Maps and Location: Acceptance of Modern Interaction Techniques for Audio Guides

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ABSTRACT
Traditional audio guides in museums and similar spaces typically require the visitor to locate a track number at each exhibit and enter it on a keypad. These guides, however, provide no information on the amount of content available. Current mobile devices provide rich output capabilities, and indoor location tracking technology can simplify the selection of content in modern audio guides. In this paper, we compare the keypad-based interface to a map-based interface with and without automatic localization. Through a field study in a local museum with 84 participants, we found that the usability of all versions is rated high, with the keypad interface coming out ahead. Nevertheless, visitors favored the overview of the map and thumbnails to find the right exhibit, while numbers were considered helpful indicators in the real world. Those who used the self-localizing guide preferred it over manually adjusting the map.

Author Keywords
Audio Guide; Museum; Location Tracking.

ACM Classification Keywords
H.5.2. User Interfaces: Interaction styles

INTRODUCTION
Museums have offered audio and multimedia guides for a long time, and many museums use them [2, 12]. While early versions were based on a predefined audio tour recorded on tape which the user had to follow closely not to lose context, random access players like CD players and later MP3 players allowed visitors to create self-paced tours through the museum [12]. Today, the standard interaction with an audio guide is expected to be entering the number of an exhibit on a keypad (e.g., [11], [15]). While this is certainly a very robust technique, it offers no visibility or information scent [8] about how many exhibits are covered by guide content. The keypad version has a lesser information scent than the map versions

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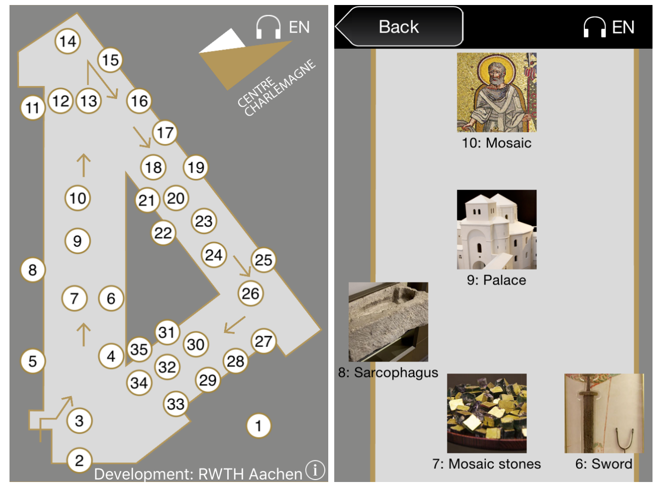

Figure 1. The left shows an overview of all exhibits with according audio content. The right image shows the detailed view which the user interacts with mostly. The area that is shown in this view is determined based on the detected location.

as it does not give a prior hint as to what can be found *behind* a number. It also requires the visitor to find the according number to each exhibit, which can be difficult, especially for large-scale exhibits that require some viewing distance, or that offer no obvious place for signage. Furthermore, exhibitions are modified over time which results in inconsistencies if not the entire numbering is adjusted. The visitor can easily misinterpret a missing number in the sequence as an overlooked exhibit and start a foredoomed search. Also, people are used to rich interaction with smartphones. A regular keypad based audio guide does not fulfill that expectation.

To overcome the problem of having to enter a number, Bederson [5] developed an audio guide in which the according audio track is triggered by an infrared beacon. While the technology to replace the keypad has evolved since then to include QR codes, object recognition, and Bluetooth beacons in the exhibit, it basically offers the same functionality. We evaluated a different approach, which shows a map of the area where the visitor is located, along with the exhibits available in her vicinity (Fig. 1). This has the advantage of providing awareness of the surroundings, along with a visible overview of available information. We deployed such a self-localizing audio guide in a museum and compared its acceptance to a traditional keypad and a manual map-based interface to see whether the prevalent use of a keypad design is due to a superior usability or if other approaches with richer interactions reach the same level. Our results indicate that while the usability of the approaches was rated high, the map versions do not reach the ratings of the keypad version. Nevertheless, visitors favored the overview given by the map and the thumbnails to quickly find the right exhibit while numbers were considered helpful indicators in the real world. Those who used the self-localizing guide preferred it over manual pan and zoom on the map. We therefore suggest a self-localizing map-based approach for visibility, with corresponding numbers on exhibits and thumbnails as a fallback.

