample with visible layers.

Figure 5.3 – Paint layer samples at the chemical laboratory at Museum of Fine Arts in Vienna.

Comparing X-Ray and Infrared images with the artwork itself allows users to reveal certain characteristics of the image, which would not be visible with the naked eye:

- **X-Ray fluorescence (XRF):** X-Ray fluorescence is a non-destructive technique widely used in the study of works of art. With XRF techniques, it is possible to detect undocumented pigments or to characterize traditional materials better. Furthermore, this technique allows to investigate impurities of elements having medium or high atomic number. In some cases, these impurities "can help to establish the provenance of the materials or to characterize differences in the same work due to restoration or to the presence of unoriginal parts" (Moioli and Seccaroni, 2000).

- **Infrared reflectography (IRR):** Infrared reflectography is a non-destructive and non-contact method for examining paintings, in which specific paint elements which are located below the top layer of a painting, can be made visible. The principle of diffuse reflections is used, by which the texture of a body can be determined. Because specific pigments do not absorb infrared light of specific wavelength, they appear transparent. Particularly paint elements which are located directly on the grounding and absorbing infrared lights (e.g. drawing inks, black chalk or boneblack), are shown dark in infrared reflectography images, even if the can not be seen with the naked eye (Cranach.net, 2012).

5.1.3 Paint Layer Samples

A second main feature of the prototype is the possibility to display paint layer samples of artworks (cf. Figure 5.4b).

Evaluating paint layer samples of artworks is mainly envisaged for more advanced persons, having basic knowledge about chemical structures of pigments and the painter's painting style.

But even lay persons are able to interpret colors of layers, shown in the samples. Thus, earlier underdrawings and their colors can be discovered and interpreted.

Figure 5.4 show paint layer samples from the laboratory at the Museum of Fine Arts in Vienna. In order to keep the damage as minimal as possible, the removed pigments are of size in the nanometer range. Nevertheless, a specific paint layer samples is only taken if there is enough proof of benefit for further interpretation and classification of the artwork. According to museum professionals in Vienna, generelly not more than five pigments are removed.

According to Klockenkämper et al. (2000), there are three main reasons why pigments are of high interest for specific persons:

- **Working methods:** Fundamental interest in the artist's working methods: Which pigments were used? Can a specific hue be attributed to one particular pigment or did the painter prepare an elaborate mixture?
- **Restoration:** Aid for restoration to distinguish the original sections of a painting from restored or later added ones. Thus, pigment characterization may be crucial for important decisions like if spurious layers should be removed or the choice of the most closely matching pigments for the retouches
- **Conservation:** If pigments may be sensitive to light, humidity, gaseous atmospheric pollutants or heat, it may require specific storage or display conditions. Furthermore, if chemical or other treatment aiming at reversing or at least stopping a deterioration process has to be applied, the identification of pigments is crucial.
- **Identification:** In some cases, the characterization of the pigments may help in assigning a probable date (limits *post* or *ante quem*) to the painting, or to reconstruct its restoration and conservation history, or it may help to detect forgeries.

In the case of Titian's *Madonna with child and saints*, there are nine different paint layer samples, which are visible in Figure 5.4a. The position of the samples was chosen carefully in order to discover colors of specific underdrawings.

Figure 5.4b shows a paint layer sample of cloth and collar of the holy Stephanus. Several images of the layer, provided by the Museum of Fine Arts, are shown in the box above. The user is able to display the next or the previous image by clicking the arrow buttons on the right or on the left. The provided images show the paint layer samples, augmentations and specific filtered images. In the case of the Titian's *Madonna with child and saints* these filters are *Protein (AB)*, *Resin (Blue filter)*, *Resin (Alkanna)* and *Oil (Rhodamin B)*

5.1.4 Textual Description

Due to the fact the visual aspects are central in this prototype. the way textual information about artworks is displayed is kept optional for the user. By clicking the button *Erweiterte Informationen*, a new window with textual information about the artwork is displayed in front of the main interface (cf. Figure 5.5).

The user is able to display several information types about the artwork by clicking the following terms in the menu list:

(a) Points of pigments taken from Titian's *Madonna with child and saints*

(b) Screenshot of a specific paint layer showing images and paint layer descriptions.

Figure 5.4 – Screenshots of paint layer samples, displayed in the implemented prototype.

- **Basisinformationen:** Basic information about the artwork, including title, artist, topic, date, culture and provenance, exhibition place, identification number, and size of the artwork.
- **Bildgenese:** Genesis and art historical Interpretation of the artwork by museum professionals.
- **Zuschreibung/Datierung:** Attribution and dating of the artwork.
- **Herkunft:** Provenances with inventories and illustrated catalogues.
- **Bildträger:** Description of the material and size of the image carrier.
- **Pigmente:** Information about the used pigments.
- **Zustand:** Description of the current condition of the artwork.
- **Restaurierungen:** Information about past restorations.

Furthermore, we used DBpedia to extend the provided data of the artwork with information about Titian. Under the menu point *Kuenstler* the following information can be selected for specific artist information:

- **Basisinformationen:** Basic information about the artist, including name, date of birth, date of death and a short comment.
- **Beschreibung:** A short biography of the artist.

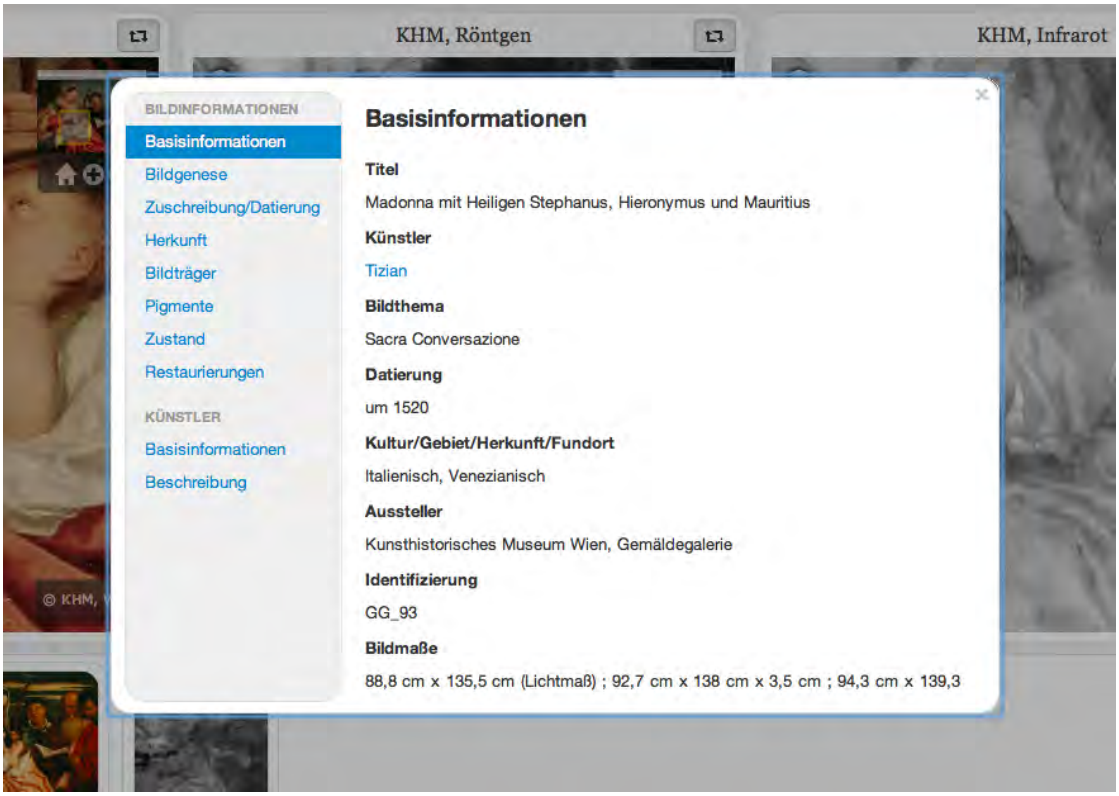


Figure 5.5 – Screenshot the textual information modal view.

Figure 5.5 shows the information window, which is placed in front of the main interface. Furthermore, the user is able to drag the window if a different position is needed.

5.2 Technologies

The prototype was designed and implemented in a three-tier architecture, which is illustrated in Figure 5.6. The prototype is developed in *Symfony2*[4], a PHP framework, and runs on a *Nginx*[5] Web server. The application uses *EasyRDF*[6] in order to connect to the Triple store and to query RDF data through *SPARQL*. Moreover an image streaming server called *IIPImage* (cf. Chapter 5.2.2) runs on the *Nginx* Web server as a *FastCGI*[7] process. *IIPImage* accesses high-resolution images on the file system and returns the relevant tiles to the client.

[4] `http://symfony.com` (accessed on January 21th, 2013)
[5] `http://nginx.org` (accessed on January 21th, 2013)
[6] `http://www.easyrdf.org` (accessed on January 21th, 2013)
[7] `http://www.fastcgi.com/` (accessed on January 21th, 2013)

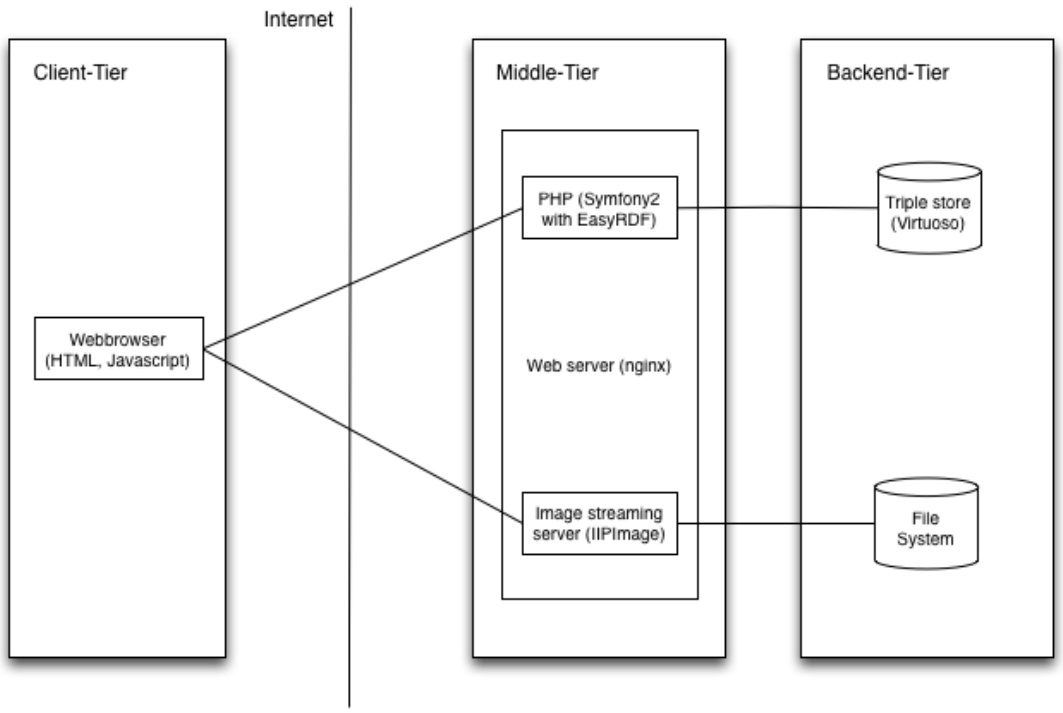


Figure 5.6 – Three-tier architecture of the developed prototype.

The following chapter answers the question why a Triple store was chosen and describes the structure of the applied data model. Next, Chapter 5.2.2 describes the image streaming server *IIPIMage* more detailed, which is used to access high-resolution images efficiently on the Web.

5.2.1 Database

The first step in the planning phase was to choose an effective and extendable database. The choice was between a relational database or a Triple store. Several advantages and disadvantages of each database type were worked out to find the proper solution:

- **Relational database:** The relational database mainly consists out of tables and fields with datatypes. Relations between tables are possible through foreign keys. The architecture is thus not very flexible, if new attributes (columns) have to be added to a specific table. Nevertheless, performance and usability are two main factors which are performing better with relational databases (Aasman, 2011).

