Exploring Spatial Narratives and Mixed Reality Experiences in Oakland Cemetery

Steven Dow[1], Jaemin Lee[1], Christopher Oezbek[1], Blair MacIntyre[1], Jay David Bolter[2], Maribeth Gandy[3]
College of Computing[1], School of Literature, Communication and Culture[2],
Interactive Media Technology Center[3]
GVU Center, Georgia Institute of Technology, Atlanta, GA 30332, USA
{steven, jaemn, blair}@cc.gatech.edu, oezbek@inf.fu-berlin.de,
jay.bolter@lcc.gatech.edu, maribeth.gandy@imtc.gatech.edu

ABSTRACT
The Historic Oakland Cemetery in downtown Atlanta provides a unique setting for exploring the challenges of location-based mixed-reality experience design. Our objective is to entertain and educate visitors about historically and culturally significant events related to the deceased inhabitants of the cemetery. We worked with the constraints and affordances of the physical environment of the cemetery to design an audio-based dramatic experience. The dramatic narrative is realized through voice actors who play the parts of cemetery residents and tell stories about the time periods in which they lived. The experience provides navigation and linearity through a main narrator who guides visitors to various gravesites. While at each grave, the visitor can choose from several categories of content using a handheld controller. Formative evaluations conducted with users in the cemetery indicate strengths of the current experience and suggest ideas for continued development.

ACM Classification Keywords
H5.1. [**Information interfaces and presentation**]: Multimedia Information Systems - *Artificial, augmented, and virtual realities; Audio output; Evaluation/methodology*

General Terms
Design, Experimentation, Human Factors

Keywords
Experience design, audio tours, spatial narratives, mixed reality, edutainment, historical sites, cemeteries

1. INTRODUCTION
In this paper, we present and discuss "The Voices of Oakland," a dramatic, audio-based mixed reality (MR) experience situated in Oakland Cemetery in Atlanta [18]. This experience tells stories about the history of Atlanta and the southern United States by guiding the visitor to the gravesites of people involved in these historical events, and using their dramatized voices to tell their part in the unfolding drama. The goal of this project is to provide visitors to Oakland with a compelling, coherent, entertaining, and engaging experience that focuses on the historical and cultural significance of events related to residents of the cemetery.

The setting for this experience, the historic Oakland Cemetery, heavily influenced its design and implementation. Cemeteries offer a unique setting for historic experiences, providing an intriguing blend of historic site and museum, in a space that continues to be a functioning social institution (i.e., a place where we bury and visit the dead). Unlike most historic sites, where the significant events associated with the place typically provide the basis for visitor experiences, a cemetery can serve as the location for stories related to its own history as well as to a vast range of experiences associated with the people buried in the space and the times in which they lived. The Oakland Cemetery grounds have their own unique history, but it also has residents who played major roles in most of the significant events in the Southern United States from the mid-1800s through the late-1900s. Generally speaking, cemeteries like Oakland are repositories of the history, culture, and memories of the community.

In cemeteries, as in traditional historic sites, computer-augmented experiences must adapt to the topology of the space. Museum curators have the luxury of planning and crafting the structure of the space and the organization of the content to tell a particular story to the visitor. A cemetery's layout, on the other hand, is determined naturally over time and cannot be manipulated. However, the fixed organization of the cemetery "content" can still be leveraged when telling a story because the layout of many cemeteries follows thematic and social patterns.

Cemeteries such as Oakland present challenging design constraints for the development of a media experience. Because the cemetery is a functioning institution with social and religious importance to many people, the physical environment cannot be altered with signage or technology. Therefore, any experience we design must be self contained, relying only on what the visitor can carry with them. In this project, we conceive of *spatial narratives*. The backbone of a spatial narrative is a single linear story that ties the content together and gives the participant the structure

ACE'05, June 15–17, 2005, Valencia, Spain.

typically provided by signage in historic sites and museums. On top of the linear story, at each site along the path, the user can explore additional content that interests them, providing them with a sense of agency and control missing from more traditional linear audio-augmented experiences.

The main contribution of this paper is to present the design and evaluation of an audio-based MR experiences based on spatial narrative. As with human guided tours, or pre-recorded audio tours common in museums and historic sites, the linear narrative provides guidances as to what is interesting, why it has been included, and what other nearby content might be interesting. While random access to vast information content is a supposed advantage of all computer-augmented tours, an underlying linear narrative enables a participant to understand what they might want to explore in this information space. Secondary contributions include suggesting cemeteries as compelling locations for historic exploration, and providing an evaluation of GPS as a location sensor for outdoor location-aware experiences (adding another data-point to the literature showing GPS alone is not reliable enough to use for fine-grained sensing).

This paper discusses our design process and the trade-offs made during the evolution of the experience. Aside from the many unique challenges presented by the cemetery, we discuss issues of story style (dramatic vs. commentary), story arc (linear vs. non-linear), agency (user vs. system control), medium (visual vs. non-visual media), and technology (location tracking, etc). We present the results of our initial user studies, designed to evaluate and guide the evolving audio experience. Finally, in the future work section, we discuss ideas for the next generation of "The Voices of Oakland".

2. CEMETERIES AS HISTORIC MUSEUMS

When considering the design of computer-augmented experiences, cemeteries have elements in common with both museums and historic sites. Like a museum, a cemetery contains unique artifacts (e.g., graves, mausoleums, cemetery residents, etc.) that are linked to distant events and places, and can serve as vehicles for telling stories related to those events and places. Similarly, like historic sites, cemeteries are unique places that have a fixed physical structure shaped through years of human and natural forces.

The unique places, objects, and people contained in historic sites, museums, and cemeteries are imbued with "aura", that intangible aspect of unique objects and places that is felt in their presence [5, 13]. We believe that the aura of historic places and objects makes experiences compelling, and that the experience of aura is directly related to the visitor's knowledge of that site or object. In an historic site, the place itself has aura. Museums and cemeteries may have their own aura (e.g., a famous museum such as the Louvre has its own aura), but they mostly derive aura through the artifacts/residents contained within. In "The Voices of Oakland", we leverage both the aura of Oakland itself and the aura of the people buried there.

Experiences in historic sites often follow fixed paths, augmented with signage to guide the user through the main parts of the site.