RELATED WORK

Ardissono et al. [3] provide a summary of research on personalized multimedia guides. The simplest implementation of a self-paced audio tour guide is the keypad-based one as it can be found in many museums (see [9] for a summary). In this approach, dedicated numbers are placed next to the exhibits and when entered into the guide, trigger the according audio sample. This method has been used in various studies as the baseline condition (e.g., [15]), or referred to as the most frequently used technique (e.g., [11]). While this interaction model is easy to understand, some problems become clear upon a closer look. Usually, the number is placed on a sign with other information about the exhibit. This works well for small exhibits that can be inspected from the same position as the sign. But imagine, e.g., a wall-size painting with its sign beside it; in order to read the number the visitor now has to approach the painting further than she normally would and then move away again to study the painting itself. If no sign is present, there is the additional problem of where to place the number so all visitors find it quickly. An exhibit hanging from the ceiling, e.g., has no obvious place to put a number. The second problem is the visibility of augmented exhibits which arises if only part of the collection has an according audio explanation. A solution would be to hand out a paper leaflet which lists all augmented exhibits, which is of course a suboptimal approach.

To overcome the problem of having to find and enter a number, Bederson [5] combined an MP3 player with an infrared beacon that encodes the number of the exhibit the visitor is standing in front of. While this simplifies the interaction, the problems of visibility and large exhibits remain. For large exhibits, one could place the beacon at the preferred viewing point, but this leaves room for error as different visitors may have different preferences, the center of a room might be a good place to study more than one painting, etc. Wein [15] compared QR-codes and visual recognition of exhibits to numbers. Visitors clearly favored visual recognition, which allows selecting an exhibit from a distance and, if the recognition works well, closely follows the user's intent. However, the study was limited to 2D exhibits. In museums with complex 3D objects the technology might fail much more easily.

None of the above approaches track the visitor's position continuously. This has been done, for example, in PEACH [13], HIPS [6], or ec(h)o [14] for indoor scenarios, and in Cyberguide [1] in outdoor situations. Tracking technologies used in these projects include GPS (only outdoors), WiFi, or beacons (infrared or Bluetooth). Many of these projects notify the user of available content when she is close to an exhibit. Lanir et al. [11] examined the effect of different content presentation styles. In the first condition, content playback was triggered automatically as soon as the visitor got close to an exhibit. In the other two conditions, the system showed an image of nearby exhibits. Exhibits with available audio content were highlighted. After an exhibit was selected, the guide either played one audio piece or offered a choice of multiple audio pieces for the selected exhibit. Visitors disliked the guide triggering playback automatically and preferred the version that offered multiple shorter audio pieces for an exhibit.

Other guide systems offer maps to show the visitor nearby exhibits. Most of these systems are designed for outdoor use, and use GPS to track visitor location. Baus et al. [4] and Kenteris et al. [10] provide overviews of such map-based guides. According to Baus et al., the benefit of maps in mobile guides is the possibility to indicate not only the presence but the location of a point of interest. In a museum scenario this means that exhibits can be displayed on a map at their locations in the museum, rather than in a simple list. Furthermore, they can indicate the current position and surroundings of the user. However, so far no study has compared keypad-based selection of content, manual map-based navigation, and automatic map-based navigation.

EVALUATION

We conducted a between groups field experiment to compare a map-based guide with automatic localization (*tracking*; see the next section for more information), a version with the automatic localization disabled (*map*), and a *keypad*-based implementation as the baseline for currently used audio guides in museums. All ran on iPhones in custom casings. For the *keypad* condition, we attached numbers to all exhibits with audio content. The number was fixed to the information sign if present, or otherwise we placed the number in proximity to the exhibit (e.g., on the glass cover of a display case). We included the map-based version without automatic localization to distinguish between the influences of the map visualization and the location tracking. For this condition, we disabled the tracking code in our location-aware guide software so that the visitor had to manually zoom and pan through the map.

We conducted the study over the course of four days in the Centre Charlemagne in Aachen, Germany with one condition used on each day. One condition was used twice to reach similar group sizes. Normal visitors to the museum were asked whether they would like to participate in the study and were equipped with a free audio guide running that day's software. All materials for the study were available in all four languages of the audio guide (English, German, French, and Dutch) to avoid any language bias. Participants could explore the museum at their own pace. We asked them to fill out a questionnaire when they returned the audio guide. The survey contained questions of Brooke's System Usability Scale [7] as well as questions regarding demographic information (age, nationality, and gender) and the participant's habits regarding museums and audio guides (frequency of visits and frequency of audio guide usage if one is available). We also included a question whether the participant had planned to use the existing audio guide before learning about our study, as our self-locating map-based guide is deployed permanently in the museum. In addition to the survey, we conducted short interviews with visitors who volunteered. The qualitative interview included an open question regarding further comments about problems, ideas for improvement, and general experience. Furthermore, we showed those participants all conditions and asked which system they would prefer, and why.

In addition to this participant-provided information, we logged the number of exhibits each participant selected, to quantify how many exhibits were found and listened to.

