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ORIGINAL ARTICLE

Enhancing and evaluating users' social experience with a mobile phone guide applied to cultural heritage

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Abstract We designed and built a mobile phone-based guidance system to support shared group experiences by suggesting the use of an eavesdropping metaphor inspired by Sotto Voce that allows visitors to eavesdrop on each other's audio. Going beyond Sotto Voce, we create a shared experience by synchronizing the audio controls of all people who are eavesdropping on each other. Our contribution is the design of a mobile phone guide for cultural tours that combines a linear tour with in-depth information exploration, GPS-based maps offering group awareness, simple content customization and suggestions, and fluid movement between individual and ad-hoc group touring. The most important contribution is the design of a simple sharing scheme that gives all users in an ad hoc group implicit control over the audio content of everyone currently linked together. We evaluated our approach using data collected from participants, and our results validated the effectiveness and usefulness of our sharing scheme and interface for group experiences. In addition, we gained an understanding of how sharing information during visits to cultural heritage sites by socially related people influences the visiting experience; differing mutual eavesdropping and content control behaviors emerged according to group types (family vs. friends). By enabling groups to share their experience on-site, our system should increase the appeal of mobile phones as electronic tour guides, providing adequate support for shared group experiences.

Keywords Mobile entertainment · Cultural heritage · User experience · User evaluation · Social interactions

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1 Introduction

With ongoing advances in location tracking and computing power in mobile phones, there have been corresponding developments in mobile entertainment media, with numerous projects aimed specifically at creating computer-based tour guides for historic locations (e.g., [1–12]). While the feasibility of using mobile phones as tour guides in cultural heritage sites requires a variety of technical challenges to be solved (e.g., power requirements, computation limits, and network connectivity), to be effective, these tour guides should also tailor the users' experience by supporting interaction of and between visitors. This issue is especially important in cultural heritage sites, which are often visited in small groups, mainly by families and friends.

There is often a vast amount of information tying a heritage site to culture, art, history, and the visitors themselves. To maximize the quality of visitors' experiences in visiting cultural heritage sites, technologies for visitors have been researched and commercialized since the late 1950s, when a tour of Eleanor Roosevelt's home was

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created using tape players [13]. Since then, electronic guides have become the primary providers of auditory and visual information for visitors. Unfortunately, individual guiding devices prevent groups from sharing their experiences, which should be a high priority for any guidance system [6].

Our work builds on a previous research project a mobile audio tour of the Historic Oakland Cemetery in Atlanta: The Voices of Oakland (VoO) [8]. While the first VoO prototype was successful in many ways, we wanted to implement a more complete mobile system without behind the scenes "Wizard of Oz" monitoring and control. Furthermore, based on feedback from the first study, a major goal of our new prototype was to support group experiences, rather than to provide each visitor with an isolated, albeit rich, experience. Our second major goal addressed the desire of previous participants to better control the categories of content of the tour and to get content elements tailored to their interests. Thus, here, we cover more interesting graves along the tour route and supply visuals to accompany the audio. We also support social interactions by enabling the visitors to share media content selectively and interactively within a small group.

Unlike the VoO mobile audio tour, we implemented our guide entirely on a Java-enabled phone. The guide provides audio and visual content tailored to the users' movements (GPS), inputs, and demographic data. The guide includes a socially acceptable eavesdropping scheme implemented via wireless networking. For group awareness, we present users with egocentric maps that show them their location, nearby interesting graves, and the location of friends and family members. The current implementation has two kinds of customized content (suggested by the demographics and interests taken from their user profile): suggestions of "off-tour" graves of potential interest and autoplay of the 1st audio clip corresponding to the interests at a specific grave. Personalization is limited by the difficulty of creating a large amount of rich content, but could be easily extended in a commercial implementation. We developed and deployed two prototype tours using our phone-based tour guide: an extended version of VoO in Oakland Cemetery in Atlanta and a new tour at the May 18th National Cemetery[1] of Gwangju (South Korea). In this paper, we present our evaluation at the new tour site.[2]

To encourage social interactions, our tour supports shared group experiences. Most visitors come to the cemetery in groups—from small groups of friends or relatives, to entire school buses of children on class trips. A major failing of most electronic tours is their inadequate support for shared group experiences. We designed our system to support group coordination by allowing members to see each other on a map and, inspired by Sotto Voce [6], to eavesdrop on each other's audio stream. However, going beyond Sotto Voce, we enable group members to create a shared experience by synchronizing the audio controls of all people eavesdropping on each other; if anyone pauses, everybody pauses, etc. This shared functionality is available to all the members of a group; rather than building complex permission schemes, we rely on social negotiation among the groups to prevent disruptive behaviors. Of course, this feature should be modified for application to large groups with asymmetric responsibilities, such as teachers leading a group of schoolchildren.

Our contribution is twofold. First, our global design based on both our and others' previous research combines a balanced set of functions and content structures that can be implemented and deployed today. We go beyond previous designs of cultural tours by combining a linear tour with in-depth information exploration, GPS-based maps providing features to enhance group awareness, simple content customization and suggestions, and fluid movements between individual and ad-hoc group touring. Second, our sharing scheme with mutual eavesdropping and content control is novel and attempts to address the most common complaints linked to computerized tours.

2 Related work

Numerous research prototypes and commercial products attempt to create hand-held electronic guidebooks aimed at improving cultural heritage experiences. First, we summarize key projects that particularly focus on social dimensions and then point out commercial work. Many mobile tour systems use location awareness (e.g., [1, 11, 14–17]). The ARCHEOGUIDE project [12], like many other tour guides [1–5, 9, 10, 18–20, 31], attempts to enhance the experience of historic locations using user context. Our work attempts to overcome the inherent limitations of electronic guidebooks that focus on individuals rather than on groups.

Sotto Voce [6] is an electronic guide supporting social interactions between visitors and their companions using an eavesdropping metaphor that allows visitors to split up then naturally come back in sync, but only for short-term shared experiences. The Lighthouse project uses voice communication to facilitate collaboration between physical and virtual visitors at museums [3]. Supporting information delivery among groups, ArtLinks [21], is a guidance system based on a public display associated with an exhibit and allows visitors to create and use tags as ways for visitors' participation in museum guidance; it aims to encourage

[1] http://www.kdu518.mpva.go.kr/.

[2] We were unable to evaluate the extended version of VoO due to a tornado hitting the cemetery just before our scheduled evaluation.

social interactions and enhance experiences by supporting visualization of people, words and their connections related to an exhibition. Similarly, MobiTag [22] is an electronic guide that supports semantic, social, and spatial navigation in museums by allowing visitors to create and vote for tags.

Many projects aim at enhancing group tours with gaming concepts. CoCicero [23] is a multidevice museum guide that supports cooperation among visitors through games suitable for schoolchildren, pushing people to collaborate and socialize. Kurio [24] is a museum guide that supports families and small groups visiting museums, providing missions such as gathering knowledge required for the map. Minpaku navi [25] is an interactive museum guide system for families and small groups at Japanese museums, allowing them to play quizzes related to the objects in the museum.

We support social interactions through information delivery rather than gaming. We started from the ideas in Sotto Voce, building a very simple interface that avoids controls such as sending/receiving of commands or connecting/accepting/rejecting collaborative experiences with specific visitors like friends or family; while such interactions may appear simple, they break the flow of the experience. Our design is different from Sotto Voce in that we allow visitors to control each other's audio experience when eavesdropping. We believe that most disagreements resulting from a lack of security will be resolved socially.