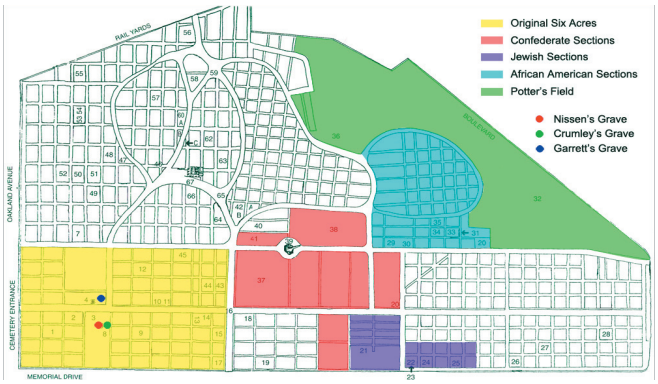

Figure 1. Map of Oakland Cemetery with color coded sections.

Museum artifacts are often organized chronologically, by genre, or through a linear story that requires a particular path be taken through the space. Although visitors are usually not physically constrained to follow a certain route, museums are often designed so that the expected path corresponds to a logical organization of the content. Establishing a logical flow through the space provides a story structure for the visitor.

When viewed as a historic museum, the cemetery layout can provide the basis for similar design elements. Linear stories are vital in helping (possibly naive) visitors understand the significance of, and relationship between, various artifacts in museums and historic sites. This is especially true for cemeteries, where the appearance of a grave may not correlate with the importance of the occupant, or how interesting the associated stories are. Other cultural factors, or properties of the "placeness" of a cemetery [11], can be leveraged to control and/or anticipate the possible flow through the space. For example, it is not culturally acceptable to walk over someone's grave. The Oakland experience is designed to keep visitors on the dedicated pathways in an organized spatial narrative.

2.1 Oakland Cemetery Details

Oakland Cemetery's peak burial period was between 1850 and 1950 and contains representatives from important eras in Atlanta history, including the American Civil War, the Civil Rights movement, and various periods of economic growth [17, 21] (see Figure 1). An entire section is dedicated to the confederate soldiers who died during the American Civil War. Because of segregation, there is an isolated African-American section with many of Atlanta's great black civil rights leaders, such as Bishop Wesley John Gaines. One section is for Atlanta's Jewish community and includes interesting figures, such as Joseph Jacobs, owner of the drug store where Coca-Cola was first served[1]. Aside from culturally significant social groups, Oakland's aura is enhanced through notable individuals buried there, such as the writer Margaret Mitchell and golfer Bobby Jones. Visitors to the cemetery often identify with a cultural group or are intrigued by the famous personalities, all of which characterize Southern history and allure. Our challenge is to exploit the cemetery

[1] Coca-Cola was invented by John Pemberton and served in Jacob's Pharmacy on May 8, 1886.

(a) (b) (c)

Figure 2: a) A user wearing the system, near the first grave in the narrative, b) the wizard monitoring the experience, and c) an overhead view of part of Oakland with circles at each grave and the intended experience path (satellite image courtesy of the USGS)

divisions and to create narratives around the most interesting aspects of the space.

As Atlanta's third largest green space and one of the oldest examples of a "garden" cemetery in the United States, Oakland Cemetery's eighty-eight acres often plays host to joggers and people walking their dogs, serving as a place for relaxation, recreation, and reflection. Oakland's visitors range from school children on class outings to tourists from outside Atlanta who stop at the cemetery, in part, due to its proximity to other popular sights, such as the Martin Luther King Jr. museum. Oakland Cemetery receives about 60,000 visitors each year from all over the world [12].

3. "THE VOICES OF OAKLAND" TOUR

"The Voices of Oakland" experience is the result of an ongoing collaboration between Computer Scientists and New Media Designers, the benefits of which we discuss in [14]. Our goal is to create an educational and entertaining experience, which exposes the historical and cultural importance of Oakland Cemetery. As with most historic sites, the existing human-guided tours at Oakland enable interaction through questions, but are limited by the human's knowledge of the space, their need to cater to an entire group, and their capacity to present the material dramatically. Computer-augmented tours, on the other hand, have the potential to offer each visitor access to the vast quantity of historical information related to the site, tailored to their interests.

Working with the Oakland Historic Preservation Society and building on the existing tour scripts, "The Voices of Oakland" attempts to present history through engaging, entertaining stories and characters that connect to visitors on a human level. Therefore, the stories are told as if by the deceased, using voices that approximate what each individual would have sounded like near the time of their death (in the case of the recently deceased narrator, Franklin Garrett, we hired a voice actor that knew him and could do a believable impression of him). Using dramatic first person narratives, we create dialogues between the narrator and the other "ghosts," and have the characters speak directly to the visitor.

In the next two subsections, we describe the first two iterations of experience as it was presented to users. In the following sections, we discuss related work, our solutions to particular design problems that we encountered, and our evaluation of these two prototypes.

3.1 First Iteration

Our initial proof-of-concept system was a simple linear script that led the user to five different gravesites in the original six acres. Visitors wear headphones and carry a backpack with a small computer. When visitors start the experience, they are greeted by the voice of Franklin Garrett, the narrator and guide.

> *"My name is Franklin Miller Garrett, and I want to start by sharing a confidence with you. The fact is that I have always loved cemeteries, ever since I was a young man…"*

The Garrett character guides visitors from grave to grave and speaks with other characters along the way. The experience progresses through time and space, as the resident of each grave represents a different era in Atlanta history. Towards the end of the tour, a secret is revealed. Garrett, our lively and trusted guide, is also buried in the cemetery.

> *"Can you see that large granite stone there on your left? You notice the name, Garrett. Yes, it's my grave."*

For this prototype, we roughly recorded all of the characters with our own voices and then loaded all of the audio clips onto a portable computer. We controlled the experience using a "Wizard of Oz" operator who triggered the appropriate audio clips based on the user's location in the cemetery [9]. The experience was strictly linear, with no explicit input from the user. At this early stage in development, while we were still working on story elements and user interaction ideas, we did not want to spend time implementing complex system logic or rely on (relatively inaccurate) GPS.