We assumed that the keypad-based guide would get the highest usability rating (H1) from visitors, due to its well-known and simple metaphor. However, we expected that visitors would select more exhibits using the map-based methods (H2) because of the increased visibility of available audio content. As for the self-localization, we thought that visitors would prefer the self-localizing map to the manual map (H3) as it reduces the number of necessary interactions and provides awareness of information close-by.

IMPLEMENTATION

Our map interface shows a section of the ground map with thumbnails and names of the exhibits with according audio comments at their respective location (Fig. 1). The thumbnails show the entire exhibit, or a prominent detail. To select an exhibit, the user taps on the according thumbnail on the map. This takes the user either to the audio piece for this exhibit if only one piece of content is associated with it, or to a list of all the content this exhibit has to offer. Along with the audio explanation, the guide presents a timed slideshow of corresponding explanatory images.

Localization Technology

We distributed a grid of 41 Bluetooth beacons in a local museum, and use these for quasi-continuous 2D visitor localization by training an SVM on signal strength fingerprints of predefined regions. While a visitor is moving through the museum, the guide measures the strength of surrounding beacons and feeds this information into the support vector machine (SVM) to assign probabilities for possible regions. Once a region has been characterized with the highest probability for five consecutive times, the device is considered to be located in that area, and the map automatically zooms and pans to display this region. If the user adjusts the visible map region manually, the automatic panning and zooming is disabled until the visitor moves physically into a new region (where it then will center again on this region). This approach does not attempt to display an exact location of the visitor in the museum (e.g., by a blue dot) since such precise tracking would require the use of more complex technology.

RESULTS

A total of 84 visitors (47 female) participated in our study. Of these, 30 were assigned to the *keypad* condition, 29 to the *tracking* condition, and 25 to the *map* condition. All but 8 of the participants reported their age, which ranges from 20 to 77 years with an average of 49 (SD=17). Most of the participants reported to own a smartphone (n=62, 74%).

Of all participants, 61 (73%) go to a museum multiple times a year, 15 (18%) visit a museum less often (one even reported this as his first visit). Only 8 participants (10%) visit a museum multiple times per month, none multiple times per week. Only 6 participants (7%) never take an audio guide, 14 (17%) do so occasionally. Most participants take an audio guide every other time (n=31, 37%), 28 (33%) every time one is available. In case of the current visit, 44 participants (52%) had the intention to use the audio guide even before they learned about our study.

All three implementations received high SUS ratings: *keypad* achieved the highest scores (M=92.4, SD=9.12); both map versions scored slightly lower (*tracking*: M=84.5, SD=9.1; *map*: M=84.7, SD=14.5). An ANOVA on log-transformed SUS scores with user as random factor showed a significant main effect of the input method on the SUS score ($F_{2,76} = 4.24, p = .0179$). Post-hoc pairwise Tukey HSD tests show that *map* ($p = .0314$) is rated significantly lower than *keypad* while the remaining differences are not significant. This trend is consistent for every user characteristic we gathered (if the visitor has a smartphone, how often the participant visits a museum, how often she picks an audio guide, and if she planned to take the audio guide on this visit). In all cases, *keypad* received higher or similar usability ratings compared to the other conditions. In conclusion, we can accept H1.

Our assumption that a map enhances the content accessed could not be verified numerically. The average number of accessed descriptions is similar in the *tracking* (M=21.9, SD=8.2), *keypad* (M=19.4, SD=7.9), and *map* (M=20.5, SD=8.5) conditions. However, visitors who always use audio guides access significantly different amounts of content based on the condition ($F_{2,24} = 4.53, p = .0213$). Post-hoc Tukey HSD test shows that those visitors selected significantly more exhibits in the *tracking* (M=26.7, SD=8.1) condition compared to the *keypad* (M=16.3, SD=6.9) condition ($p = .0169$). However, as the overall amount of selected exhibits does not change significantly when using a map representation, we reject H2.

Feedback

After filling out the questionnaire, 20 (*tracking*: 8, *map*: 10, *keypad*: 2) participants agreed to stay for our interview regarding possible issues with the audio guide and ideas for improvement. We showed and explained all three implementations side-by-side and asked for their opinions and comments. Participants that had used the *keypad* version mentioned that they liked the ease of use of this input method, but would like to have some form of overview over available exhibits, either as a list or map.

Participants who had used the *map* implementation found it very useful, and mentioned that they liked the thumbnails because they helped find the according exhibits. However, some requested corresponding numbers next to the exhibits (as in the *keypad* condition) to help find the correct match when thumbnails only showed a detail that they could not find immediately. They were also reserved when asked about the automatic localization and assumed it to be confusing.