Antenna Audio [26] supplies museums, historic sites, and cultural attractions worldwide with audio-visual interpretive tour solutions using a wireless hand-held device. For example, the High Museum[3] of Atlanta has adopted an Antenna Audio solution to develop tour guides for its exhibits [20]. Their systems are designed for large groups and lack the flexibility of our approach. Their solutions are aimed at enhancing the experience of each individual visitors through intuitive controls, high-quality audio, and non-linear, self-paced viewing. Eyeled supports localized mobility—position is determined with infrared beacons installed throughout the museum, transmitting unique identifiers [27]. In Berlin, the Mauerguide project [28] lets visitors trace the history of the Berlin Wall by means of multimedia and of a GPS-enabled PDA. While these systems use custom hardware or PDAs to enhance users' experience, we use standard mobile phones that support location awareness and rich user-friendly interfaces. As they become more powerful, phones are likely to become the platform of choice for museum tours. Antenna, for example, already includes a service letting customers download audio tours onto their phones. If people use their own devices, the providers for historic sites will not need to invest in hardware management and support.

[3] http://www.high.org/default.aspx.

3 Mobile phone prototype

Building on our early evaluations, we completed a mobile phone application that includes and extends the features of our wizard-based prototype. In this section, we describe early prototype evaluations and current implementation of our mobile tour guide for a cultural and historical site.

3.1 Early prototype evaluations

The Voices of Oakland mobile audio tour was programmed with Macromedia Director on a small PC with a "Wizard of Oz" interface to select audio segments as users move through the cemetery [8]. The wizard wore headphones and used a Tablet PC to communicate wirelessly with the user's backpack computer. During that user study, we collected GPS data for our evaluation, but did not use it to trigger audio segments, since the wizard controlled what the user heard. Our evaluations informed the iterative design of that prototype and guided the design of the current system. From these evaluations, we extracted design goals regarding visual content, navigation, content diversity, group experience, and the platform.

Our early studies showed that an audio-only system fails to keep users visually stimulated. While museum displays tend to cluster related artifacts, natural historic sites present unique design challenges as historically interesting artifacts may be far apart, deteriorated, or unnoticeable. This problem is particularly acute in cemeteries, where interesting residents may be buried beneath non-descript headstones. Our newest system incorporates a small visual display and provides images of historical figures to supplement the audio narratives.

While our early user studies did not reveal navigation problems (likely because few stops were on the tour), some users expressed a desire for a better sense of location in the cemetery. Taking advantage of our visual interface, the newest prototype includes a GPS-based map of the environment that shows visitors their location, friends' locations, and nearby landmarks. The GPS is only used to place and center the content elements on the map; the audio-visual media tour can function without it. To address users' desire for more content, we expanded the number of story nodes from three graves to nine. We also provided additional ancillary content throughout the tour.

To support groups, we enabled visitors to find out what other group members are doing by locating them on the map and "eavesdropping" on them. While eavesdropping, a user sees and hears the same content as his/her friends. Unlike in Sotto Voce, however, the eavesdropper can also control the tour for group members. This allows group members to "join up" and take a tour together, pause to talk, or skip content. At any time, an eavesdropper can return to his/her previous tour location and resume from there.

Users were reluctant to carry around a backpack computer with an antennae and a game controller to navigate contents [8]. For the newest prototype, we used, instead of a Nokia N95, a J2ME-capable mobile phone with a built-in GPS. Besides, we exploited a more accurate external GPS device (to improve signal stability and accuracy) and asked testers to wear a single earphone, leaving one ear free for conversations. We first checked the performance of our system with objective measures and quantitative analyses [30]. In this paper, we evaluate the system design through formal user evaluations, subjective measures and qualitative analyses, especially focusing on the “sharing” feature. Ultimately, the J2ME implementation can be ported to diverse devices and lets ordinary visitors download the tour application onto their own phone on-site [29].

As an initial verification of system effectiveness, we have done objective measures and quantitative analysis for the performance evaluation of the implemented system [30]. In this paper, we present subjective measures and qualitative analysis of the system design and especially sharing feature through formal user evaluation.

3.2 Device details

Our cemetery tour guide was programmed on a Nokia N95 with Java 2 Micro Edition (J2ME), using the Sun Java Wireless Toolkit for CLDC version 2.5.1. To support real-time in-group eavesdropping, the N95s communicate with a server over the WLAN using Internet protocols (TCP/IP). To obtain location data without the extra installation of sensing equipment on-site, we adopted the built-in GPS of the N95, as well as a Bluetooth-enabled GPS device (the HoluxGPSlim 236 Bluetooth GPS receiver) that users could carry with their mobile phones to increase signal stability and accuracy. The mobile phone transfers the GPS data to the server via WLAN. The Nokia N95 has a 240 × 320 mm display, similar to most PDAs. Some phones and PDAs use touch screens for direct manipulation and rich interaction, but many phones only feature traditional keypads. To support the widest range of devices, our design minimizes redundant or insignificant features, allowing us to control the interface with a typical phone keypad.

3.3 Basic functions and interface

When visitors start the tour application, they enter basic user demographic information (name, age, gender) and their level of interest for various themes. Any user can choose to create a new group. Only one group can be joined at a time, but users can join a group at any time during a tour. The visitors are guided from grave to grave by navigational audio clips that lead them along the main tour path. Users can control the playback of all audio clips (pause/replay, previous/next, volume up/down, etc.) using the keypad. We avoided menus where possible by mapping the functions to the keypad in each of the two modes of the tour (see Fig. 1). The functions mapped to keys in both “map” and “grave” modes are described in Fig. 1a and b, respectively. When the visitors have finished navigating from one grave to another, they can listen to the thematic audio clips about each grave while viewing related visual media (see Fig. 1b). While listening to thematic content at a grave, the visitors can go back to the map screen and browse the map (see Fig. 1a). If a user selects a grave when viewing the map, he/she is taken to the grave screen where related audio-visual content can be explored. The sharing functionality allows multiple visitors to experience and control a tour simultaneously by toggling the “sharing” button.

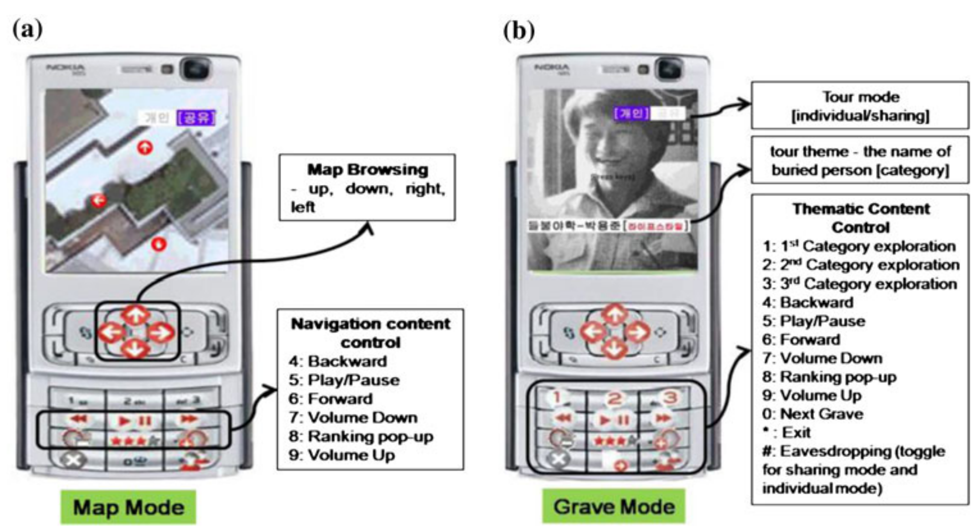


Fig. 1 User interface of our mobile phone-based tour guide **a** on the way to a grave and **b** at a grave. **a** a map of the cemetery with arrows indicating users' location and with a navigation icon, including the navigation content control interface. **b** Photograph of a person with the theme of the tour, name of the deceased, and category, including the thematic content control interface

3.4 Sharing with mutual eavesdropping and content control

The most important aspect of our work is our support for social interactions, letting visitors share their experiences by implementing “eavesdropping and content control”. Visitors may eavesdrop on group members to see whether they are listening to something interesting, then perhaps meet them at their point in the tour. When someone eavesdrops on a group member, the two clients become synchronized in “Sharing mode”. The notifications of “Sharing mode” are not pop-ups (that need to be dismissed or otherwise interacted with), but small status overlays. In “Sharing mode”, eavesdropping occurs: the user sees and hears the same content as his/her friends. Users can see they are synchronized, and after eavesdropping, any of them can control the content or disconnect. If a third person eavesdrops, the three see they are synchronized. Synchronization works only in “Grave mode”; in “Grave mode”, all users see the same visuals corresponding to the current audio clip that is synchronized. Users can thus browse the map in “Map mode”, while the audio is playing. If someone switches to another grave while synchronized, everybody switches to the new grave.