The WOz method enabled us to create a rough working system and to conduct a quick user evaluation of it (described below). We incorporated feedback about the story and interaction into a second iteration.

3.2 Second Iteration

In the second iteration of "The Voices of Oakland", we added content to the main linear narrative and allowed the user to choose among various audio segments. We also added a GPS (global positioning system) receiver and head-orientation sensor to the system to support our evaluation (neither are used by the system). The story maintains a linear narrative spine with the opportunity for user input through button interaction to obtain ancillary content. The linear script from the first iteration is divided into two parts: segments for navigating between and introducing each grave, and additional content segments available to the user at a grave. The audio clips used for navigation between graves remain the same as the first iteration and provide a fixed linear structure. The content segments are further divided into three categories: life stories, history, and architecture. Visitors carry a controller to indicate what category of content they would like to hear while at each grave. After listening to one audio segment in a category, visitors can press the button for that category again to receive more content or change to a different category. The controller also has buttons for pause, repeat, volume up, volume down, and next grave.

The visitor experiences three gravesites that mark a chronology in Atlanta's history: James Nissan – the first man buried in Oakland, Carrie Berry Crumley – who kept a diary as a child during the Civil War, and Franklin Garrett – the recently deceased narrator and guide of the story and Atlanta's unofficial historian. In this iteration we employ professional actors for the character voices and use sound effects to increase the dramatic tension. At the Crumley site, for example, we overlay the sound of cannon fire as the women recalls her fright while trapped in the basement of her home during the siege of Atlanta.

As in the first iteration, a WOz operator monitors and controls parts of the experience. Although most of the content flow is handled through the user's button interaction, the WOz is there to make sure the user navigates correctly from grave to grave. In our formal evaluation of the experience, we capture data from the users, specifically button presses, GPS location, and head rotation.

4. RELATED WORK

The contrast between museums and historic sites and their relationship to cemeteries can be seen by looking at existing multimedia tour guides. The audio tour of Alcatraz Prison in San Francisco uses authentic voices and sound effects [2], qualities we adapt into the Oakland experience because we feel it heightens the dramatic effect for visitors. However, the Alcatraz story is entirely linear and makes heavy use of signage and carefully placed props, guiding the visitor down a single path and presenting content in a specific order. Like Alcatraz, the Oakland experience relies on a linear narrative to give the user a framework for the experience. However, unlike Alcatraz, the Oakland experience supports user agency by allowing the participant to explore additional content at each grave along the linear tour.

In contrast to linear tours, the ability to explore a large collection of content is a common feature of more technically advanced multimedia museum systems. For example, in the Experience Music Project (EMP) in Seattle, users can select content based on the nearby artifacts or explore the entire content database without exploring the physical museum at all [10]. Although the physical displays in the EMP are organized into sections that suggest a particular flow, each multimedia content element is independent from the others. "The Voices of Oakland" experience relies on the linear story to build tension and create a more engaging tour experience.

The ARCHEOGUIDE project, like many technology driven tour guides [1, 4, 6, 8, 19, 20], attempts to enhance the experience of historic locations using user context [22]. ARCHEOGUIDE provides an index to rich contextual information and closely resembles a mobile encyclopedia. Similarly, visitors to most museums have the option to listen to an audio commentary about the artifacts. In these examples, the additional content contributes to the visitor's knowledge, but falls short of enhancing the experience in the way a dramatic narrative like the Alcatraz tour does. In the Oakland experience, we follow Alcatraz and use a dramatic presentation to engage the user.

Our work on spatial narratives shares many overlapping themes, such as narrative structure and issues of agency, with the interactive gaming community. For example the Façade project explores generative plots and AI-based characters to create an interactive fiction where the story changes based on the user's interaction with the characters [16]. In the quest to create *Hamlet on the Holodeck* [17], the gaming research community has the luxury of manipulating the elements in ways that cannot be achieved in mixed reality. Game developers do not have to deal with the intractability of physical space (such as the layout of the cemetery). The relationship between "The Voices of Oakland" experience and virtual games is similar to the relationship in traditional media between live-action film and animation, because in animation the designers can mold the space to fit the needs of the narrative.

Although it is difficult to manipulate, the physical environment presents an important design feature, especially for historic sites; it more directly connects the user to the aura of the place. Projects such as BENOGO [7] attempt to replicate the important qualities of the concept of "place" in virtual reality (VR). In VR the human is detached, often located remotely from the historic site. Synthetic environments cannot replicate the authenticity and aura afforded by the actual physical place or artifact. One of our project's goals is to understand and leverage Oakland Cemetery's aura, which we postulate is best achieved in the actual physical space.

5. DESIGN DISCUSSION

Working in a cemetery, we are confined to the layout of the physical space and unable to alter the environment to add technology, signage, or props of any kind. On the other hand, Oakland offers many opportunities for storytelling; the cemetery

is rich with stories about events that took place in the graveyard, as well as stories about the inhabitants that reveal a deeper historical perspective of Atlanta. The constraints and affordances offered by the cemetery guide the content and structure of our narrative. This section discusses a range of design issues we considered and relates them to the creation of the Oakland experience.

5.1 Story Style

The delivery style is an important consideration in developing an experience. We considered delivering the Oakland experience using dramatic narratives that unveil history through characters and plot, as well as using a more objective commentary-style (e.g., in the style of Ken Burns' documentaries[2]). On one hand, the commentary script is easier to implement, especially with the non-linear interaction we desire. On the other hand, a dramatic script, with dialogue between characters, is potentially more compelling and more likely to fulfill our goal for enhancing the aura of the space. While non-linear narrative design is traditionally very difficult, the structure of the spatial narrative (a linear story with pockets of non-linearity) makes the narrative design tractable. Our narrative's tone is genuine and convincing, influenced by the overarching goal of delivering an educational historical experience. Finally, we maintain respect for the cemetery, relatives of the occupants, and all of the other stakeholders by avoiding "ghosts and goblins" stories.

5.2 Story Arc

Most dramatic stories follow a natural arc where the main character faces a challenge that reaches a peak before arriving at a resolution at the end. For the story to make sense while it unfolds, the story narrative should be linear or have linear elements, to support the arc. For the design of the Oakland experience, we chose to utilize the cemetery's natural breakdown to suggest several main linear stories. Our design plays with the linearity of the story by giving the user control of the media content presented at any particular grave. Our spatial narrative juxtaposes these non-linear elements with the linear narrative spine that leads the participant between graves and provides them with a grounding on which to base their explorations.