In contrast to that, people who used the self-localizing guide found this feature to be helpful. One participant mentioned that it felt a little confusing at first but that she quickly understood the principle. Another one liked the localization feature but was concerned that it might be confusing for elderly users.

Overall, none of the participants that used the *map*-based guide, with or without *tracking*, preferred the *keypad*. In conclusion we accept H3 under the condition that visitors need to experience this feature in order to like it.

DISCUSSION

Based on their SUS scores, all three selection methods tested seem suitable for a museum setting. The *keypad*-based selection of audio content appears to be superior in this regard. An influencing factor might be familiarity as many participants mentioned that this method is well known to them and only requires a simple interaction.

We could not verify our assumption that the visualization of exhibits on the map increases their visibility in general as participants selected a similar amount of exhibits during their visits regardless of condition. That visitors who always take an audio-guide if it is available selected significantly more exhibits in the location-based version compared to the *keypad*-version is an interesting finding. If we assume that this visitor group likes to get as much information as possible during their visit, this could mean that the self-localization enabled them to access more of the content in their vicinity. Alternatively—as this group did not select more exhibits in general—they possibly enjoyed a new interaction technique and used it more because of that. However, their usability ratings for the conditions did not show significant differences.

Our qualitative results suggest that visitors like to see visual representations of the exhibits to match the available content to their real-world counterparts, therefore acknowledging the higher information scent of the map visualization. Furthermore, visitors like to have an indicator beside the exhibit that could both show whether an exhibit has a corresponding audio content available and also assist in connecting the digital information to the exhibit. For an optimal solution, the important channel from the exhibit to the visitor should also be included into the map visualization. In addition, the map allows to indicate *difficult* exhibits with no obvious place to attach a number which, so far, would require a workaround.

DESIGN RECOMMENDATIONS

As a result of this experiment, we recommend a combination of the *keypad* and the self-localizing approach. Similar to our implementation, both thumbnails and physical exhibits should be equipped with corresponding numbers (Fig. 2). This still allows to match content and exhibit if the thumbnail fails, e.g., because the thumbnail can only show a small part of the larger exhibit. Furthermore, this assists the visitor in discovering which exhibits have associated audio content without having to check their guide the whole time (to achieve this link, a headphone icon would be sufficient). The

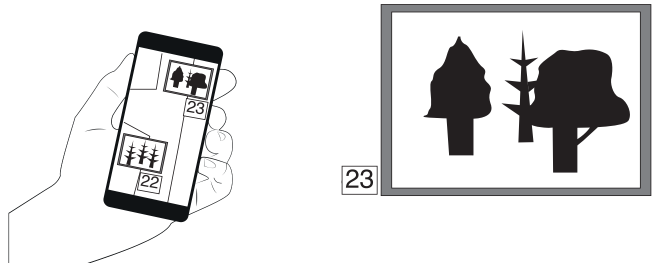

Figure 2. Our design recommendation is to use a self-localizing map-based guide where thumbnails and exhibits are labeled with a corresponding number to provide a channel back to the guide

map and the overview help to discover exhibits that are not directly visible. Modern museums sometimes integrate a notion of exploration into their visits, in which visitors are allowed to pull open drawers or look behind curtains (also noted in [14]), an approach that is certainly engaging but also poses the risk for the visitor to miss something interesting. If all (main) exhibits are represented on a map, the visitor might search a little longer and has a hint what to look for.

The self-localization feature is helpful, but if it is used, it has to work reliably, otherwise this leads to too much confusion. However, with the growing number of people owning a smartphone, automatically localizing the device on a map is a functionality that will be assumed in a modern audio guide. Therefore, we recommend its integration.

CONCLUSION

Many museums offer multimedia guides that allow visitors to explore the museum at their own pace. The traditional approach is to use a number that a visitor has to enter to select an exhibit and get to the associated audio content. This approach does not provide an overview over which exhibits have associated audio content, and some exhibits (e.g., when hanging from the ceiling) may not have obvious locations to place a number. We evaluated a *map*-based approach that visualizes the location of exhibits. As further assistance to the visitor, we also implemented location *tracking* to automatically adjust the map location to the position of the visitor. We tested these three conditions using a field study in a local museum and measured the usability, user preference, and number of selected exhibits. All three conditions received high SUS scores, with the *keypad*-based selection method coming out ahead, likely because of its familiarity. The number of selected exhibits did not differ significantly between conditions. However, visitors mentioned that they liked the visual representation, and none who used a map-based guide preferred the *keypad* version. Furthermore, those who experienced the self-localizing guide found this feature to be helpful. As visitors missed a visual indicator beside the exhibits, we suggest a mixture of the systems: Using a map-based visualization that adjusts to the visitor's location, while providing numbers as visual cues beside each exhibit to link the digital content to it, and also to indicate available content in the real world.

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