The state chart in Fig. 2 shows the possible state transitions of the synchronization manager (SM) for sharing content among group members, along with the methods called during transitions. When a user creates a group, the SM creates a new group in a “created” state. The state changes to “left” or “removed” according to subsequent actions. The “sharing” mode of the group is inactive until a request for eavesdropping arrives from a group member; the state of “sharing” mode changes from “inactive” to “active”. The sharing mode has two submodes: “mutual eavesdropping” and “content control”. When a user selects the sharing functionality, he/she first hears her companion’s audio clip and can immediately begin to control the audio. In other words, as soon as sharing is activated between a group of users, they are synchronized and controlled the group audio. If anyone in a group gets out of this mode by toggling the “sharing” button, the synchronization is broken, and their state is changed to “destroyed”; that user then resumes his/her individual tour where it stopped when he/she entered the “sharing” mode.

Transitions between “sharing” and “individual” modes are completed with minimal user intervention, as illustrated in Fig. 2. We explain the processes from the user’s point of view and from a technical point of view to offer a comprehensive description. First, users can host or remove a group with their phone identifier. Alternatively, they can join or leave a group at any time during a tour. When selecting the join option, the users are presented with the list of available groups. The SM processes group actions such as create/remove/join/leave from a client and requests response from a server. Users belonging to a group can use the sharing functionality. This simultaneously heightens users’ experience and allows the control of a tour. Anyone can eavesdrop on anyone within their group, at any time without permission. However, users are notified of eavesdropping, possibly from multiple users at the same time. The SM registers a client to the “push-onto-client” thread in a server, which involves automatic notifications, dynamic updates of the phone states, and content for synchronization in the sharing mode.

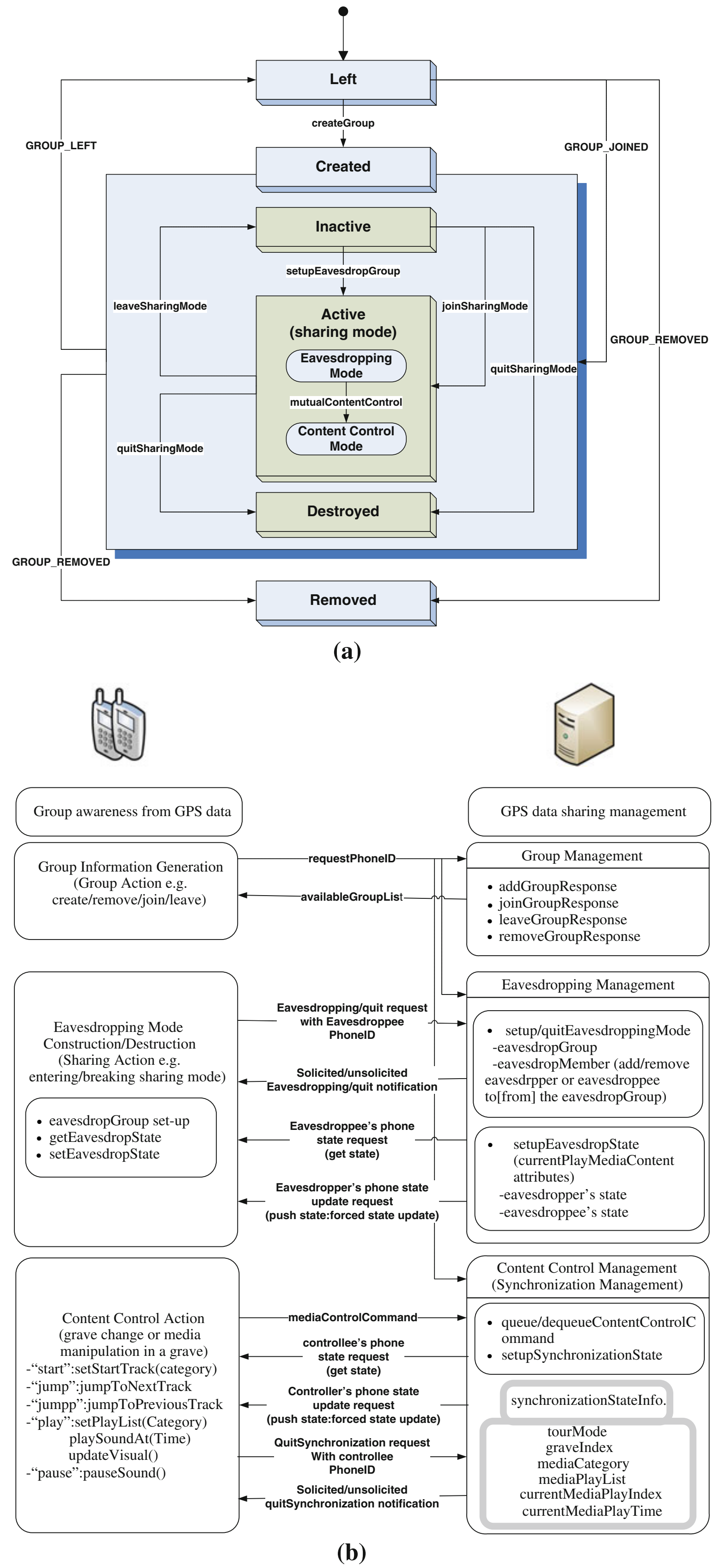
After registration, the server creates a dedicated thread that periodically checks the database for new eavesdropping requests. If a client issues a new request matching the subscribed eavesdropping group (e.g., the setups for a eavesdropping group are finished), the thread creates a sharing data key with the description of the eavesdropping group, member, and state, stores the data in the database, and notifies all tour subscribers through wireless network. In this step, the notifications are either solicited (in the case of eavesdroppers) or unsolicited (in the case of eavesdroppees). Finally, users can go further and control the content after the eavesdropping mode is established. If a synchronized user controls their device, everybody sees the same content; if he/she switches graves while in synchronization, the others will switch graves as well.

GPS positions are shown on the screens of the group members. Whenever somebody releases content control and breaks the eavesdropping connection, the SM checks the database for new control commands (e.g., grave change or media manipulation for the current grave). Those commands are internally parsed to produce the key information to be synchronized such as tour mode, grave index, media category, media playlist, current media play index, and current media play time. Then, the SM processes the notifications and states updates for all synchronized clients.

Our audio-sharing metaphor is similar in spirit to the functionality of Sotto Voce, but differs on subtle yet significant ways. In Sotto Voce, paired visitors share audio content as follows: when visitor A selects a specific object on his device, he always hears his own audio clip about the object. If A is not currently playing an audio clip, but his companion B is, then B’s audio clip can be heard on A’s device. In other words, personal clips are preferentially played. Instead, visitors with our system can freely pause personal clips to eavesdrop on others’ clips then resume their personal clip.