- **Triple store:** The Triple store consists of triples and is easy extendable. If there is a necessary of extending datasources and datasets, new predicates can be easily added to existing nodes. Furthermore, if it comes to complicated ad hoc queries or performing rule pro-

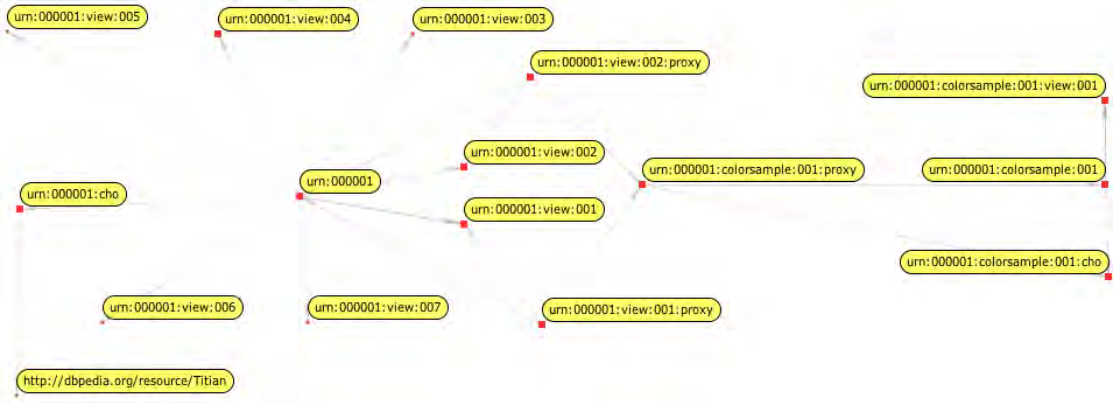


Figure 5.7 – Extract of the EDM data model showing Titian's "Madonna with child and saints" with URI "urn:000001", used for the implemented prototype.

cessing and inferencing, Triple stores perform better than relational databases (Aasman, 2011).

As a result, a Triple store seemed to be the right choice to persist the underlying data, as it is more extendable than relational databases. Furthermore, external datasources like described in Chapter 4.3 may be included, which can be easily done with a Triple store.

In the next step, a specific Triple store had be chosen. We decided to use OpenLink's Virtuoso[8] , as it offers a full package and is delivered as an open-source version. OpenLink Virtuoso is a high-performance object-relational SQL database and supports SPARQL embedded into SQL for querying RDF data stored in the database (OpenLink Software, 2012).

The textual data, provided by the Museum of Fine Arts Vienna, was delivered through Microsoft Word files, which had to be converted into a RDF/XML structure. The textual data was copied out of the documents into a RDF/XML file. As underlying data model, Europeana Data Model (EDM) was used, which is further described in Chapter 4.2.2. Figure 5.8 shows an extract of the EDM data model, used for this prototype. *urn:000001* is the URI for the an aggregation of type *ore:Aggregation*, which represents Titian's *Madonna with child and saints*. The node *urn:000001* is connected with *urn:000001:cho*, which represents all metadata description about a *Cultural Heritage Object (CHO)*. It may be a physical object (e.g. painting, book) or a digital object and is described through:

- **Title:** *dc:title*.
- **Topic:** *dc:type*.
- **Date:** *dcterms:created*.
- **Identifier:** *dc:identifier*.

[8] `http://virtuoso.openlinksw.com/` (accessed on November 7rd, 2012)

- **Extent:** *dcterms:extent*.
- **Publisher:** *edm:publisher*.
- **Spatial provenance:** *dcterms:spatial*.
- **Short description:** *dc:description* with *rdf:ID* (e.g urn:000001:cho:basic).
- **Artwork genesis:** *dc:description* with *rdf:ID* (e.g. urn:000001:cho:subject).
- **Image carrier:** *dcterms:medium* with *rdf:ID* (e.g. urn:000001:cho:imagecarrier).
- **Pigments:** *dcterms:medium* with *rdf:ID* (e.g. urn:000001:cho:pigments).
- **Condition:** *dcterms:medium* with *rdf:ID* (e.g. urn:000001:cho:condition).
- **Restorations:** *dcterms:medium* with *rdf:ID* (e.g. urn:000001:cho:restoration).
- **Temporal coverage:** *dcterms:coverage*.
- **Provenance:** *dcterms:provenance*.

The aggregation *urn:000001* has several views (*edm:hasView*), which are of type *edm:WebResource*. These views contain information about a specific image of the artwork, like a title (*dc:title*), format (*dc:format*) and rights owner (*dc:rights*).

In the case, that a specific image contains paint layer samples, a proxy for this view is used (e.g. urn:000001:001:proxy). This proxy is connected with a paint layer sample proxy (e.g. urn:000001:colorsample:001:proxy), which represents a certain paint layer sample (e.g. urn:000001:colorsample:001) of type *ore:Aggregation*. In the case of the aggregation *urn:000001:colorsample:0* its metadata description is included in *urn:000001:colorsample:001:cho*, which is of type *edm:PhysicalThing*. The description of the paint layer sample contains:

- **Title:** *dc:title*.
- **Description about the sample position:** *dc:description*.
- **Layer descriptions:** *dcterms:medium*.
- **Sample coordinates on the artwork**: *dcterms:extent*.

Furthermore, the aggregation is connected (*edm:hasView*) with one view (*urn:000001:colorsample:001:view*) which represents an image of the first view of *urn:000001*.

In order to import the data into Virtuoso, the RDF/XML file had to be translated into N3 notation, which is supported by Virtuoso. A RDF validator and convert had to be used, which is available on the Web[9]. At the Virtuoso *Quad Store Upload*, the file was imported into the graph *http://debserver/gallery/*, which is also the URL for accessing the prototype in the browser.

[9] `http://www.rdfabout.com/demo/validator/` (accessed on November 13th, 2012)

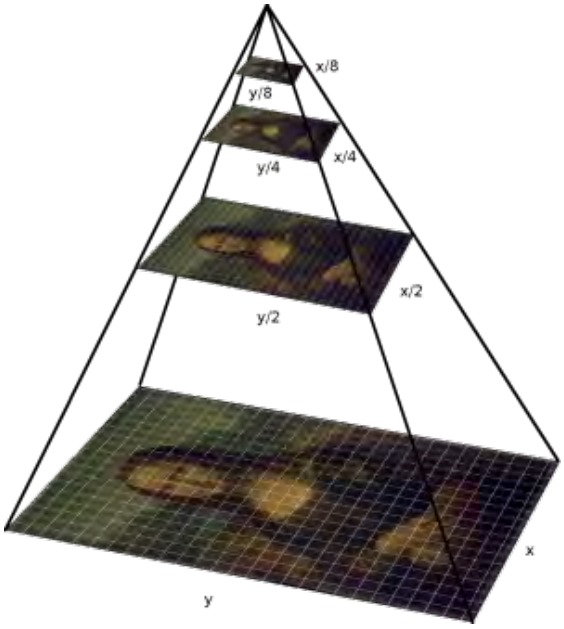


Figure 5.8 – Multi-resolution format with image tiles, allowing efficient access to high-resolution images.

As the provided data comprised only data about the artwork itself, a further datasource had to be chosen to display also information about the artist. DBpedia.org[10] has a large database, which includes also information about artists, and datasets can be exported as RDF with N-Triples, N3, XML notation. The dataset about Titian was searched on dbpedia.org, exported as RDF file with N3 notation and imported into the graph *http://dbpedia.org* in Virtuoso. Finally, the node *urn:000001:cho* had to be connected with the URI *http://dbpedia.org/resource/Titian* in this new imported graph.

Due to the fact, that external data can be included by referencing it in RDF, the system is kept extendable. Several datasources, mentioned in Chapter 4.3 can be included easily in future work.

5.2.2 Image Streaming

In order to display high resolution images of artworks efficiently on the Web, *IIPImage*[11] was chosen. IIP (Internet Imaging Protocol) allows efficient access to multi-resolution images over the Internet and intranets (Hewlett Packard and Kodak, 1997). It takes advantage of the Flash-Pix[12] image architecture, which enables fast browsing, high-resolution printing, complex image manipulation, and simple snapshot viewing of single image files.

[10] `http://dbpedia.org/` (accessed on November 5th, 2012)

[11] `http://iipimage.sourceforge.net/` (accessed on November 7th, 2012)

[12] `http://www.i3a.org/technologies/digitalimaging/flashpix/` (accessed on November 7th, 2012)

IIPImage is an advanced imaging server system for Web-based streaming viewing and zooming of high-resolutions images based on the Internet Imaging Protocol (Pillay, 2012). The streaming works tile-based, making it possible to view, navigate and zoom in real-time around gigapixel size images. Therefore, the source images must be in a multi-resolution format. These individual image tiles can be loaded at any resolution (cf. Figure 5.8). As the images need to be in TIFF or JPEG2000 format, a converter tool called *VIPS*[13] was used.

In this implementation, *IIPMooViewer*[14] was used to display the streamed tiles from the IIP Server. IIPMooViewer is a HTML5 Ajax-based client which uses the Mootools[15] Javascript framework and allows the user to pan, zoom and rotate high resolution images. In version 2.0, IIPMooViewer supports to display annotations on images. This annotation feature was used to display paint layer samples by using provided images, textual descriptions and coordinates. Furthermore, IIPMooViewer allows to synchronize specific views. As synchronized views are very helpful to navigate and zoom to the same specific regions of several images, this feature was also implemented in this prototype.

[13] `http://vips.sf.net` (accessed on November 13th, 2012)

[14] `http://iipimage.sourceforge.net/documentation/iipmooviewer/` (accessed on November 13th, 2012)

[15] `http://mootools.net` (accessed on November 13th, 2012)

CHAPTER 6

Demonstration/Proof-of-concept

This chapter aims to demonstrate the prototype's feasibility. When the prototype was evaluated, the implementation was finished and all functions, described in Chapter 5.1, were implemented.

According to Peffers et al. (2007), when evaluating an artefact two activities have to be distinguished:

- **Demonstration:** Demonstrate the prototype's feasibility to "solve one or more instances of the problem". This could involve an experimentation, simulation, case study, proof, or other appropriate activity (Peffers et al., 2007).

- **Evaluation:** An evaluation aims to observe and measure how well an artefact supports a solution to a problem. This could involve comparing objectives of a specific solution to actual observed results from the use of the artifact in a demonstration. Evaluation could include objective quantitative performance measures, the results of satisfaction surveys, client feedback, or simulations. Furthermore it could include quantifiable measures of systems performance like response time or availability, or any empirical evidence or logical proof (Peffers et al., 2007).

The first part of this chapter (cf. Chapter 6.1) demonstrates a comparison process of Titian's *Madonna with child and saints* while using the implemented prototype and thus provides a first impression about its functions and its usability. Additional information of museum professionals illustrates how comparing images of artworks can complement the exploration of artworks. The second part comprises a proof-of-concept, where three persons from different fields and knowledge in the field of art were asked about using the implemented prototype in order to receive initial feedback from users about its usability and the degree of interaction with the provided content. The test results are summarized in Chapter 6.2. Finally, the evaluated results are discussed in Chapter 6.3.

Figure 6.1 – Tiziano's "Madonna with child and saints" exhibited in the Museum of Fine Arts in Vienna.

6.1 Demonstration

Titian's *Madonna with child and saints* is exhibited in the Museum of Fine Arts in Vienna and is one of Titian's best preserved artworks in the museum. The museum has the second largest archive of works of Titian behind the Museo del Prado in Madrid. The following textual description, provided by the Museum of Fine Arts in Vienna reveal how museum experts describe Titian's painting:

- The sitting Madonna and the three saints are shown in a three-quarter view.
- Hieronymus as an old man, wearing a Cardinal's jacket and holding an open book in the hand is sitting in the foreground.
- Stephanus with green Dalmatic and golden application on shoulder, collar and chest, holding the palm of a martyr in his right hand is standing left behind.
- Mauritius as bearded warrior with armor, standing on the right side, is finishing the composition.
- Behind the Madonna the space is confined with an upstream pilaster, which is positioned in front of the opening sky.

The image files provided by the Museum of Fine Arts Vienna contain a high resolution photograph, a high-resolution X-ray image and a high-resolution infrared image of Titian's *Madonna with child and saints* (cf. Figure 6.1). Furthermore, the museum provided a photograph and X-ray image of two further versions of Titian's *Madonna with child and saints*. While one version is owned by the Louvre, the other belongs to the Chiswick House in London.

Comparison of Titian's Madonna with child and saints from the Museum of Fine Arts in Vienna with its X-ray and infrared image

The interface allows users to compare artworks with its X-ray, infrared or other images. As described in Chapter 5.1.1, X-ray fluorescence as well as Infrared reflectography are non-destructive methods for examining paintings, with which specific overpainted paint layers can be made visible. Figure 6.2 shows a comparison of Titian's *Madonna with child and saints* with a X-ray and infrared image.