5.3 Agency

A key question in location-aware experience design is how to split control between user input and user position; for a spatial narrative, the question becomes "should the user's location control the story's narrative or should the story guide the user to certain locations?" The design of our linear narrative leans toward the latter option, leading the user between locations but not triggering content automatically based on location. The characters in our story have agency, and speak to visitors with knowledge of where they think they are. The main narrator, Garrett, might say "you see that brick structure across the road?" as if he knows something about the visitors' position and body rotation. In our evaluation, and our own experiences at sites like Alcatraz, users tend to wander around and explore the site while listening to the narrative, making location an unreliable way to control the experience.

A second question is "what form of explicit control do we give the user, if any?" In the Alcatraz audio tour, the visitors have limited control of the audio (pause, rewind, play, volume control). In the Oakland experience, we replicate these controls and also provide visitors more fine-grained control over the content. In our design, visitors choose between life stories, history, and architecture while at a particular grave. The user also has a "next" button to signal they are ready for the next grave; that is when Garrett chimes in and verbally escorts the user to the next grave. Understanding the appropriate balance of agency is a fundamental challenge in designing spatial narratives.

If the user leaves the linear narrative spine, our design includes a number of simple navigation statements (i.e. "Go back ten steps" or "Turn around") that are used to help the participant return to the narrative path. In our current implementation, the Wizard of Oz operator triggers those statements, acting as an intelligent agent in the system. As discussed in the user evaluation section, these additional statements were rarely needed during our tests because the current script is effective at navigating the user between graves, and because there is no content off the linear path for them to explore. As we move toward adding content to the graves passed by the user along the story path, and thus encouraging users to explore more freely, we expect that the need for incremental navigation will be more vital.

5.4 Medium

As stated above, the cemetery grounds can not be augmented with signs or displays, requiring us to create experiences that are presented entirely through the mobile media device carried by the user. We chose to present the stories as audio-only narratives, partly because we believe that visual media would distract the user's attention from their surroundings (i.e., we do not want people to walk around with their eyes focused on a small display) and partly because the technology for implementing auditory experiences is far more mature than that needed for spatialized visual augmented reality experiences. Since the cemetery is not a visually dynamic environment, during user evaluation we watched for signs of boredom and tried to elicit comments from the study participants about the need for additional visual media.

5.5 Technology

One of our design objectives, particularly in setting up the user evaluation, is to learn more about the practical capabilities of current outdoor tracking systems, and how they would impact experiences such as this. In our study, we collected head rotation using an Intersense IntertiaCube2 and positioning data using a differential GPS receiver. Figure 3 illustrates the hardware setup for the user. The CSI PowerMAX GPS is larger and more expensive than consumer-grade differential GPS, and but typically gives ~80-120cm accuracy. This is far better than the 2-5m typical accuracy of consumer WAAS GPS, and is as good as can be achieved without using survey-grade, RTK GPS technology.

[2] A discussion by Melton of Ken Burns' Civil War documentary can be found here: http://www.regent.edu/acad/schcom/rojc/melton.html

Figure 3: The equipment carried by the user in "The Voices of Oakland." The wizard wears headphones and uses a Tablet PC that communicates wirelessly with the user's tablet.

We use the WOz technique to facilitate the experience while capturing sensor data. Using WOz to control the experience enables us to respond to user miscues or navigate the user manually without having to rely on complex application logic. Our CHI short paper discusses the tradeoffs of using WOz versus other methods during the experience design evolution [9]. In the results section we present the GPS data collected in the study and analyze the device accuracy in anticipation of using these devices as part of a working system.

The interfaces for the user and the wizard are prototyped in DART, the Designer's Augmented Reality Toolkit [15]. DART is a set of prototyping tools integrated with Macromedia Director that facilitates rapid exploration of mixed reality experiences. We leverage DART to quickly build prototypes and to evaluate each iteration of our design.

6. EXPERIENCE EVALUATION

Our philosophy is to create rapid prototypes and to iterate frequently so that the content, interaction, and technology can co-evolve towards a final form. Guided by specific research questions, we conducted two separate evaluations of "The Voices of Oakland" experience. In the first study, our questions involved the basic setup of the experience. Is the content compelling? Are users satisfied with their ability to control the experience? What are the limitations of the design? We wanted to identify major issues in our rough prototype early in the design.

We also evaluated our current iteration, with the following specific questions in mind. Are the categories of content appropriate? Is there enough content or too much? How do users interact with the buttons? Is the GPS device consistent and accurate enough to start building the actual application? What can we ascertain from the head rotation data?

6.1 Preliminary Study

The first iteration of our experience was a proof-of-concept prototype with a linear narrative recorded with amateur voices. We used the Wizard of Oz method to control the flow of content to the user and conducted two heuristic evaluations of the experience. The two script writers acted as the WOz operators, and two HCI professionals were asked to be experience participants. In both cases, the experience lasted about fifteen minutes followed by twenty minutes of interview questions and experience discussion.

Although the results of our preliminary study are qualitative, they provided valuable feedback for early in the design process. Both participants enjoyed the experience, but thought that some of the story segments were too long. They wanted more control over the content so that they could fast forward or jump to different audio stories.

The linear narrative succeeded in navigating the user between five different graves. We learned that the Maynard Jackson grave (2nd to last on the tour) was physically too far away from the others, so we decided to drop it for the second iteration. We also dropped the first grave on the tour because the story elements were fairly limited. We plan to re-introduce these graves (and others) in future iterations.

6.2 Formal User Study

In the second (current) iteration of "The Voices of Oakland," the characters' voices were recorded by professional actors, and sound effects are used to create a rich, believable audio design. We include three categories of content (life stories, history, and architecture) available at each grave. The user carries a controller with buttons and has control over basic features of the experience (three categories of content, pause, unpause, repeat, volume control, and next grave). The audio segments are shorter and are arranged into the three content categories, allowing the user to hear the essential story and dig deeper for more details.