Moreover, there is an important difference in how we designed audio synchronization for sharing. In Sotto Voce, if both A and B listen to personal clips and A’s clip ends first, then A will hear the remainder of B’s clip as if it had “started in the middle”. We rather allow visitors to control others’ audio experience. For example, if an eavesdropper A wants

Fig. 2 State transitions and process flows of the synchronization manager for sharing content among group members. **a** State transitions **b** Process flows



to share a clip with user B, user A simply has to select it, since all “synchronized” listeners implicitly control what others are listening to. We believe that difficulties or disagreements that result from such interactions can and will be resolved socially. By relying on social negotiation, rather than an elaborate security and permission scheme, the tour interface remains simple and transparent while providing much flexibility. We decided not to synchronize the displays in the “Map mode” because doing so would prevent people from doing other things while synchronized, such as browsing nearby graves. To clarify, while user A eavesdrops on user B, he/she can still look at the map to scan around the cemetery and find interesting graves; user B’s display should not display the map checked by user A.

4 Experience observation and evaluation

Our mobile tour guide seeks to enrich group experiences at cultural heritage sites by supporting social connectedness. In this section, we present how we conducted a user study of our guidance system at a cemetery and report the results of this study.

4.1 Study design rationale

We observed the participants’ interactions with our prototype to determine its strengths and weaknesses. Our basic contribution is the global design of the phone-based guide for cultural tours, combining a linear tour with in-depth information exploration, GPS-based maps providing features to enhance group awareness, simple content customization and suggestions, and fluid movements between individual and ad-hoc group touring. Our most important contribution is the content-sharing scheme of mutual eavesdropping and control with the sharing interface, a novel design addressing the most common complaints about computerized tours.

Aoki et al. suggest tour guidance should balance the interaction demands of three primary entities: the information sources, the visitors’ companions, and the physical environment [6]. In our evaluation, we embody this principle, focusing on the spatial, personal, and social aspects of a visit and bringing together the location data about visitors, user profiles, and the interests and activities of their friends. Accordingly, we wanted to validate a general initial set of requirements reflecting the spatial, personal, and social aspects of tours with a pamphlet, human guide, or our current prototype. Thus, we categorized the evaluation criteria as spatial, personal, and social. We developed a questionnaire (objective and subjective) and subsequently interviewed participants to elicit information on satisfaction after three tours.

Cyberguide [1] regards tour guides as cartographers, librarians, navigators, and messengers. When developing questionnaires on the spatial aspect, we found it useful to include the three first roles due to the generic functions tourist wish when exploring sites. For the personal aspect, we integrated issues from GUIDE [4], an intelligent electronic tourist guide to present city visitors with information tailored to their personal and environmental contexts.

We use the questionnaires to measure the social aspect, referring to design principles of the following: (1) group decision support and (2) context-aware systems. Content sharing among group members during tours has similarities with group decision support, as multiple users make decisions together and share the results [32]. We also added criteria from guidelines that context-aware systems must embody to support “accountability” when mediating user actions that impact other people [33]. The questionnaires investigate both the usefulness of the decision-making procedure during content sharing, and the users’ satisfaction after content sharing. Table 1 shows the resulting evaluation criteria and questionnaire items.

For the verification of our content-sharing scheme of mutual eavesdropping and control with the sharing interface, we investigated different types of groups to extend our understanding of how sharing information among related people at cultural heritage sites influences visiting experiences. We were particularly interested in verifying that our design facilitates group interactions. In addition, we wanted to validate our simple, transparent, and flexible interface for group tours.

4.2 Experimental setting

We deployed our prototype at the May 18th National Cemetery[4] of Gwangju (South Korea), location of an annual memorial service recognizing a grassroots struggle, a civilian uprising calling for democracy that refused to accept militarists led by Jeon Du Hwan (who schemed to illegally take control during a vacuum in power following an assassination). During the movement, citizens sacrificed themselves to defend Korean democracy. We selected the theme “A Man of Staunch Principles” as a main tour story, concerning patriots affirming that enlightened people are the driving engine for democratic development. Nine graves form story nodes, three are main-tour gravesites and six are off-tour gravesites. The audio segments of the main graves are arranged into three categories of content, allowing users to hear a basic story then access details; the additional graves have uncategorized content.

To support mutual real-time eavesdropping and control within a group, paired N95s communicate with a server

[4] http://www.kdu518.mpva.go.kr/.

Table 1 List of evaluation criteria and measurement items

Evaluation criteria		Questionnaire items
Questionnaires about the pamphlet, human guide, and system (5-level scale)		
Spatial	• Guide to next grave	• It is adequate to guide you from one grave to another
	• Useful information	• It is useful to get access to all the information about graves that you might encounter along the tour path during the visit
	• Easy-to-find	• You can have intimate knowledge of the physical surroundings, such as the location of graves, interesting graves within a tour path, or pathways that you can access
Personal	• Preferred	• You are satisfied with interests of the media content at offered each grave
	• Informative	• You learnt various facts about the people buried
	• Understanding	• You can have a clear understanding of the deceased's identity and of the associated historical events
	• Easy selection	• It is useful to decide the next grave and select content
Social	• Easy-to-use	• It is easy to share information with others
	• Co-understanding	• It is useful to share content in order to understand the tour with others
	• Communication	• Sharing content usefully contributes to conversations with others
	• Negotiation	• Sharing content usefully contributes to negotiations of what to listen and see next with others
	• Experience sharing	• Sharing content usefully contributes to sharing of visiting experience, being aware of others' interest
	• Controllability	• Switching to individual from group mode usefully contributes to freely tour in your own pace
	• Group awareness	• It is useful to tour together with group awareness through companion's position
Overall satisfaction		• I'm globally satisfied with the tour to enrich the experience of visiting a cemetery
Questionnaires about our system		
Contents		• Are there parts of the script that seem particularly long? Short? Confusing? Rushed? Exciting?
		• Which graves did you find most interesting, and why? How did you feel?
		• Was there anything you wished to know more about?
		• Were the contents what you expected (in this context)? Is this the type of experience that you would like to have in historic sites?
		• Was this experience engaging? If no, what prevented you from being immersed?
Story flow & navigation		• How important is it for you to be able to wander away from the main story line to explore other points of interests?
		• What is the best way to facilitate leaving and coming back to the main story? How much flexibility should be allowed in the experience?
		• Were the navigational audio clips that guided you from grave to grave adequate? Did you get lost when moving from one dedicated grave to another?
		• Would you like navigational commands for when you leave the path to explore other graves?
		• What is the best way to navigate such experiences: Finding points of interest by navigating freely, taking a guided tour, or sitting somewhere to listen to the stories?
Interaction & Interface		• Would you prefer to control content by using a mobile phone (as input device)?
		• Was the audio-only experience appropriate? Are visuals helpful?
		• What type of media would you want for such experiences: Audio only, visual only, audio & visual, or something else?
		• Did the audio tour differ from other audio tours you have done? How?
		• Could you hear the sounds/voices well? Is the mobile phone you are carrying portable? Are the headphones comfortable? Was it easy to manipulate the mobile phone (as input device)?

Table 1 continued

Evaluation criteria	Questionnaire items
Overall	• On a scale from 1 to 5, where 1 is "I never want to do anything like this ever again" and 5 is "This was the best thing ever", how would you rate the overall experience? • How would you rate the quality of the audio and visual content (on the same scale)?
Post-study interviews	
1. Describe your overall experience using the device while touring the 5.18 Cemetery	
2. Explain how you used the device	
3. Describe the unique features of the device. Did you use any?	
• A. If yes, can you explain about it in detail?	
4. Describe problems with the device. Did you have any difficulty?	
• A. If yes, can you explain about them in detail?	
• B. Describe the features you did not like	
• C. Describe why you did not like them	
• D. Describe what features seemed difficult	
• E. Describe why you felt they were difficult	
5. Describe features you liked about our system. Did you use any?	
• A. If yes, explain them in detail	
• B. Describe the features you liked	
• C. Describe why you liked them	
6. Did you interact with other people?	
• A. If yes, describe in detail how and about what you interacted with others	
7. What suggestions do you have to improve the design?	

through an infrastructure-based wireless network with an access point (sufficient for our small-range setup). Figure 3 shows users participating alongside the hardware setup.