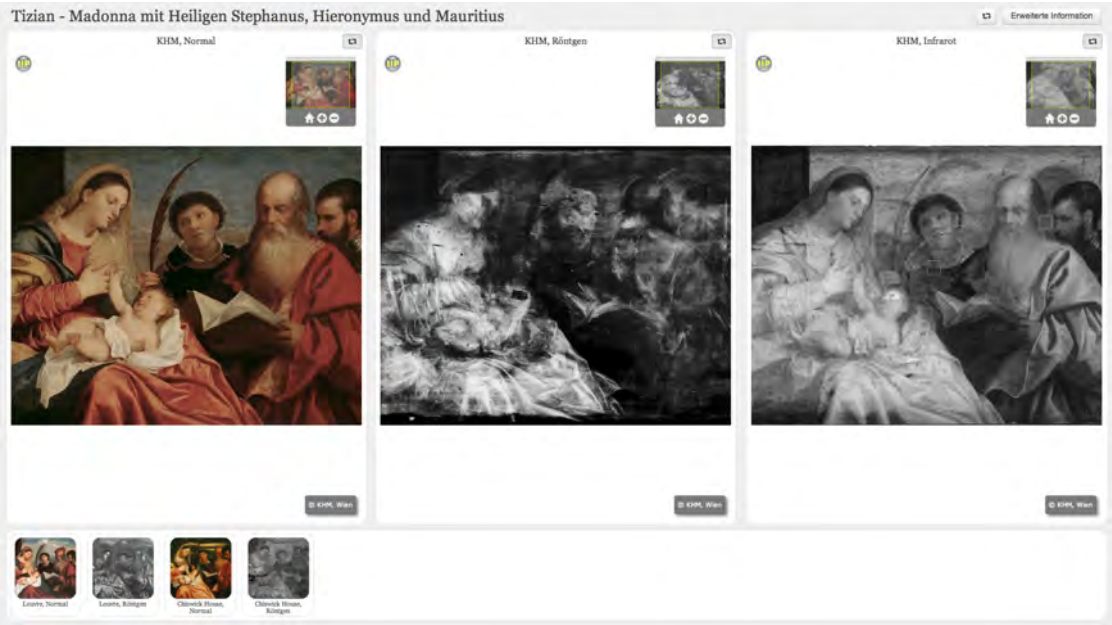


Figure 6.2 – Comparison of Titian's Madonna with child and saints from the Museum of Fine Arts in Vienna with its X-ray and infrared image

By zooming into specific regions of the artwork, interesting patterns in the X-Ray and Infrared image are revealed: Figure 6.3 shows the head of Stephanus, who was positioned between Madonna and Hieronymus. In the X-ray image, additional to Stephanus' head, a boy is visible who has turned his head to the right. Moreover a paint layer sample in Figure 6.4a shows earlier flesh tones at the position of Stephanus' hair. Furthermore, the infrared image shows that the earlier painted boy also held a palm branch in his right hand, even a little more right than the one visible in the X-ray image and the final version.

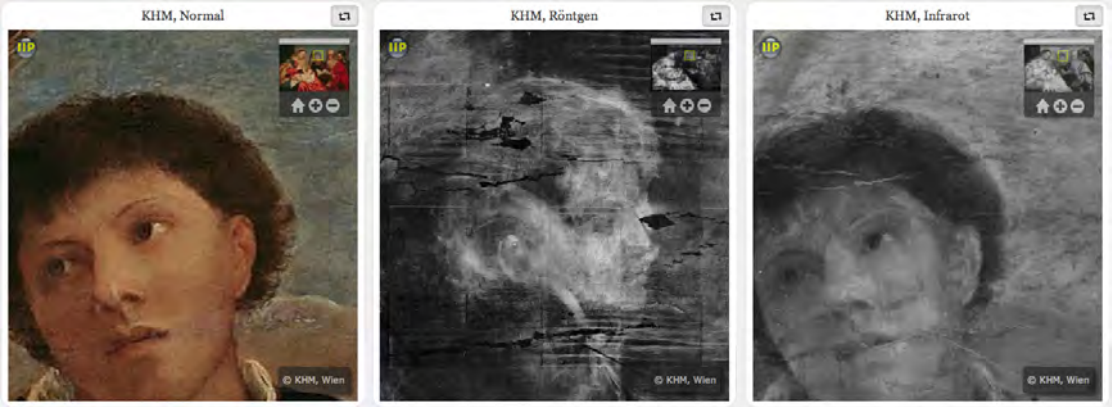
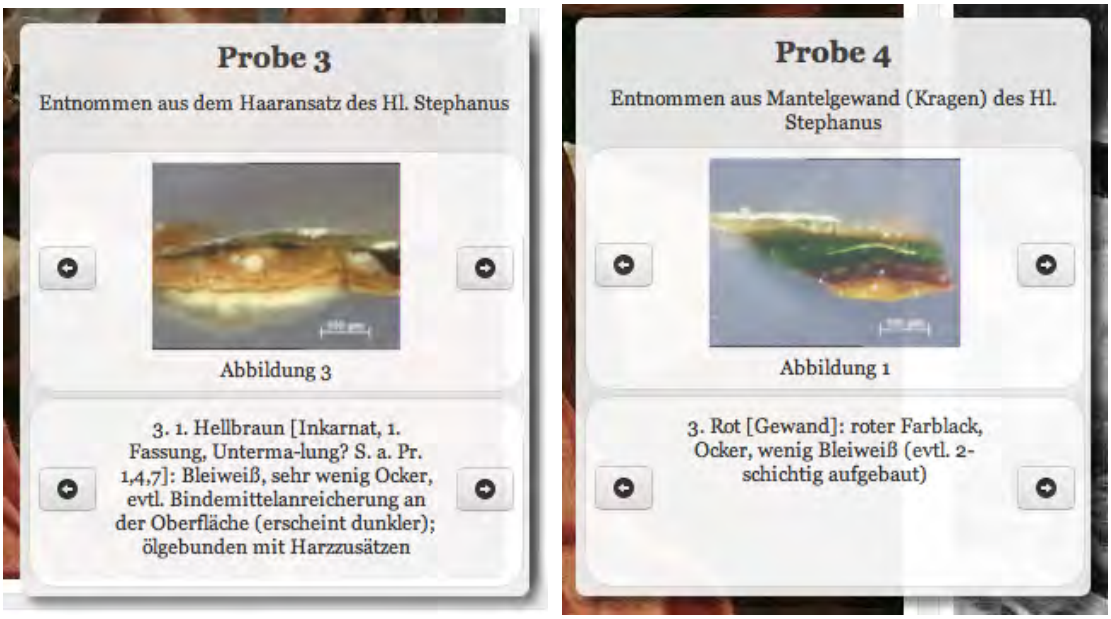


Figure 6.3 – Screenshot showing underdrawings of Stephanus' head.

In paint layer sample four, visible in Figure 6.4b, which was taken at the position of Stephanus' cloth, a red painting layer is visible. According to museum professionals, there are two reasonable explanations: On the one hand, the boy could be a shepherd, as the head shape and the red robe remind one of the *Holy Family* in London. Together with the Christ Child lying in the basket, this could indicate on a variation of the old composition. On the other side, the palm branch visible in the infrared image supports the thesis, that the boy was already Stephanus.



(a) Paint layer sample three showing earlier flesh tones at Stephanus' hair.

(b) Paint layer sample four showing a red paint layer at Stephanus' cloth.

Figure 6.4 – Paint layer samples showing earlier pigments on the position of Stephanus.

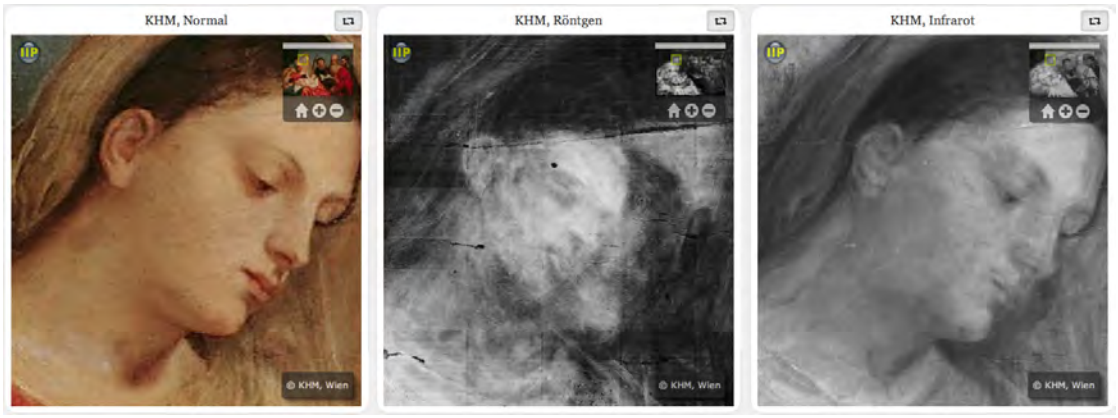


Figure 6.5 – Screenshot showing underdrawings of Madonna's head.

Zooming into the head of Madonna and comparing the X-Ray and infrared image with the normal perspective reveals a similar pattern (cf. Figure 6.5). An earlier painted head, showed in the X-Ray version, indicate that the second assumption set up above seems to be correct, as the ratio is much smaller than the final head. Even on the infrared image, this earlier painted head is slightly visible. It seems that the earlier painted head looked similar to the one in the final version, as the eyes, nose, mouth and chin were positioned in the same angle. Museum professionals state, that the clothes were partly reused after repainting Madonna. Finally, paint layer sample nine (cf. Figure 6.7a) from Madonna's blue cloth show diversities of the color, as there is found a red paint layer.

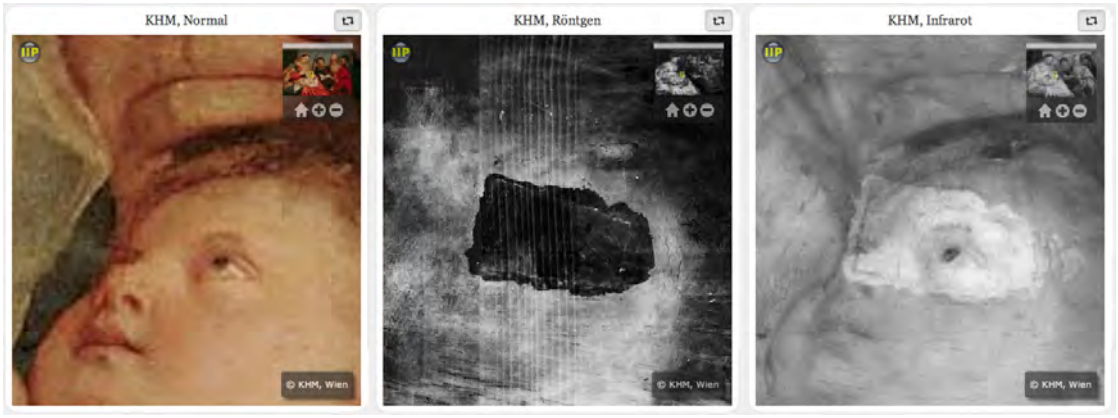
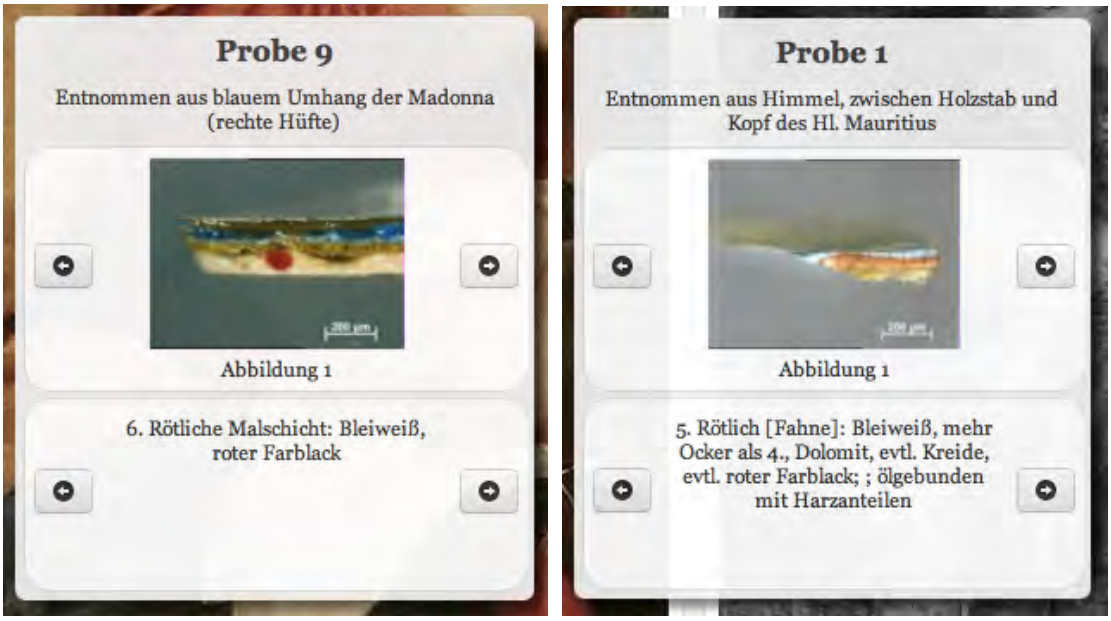


Figure 6.6 – Screenshot showing the comparison of the head of Child Jesus.

