A Comparative Analysis of Locative Audio for Mobile Cartography: A Preliminary Study

Robert E. Roth*, Nuzhat Tabassum Nawshin*, Annika Anderson*, Gareth Baldrica-Franklin*, David A. Hart**

* Cartography Laboratory, Department of Geography, University of Wisconsin–Madison
** University of Wisconsin Sea Grant Institute

Abstract. In this preliminary study, we present a comparative analysis of locative audio design and technology for mobile cartography. Locative audio describes the placement of sound into the landscape, and is now widely supported in mobile technology using the device's GPS and other spatial sensors. Sound cartography occupies a relatively small space in cartographic research in favor of visual methodologies, despite the growing relevance to both mobile-first and inclusive cartographic design. We analyzed 38 locative audio tours by five criteria: app technologies, tour characteristics, visual representations, sonic representations, and interactions. In the presentation, we present the preliminary design insights and future directions derived from the comparative analysis.

Keywords. Locative audio, mobile cartography, location-based services, sense of place, comparative analysis

1. Introduction

This paper introduces a comparative analysis of locative audio design and technology for mobile cartography. *Locative audio* describes the placement of sound into the landscape (Behrendt 2015). Analog locative audio long has been used in art installations to support an immersive sense of place (Aceti 2016; Fedorova 2016). Digital locative audio is now widely supported through mobile technology, using the device's GPS and other spatial sensors to deliver sounds to mobile devices as users are moving (Indans, Hauthal, and Burghardt 2019). Locative audio is particularly popular in mobile *guided tours* that lead users through a sequence of points of inter-

Published in "Proceedings of the 18th International Conference on Location Based Services (LBS 2023)", edited by Haosheng Huang, Nico Van de Weghe and Georg Gartner, LBS 2023, 20-22 November 2023 Ghent, Belgium.

This contribution underwent single-blind peer review based on the paper.
https://doi.org/10.34726/5699

est, with audio supplying context on the historical, geographic, and otherwise invisible dimensions of the visited places (Roth et al. 2018).

Sound cartography drew some interest early in the digital revolution (e.g., Krygier 1994; Golledge et al. 1998), but since has occupied a relatively small space in cartographic research in favor of visual methodologies (Schiewe 2014). Audio and other multi-modal forms of representation and interaction are particularly relevant to mobile-first cartographic design, where visual attention is divided between the map and environment with sound potentially offloading visual complexity to promote safety (Roth et al. forthcoming). Finally, research on locative audio is an ethical imperative for inclusive cartographic design, with translation from visual to audio promoting accessibility for non- or low-sighted users in both mobile and non-mobile use contexts (Shum et al. 2016; D'Ignazio and Klein 2016)

In this paper, we present a comparative analysis of 38 guided tours that include locative audio (henceforth described as *locative audio tours*). This research is the initial step in a user-centered design process to design a series of audio-enhanced guided tours about recent and planned green infrastructure projects in the City of Milwaukee, Wisconsin, a collaboration between the University of Wisconsin Cartography Laboratory and the University of Wisconsin Sea Grant Institute. We present our comparative method design in the next section, discuss preliminary results in the third section, and conclude with future direction in the final section.

2. Method

2.1. Sample

Comparative analysis (sometimes "competitive analysis") is a usability engineering method that critically compares a sample of related designs or technologies by their content and functionality (Nielsen 1992). We primarily collected our sample from the top-ranked mobile applications listed in AndroidRank.org and SensorTower.com. To prevent bias towards a particular platform or template, we sampled only the two highest-rated locative audio tours from the same source. We appended this list through keyword search of "locative audio tour", "locative audio story", and "location-based audio story" in the Google Play Store and iOS App Store.

We identified six inclusionary criteria for the comparative analysis: 1. Published and fully-functional (i.e., not beta-ware); 2. Includes audio; 3. Includes an interactive map; 4. Includes an offline version (i.e., "armchair" mode; Behrendt 2015); and 5. Includes one suggested audio route.

2.2. Codes

We developed five categories of codes form the competitive analysis based on a literature review of locative audio and sound cartography:

1. **App Technologies:** Basic identification—including categorization as applied by the app store category as well as Behrend's (2015) locative audio taxonomy—the underlying mobile mapping technology (after Roth et al. 2014), and platform availability.
2. **Tour Characteristics:** Travel modality, route characteristics (e.g., linear, non-linear, branching; after Röber et al. 2006), site characteristics (e.g., total number of POIs, total audio clips), and geofencing triggered upon entering versus leaving the site.
3. **Visual Representations:** Basemap type, egocentrism, user symbolization, POI symbolization, route symbolization, context layers, map elements, and multimedia (all based primarily on Abraham 2019).
4. **Sonic Representations:** Narrator type (e.g., objective outsider, subjective local, real interviews, fictional characters; expanded from St Clair 2018), sense of place or "embeddedness" (e.g., historic, nature, culture, community, or futuristic background sounds; expanded from Fedorova 2016; St Clair 2018), and sonic variables (after Krygier 1994; MacEachren 1995).
5. **Interactions:** Interaction operators (after Roth 2013), differentiated by user- versus location-triggered.