4.3 Subjects and procedure

First, we utilized the assistance of the administrator who keeps the results of a documentary survey in a visitors' book to investigate the demographic characteristics of typical visitors at the May 18th National Cemetery. We found several categories, including people interested in a civilian uprising calling for democracy in the "20–35" age range, relatives of victims buried in the cemetery across a wide range of ages, and citizens of Gwangju in the "40–60" age range wanting to look back on that time. The small groups comprised close visitors (e.g., mother/daughter or friend/friend pairs). The large groups are school groups, which would require a different system, and were thus ignored in our study.

We recruited 18 participants, 4 individuals and 14 people who took the tour in pairs (4 groups of 8 people for friends and 3 groups of 6 people for families). All

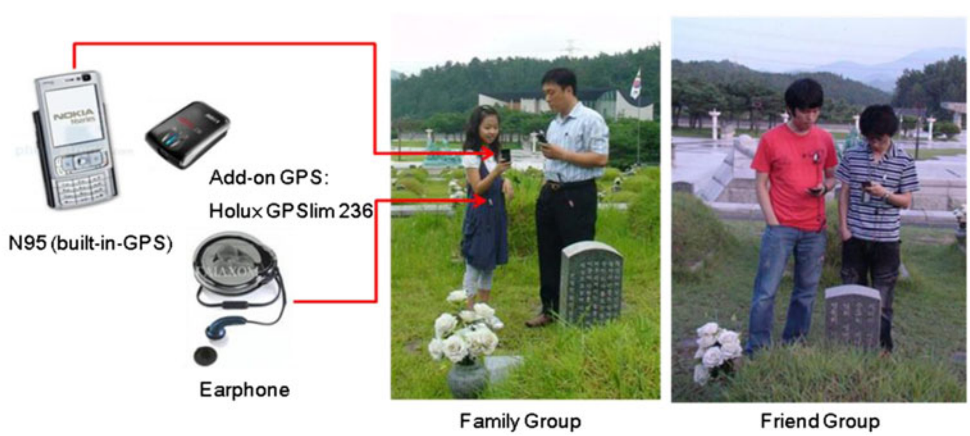


Fig. 3 Users participating in group tours with our hardware

participants participated in this study on-site in the May 18th National Cemetery. Each family group consisted of a parent (40–50 years old) and a child (11–16 years old); each friend group (20–35 years old) consisted of similarly aged persons.

We conducted our study with the participants at the May 18th National Cemetery in 2009, which usually offers two types of guidance: pamphlets and human guides, without electronic guides. To verify the effect of our system, we asked each group to experience the pamphlet, a human guide, and our system on the same zone over a period of a few weeks; to counterbalance order effects in our within-subjects design, we assigned subjects to each type of guide as follows: 6 subjects started with the pamphlet, 6 subjects started with a human guide, and 6 subjects started with our system. Each tour was divided into three common sessions.

4.3.1 1st session: preparation

Before starting, the participants were taught how to tour with the pamphlet, human guide, and our prototype; they were also given a brief presentation on the background and history of the cemetery. The participants were asked to take 10 min to get familiar with our system.

4.3.2 2nd session: visit

The participants were asked to do each tour with the pamphlet, human guide, and prototype for up to 20 min. During the tour with our prototype, the system logged in background data such as the user's location during the tour, commands and media playing time, group activities, and sharing.

4.3.3 3rd session: post-visit questionnaires

After each tour, the participants filled in questionnaires about the spatial, personal, and social aspects of the tour. In addition, we conducted interviews of up to 20 min with the participants regarding their experience. For the last tour, the procedure lasted up to 30 min, as we conducted semistructured interviews, focusing on experience with the system and its design/interface.

To understand the impact of our scheme on their experience, we studied pairs of visitors. The content control was optional, and visitors could stop using at any time after eavesdropping. We studied how much or often pairs of visitors used mutual content control.

4.4 Data collection

For the quantitative and qualitative analyses, we prepared questionnaires, carried out post-visit interviews and logged data related to our observation factors. Table 1 lists the evaluation criteria and measurement items used in the questionnaires. For the quantitative analysis, we logged the user's location during the tour, commands and media playing time, group activities (group creation/joining/leaving), sharing (eavesdropping, control), and specific sharing functionalities.

4.5 Results and analysis

4.5.1 Overall system design

Most participants preferred our prototype to the pamphlets and human guides. As shown in Fig. 4d, most users favored our system for the personal and social aspects but not for the spatial aspect. Specifically, most users favored the human guide over the pamphlet and our system with respect to "easy-finding" even though users equally enjoyed "guide to next grave" and "useful information" subitems in the human guide and our system (Fig. 4a). The subjective questionnaires show that browsing visual maps with navigational audio clips is less effective than using a human guide. One difficulty with our system arises from the effort required to find where one is by browsing the map with the cursor (since we do not keep the map centered on the user's GPS location).

However, most users favored our system with respect to "personal" subitems and showed higher satisfaction, especially as "preferred tour" (Fig. 4b). Most users also favored our system in respect to "controllability", although users equally enjoyed human guides and our system with respect to easy-to-use, co-understanding, and communication (Fig. 4c).

To test statistical significance, we performed repeated measures analyses with a within-subjects design. When comparing the three tours, the differences are significant: the paired t-test of a pamphlet and human guide ($t = -6.23$, $p < .05$), of a human guide and our system ($t = -2.15$, $p < .05$), and of a pamphlet and our system ($t = -6.78$, $p < .05$).

Our system was superior in the social aspect, especially with respect to "controllability" (Fig. 4c). Here, "controllability" implies freedom to switch between individual and group modes. During the interviews, most participants indicated they enjoyed being able to easily be in both the individual and group modes while using our prototype. Thus, most users are most satisfied with our system; still, other solutions may offer good experiences in different settings.

Family members and friends showed different overall and social satisfaction, as Fig. 5 shows. The friend group favored our system, whereas the family group preferred the human guide to our system by a narrow margin. To test