Looking more detailed on the head of the Jesus Child (cf. Figure 6.6), the X-ray and Infrared images show a strange spot. While this part is shown very dark in the X-ray image, it is displayed almost white in the infrared image. Apparently this part was damaged and renewed with canvas

and new layers of paint. According to museum professionals, the damage could be caused by an knothole in the wooden image carrier. Furthermore, according to them, the X-ray image neither reveals the size nor the former position of the child in the previous version. Perhaps the child was sitting in a basket, similar to "Madonna with holy family and shepherd" (National Gallery, London). In the second version, the Jesus Child was resized and the basket was removed.



(a) Paint layer sample three showing showing red pigments at Madonna's cloth.

(b) Paint layer sample one showing red pigments of an earlier painted flag.

Figure 6.7 – Paint layer samples of Madonna and the sky between Mauritius' head and the wooden rod.

In Figure 6.8, another example of Titian's underdrawings is visible: Mauritius, standing right behind Hieronymus in a suit of armor, was repositioned three times in earlier versions. According to museum professionals, all three earlier painted versions seem to bow to Hieronymus' direction. While two versions seem to be of similar size, the third version is noticeable smaller and therefore belongs to Titian's earlier painted full-length composition. The dark shape, shown on the infrared image between Hieronymus and Mauritius, represents an intermediate state of Mauritius' head. Due to the repositioning of this head head, the suit of armor had to be repainted slightly above the old one. The paint layer sample number two in Figure 6.9, which was taken from Hieronymus left ear, confirms this earlier painted head, since it shows flesh tones in earlier layers. Visible on the X-ray image in Figure 6.8, Mauritius was holding a flag in his right hand. The infrared image further highlights the flag, which appears as dark spot in the upper right. The paint layer sample number one shows (cf. Figure 6.7b) red pigments of the flag, which fits as a holy attribute.

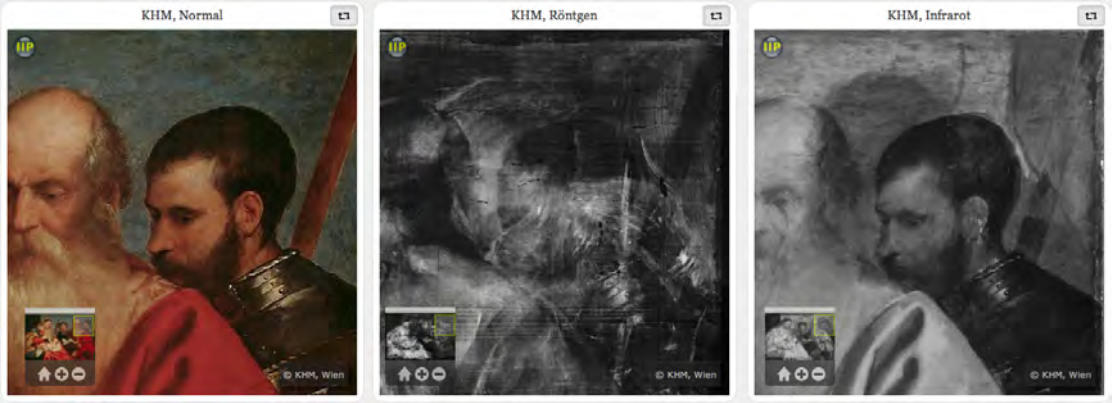


Figure 6.8 – Screenshot showing underdrawings of Mauritius' head.

Only visible on the X-ray image at the position of Hieronymus (cf. Figure 6.10), an old bearded man is kneeling with a bent-over position, his head turned to Madonna. While the contours of his back are nearly identical to the contours of the final Hieronymus, the shape of his hands is no longer traceable. As museum professionals state, it is possible that his left hand was hold to his chest. According to them, the physiognomy of the old man largely conforms to Hieronymus. Furthermore, it is also conceivable that the old man represents an donor, who steps forward to Madonna in a praying and humble gesture. Typically for Titian's style, the cloth of the old man was largely reused for the final Hieronymus. Furthermore, as the infrared image shows, Hieronymus' face was slightly repainted by Titian.

Figure 6.9 – Paint layer sample showing earlier flesh tones.

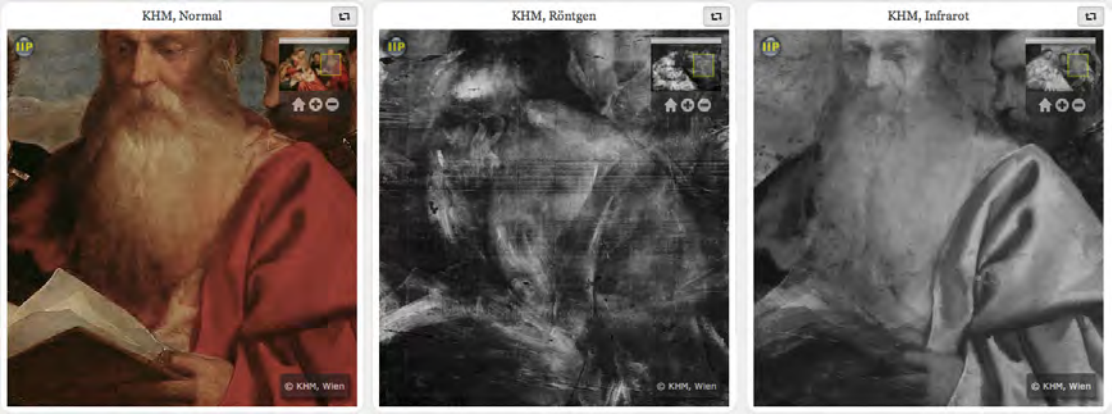


Figure 6.10 – Screenshot showing underdrawings of Hieronymus.

In the final version, Hieronymus is holding a book in both hands. As Figure 6.11 shows, the book was repainted twice. According to museum professionals, the changes of Mauritius' head and its posture could have been the reason for this repainting.

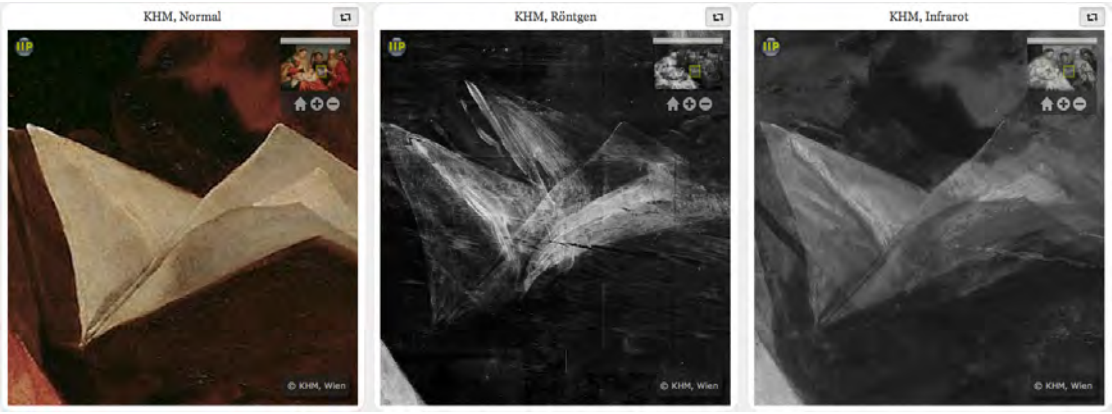


Figure 6.11 – Screenshot showing the comparison of the book hold by Hieronymus.

As museum professionals state, the earlier full-length composition was already planned as "Sacra Conversazione". The figures were probably painted in a landscape and were more or less concerned with the Virgin Mother. Thus the composition can be compared with Titian's *Madonna and Child with Sts Catherine and Dominic and a Donor* (cf. Figure 6.12), which is held at the Fondazione Magnani-Rocca in Traversetolo and shares the background, which is dominated through architecture and landscape.

Figure 6.12 – Titian's "Madonna and Child with Sts Catherine and Dominic and a Donor" from the Fondazione Magnani-Rocca in Traversetolo, showing a full-length composition.

Comparison of three versions: Museum of Fine Arts in Vienna, the Louvre in Paris, and the Chiswick House in London

Subsequently, Titian's version of the Museum of Fine Arts in Vienna is compared with the versions owned by the Louvre in Paris and the Chiswick House in London (cf. Figure 6.13). According to museum professionals, the version in London is classed between the version in Vienna and Paris. Unlike in the versions in Vienna and Paris, in the version in London the heads of the saints are decorated with halos. Comparing more detailed sections of these artworks, more small diversities become visible:

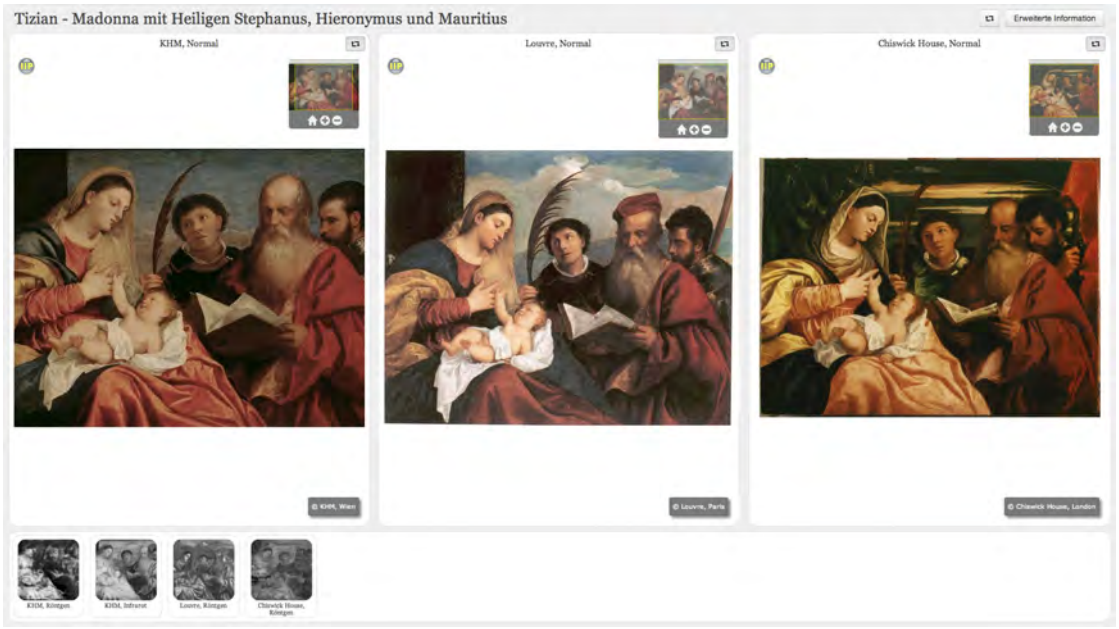


Figure 6.13 – Titian's Madonna with child and saints in the version of the Museum of Fine Arts in Vienna, the Louvre in Paris, and the Chiswick House in London.

Zooming into the part showing Hieronymus and Mauritius standing on the right, small differences can be detected. In the Louvre Version, Hieronymus is wearing a red Cardinal's cap, while in the Museum of Fine Arts Vienna and Chiswick House version his head is painted bareheaded. Mauritius' hair seems to be longer and curly in the Louvre and Chiswick House version.

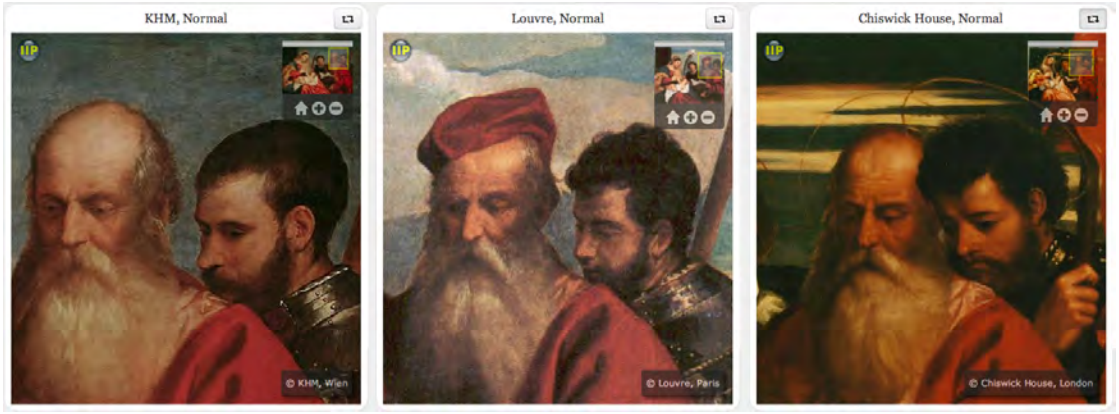


Figure 6.14 – Screenshot showing the comparison of Hieronymus and Mauritius in the version of the Museum of Fine Arts in Vienna, the Louvre in Paris, and the Chiswick House in London.