Prior to conducting the formal study, we demonstrated our work at a yearly festival at Oakland Cemetery. Approximately fifteen participants experienced the audio tour and provided anecdotal feedback. For the demo day, the user button interaction was displayed in the wizard interface, and the wizard controlled the content based largely on which buttons the user pressed. We chose to route the button interaction through the wizard because we had questions about the level of control the user should have and what users would expect from the button device. The event was successful, and the content chosen by the wizard followed along closely with the button interaction of the user.

For the formal evaluation, we enabled the user's button interaction to directly control the audio content, but empowered the wizard to oversee the user activity and to override the content choices if needed. The only explicit role for the wizard was to watch for the users' request for the next grave and to trigger the navigation content. On certain occasions the user pressed the "Next Grave" button several times before the wizard responded, suggesting that it was difficult for the wizard to attend quickly enough to user requests.

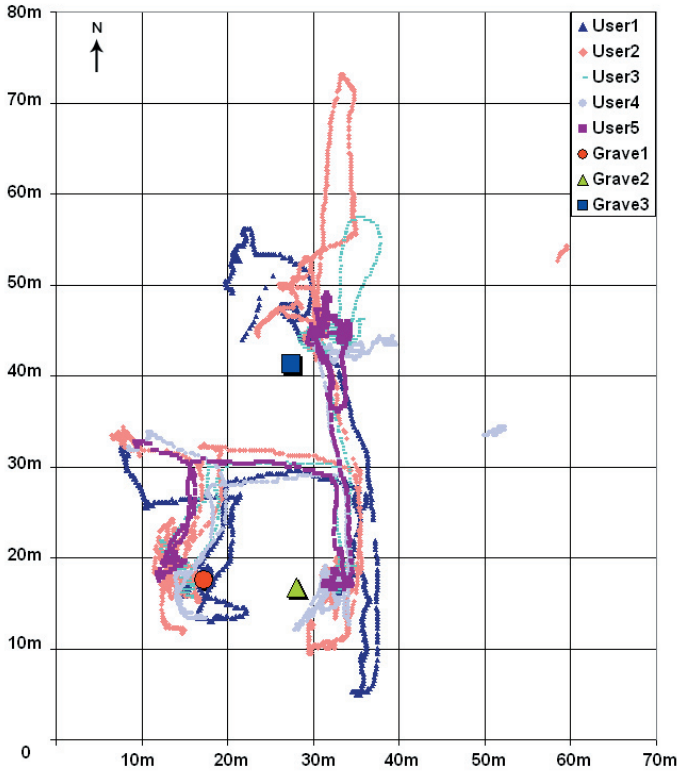

Figure 4: GPS data for all participants

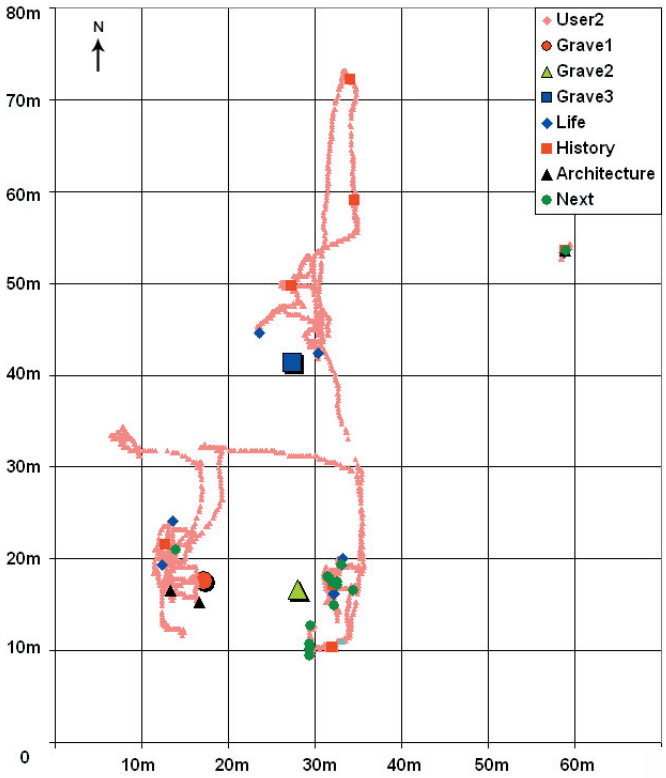

Figure 5: GPS data and button interaction for User 2

Six participants (2 males, 4 females, ranging in age from 27-63) were recruited to take part in the formal study and to provide situated feedback. Each participant carried the controller with buttons, headphones with a head rotation sensor, and a backpack with a computer and GPS device. We time-synchronized and recorded GPS location, head rotation, and button interaction, and documented the entire study with video and audio so that we could capture participants' statements throughout the tour. Each participant took the tour alone and was asked to think-aloud if anything came to mind (questions, comments, ideas, etc). At the end of the tour, we walked with the participant along the path (without the technology) and interviewed them about the content and flow of the experience.

As other attempts at using GPS for location-based experiences have shown, GPS technology has limited absolute accuracy, but can still enable the system to make certain decisions at runtime. Figure 4 shows the GPS data from five of the six participants on three days over a period of a few weeks[3]. Despite using high-end GPS technology, the raw position data reveals inconsistency and occasional serious errors. For example, on the path leading North/South from Grave 2 to Grave 3, where the user is walking back over the same path as when coming from Grave 1, the physical lane narrows to about one meter. The visualization shows a fluctuation of about five meters difference in User 1 and User 5. Since the study took place over a long period of time, some of the errors can be attributed to different environmental conditions, but even data gathered on the same day varied significantly. Large scale assertions will still be possible using GPS (e.g. such as knowing when a user is near a group of graves) and we are considering how to design under this constraint in future iterations.

The data also indicates that knowledge of a user's position should not be the only factor that determines which audio segment to play. Even in our small test population, the position of the user could not provide a direct mapping for the spatial narrative. Many of the users walked away from the graves (5-10 meters) and continued interact with the system by pressing buttons to trigger content. For example, in Figure 5, User 2 takes a significant detour while listening to content for Grave 3. In the post-experience interviews, several participants indicated they enjoyed being able to roam while listening to the voices. The participants were aware that the system was keeping track of their location and responding to their position (in our experiment, the WOz could react to user position, if desired); this prompted participants to stay within an implicit boundary. One participant said he wanted to walk around, but he didn't want to go too far fearing that the computer would get the wrong idea. Our data collection has uncovered unexpected user behavior (walking away from a grave, but still wanting to hear content related to that grave) and mental models of the technology (assuming a non-existent boundary that communicates to the computer to present different content).