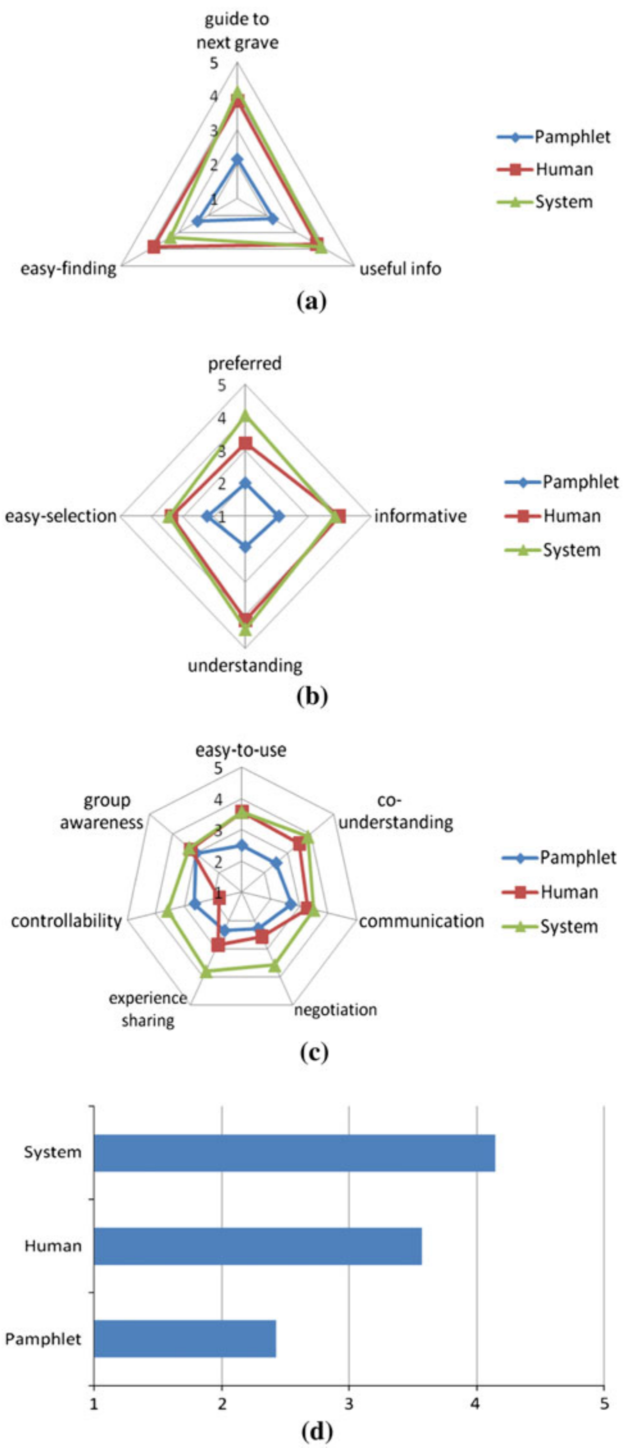


Fig. 4 Comparative satisfaction for a pamphlet, human guide, and our system. **a** Spatial aspect. **b** Personal aspect. **c** Social aspect. **d** Overall satisfaction

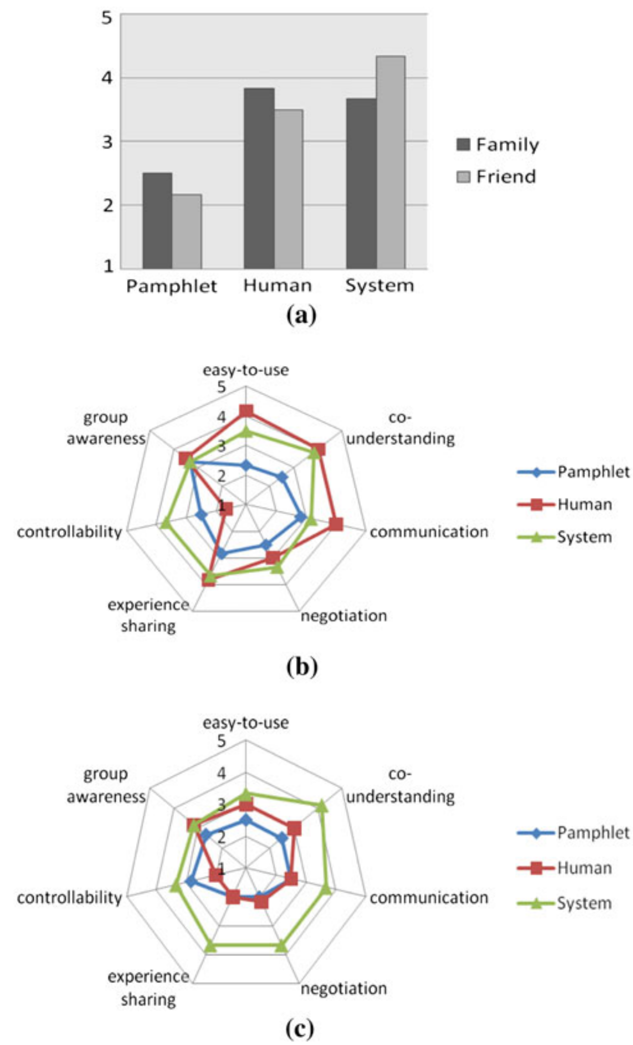


Fig. 5 Comparative satisfaction for the overall and social aspects between family members and friends. **a** Overall satisfaction. **b** Satisfaction for the social aspect: family. **c** Satisfaction for the social aspect: Friends

statistical significance, we would need more participants for a two-factor mixed-design analysis of variance (ANOVA) with three different tours as the within-subjects variable and two different groups as the between-subjects variable.

With the exception of "negotiation" and "controllability" among all "social" subitems, the family group preferred the human guide to our system. In contrast, the friend group always favored our system, especially with respect to "co-understanding", "communication", "negotiation", and "experience sharing". As for "controllability", both groups preferred the system, and the pamphlet is favored over the human guide.

4.5.2 Sharing functionality

We analyzed the logged data to understand how people shared and controlled content. We compared how each group perceived sharing features and used specific functions, such as eavesdropping requests, unsolicited eavesdropping notification, content control, eavesdropping

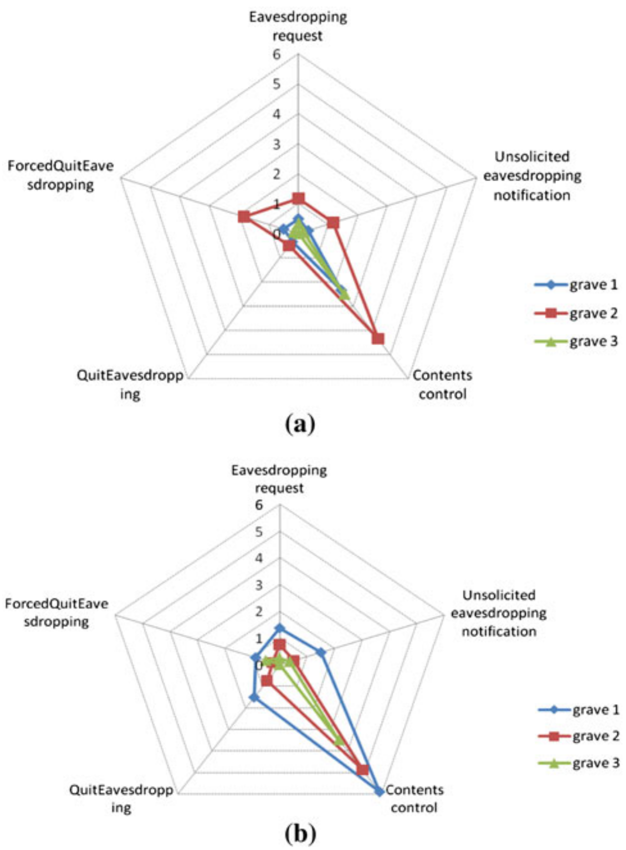


Fig. 6 Sharing behavior according to group types at each grave. **a** Family. **b** Friends

quitting, and forced quitting of eavesdropping. We describe each function as:

- Eavesdropping request: someone chooses to eavesdrop on a group member (go into sharing mode).
- Unsolicited eavesdropping notification: eavesdrop members consist of eavesdropper and eavesdroppee. The notifications of setting up eavesdropping are either solicited (in the case of eavesdroppers) or unsolicited (in the case of eavesdroppees).
- Content control: after eavesdropping, any group member can control the media file (audio, image) through media manipulation actions. Then, all members are synchronized.
- Eavesdropping quitting: someone stops eavesdropping on a member. (go into individual mode)
- Forced quitting of eavesdropping: the notifications of quitting eavesdropping are either spontaneous (in the case of terminator) or forcible (in the case of the other members).

As shown in Fig. 6, many users actively controlled content at all graves and continued to interact with our system by entering or breaking the sharing mode either spontaneously or forcibly. Considerable differences exist for mutual eavesdropping and content control according to the group types (family vs. friends). Mutual eavesdropping and content control were more common among friends than within families. However, at the second grave, the families used mutual eavesdropping more than friends. During the interviews of the family group, children said they occasionally used eavesdropping to know what their parents were interested in and listened to. A parent used eavesdropping to continuously observe what his/her child was listening to. Active control behavior occurred at grave 2 in the case of the families and grave 1 in the case of friends, which implies that the friends adopted our technology quickly; a fact confirmed during the interviews. The families needed time to get used to our system.