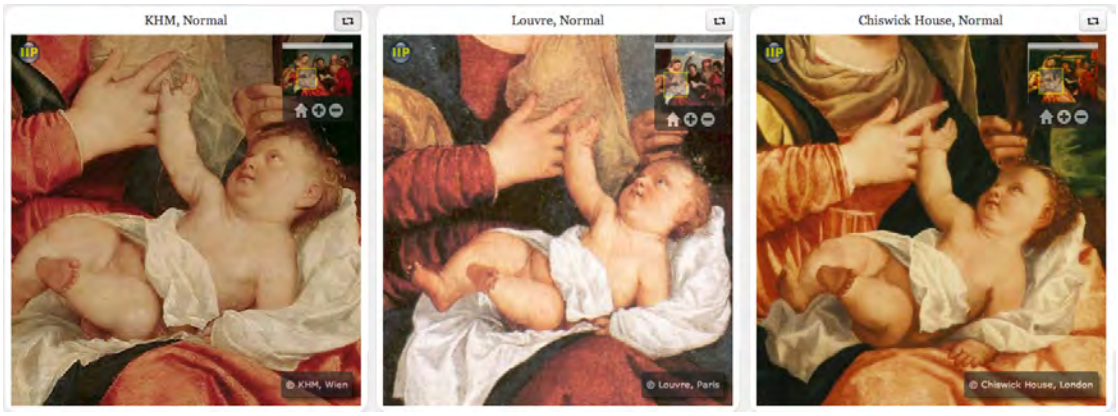


Figure 6.15 – Screenshot showing the comparison of Jesus Christ in the version of the Museum of Fine Arts in Vienna, the Louvre in Paris, and the Chiswick House in London.

Zooming into the part showing Jesus Christ laying on Madonna, there are seemingly no major differences between the three versions of Titian's work (cf. Figure 6.15). The left hand of the Christ child is painted different on the Chiswick House version, as it is not wrapped into the white blanket.

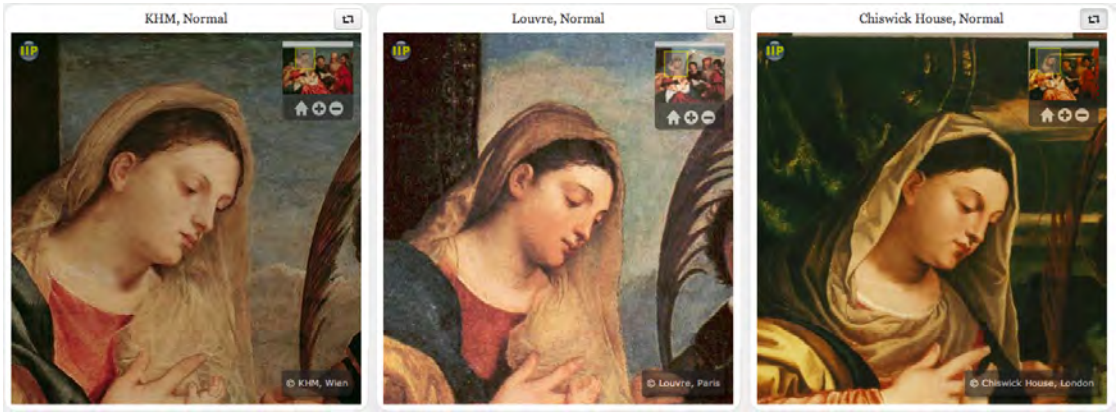


Figure 6.16 – Screenshot showing the comparison of Madonna in the version of the Museum of Fine Arts in Vienna, the Louvre in Paris, and the Chiswick House in London.

The cloth of Madonna is painted slightly different in the Chiswick House version, as her ochre-colored veil is placed around her neck. Similar to the version in London is the puckering of Madonna's robe in the version in Vienna, which was painted as more coarser materiality.

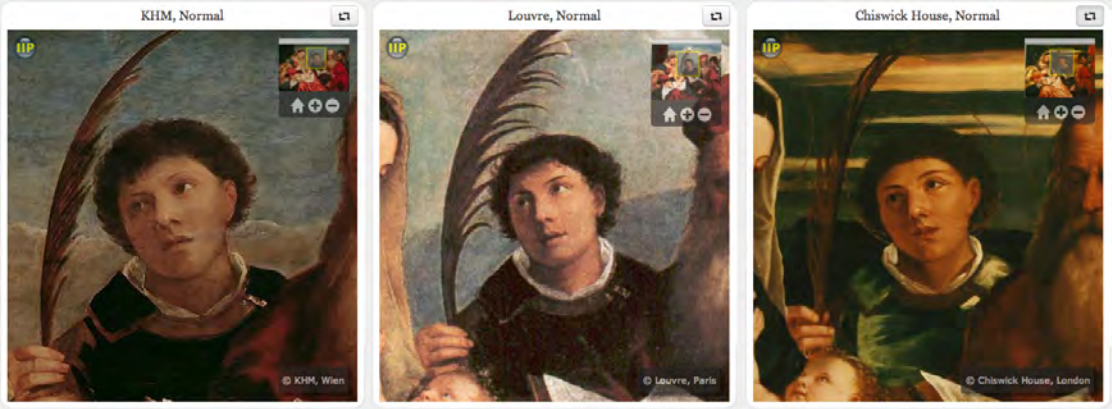


Figure 6.17 – Screenshot showing the comparison of Stephanus in the version of the Museum of Fine Arts in Vienna, the Louvre in Paris, and the Chiswick House in London.

The comparison of Stephanus in the three versions of the Museum of Fine Arts Vienna, the Louvre in Paris and the Chiswick House London shows also small variations (cf. Figure A.4). Stephanus is holding on all three versions the palm of martyrs in his right hand. Furthermore, it seems that Stephanus' look is fixating Madonna in the version of the Museum of Fine Arts in Vienna and Chiswick House, while in the Louvre painting he seemingly looks above her head, possibly at the sky.

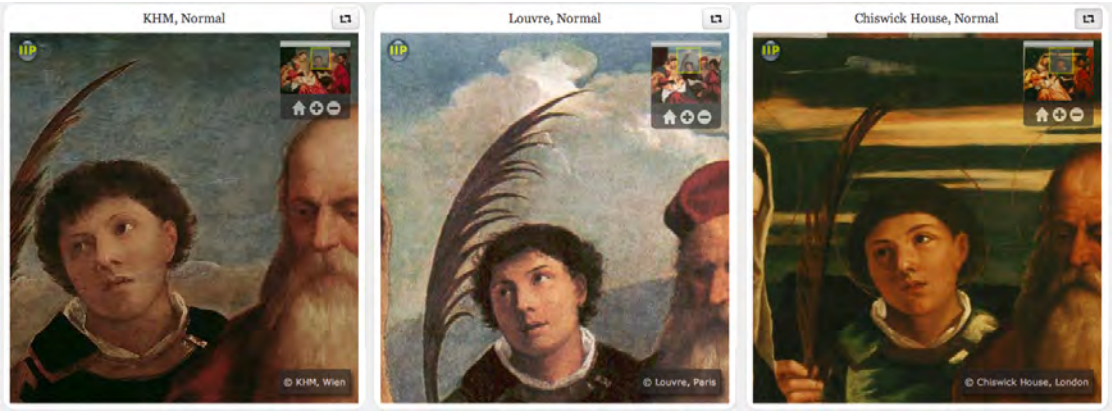


Figure 6.18 – Screenshot showing the comparison of the sky in the version of the Museum of Fine Arts in Vienna, the Louvre in Paris, and the Chiswick House in London.

Figure 6.18 shows the sky of all three versions of Titian's painting. Surprisingly, the sky in Titian's works was painted completely different in each version. The version of the Museum of Fine Arts in Vienna shows a slightly dark blue sky, without any clouds or a sun. The Paris

version was painted with clouds, hiding a seemingly sunny sky. In the Chiswick House version the sky is dark, which gives the painting a more gloomy impression.

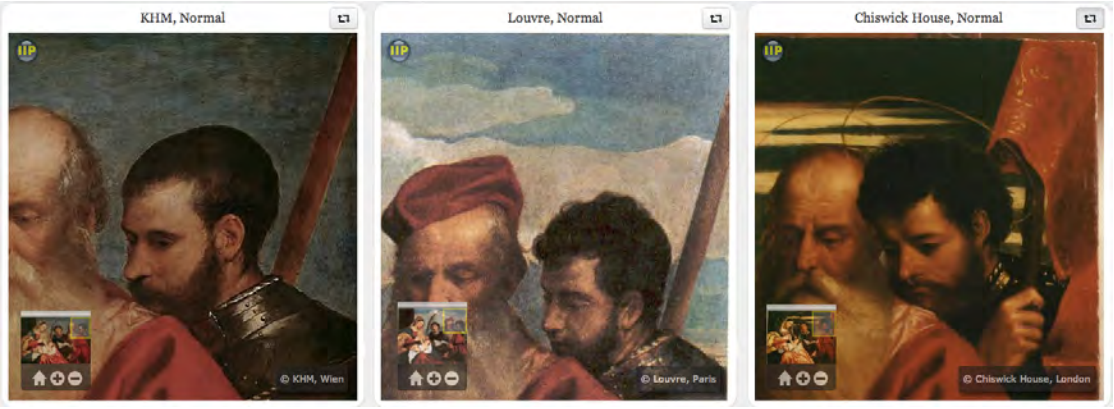


Figure 6.19 – Screenshot showing the comparison of Mauritius and his wooden rod in the version of the Museum of Fine Arts in Vienna, the Louvre in Paris, and the Chiswick House in London.

Figure 6.19 shows Mauritius and a wooden rod in his right hand. While in the version of the Museum of Fine Arts in Vienna and Louvre in Paris this rod is painted on his right side, in the version in London Mauritius holds it on his left side. Furthermore, in the Chiswick House version, a red flag is hanging on this rod. As described in the chapter before, an intermediate version of Titian's work in Vienna shows Mauritius holding a flag in his right hand, similar to the version of the Chiswick House.

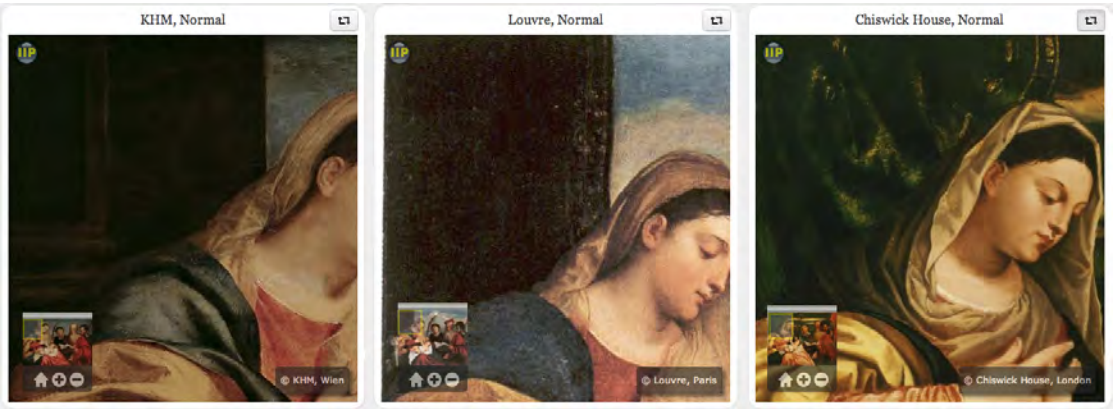


Figure 6.20 – Screenshot showing the comparison of the wall behind Madonna in the version of the Museum of Fine Arts in Vienna, the Louvre in Paris, and the Chiswick House in London.

The green curtain in the version in Paris is similar to the London version, which opens the sight to the landscape and sky in the background (cf. Figure 6.20).

Comparison of X-ray images of three versions: Museum of Fine Arts in Vienna, the Louvre in Paris, and the Chiswick House in London

Next, the X-ray images of the three version in the Museum of Fine Arts, Louvre and the Chiswick House are compared:

Similar to the version of the Museum of Fine Arts in Vienna, the X-ray image of the Chiswick House painting shows smaller painted heads of Madonna, due to the earlier planned full-length composition. The X-ray image of the version in London furthermore shows a larger head on the right, which depicts an independent composition of Vienna, according to museum professionals.