The button interaction data reveals patterns in participant interaction. In Figure 6, we show button presses over time with content choices separated from more basic system interaction. Overall, the users followed distinct patterns in their navigation of the

[3] One of the participants' data was lost; the computers, GPS device, and other sensors were all stolen from our vehicle while at the cemetery one day.

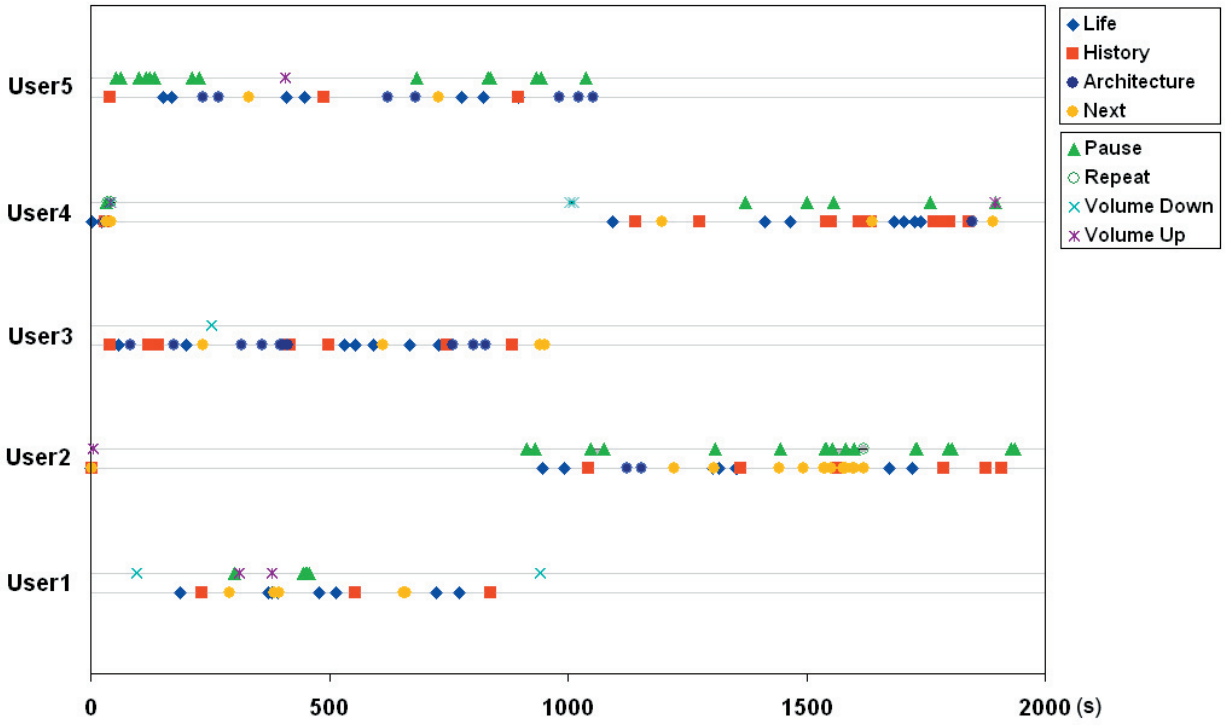

Figure 6: Button interaction of all users during the study. Offsets for user 2 and 4 are due to the accidental recording of the training session; we can not accurately align the button interaction times due to inconsistent times for starting the capture with respect to when the audio started playing. The top bar shows the user button interaction over time for basic functionality (pause, repeat, and volume); the lower bar shows the interaction with content (life stories, history, architecture, and next grave).

audio. With the exception of user 2, the users' interaction follows the general pattern of one or two segments of life story content followed by one or more segments of history. Occasionally, users explored the architecture content. For example, user 2 interacts with content in this order: L-L-H-A-A-Next Grave-L-L-H-Next Grave-L-L-H-H-H[4]. This distinct pattern may be due to the ordering of the buttons on the controller: L-H-A is a natural physical sequence. The ordering also follows a logical content model, in that, life stories and history reveal the most relevant information to the overarching story, and the architecture is ancillary and not as essential to the ongoing narrative.

The button sequence for User 3 is unique, in that, he returns to the same category of content after listening to the others (at grave 1), then at grave 2, he listens to all the content in each category before moving on to the next category. He also tended to favor the architecture content much more than the other users (see Figure 7). Our design supported a number of strategies for content navigation and user behavior. During interviews, the participants appreciated this aspect of the experience, but they wanted to have more information about the content so that they can more effectively form strategies for listening to the content they are interested in.

It is evident that users prefer to have a variety of content, organized into many short segments to enable browsing. Figure 7 is a representation of all the content in the experience. Each rectangle represents an audio segment. Blue regions show the amount of a particular audio segment a user listened to, and yellow regions show the amount that was not heard. The content is not distributed evenly across all of the categories, with history representing most of the experience's content. Most users favored life stories over history and architecture, although clearly users enjoyed having a variety of content choices. Overall the participants listened to 81% of life stories, 37% of history, and 32% of architecture.

Many of the audio segments are skipped over after the users start listening (in Figure 7, these are blocks that are partially filled with blue; this happened most frequently for users in the history segments). For example, the second history segment at grave 2 is cut short three times by users. The other two users never reached that particular segment. This might be an indicator that we need to rewrite and shorten the content for that segment. In general, the content data argues for having shorter segments, but plenty of depth at each grave for the visitor to delve into. During interviews, most of the participants asked for better feedback about the quantity and length of stories in each of the categories. Some suggested having a visual interface so that they could see a summary of the content or images related to the stories. Participants often inquired about nearby graves, indicating a need for more ancillary content that is deeply connected to the physical environment.

[4] User 2 used the "Next Grave" button several times in a row, because the wizard failed to notice and trigger the navigation content. This user also made sufficient use of the "Pause" button because she provided substantial verbal feedback during the experience.