3. Preliminary Results

Figure 1 provides the preliminary results from the comparative analysis.

App Technologies: The majority of locative audio tours use proprietary technologies including the Google Maps (14/38), Mapbox (13/38), Apple Maps (2/38), and Mapy.cz (2/38) APIs. While we could not identify the underlying technology of seven locative audio tours, only 9/38 use fully open source technologies. Although most locative audio tours are advertised as "Travel and Local" in the Google Play Store and iOS App Store, we observed a greater diversity of purposes following the Behrend et al. (2015) taxonomy, with the most common categories including touristic (24/38), historical (17/38), cultural (17/38), and educational (10/38). Most locative audio tours support offline (37/38) and remote "armchair" modes (33/38), indicating the importance of having fail-proof and preview options to avoid connectivity issues and promote uptake, respectively. However, only 10/38 are responsive between mobile and non-mobile devices, a surprise since we designed our own past guided tours using responsive design frameworks. This finding illustrates the broader shift towards mobile-first over responsive design, particularly for delivery of larger files such as audio.

Tour Characteristics: The majority of the locative audio tours are designed for an outdoor walking modality (27/38), with personal automobile (7/38) the only other modality supported by more than three locative audio tours, an opportunity since some modalities like tram, bus, train, and airplane are chauffeured and do not exhibit the same split attention and safety concerns. Most locative audio tours follow a linear sequence (32/38), with only five non-linear and none using a branching sequence. This perhaps suggests a preference towards linearity for users unfamiliar with the tour location, but also a potential gap for experimenting with non-linear and branching storytelling forms to support transformative experiences in known landscapes. Notably, the majority of locative audio tours supply tour directions through external links to other wayfinding apps (25/38) or as part of the audio recording (22/38), but relatively fewer provide route directions as text (14/38) or visually in the map (3/38). The latter is quite surprising, but perhaps indicates a limitation of route calculation in existing tools supporting locative audio. Finally, the majority of sampled locative audio tours trigger audio content when reaching a POI (25/38) or not at all (10/38), with only one tours triggering audio about the next POI when leaving a POI; the latter design strategy could be effective for longer audio recordings providing background context between sites.

Visual Representations: Most locative audio tours use vector street basemaps (30/38), suggesting a more urban focus, or at least a focus on navigation on roads versus trails. Fewer locative audio tours take advantage of egocentrism to orient the user, with only half (19/38) centering the map on the user and six reorienting the map so that forward is up, with no tour supporting both forms of egocentrism. However, the current user location (36/38) and orientation (25/38) are commonly symbolized on the map. Interestingly, the sampled locative audio tours more commonly symbolize POIs by their absolute sequence (19/38) than their relative sequence (11/38) or non-linear categories (7/38), a finding that perhaps reinforces emphasis on tour linearity. The route most commonly is represented in its entirety (27/38), with only three highlighting the route just between sites, none highlighting just the remaining route, and eight locative audio tours not depicting the route at all. As above, this lack of dynamic symbolization may be a limitation of existing software (excepting WeGoTrip, which appears to support dynamic symbolization). Notably, additional context layers are not commonly included on the sampled locative audio tours, with 9/38 including additional point layers beyond the POIs and no tour including additional line or polygon layers. While this could indicate a preference towards simplicity to avoid confusion along the tour, it also might suggest a design opportunity to better integrate the POI multimedia content into the map itself. Map elements are more common however, with 24/38 indicating north—important given the use case of wayfinding—and 10/38 indicating scale—perhaps more important as the distance increases with a travel modality change away from walking. Legends are not common given minimal inclusion of thematic context layers. Finally, the photos (35/38) and text (27/38) are the most common non-audio multimedia supplement, indicating access of POI content through detail retrieval. The ability to share content on social media also is common (27/38), perhaps unsurprisingly so given emphasis on mobile-first design. Advanced forms of multimedia are not common despite their relative discussion in the literature.

Sonic Representations: Objective outsider narration is most common among sampled locative audio tour (32/38). However, we found the limited examples (four each) of subjective local, real interviews, and fictional character narration to be more interesting, suggesting a missed opportunity to bring multiple perspectives and creative solutions into the narration. Cultural-presentation is the most common non-narrative audio for developing sense of place, presented primarily (although not exclusively) in the form of music. As with narration, we qualitatively found the examples, while limited, of historical/archival (6/38), nature-present (3/38), and community-present (3/38) non-narrative audio to add rich texture to the experience. Only 17/38 locative audio tours intentionally use the sonic variables, most commonly varying the timbre (12/38), loudness (8/38), or order (7/38) of the non-narrative audio. Interestingly, two locative audio tours use the sonic variable location, playing stereo sounds from the left or right audio channels to create an embodied locative audio experience.