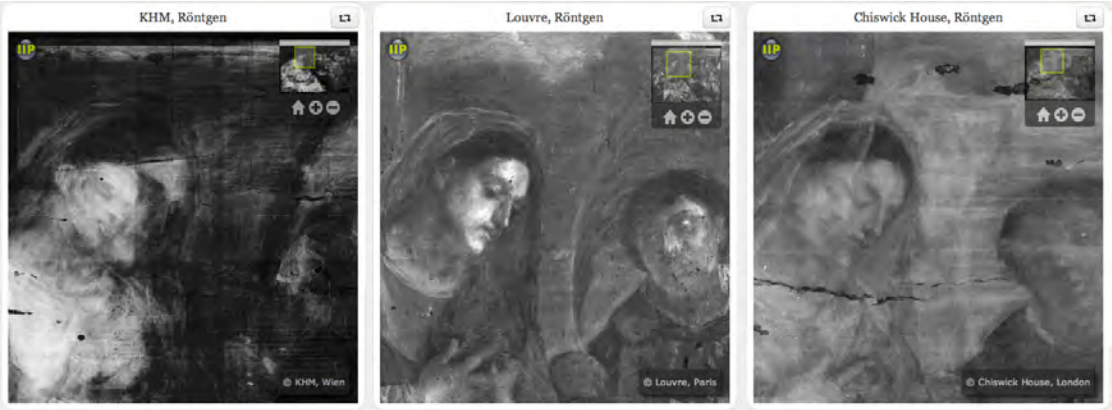


Figure 6.21 – Screenshot showing the X-ray comparison of Madonna's head in the version of the Museum of Fine Arts in Vienna, the Louvre in Paris, and the Chiswick House in London.

As already described in the previous chapters, in the version in Vienna Mauritius' head was moved to the right and the flag was replaced through a rod (cf. Figure 6.22). The X-ray image of the Paris version shows similarities, as museum professionals see earlier pigments between Mauritius' and Hieronymus' head. These pigments indicate an different positioned head of Mauritius in an earlier version, similar to Vienna. Moreover, museum professionals assumed that he originally wore a helmet in the version in Paris. Presumably he had straight hair in an earlier version, similar to Vienna. Furthermore, continuous contours on Hieronymus' head, visible in Figure 6.22, indicate that the figure was previously planned without a Cardinal's cap.

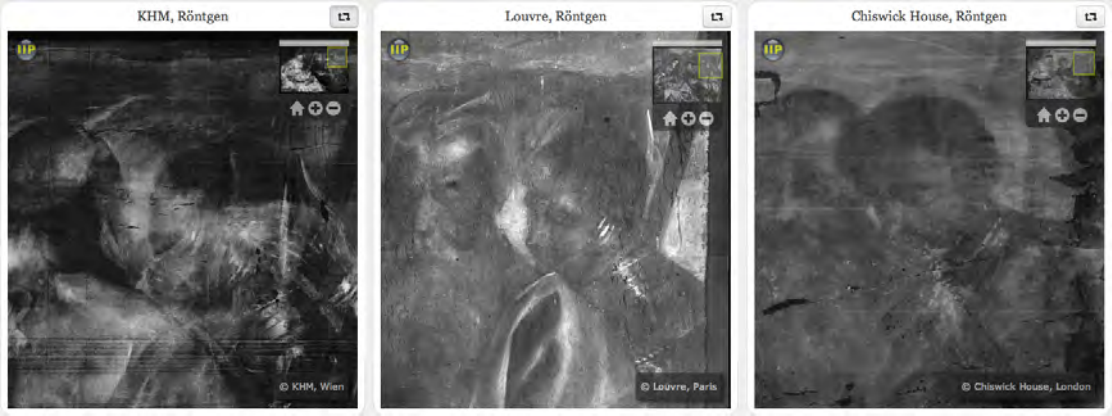


Figure 6.22 – Screenshot showing the X-ray comparison of Mauritius' head in the version of the Museum of Fine Arts in Vienna, the Louvre in Paris, and the Chiswick House in London.

According to museum professionals, the changes of Mauritius' head and its posture could have been the reason for this repainting in the Vienna and Paris version. Similar to the version in Vienna, the book was previously positioned slightly above the final version. In the version of the Chiswick House, similar underdrawings are not found.

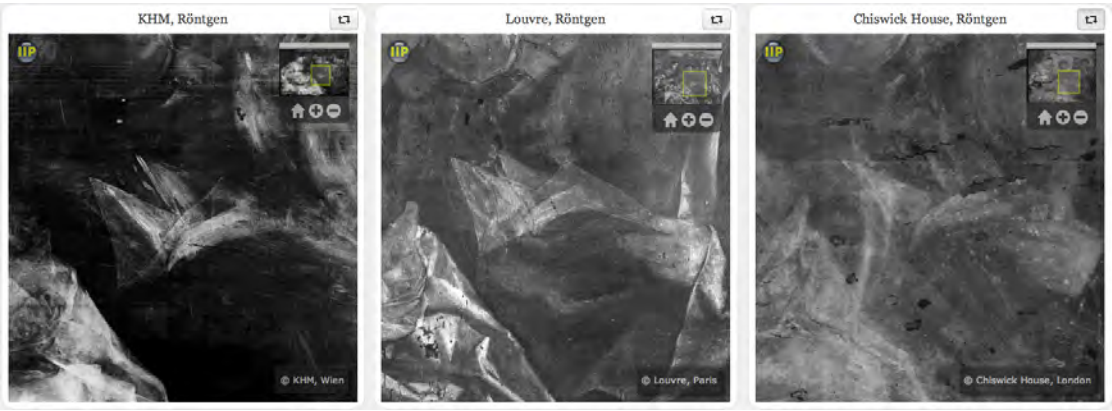


Figure 6.23 – Screenshot showing the X-ray comparison of the book hold by Hieronymus in the version of the Museum of Fine Arts in Vienna, the Louvre in Paris, and the Chiswick House in London.

Finally, the regions examined with the prototype are illustrated in Figure 6.24. The intensity of the white color indicates the frequency of explored regions. Black spots show less displayed regions. Madonna's head, Jesus Christ, as well as the head of Stephanus was explored significantly most often.

Figure 6.24 – Displayed regions of Titian's "Madonna with child and saints".

Interpretation

As the technological studies show, the version in Vienna was created as a creative preparation stage, which is reflected in various compositional approaches and changes of the whole image and specific parts. Individual characteristics of the artwork genesis in Vienna are also found in the two versions in London and Paris.

As museum professionals state, all three artworks were held at Titian's workshop at the same time. Furthermore, the comparison also indicate a parallel creation of the Vienna and London version, which probably was painted by *Francesco Vecellio*. The version in Paris, on the other hand, was based on the version in Vienna, even though the time interval between the two versions was not very large.

As described before, Titian's work in Vienna was initially planned as a full-length composition with a seated Madonna, Jesus Christ and three accompanying figures. According to museum professionals, the change from the full-length to a three-quarter composition was repeated several times by Titian and corresponds to a new trend: In the first decade of the 16^{th} century, devotional images were generally composed as half-figure compositions, in order to give the viewer a closer look to the story. Thus an intimate relationship between the viewer and saint is created. By creating a slight view from below the distance to divinity is kept and the supernatural aspect is emphasized.

Titian's *Madonna with child and saints* show that replicas were not only important in his life as a famous painter for the emperor or pope but also in the beginning of his career. According to museum professionals, he was convinced to gain interest in other customers with his motive inventions. Therefore he caused to make new versions in his workshop. The success of his pictorial invention, the intimate portrayal of mother and child, which is expressed through Madonna's inclined head and her protective look, found several imitators even during his lifetime: Titian's workshop with *Francesco Vecellio*'s *Holy Family* in Edinburgh (National Gallery of Scotland), or *Van Dyck*'s *Madonna and child* in London (Royal Collection) and *Madonna with child and Holy Rosalia, Petrus and Paulus* in Vienna (Museum of Fine Arts).

6.2 Proof-of-concept

To verify the developed prototype's feasibility in a real environment the following proof-of-concept was performed. Furthermore it aims to obtain initial feedback about the prototype's usability and the degree of interaction with the provided content. The proof-of-concept was examined with three persons: One person who is acquainted with the scientific field of art history and two persons who represent lay persons. All three participants were previously introduced to their task: Exploring the prototype's functions and comparing the images of the envisaged artwork, while describing their thoughts at the same time.

Due to the complexity of these tasks, the proof-of-concept is of qualitative nature. Thus quantification is not part of this Master's thesis (cf. Chapter 7.2). The results of each participant are described in the following sections and are subsequently discussed in Chapter 6.3.

6.2.1 First Participant

The first participant is a 50 year old female woman, who can be defined as lay person in the scientific field of art history.

As the participant entered the Web page, she initially discovered several artworks in the selection window. The artist and title of the artwork were discovered correctly by moving the cursor over the image.

After asking the participant to discover several features of the start page, she began to use the search window by entering the name of the artist and correctly pushing the *Search* button. Furthermore she used the filter function by clicking entries in the lists on the left side. According to the participant the ordering of the filters would be more preferable if the artist and the publisher are displayed in a first position, as these aspects are more relevant for lay persons. The other aspects (i.e. *art topic*, *date* and *provenance*) need basic knowledge in historic art.

After asking to select Titian's *Madonna with child and saints*, the correct image was found and clicked. The initial comparison of the normal perspective, X-ray and infrared image of the version in the Museum of Fine Arts in Vienna is preconfigured in the application. Initially the participant recognized "white shadows" on the X-ray image of the Museum of Fine Arts, which she correctly identified as earlier pigments. At the position of Stephanus' head, she recognized an earlier painted head in the X-ray image, which indicates a shepherd or an earlier version of Stephanus' head. Furthermore the participant found a spot at the head of Child Jesus, which

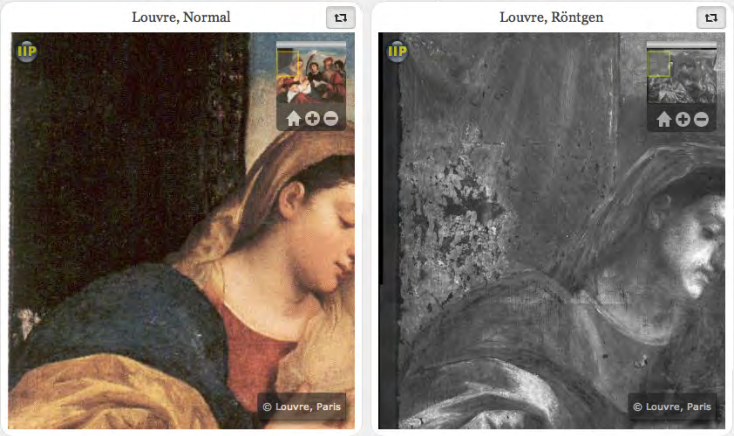


Figure 6.25 – Screenshot of the first participant showing restored spots, caused by earlier damages, in the version of the Louvre.

she correctly identified as a damaged part. Moreover she discovered an earlier painted head of Madonna and the palm branch, which she identified as a "feather". Earlier pigments at the position of Mauritius and Hieronymus the participant could not interpret correctly. Finally she suggested to display information about the museums who provide the artwork images. Moreover she recommended to display the year of creation of the artwork images in order to get further help for the investigation.

After being shortly introduced to paint layer samples in general, the participant was able to interpret the images of these samples correctly. At the position of Stephanus' head she recognized earlier pigments, which confirmed her assumption of an earlier painted head. Moreover the participant asked about paint layer samples at the position of Jesus Child and Hieronymus, as she wanted to interpret earlier pigments with the help of their colours.

Furthermore the participant discovered several spots of interest on the infrared image: Dark spots, damages, the palm branch, and cracks in the canvas. As the participant was not able to interpret the dark spots correctly, she was shortly introduced to infrared images.

As a next step the participant compared the Louvre's version with its X-ray image. Even though the participant found no earlier pigments he recognized restored spots, which were repaired due to earlier damages (cf. Figure 6.25).

Subsequently the participant began to compare the Chiswick House version with its X-ray image, where she found no earlier pigments. The dark spots were correctly identified as restored spots, which were repaired due to earlier damages. Furthermore the participant found cracks on the canvas, which had been restored. Both spots can be found in Figure 6.26.

As a next step, the participant started comparing the normal perspective images of the versions of the Museum of Fine Arts Vienna, the Louvre and the Chiswick House. At a first glance she recognized a different painted heaven in each of the three versions, as well as a different color tone in the Chiswick House version. Furthermore the participant found a cap on Hieronymus' head in the Louvre's version, as well as diversities on Mauritius' head.