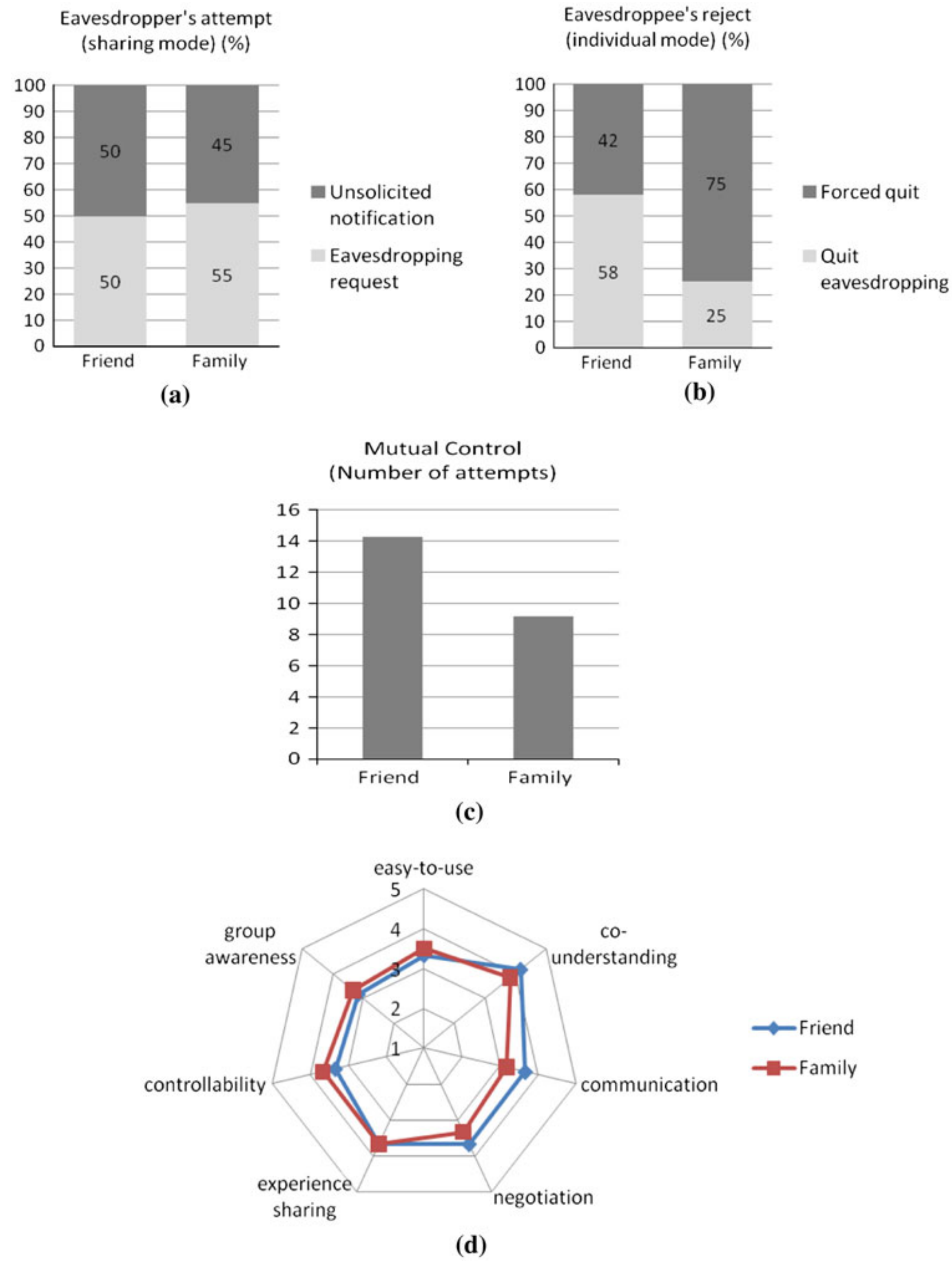
During the interviews of the family group, the parents said they rarely tried to control the content, since their children (14–16 years old) did not want to be disturbed by their parents. The children also wanted their parents to respect their own preferences and wanted to stay in the individual mode. Still, they used the mutual control function to decide together what to listen to next by verbally asking each other's willingness to accept/reject the content synchronization.

During the interviews of the friend group, some commented that they attempted control to elicit their friends' opinion about the content. For example, a user let his friend listen to a certain clip of "the interview while alive" category to see whether it was recorded as a real human voice or it simply made sounds like the human voice. Some wanted to recommend things that might interest their friends, another would share interesting clips if friends needed too much time to reach it through the interface when arriving at the grave. Others wished to get the most impressive content when arriving at a grave but ignored what to listen to first.

The absolute amount proportion in "Eavesdropping request" to "Unsolicited eavesdropping notification" at each grave differs between the groups. However, their frequency is similar because they function in pairs. Interestingly, the frequency of "ForcedQuitEavesdropping" versus "QuitEavesdropping" differs between the groups. Figure 6 provides more details.

Figure 7 shows the reaction patterns to disagreements resulting from a lack of security, according to group types, with respect to our sharing interface. The usage percentage of the eavesdropping request pertains to how many times the users wanted to spontaneously be in the sharing mode. The unsolicited eavesdropping notification pertains to how many times the users forcibly entered the sharing mode. Both groups requested eavesdropping and got unsolicited notifications with similar percentages (Fig. 7a) but with different motivations. The families showed a distinct pattern: the parents eavesdropped much as passive observers;

Fig. 7 Reaction to disagreement that results from the lack of security according to group type (family vs. friends). **a** Eavesdropping requests. **b** Request rejections. **c** Mutual control. **d** Satisfaction about the social aspect of our prototype (from questionnaires)



the children actively controlled content with little eavesdropping. The children requested eavesdropping to let their parents listen to their clips, not to know what their parents were doing. The friends seemingly requested eavesdropping to give recommendations through content control and to solicit comments; they were active controllers rather than passive observers.

The friends broke synchronization to leave the sharing mode spontaneously 58% of the time and forcibly 42% of the time (Fig. 7b). The family group quitted eavesdropping spontaneously 25% of the time and forcibly 75% of the time (Fig. 7b). As far as the eavesdroppee's reject is concerned, the family group showed a higher percentage of forced quit eavesdropping than the friend group. Here, there are some validations from questionnaires regarding the social aspect of our prototype (Fig. 7d). The families showed higher satisfaction about "controllability" than the friends: either member in family groups enjoyed the freedom to switch between individual and group modes. And the other member was rejected in sharing mode. Both groups in the sharing mode were similarly satisfied with "easy-to-use", "group awareness", and "experience sharing". Interviews with the families elicited the following. Children were usually displeased when parents eavesdropped and quickly rejected the parent's eavesdropping request. At the beginning, some children were controlled by their parents and had a good time due to curiosity but broke the synchronization when novelty disappeared; then, they wanted to do what they wanted. The friends usually accepted the partner's wish for eavesdropping and control, feeling no antipathy toward it because they were "just" friends and because the tour guide is an entertainment application. In fact, they particularly enjoyed moments when they felt they had something in common.

The friends attempted mutual control more often than the families (Fig. 7c), which can be explained by results from the questionnaires (Fig. 7d). The friends were more satisfied by "co-understanding", "communication", and "negotiation" than the families.

5 Discussion and implications

5.1 Effectiveness and generalization of the system design

In this section, we draw the observations from the previous subsection together to discuss the effects of our sharing scheme on the visitors' experience and to discuss the generalization of our design.