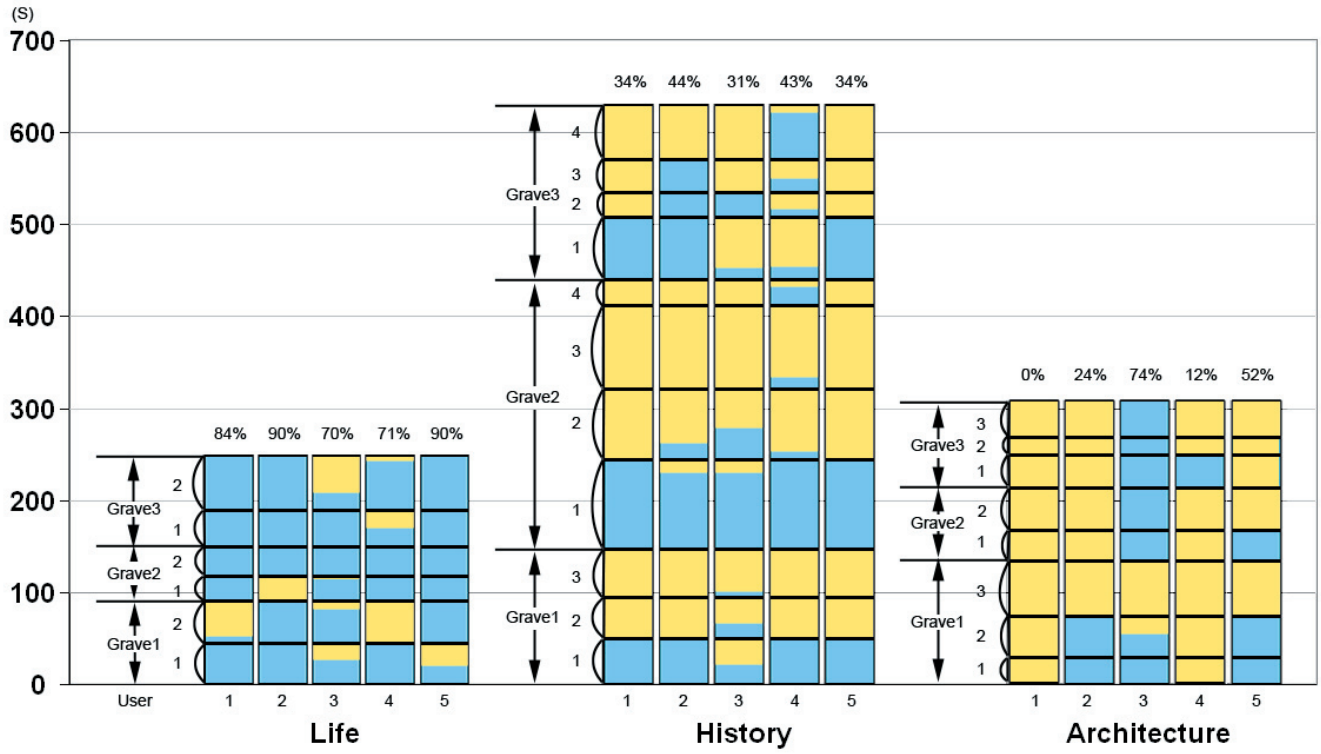

Figure 7: Visualization of the content for entire experience. Each rectangular block represents an audio segment, the blue region indicates the portion listened to by each user, and the yellow region the portion not heard. The top of each column displays the percent of audio heard. For example, User 1 did not listen to any architecture content, where as, user 5 listened to 90% of the life story content only skipping the last half of one audio segment.

Overall, the participants were happy with the experience and cited the dramatization and rich content as reasons for its success. The interviewees did suggest specific ideas for improvement in the content and interaction model. We had chosen a single voice for each character that was representative of what they would have sounded like near the time of their death; the scripts had them talking about their life in the past tense. One participant suggested we could use a girl's voice to play a young Crumley (grave 2) reflecting back on her childhood during the Civil War. One user was adamant about hearing stories of politics and corruption. Many of the participants support further research of group experiences and expressed concern that this current experience (like other audio tours) will be unsuitable for a group to take together.

7. FUTURE WORK

We view "The Voices of Oakland" project as a work-in-progress. Based on user feedback and brainstorming, we have developed design ideas for the next iteration of the experience. Most visitors come to the cemetery with a small group of friends or relatives, but often Oakland gets entire school buses of children. There is a need to expand the audio tour into a group experience. The Sotto Voce project suggests the use of an eavesdropping metaphor that would allow visitors to split up and then naturally come back in sync [3]. The Lighthouse project uses voice communication to assist collaboration between physical and virtual visitors to a museum [6]. In the Oakland experience, if all our participants can choose their own order for content and can move around the space at different rates, group alignment will be quickly lost. Our initial inclination is to follow the Sotto Voce project in building simple facilities that support social behaviors that occur naturally and to rely on social rules to resolve problems. For example, we might allow visitors who are close in proximity to "join up" and hear a single synchronized experience, allowing any participant pause the audio for everyone in the group or advance to the next piece of content. Difficulties or disagreements that result from this level of interaction can likely be resolved socially. The larger question is whether the learning goals and overall enjoyment are better achieved through a social or individual experience.

Our long term goal is to provide a variety of linear narrative spines suggested by the topology of the space and the predominant themes (e.g., the American Civil War, the Civil Rights Era, Famous Residents, The Jewish Community, etc.), while permitting non-linear information retrieval at each grave or nearby graves. At times the visitors are guided by the experience, and at other times, they are free to explore the space and create their own narrative. We envision that the system will keep track of where users have been and what content has been presented so that a personalized narrative can be generated based on each user's spatial movements or other input control. At this point we lack much of the ancillary content needed to enable this vision, but stories are available in historical records and through family members of the deceased. Moving toward a large story repository, we will eventually deal with issues of scale, both in terms of finding the desired content and in using the current interaction to interface with the content.

We also plan on exploring other technology enhancements, such as using a small visual display and spatialized audio. Displaying a visual interface would enable feedback about the type and quantity of content available at any moment. A visual interface could provide a map showing the visitor's location, helping to solve navigation problems. Spatialized audio could enhance the perception of characters in the space and perhaps make the experience more engaging.