Finally the participant tried to compare the X-ray images of the the versions of the Museum

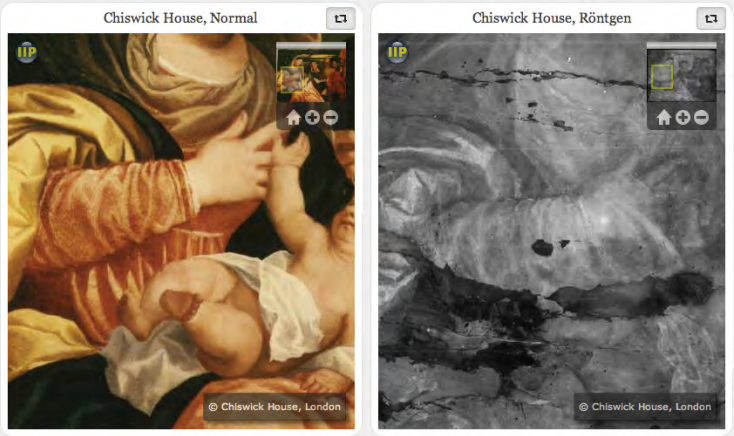


Figure 6.26 – Screenshot of the first participant showing restored spots, caused by earlier damages, and cracks on the canvas in the version of the Chiswick House.

of Fine Arts Vienna, the Louvre and the Chiswick House, but could not discover anything new and unexpected.

Subsequently the participant tried to assign specific production years to each artwork. She correctly defined the version of the Museum of Fine Arts as the oldest version, followed by the version in the Louvre in Paris and the Chiswick House in London.

After the comparison process, the textual information was opened after a hint was given. Interestingly, the participant read almost all information parts except the artwork genesis due to its length. Subsequently she wanted to compare the textual information with the images. In the currently implemented approach, a draggable window is laid over the images. Thus, after a hint was given, the participant dragged the window to the right lower area (cf. Figure 6.27) in order to compare the artwork genesis text with the specific image. She suggested to display the textual information side-by-side, which allows a parallel investigation of the images. Furthermore, she recommended to make the selected images interchangable.

6.2.2 Second Participant

The second participant is a 27 years old female who finished her degree in art history. She represents a person who is acquainted with the field of art history.

At the Home screen, she initially recognized the displayed artworks in the main window. Subsequently she discovered the filter function, where she tried to narrow down the results. Due to a lack of visibility of the scrollbar the participant did not find the scrolling function. Moreover, in order to shorten the list, she suggested to use more coarser dates (e.g. centuries or decades).

After asking her to select Titian's *Madonna with child and saints*, the correct image was found and clicked. At first glance she recognized the paint layer samples on the images. She initially opened sample number 3, which was taken from the position of Stephanus' head. When asking her if she thinks the paint layers are helpful for the interpretation of certain characteristics of artworks, she stated that she would need to know basic knowledge about interpreting paint

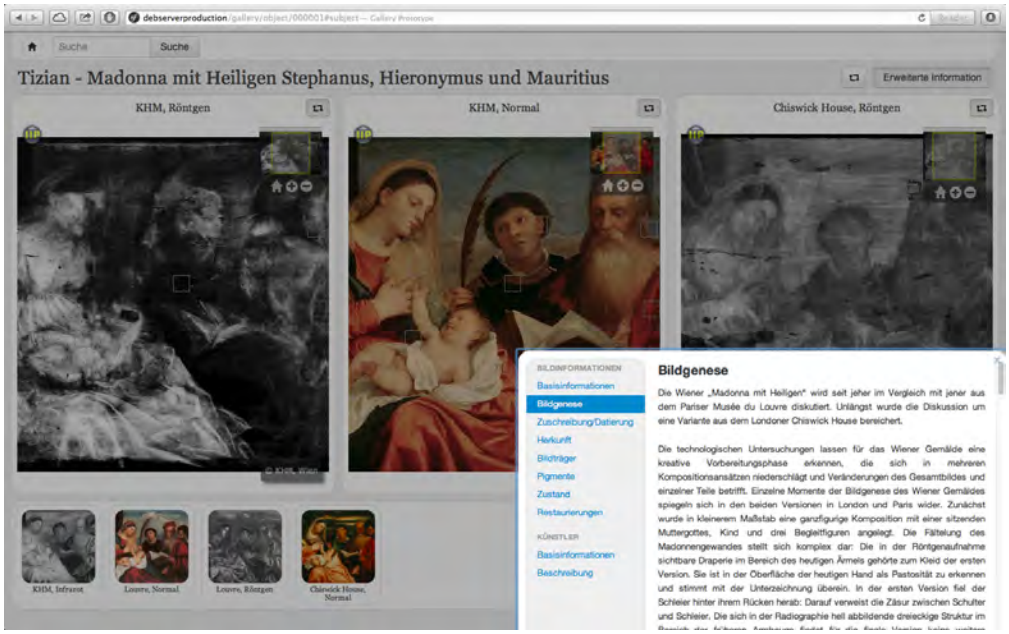


Figure 6.27 – Screenshot of the first participant dragging the textual description window to the lower right, in order to compare the images with the description.

layers. Therefore this feature would be a benefit for restorers, who have knowledge about artwork conditions, materials and pigments. Due to the fact that the sample boxes on the images are hard to recognize on bright locations, she suggested to make the paint layer sample boxes more visible. In order to determine the specific layers more detailed, she recommended to increase the size of paint layer sample images. According to the participant it would be more transparent if paint layers are listed and connected with the images.

Subsequently the participant discovered the zoom and navigation functions. Initially she recognized earlier paint layers at Stephanus' position, which indicate a shepherd or an earlier version of Stephanus' head. Moreover she highlighted the overview window on the right side, where the current viewpoint on the image is visible. Similar to the first participant, she was not able to discover the function of the synchronization buttons.

In order to get more information about the artwork and paint layer samples, the participant opened the extended description window, where she initially skimmed through the basic information. As the image genesis was too long, the skipped it after reading the first sentences. In the pigment section, the participant expected information about the specific paint layer samples. As she recognized that the information was only general description about pigments of the artwork, she skipped it and continued reading the restoration section. Moreover she shortly skimmed through the condition and provenance section.

After closing the extended description window, the participant was asked to compare different views and describe her thought process and her discoveries. With the intention to select the first view in the selection window, she double-clicked the image. As she stated, she expected an automated exchange of all three comparison views by clicking on a certain artwork in the

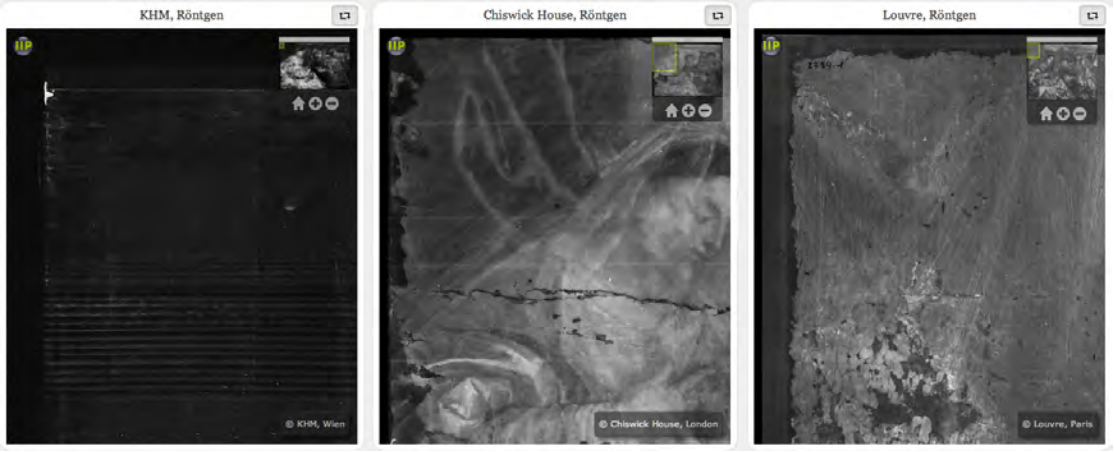


Figure 6.28 – Screenshot of the second participant showing diversities on the image carrier, visible on the X-ray images of the versions of the Museum of Fine Arts Vienna, the Louvre, and the Chiswick House.

selection window.

In order to continue the comparison process, the Drag & Drop function was explained to the participant. Moreover, she was introduced to the usage of the synchronization buttons. After the introduction, the participant started explaining the importance of comparison in the scientific field of art history. Especially in her studies, comparing images of artworks is very important. She also recommended that the comparison should be also expended to images of other artworks. Furthermore she stated that X-ray and infrared images are interesting especially for restorers, who do have a basic knowledge about interpreting these images. Therefore she suggested to offer an extended description about X-ray and infrared images in general, in order to introduce users about the interpretation of these images. Furthermore she recommended to make the selected images interchangeable. According to the participant, it is also preferable to offer display images in full window size (e.g., by double-click).

Initially the participant started comparing the X-ray images of the versions of the Museum of Fine Arts Vienna, the Louvre and the Chiswick House. After zooming into the images, she recognized diversities at the imager carrier's material (cf. Figure 6.28). According to her, she additionally searched for signatures in order to check if all three version were painted from the same painter. Subsequently the participant found earlier pigments at the position of Madonna and Stephanus. By comparing Madonna's head on the X-ray images, the participant concluded that the version in the Louvre was older than the others, as there were not the same amount of earlier pigments. As a result, the participant was curious about the year of creation, which would be preferable to display on the top of each view window.

As a last step, the participant started comparing the normal perspective images of the versions of the Museum of Fine Arts Vienna, the Louvre and the Chiswick House. At a first glance she recognized diversities of color tones of all three versions. For art history students, comparing diversities in the portrayal of painted persons help them for interpretations. Moreover the

participant suggested to expand the comparison to other artworks to make the function more flexible, since art history student need to compare all kind of artworks and images.

6.2.3 Third Participant

The third participant is a 26 year old male former student of information technology. He represents a lay person in the scientific field of art, but who is acquainted with technical aspects like user interfaces.

When the participant entered the site, he discovered all features correctly: The Search function, a Filter function and tooltips when moving the cursor over the artwork pictures in the selection window. He entered the search term "Madonna" into the search field and received three artworks as a result: *Madonna with child and saints*, *The Cherry Madonna*, *The Gipsy Madonna*. Subsequently he used the filter function to further narrow down the results. He suggested to use more visible scroll bars in the filter selection boxes, as they are hardly visible for users.

After asking him to view Titian's *Madonna with child and saints*, he found and selected the correct image. The participant initially found the zoom, navigation and the synchronization function. Moreover, he was able to drag and drop new images from the selection window. Nevertheless the participant suggested to use a hand symbol as cursor in order to make the Drag & Drop function more transparent.

Without giving him any hint, the participant's first thought was to find and investigate forgeries. He therefore opened the textual description, where he initially selected the artwork genesis. Due to its length, he read only the first paragraph. Moreover, he skimmed through all other text parts, before closing the window.

Next, the participant opened a specific paint layer sample, which he correctly identified as such. Due to his lack of basic knowledge, he was not able to interpret the images correctly. He therefore suggested a short description about paint layer samples.

Subsequently the participant started comparing the version of the Museum of Fine Art in Vienna and the Chiswick House in London. He discovered differences of Mauritius' head (e.g. Mauritius' hair, halo) in the Chiswick House version. Furthermore he found the overpainted flag in the version of the Museum of Fine Arts. At Child Jesus, he discovered a different painted hand.

Subsequently the participant started comparing the X-ray images of the Louvre and Chiswick House version. He discovered several cracks in the canvas, which are visible in Figure 6.29.

Subsequently he asked for a short introduction about how to interpret the X-ray and infrared images. Next, after exploring the images again, he tried to sort the three versions in respect of their creation. He correctly assumed the artwork in Vienna as the earliest version, followed by the version in London and Paris.

Generally, the participant suggested to use more tooltips, in order to clear up the implemented functions. The synchronization buttons, as he proposed, would be more transparent. Furthermore, he suggested to use predefined comparison samples of specific images: X-ray and infrared comparison with normal-perspective images, normal-perspective image comparison of versions in the Museum of Fine Arts Vienna, Louvre and Chiswick House, X-ray image compar-

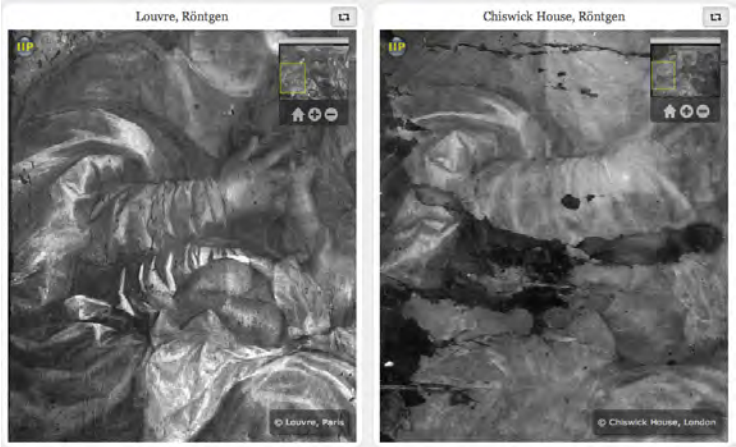


Figure 6.29 – Screenshot of the third participant showing cracks on the canvas in the version of the Louvre and the Chiswick House.

ison of these three versions. Finally, tips and suggestions to discover certain characteristics of artworks could ease the user experience: This can help to uphold a certain interest and curiosity.