5.1.1 Effectiveness of our design

Our user study proved that exploiting fluid movements between individual and ad-hoc group touring can enhance user satisfaction during group tours, compared to pamphlets and human guides. Our design is influenced by the following principle: the electronic tour guide should support visitors' interactions with information sources, companions, and physical environments [6]. We validated an initial set of requirements (spatial, personal, and social) for our prototype by comparing tours supported by a pamphlet, human guide, or our prototype. The analysis shows we did not compromise visitor interaction with other entities (e.g., spatial aspect of visitor–environment interaction, personal aspect of visitor–guidebook interaction) as we added functions enhancing social aspect of visitor–visitor interaction. However, it would be valuable to check the statistical significance with more participants to do an analysis of variance with three different tours as the within-subjects variable and two different groups as the between-subjects variable.

5.1.2 Generalization of the design

We would like to add a word of caution about the generalization of our results to other contexts. Our experiment was based on a representative example of current mobile phones (Nokia N95), and mobile phone support for Java MIDP and CLDC is likely to be safe and widely available in the market. So, our study could be easily repeated with other standard Java-enabled phones. Furthermore, applying our system to people with different cultural backgrounds would not be that difficult because technology can be re-implemented and deployed. However, we would like to analyze the behavior of non-Koreans to understand whether the system fits visitors with different cultural backgrounds. (We had intended to run a parallel experiment in Atlanta, at Oakland Cemetery, but a tornado hit the site during the time we intended to run our study.)

Applying our results to other types of places or cultural sites will be important, especially when electronic guidebook developers feel the need to provide indoor and outdoor sites with different interfaces. Focusing on the technical support of spatial, personal, and social aspects in electronic guidebook would be a good solution as location awareness, adapting to user preferences and demographics, and content synchronization are fundamental technologies regardless of environmental settings, and as other challenges are currently very few.

5.2 Interesting results regarding the sharing feature

In our evaluation, we extended our understanding of how sharing information among related people at cultural heritage sites influences visiting experiences.

5.2.1 Facilitate group interactions

Most importantly, we found that our design of the sharing scheme with mutual eavesdropping and content control facilitated group interactions, especially supporting conversations around information sharing and content synchronization. During the interviews, most users indicated they had more chances to converse with each other because of the sharing function in our system than they had in any other electronic tour guides. They were able to exchange opinions regarding the content they were currently sharing. And they could talk together without using the sharing function.

However, they also thought it very troublesome to need manual synchronization. They actually synchronized content with their group either with the sharing interface or without it. They said it was not convenient to synchronize a specific clip without the sharing interface, since they needed to fix the clips' category and location in the list of the category, one by one. In particular, they said our sharing interface is very useful when finding an undeniably impressive clip they wished to share immediately. Thus, they were frequently motivated to share content with our interface, being ready to press the "toggle sharing" button.

5.2.2 *Provide a rich and creative way for groups to share their experience, despite a lack of security*

Social relationships affect the sharing patterns, especially with respect to the users' attitudes and reactions to other group members' seeking agreement to be in the sharing mode. We found quite different mutual eavesdropping and content control behaviors according to group types (family vs. friends). The overall sharing activities with mutual eavesdropping and content control were more common among friends than in families. Also, the two groups have different motivations for asking their group members to enter the sharing mode. The family group tended to show a distinct pattern in that the parents spent much time eavesdropping as passive observers of their children and the children spent more time actively controlling the content, without eavesdropping. However, the friend group used this function for communication, co-feeling, and co-understanding, with natural negotiation. The friend group usually accepted partners' preferences regarding eavesdropping and control.

We believe this happened because friends have a symmetric social relationship and more easily identify each other. In contrast, parents want to have their eyes on, and take care of, the children, while the children wanted their parents to leave them alone and let them be independent. During interviews, we observed a tendency for the relations between a parent and child to have grown in intimacy at the end of the tour, so it may be the case that our system (or any system that encouraging such eavesdropping) encouraged closer contacts in the family group.

5.2.3 *Provide an interface for group tours that is simple, transparent, and flexible*

Our interface for the group tour is simple and almost completely transparent, while at the same time providing significant flexibility. The interviews indicated most users made short but frequent conversations before entering or leaving the sharing mode to inform each other of their willingness to accept or reject synchronization, supporting our belief that social negotiation would obviate the need for technical features to control privacy and sharing. The participants did not feel uncomfortable that our sharing interface enabled listeners to control what others are listening to. They said that complex interfaces, such as pop-ups for permission and security, might hinder social interactions, isolating each visitor with his own device. They thought conversation was a good alternative to pop-up interfaces, especially when users tour together. They also commented that the social protocols due to friendship could provide "security", instead of a collection of annoying button clicks, etc.

The users indicated that small refinements of the interface are needed in the case of difficulties or disagreements when away from each other. For example, user A may want user B to listen to a particular clip, while it is disruptive for user B, who is either already listening to something or browsing the map to find another grave to visit. They suggested that a small "alert" sound and visual "blinking" from a distance could be a substitute for conversation at close range. By adopting this advice, we believe we can reach a satisfactory compromise between a simple interface and undisruptive user interactions. Finally, users indicated that they appreciated the possibility to do other things while synchronized, such as browsing nearby graves or checking the map to find other interesting graves.

In the end, our design has the advantage of offering a simple audio sharing that enables listeners to implicitly control what others are listening to. Also, there is no synchronization of the phone displays outside of "Grave mode", only audio. Users can thus browse the map, while the audio is still playing, reducing disruptions.

6 Conclusions

We built a mobile phone-based system to satisfy users' social desires for group experiences when visiting an historic cemetery and designed a tour to support shared group experiences by allowing group members to know what each other is doing by seeing partners on a map, by eavesdropping on them, and by controlling their audio content. A unique contribution of this work is the design and evaluation of a simple sharing interface that lets users control the audio content of people currently "linked together". This sharing functionality is available to all group members and relies on intra-group social negotiation rather than technically enforced permission schemes, which avoids disruptive interaction behaviors.

We evaluated our approach using data collected from participants and showed that the design of our sharing scheme facilitated group interactions, such as conversations around shared information and synchronized content. The interactions of visitors indicated a remarkable degree of overall enjoyment, allowing users to focus on desirable and/or natural activities such as conversations, instead of distracting activities such as coordinating with their companions to manually synchronize and listen to audio clips. Furthermore, the different sharing behaviors of two groups exposes different ways that visitors can use our sharing scheme for their own purposes (e.g., to enhance their social interactions such as monitoring one's children and recommending content to one's friends). The results also validate the simplicity, transparency, and flexibility of the interface for the group tour. We expect these results to serve well mobile tour guide designers as well as cultural heritage associations in Korean and elsewhere.

7 Future work

To discover more sophisticated design implications from our study, we plan to use a form of conversation analysis, a sociological method used to examine naturally occurring social interactions, to explore possible patterns under the "social resolution" or "social negotiation". Also, we focused on "family" and "friends" groups and wish to extend our investigations to other groups, such as groups on a high school class trip, in which various and complex relationships could be observed. Our system can deal with more than two people, but we studied only pair interactions; it would be valuable to know how the group management scales up. For this, we need to modify our design for large groups.

In historical sites such as graveyards with scattered points of interest, two people can stand close while looking at entirely different things. We implemented eavesdropping as a method to easily "skim" or "browse" interesting content another user has discovered. Another technique would be to allow visitors to selectively share what they have experienced. System cues may facilitate additional social interactions without the need for synchronous listening. We can look at how long the user has been listening and recently played items to help a group find points of interest and avoid non-interesting items. Thus, we could compare the typical behavior of visitors using our current prototype with that of visitors using a selective experience sharing scheme.

Over the next year, we hope to enable visitors to download our software onto their own device and access our tour application on demand. Since visiting cultural heritage sites is a voluntary activity, the visitors should be willing to use their own phones if our system enriches visits without adversely affecting the device. Leveraging mobile phone support for Java MIDP and CLDC, safe and widespread standards, should enable this in the near future.

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