Interactions: Nearly all locative audio tours implement zoom (38/38), pan (37/38), and retrieve (35/38), with nearly two-thirds also implementing rotate (26/38). This is an expected finding, as zoom, pan, and retrieve are the most common operators supported in “slippy” web maps. Common inclusion of rotate is logical given the focus on wayfinding, and supplies further evidence that rotate should be considered a separate map browsing operator from reproject. Other operators are less common, indicating an emphasis on interface constraint to keep the UI simple. Overall, fewer operators are triggered by location through geofencing. Retrieve (28/38) and pan (23/38) are the most common location-triggered operators, expectedly so as they update the map position and activate new content for a POI. However, zoom (9/38) and rotate (4/38) are not commonly part of geofencing; this perhaps makes sense for zoom, as a scale change when arriving at a POI may be disorienting, but less so for rotate where map orientation can be updated based on the user’s orientation. Interestingly, calculate, while infrequent, is more commonly a location- versus user-triggered operator, included in four locative audio tours to calculate the route to the next POI.

Figure 1: Preliminary results of the comparative analysis.

Future Directions

As stated above, the comparative analysis is the initial step in a user-centered design process to design a series of locative audio tours about recent and planned green infrastructure projects in the City of Milwaukee, Wisconsin. We identified Echoes and VoiceMap from the comparative analysis as two candidate platforms for our locative audio tours given their overall utility and stability. We also are developing a third, open source solution based on Leaflet.js and plan on field testing the three alternatives on a case study walking tour on Shorewood, WI, green infrastructure before expanding to the complete suite of walking, biking, and bus guided tours.

References

Abraham, L. 2019. Where do we go from here? Understanding mobile map design, Geography, University of Wisconsin-Madison, Madison.

Aceti, L. 2016. Meanderings and reflections on locative art. *Leonardo Electronic Almanac* 21 (1):10-13.

Behrendt, F. 2015. Locative media as sonic interaction design: walking through placed sounds. *Wi: Journal of Mobile Media* 9 (2):25.

D'Ignazio, C., and L. F. Klein. 2016. Feminist data visualization. Paper read at Workshop on Visualization for the Digital Humanities (VIS4DH), Baltimore. IEEE.

Fedorova, K. 2016. Sound cartographies and navigation art: In search of the sublime. *Leonardo Electronic Almanac* 21 (1):44-59.

Golledge, R. G., R. L. Klatzky, J. M. Loomis, J. Speigle, and J. Tietz. 1998. A geographical information system for a GPS based personal guidance system. *International Journal of Geographical Information Science* 12 (7):727-749.

Indans, R., E. Hauthal, and D. Burghardt. 2019. Towards an audio-locative mobile application for immersive storytelling. *KN-Journal of Cartography and Geographic Information* 69:41-50.

Krygier, J. B. 1994. Sound and geographic visualization. In *Modern cartography series*, 149-166: Elsevier.

MacEachren, A. M. 1995. *How maps work*. New York, NY, USA: The Guilford Press.

Nielsen, J. 1992. The usability engineering life cycle. *Computer* 25 (3):12-22.

Röber, N., C. Huber, K. Hartmann, M. Feustel, and M. Masuch. 2006. Interactive audiobooks: combining narratives with game elements. Paper read at Technologies for Interactive Digital Storytelling and Entertainment: Third International Conference, TIDSE 2006, Darmstadt, Germany, December 4-6, 2006.

Roth, R. E. 2013. An empirically-derived taxonomy of interaction primitives for Interactive Cartography and Geovisualization. *Transactions on Visualization & Computer Graphics* 19 (12):2356-2365.
Roth, R. E., A. Çöltekin, L. Delazari, B. Denney, A. Mendonça, B. A. Ricker, J. Shen, Z. Stachoň, and M. Wu. forthcoming. Making maps & visualizations for mobile devices: Challenges for mobile-first and responsive cartographic design. *Journal of Location Based Services*.
Roth, R. E., R. G. Donohue, C. M. Sack, T. R. Wallace, and T. M. A. Buckingham. 2014. A process for keeping pace with evolving web mapping technologies. *Cartographic Perspectives* (78):25-52.
Roth, R. E., S. Young, C. Nestel, C. Sack, B. Davidson, J. Janicki, V. Knoppke-Wetzel, F. Ma, R. Mead, and C. Rose. 2018. Global landscapes: Teaching globalization through responsive mobile map design. *The Professional Geographer* 70 (3):395-411.
Schiewe, J. 2014. Physiological and cognitive aspects of sound maps for representing quantitative data and changes in data. In *Modern Trends in Cartography: Selected Papers of CARTOCON 2014*, 315-324: Springer.
Shum, A., K. Holmes, K. Woolery, M. Price, D. Kim, E. Dvorkina, D. Dietrich-Muller, N. Kile, S. Morris, J. Chou, and S. Malekzadeh. 2016. Inclusive design toolkit.
St Clair, J. 2018. Stories that walk with you: Opportunities in locative audio for feature journalism. *Australian Journalism Review* 40 (1):19-33.