6.3 Discussion

All three participants were confronted with a new approach of discovering and experiencing cultural artworks, independently of their previous knowledge in the field of art history.

The proof-of-concept showed that the participants were able to use most of the implemented functions correctly. In some cases, additional tooltips are necessary to describe functions of buttons and other interface elements. A general introduction about X-ray and infrared images is necessary in order to give unexperienced users, who do not have basic knowledge about the restoration of artworks, the chance to compare and interpret these images correctly. After the participants knew more about X-ray and infrared images in general, it was more likely for them to discover something new and interesting. Apparently the more the participants discovered, the more they were interested and thus motivated to continue the exploring process. In the proof-of-concept the participants were shortly introduced to X-ray and infrared images by describing them how X-ray fluorescence and infrared reflectography (cf. Chapter 5.1.2) works and how to interpret these images. A possible way to introduce users to the comparison of images (e.g. X-ray and infrared images) on a Web platform could be to show an example on the start page:

One example could be to tell the story about Titian's *Lucretia and her husband*, which exhibited in the Museum of Fine Arts in Vienna (cf. Figure 6.30). The following description of the artwork is provided by museum professionals from the Museum of Fine Arts:

> *This material for painting derives from Ovid's "Fasti" and was used by Titian several times: Lucrecia, wife of Lucius Tarquinius Collatinus, was raped by Sextus Tarquinius, son of the king. To save her honour as a woman and thus that of her husband, she stabs herself after demanding that her husband takes revenge. By*

Figure 6.30 – Screenshot showing the comparison of the X-ray image of Titian's Lucretia with the original artwork in the Museum of Fine Arts in Vienna.

means of brush-work that is in part highly delicate and by paying great attention to the sensuality of the material, Titian succeeds in bringing to life the heroine's moral greatness.

Looking on the X-ray image in Figure 6.30, earlier pigments are found in the region of Lucrecia's hand. These pigments indicate that the hand holding the knife belonged to Sextus Tarqunius, who was previously standing behind Lucrecia. According to museum professionals, this previous painted scene represented a raping scene, where Sextus Tarqunius threatened Lucrecia with a knife. For some reasons, Titian repainted this image, letting Lucretia stab herself to save her honour. Moreover, he changed the raper Sextus Tarquinius to her husband, Lucius Tarquinius Collatinus, who was demanded by her wife to take revenge.

As a starting point to this Web page, this example could introduce users how X-ray and infrared images can lead them to discover something unexpected and new. Similar to the example about X-ray and infrared images above, comparing replicas of artworks should be introduced in

order to correctly identify and interpret similarities as well as diversities of replicas.

Moreover, the results show that the participants initially could not interpret the paint layer samples correctly. Nevertheless, after giving a short introduction to paint layer samples in general, the first participant was able to interpret specific pigments of underdrawings. Therefore it is necessary to give users also a general introduction to paint layer samples: One way could be a help text in the paint layer sample boxes, another way would be to include an example in the example description of the comparison process above.

Interestingly, all three participants tried to perform a simple interpretation in the end of their participation: Sorting the artworks in respect of their year of creation, similar to the interpretation made in Chapter 6.1. Museum professionals try to analyze and find artworks, which have served as creative preparation stage. Thus they are able to find replicas, which are based on a specific prototype.

CHAPTER 7

Summary, Limitations and Future Work

7.1 Summary

The task of the Master's thesis was to describe current trends of Web presentation forms of cultural artefacts and subsequently implement and evaluate an alternative approach, based on the gained knowledge.

The main provider of cultural information on the Web are cultural institutions, who aim to distribute information to a possible large user base. The relevant institutions, stated in this Master's thesis, are libraries, archives, and museums. The World Wide Web allows them to provide their potential visitors an unrestricted around-the-clock access to their cultural collections. Furthermore, it is a powerful communication tool for museum curators to deliver fast, user-friendly and low-cost information about the museum to their visitors.

The Master's thesis provides a comprehensive overview of current approaches of the presentation of art history artefacts on the Web. These interaction methods are divided into the following Web paradigms: *Web 1.0*, *Web 2.0*, *Web 3D* and *Mobile Web*. Web 1.0 represents a simple Web paradigm, where the user acts simply as a consumer of content. While the *Cranach Digital Archive* provides a classical approach of presenting information about art history artefacts on the Web, the *Timelines: Sources from History* website offers a more technological advanced approach. Web 2.0 means to raise the user to an active participant who also contributes content. As part of the Web 2.0 movement, *personal digital collections*, *social tagging*, and *social media networks* are described more detailed in this Master's thesis. Personal digital collections allow users to bookmark their favorite cultural objects on the Web, annotate them with comments and share the collections via email or using social network platforms like Facebook, Twitter or others. A famous example of personal digital collections is provided by the *Google Art Project*. Social tagging allows users to give images specific text associations in order to engage the public and make object descriptions more generally comprehensible. Examples, mentioned in this

Master's thesis, are the *Your Paintings* project by a collaboration of the BBC, the Public Catalogue Foundation and about 3.000 participating collections and museums across the United Kingdom, as well as the *explorARTorium* of the University of Technology in Vienna. Social media networks provide an useful addition to the museum's information and other online publicity to inform people about upcoming events and exhibitions. Therefore it is hoped to raise the institution's publicity amongst, between and around individuals and communities in social media spaces. The Master's thesis mentions the *National Gallery* as a good example of cultural social media presentations, as it offers their information on a broad spectrum of platforms like Facebook, Twitter, and others. Web 3D in the cultural sector became also more important in the last years, due to improvements of graphics hardware and the growing availability of broadband internet connections. Unfortunately there is a lack of established standards for presenting 3D applications in browsers, despite HTML5 and WebGL19 is very promising. As as result, Web users have to install different plugins, which might be an obstacle for inexperienced users. As examples of Web 3D experiences in the Web, the *MUVA - Museo Virtual de Artes* and *ThIATRO* are described in the Master's thesis. Finally, mobile media also found its successful way in the cultural heritage domain, thanks to its characteristics of portability, handiness, ubiquity, and social networking. The Master's thesis mentions three examples of mobile Web presentations: The *Museum of Fine Arts* Vienna mobile application illustrates how museums offer information about their building and present additional content to their potential visitors on mobile platforms. The mobile Web page of the *Powerhouse Museum* in Sydney shows an excellent example of presenting information on mobile platforms. Furthermore they are using QR codes in order to link visitors to mobile Web pages with cultural object descriptions. Finally, *QRpedia* links to corresponding Wikipedia Web pages in their users' preferred language.

Semantic Web reflects the idea of a global knowledge base in form of machine-accessible and structured data, whose popularity in the cultural sector gained significantly over the last years. Enhanced visibility of content through aggregators, portals, and search engines by the exposure of metadata led to an increased usage of those data. To enable the representation and sharing of semantic data, the World Wide Web Consortium (W3C) has introduced several standards like the *Resource Description Framework* (RDF), as well as ontologies like *RDF Schema* (RDFS) and the *Web Ontology Language* (OWL). Furthermore, the International Council of Museums (ICOM) has introduced two standards: *CIDOC CRM* and *LIDO*. On the one side CIDOC CRM is a formal ontology for the cultural heritage sector to encourage the integration, access, and interchange of a variety of different information in the cultural heritage sector. LIDO, on the other side, is intended to deliver metadata from organization's online collection databases to portals of aggregated resources, as well as exposing, sharing and connecting data on the Web. Moreover, the *Europeana* has introduced their own semantic data model (*Europeana Data Model*) in order to build a bridge between Europe's cultural institutions and their portal for cultural heritage objects, where data appears in a cross-cultural multilingual context. Finally, the Master's thesis describes the following knowledge bases and vocabularies, which are relevant in the cultural sector: *DBpedia*, *Getty Union List of Artist Names (ULAN)*, *Art and Architecture Thesaurus (AAT)*, and *The Getty Thesaurus of Geographic Names (TGN)*.

The implementation of an alternative approach is supported by the obtained knowledge of the previously described State-of-the-art analysis. The main goal was to find an approach which

gives the virtual visitor the chance to discover something new and unexpected. Thus the prototype mainly concentrates on visual aspects, trying to give lay person the chance to understand and gain interest in art history by being confronted with a new approach of user interaction: Comparing and analyzing images of artworks, which are of different types (e.g. X-ray, infrared, artwork replicas). Several aspects of the implementation phase and the final functions are described in the master thesis: First, a *Object selection* page to find and select specific artworks. Second, an *Image comparison* to discover, analyze and interpret specific artworks. Third, the ability to display *Paint layer samples*, which supports the analysis and interpretation of artworks. And finally, the possibility to display *Textual information*, which further supports the analysis and interpretation and gives the user the ability to see the results of museum professionals. Furthermore, two relevant technologies are described: On the one hand *Triple stores* in order to persist the underlaying semantic data model in RDF notation. On the other side *IIPImage* to stream high resolution images efficiently on the Web.

Finally, the prototype's feasibility is demonstrated. The description of a comparison process of Titian's *Madonna with child and saints* provides a first impression about the prototype's functions and its usability. Additional information of museum professionals illustrates how comparing images of artworks can complement the exploration of artworks. Subsequently, a proof-of-concept verifies the developed prototype's feasibility in a real environment. Moreover it aims to obtain initial feedback about the prototype's usability and the degree of interaction with the provided content. The proof-of-concept was examined with three persons: One person who is acquainted with the scientific field of art history and two persons who represent lay persons. The results of each participant show that each person was able to use most of the implemented functions correctly. In order to analyze and interpret the provided X-ray, infrared, and replica images correctly, a short introduction of X-ray fluorescence, infrared reflectography, and replicas in general is necessary. Showing X-ray, infrared or replica comparison examples, possibly Titian's *Lucretia and her husband* as X-ray image, could be a possible starting point. Furthermore, descriptions about paint layer samples are necessary in order to give unexperienced users the chance to interpret these images correctly.

7.2 Limitations

The following limitations regarding this Master's thesis and the developed prototype have to be considered:

- **Development:** The alternative approach was conceptually developed and is not considered for real operations.
- **Data:** The data used for the prototype consists of Titian's *Madonna with child and saints* and several dummy datasets, which are only partly filled with textual information and images.
- **Evaluation:** Due to the complexity of the prototype's functions the proof-of-concept was performed as a qualitative test with three participants.

7.3 Future Work

The following chapter describes potential improvements and additional features for future work, which are not part of this Master's thesis:

- Enrichment of information with other Semantic knowledge bases and thesauri, as described in Chapter 4.3.
- An introduction to X-ray and infrared images is necessary in order to give unexperienced users, without any basic knowledge on restoration of artworks, the chance to compare and interpret these images correctly (cf. 6.3). Showing an example could be a good starting point, as described in Chapter 6.3.
- Inclusion of paint layer descriptions on the paint layer sample images eases the interpretation of those. A possible solution could be to show tooltips with a description in the layer images, similar to the samples in the artwork images. Furthermore, showing high-resolution images of paint layer samples is necessary to improve the interpretation of these images.
- Overlay of images can support the comparison process, as discussions with museum professionals showed. With a slider, the opacity of these images can be set by using a percentage scale.
- Expansion of the comparison of images to other artworks makes the function more flexible. Art history students need to compare all kind of artworks and images, as the second participant stated in the evaluation Chapter 6.3.
- Predefinition of specific comparison sets to ease the comparison process for beginners (e.g. X-ray and infrared comparison with normal-perspective images of a specific artwork, Comparison of normal-perspective or X-ray images between a specific artwork and its replicas). Predefined sets can be selected in order to set the three side-by-side images automatically.
- Display of tooltips and suggestions at artwork images to discover certain characteristics of artworks in order to uphold a certain interest and curiosity.
- Display of tooltips and help texts in order to reveal the functionalities of certain user interface elements.
- Extension of social tagging, in order to make the search process more efficient.

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APPENDIX A

Figure A.1 – Presentation of a X-ray comparison of Titian's "Young girl in a fur" by museum professionals in the Museum of Fine Arts in Vienna.

Figure A.2 – Presentation of a X-ray comparison of Titian's "Jacopo Strada" by museum professionals in the Museum of Fine Arts in Vienna (Part 1).

Figure A.3 – Presentation of a X-ray comparison of Titian's "Jacopo Strada" by museum professionals in the Museum of Fine Arts in Vienna (Part 2).

Figure A.4 – Presentation of a X-ray comparison of Titian's "Mars, Venus and Cupid" by museum professionals in the Museum of Fine Arts in Vienna.