We believe that our work demonstrates the value of spatial narratives as a structuring mechanism for audio-based MR experiences. The use of a linear story gives the user a framework on which to base the rest of the experience, and enables the use of relatively inaccurate GPS by only requiring the system to know when the user is in the general area of a spatial node. We are continuing to explore the use of spatial narratives in historic sites such as Oakland Cemetery.

8. ACKNOWLEDGMENTS

We would like to thank Danny Muller, Susan Bryant, Susan Wyche, Kevin Kuharic, and John Avery. Thanks to the Digital Arts Entertainment Lab at Georgia State University for access to their sound studio. This work is supported by NSF CAREER Grant 0347712.

9. REFERENCES

[1] Abowd, G., Atkeson, C.G., Hong, J., Long, S., Kooper, R., and Pinkerton, M. Cyberguide: A mobile context-aware tour guide. *Wireless Networks,* v.3, 1997, pgs. 421-433.

[2] Alcatraz Island, http://www.nps.gov/alcatraz/, 2005.

[3] Aoki, P.M., Grinter, R.E., Hurst, A., Szymanski, M., Thornton, J.D., and Woddruff, A. Sotto Voce: Exploring the Interplay of Conversations and Mobile Audio Spaces. In *Proceedings of ACM SIGCHI Conference of Human Factors in Computing Systems (CHI'02)*, Minneapolis, MN, USA, Apr. 20-25, 2002, pgs. 21-30.

[4] Bederson, B. Audio Augmented Reality: A Prototype Automated Tour Guide. In *proceedings of ACM SIGCHI Conference of Human Factors in Computing Systems (CHI'95)*, Denver, CO, USA, May 7 - 11, 1995, pgs. 210-11.

[5] Bolter, J.D., MacIntyre, B., Gandy, M., and Schweitzer, P. New Media and the Permanent Crisis of Aura. Submitted to *Convergence*, Dec. 2004.

[6] Brown, B., McColl, I., Chalmers, M., Galani, A., Randell, C., and Steed, A. Lessons from the Lighthouse: Collaboration in a Shared Mixed Reality System. In *Proceedings of the Conference on Human Factors in Computing Systems (CHI'03)*, Fort Lauderdale, FL, USA., Apr. 5-10 2003, pgs. 577-584.

[7] Carroll, F., Smyth, M., and Dryden, L. Visual-Narrative and Virtual Reality. In *Book of Selected Readings: The International Association Of Visual Literacy (IVLA 2004)*, Jahoannesburg, South Africa, Oct. 4-7, 2004.

[8] Cheverst, K., Davies, N., Mitchell, K., Friday, A., and Elfstatiou, C. Developing a Context-aware Electronic tourist Guide: Some Issues and Experiences. In *Proceedings of ACM SIGCHI Conference of Human Factors in Computing Systems (CHI'00)*. The Hague, Netherlands, Apr. 1-6, 2000, pgs. 17-24.

[9] Dow, S., Lee, J., Oezbek, C., MacIntyre, B., Bolter, J.D., and Gandy, M. Wizard of Oz Interfaces for Mixed Reality Applications. In Extended Abstracts of *Proceedings of ACM SIGCHI Conference of Human Factors in Computing Systems (CHI'05)*. Portland, OR, USA, Apr. 2-7, 2005, pgs. 1339-43.

[10] Experience Music Project, http://www.emplive.com/, 2004.

[11] Harrison, S., and Dourish, P. Re-Place-ing Space: The Roles of Place and Space in Collaborative Systems. In *Proceedings of ACM Conference of Computer-Supported Collaborative Work (CSCW'96)*. Boston, MA, USA, Nov. 16-20, 1996, pgs. 67-79.

[12] Kuharic, Kevin. Historic Oakland Foundation *Personal Interview*. December 3, 2004.

[13] MacIntyre, B., Bolter, J.D., and Gandy, M. Aura and the Presence of Meaningful Places. In *Proceedings of Annual International Workshop on Presence (PRESENCE'04)*. Valencia, Spain, Oct. 13-15, 2004, pgs. 36-43.

[14] MacIntyre, B., Bolter, J.D., Moreno, E., and Hannigan, B. Augmented Reality as a New Media Experience. In *International Symposium on Augmented Reality (ISAR 2001)*, New York, NY, October 29-30, 2001.

[15] MacIntyre, B., Gandy, M., Dow, S., and Bolter, J.D. DART: A Toolkit for Rapid Design Exploration of Augmented Reality Experiences. In *Proceedings of User Interface Software and Technology (UIST'04)*, Sante Fe, NM, USA, Oct. 24-27, 2004, pgs. 197-206.

[16] Mateas, M., and Stern, A. Facade: An Experiment in Building a Fully Realized Interactive Drama. In *Game Developers Conference (GDC'03)*, San Jose, CA, USA, Mar. 6-8, 2003.

[17] Murray, J. *Hamlet on the Holodeck: The Future of Narrative in Cyberspace*. Simon & Schuster, Inc., New York, NY, 1997.

[18] Oakland Cemetery, Atlanta, http://www.oaklandcemetery.com, 2005.

[19] Petrelli, D., Not, E., Zancanaro, M., Strapparva, C., and Stock, O. Modeling and Adapting to Context. In *Personal and Ubiquitous Computing*. Vol. 5., 2001, pgs. 20-24.

[20] Rozier, J., Karahalios, K., and Donath, J. Hear&There: An Augmented Reality System of Linked Audio. In *Proceedings of International Conference on Auditory Display (ICAD'00)*, Atlanta, GA, USA, Apr. 2-5, 2000.

[21] Taliaferro, T. Historic Oakland Cemetery, Tempus Publishing, 2001.

[22] Vlahakis, V., Karigiannis, J., Tsotros, M., Gounaris, M., Almeida, L., Stricker, D., Gleue, T., Christou, I.T., Carlucci, R., and Ioannidis, N. ARCHEOGUIDE: First results of an Augmented Reality, Mobile Computing System in Cultural Heritage Sites. In *Proceedings of the Conference on Virtual Reality, Archeology, and Cultural Heritage (VAST'01),* Glyfada, Greece, Nov. 28-30, 2001, pgs. 131-140.