Time Travelers: Mapping Museum Visitors across Time and Space

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Abstract
Open-air museums may encompass structures, buildings, sites, and other types of objects and artifacts that span across space and, because these objects were built and/or used during multiple periods of significance, across time. The multiplicity of storylines can confuse visitors. Thus, this paper introduces *Somewhere in Time*, a novel installation that integrates a combination of technologies with historic content that allows users to explore both time and space across museum structures/sites. We describe our work conceptualizing and designing a personalized, interactive map (*Time Travelers*) that allows visitors to explore complex narratives across both time and space.

Author Keywords
Full-Body Interaction; Public History; Museums; Identity-Preserving Tracking; RFID; Design; Historic Site Interpretation

ACM Classification Keywords
H.5.2. Information Interfaces and Presentation: User Interfaces; J.5. Computer Applications: Arts and Humanities; I.4.8. Image Processing and Computer Vision: Scene Analysis.

Introduction
As the American public changes, so too does their preferences for consuming historic content. Today's visitors want to "come to conclusions on [their] own,

Figure 1. Historic New Harmony. From top to bottom, the Visitors Center, the Community Oven near the Lenz House, Community House #2, and the inside of Community House #2.

instead of listening to someone else's tainted conclusions." [12] Not surprisingly, studies suggest that for many museum visitors, the traditional guided tour, based upon transmission-based learning –i.e. disseminating information from a (presumably) knowledgeable authority figure to those who lack either authority or knowledge, falls flat. Perhaps this was best articulated in a Connecticut Cultural Consumers survey conducted in 2008. When asked to explain how they felt about guided tours, nearly 48% of the 4,500 respondents used words with negative connotations such as "Trapped. Controlled. Insipid. Intimidating. Monstrous [and] Claustrophobic." [13]

Yet, traditional guided tours can help marry complex narratives across both time and space –a methodology particularly pertinent to open-air museums whose collections include structures, buildings, and sites built and/or used during multiple historical periods. Unless the visitor is an expert in architecture and material culture of those time periods, she or he may not understand what collection material (including structures) belong to when. Thus, the tour guide can help provide the visitor with important historic contextual information. Yet, if the visitors are disengaged by the tour, it has no purpose. So, the question arises, how can an outdoor museum provide historic and spatial continuity for visitors, without relying on the traditional guided tour?

We believe that an interactive, personalized map can provide visitors with a first entry-point to these complex narratives. In fact, museum maps are an integral part of the visitors' experience: almost all museums provide maps at the ticket counter and across the exhibition space. Many visitors, however, do not read those maps, or those who do read them, find them only marginally useful [4].

In recent years, there has been an increasing interest on how technology can be used to create more engaging, personalized museum maps. For example, [3] describes the design of a location-aware guide for hand-held devices, while the CHIP project [11] attempts to deliver personalized maps to visitors' mobile phones. In some history museums, however, orienting visitors in space is not enough as the narrative the museum espouses is more complex and/or spans across multiple periods of significance. In that case, museums should also consider orienting their visitors in time as well.

In this paper, we discuss the research challenges we are encountering in our design of *Somewhere in Time*, a prototype installation at Historic New Harmony (Figure 1) that attempts to address these challenges. In particular, this paper details our endeavors of designing an interactive map (*Time Travelers*) that will be one element in this traveling alternative to the traditional guided tour. We present preliminary results from this work, and propose a research agenda for future work in this area.

Scenario

Historic New Harmony

New Harmony, Indiana (Figure 1) provides an effective scenario for this exploration. Founded in 1814, New Harmony was conceived as a utopian community by German immigrant George Rapp and his followers, the Harmonists. Rapp and his Harmonists built this planned community from 1814 through 1824 when Rapp sold the community (and all its existing structures) to utopian-socialist and factory-owner, Robert Owen of Scotland. Though Owen abandoned New Harmony shortly after

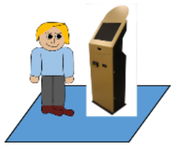

Figure 2. Museum visitors register at a kiosk and are assigned a profile.

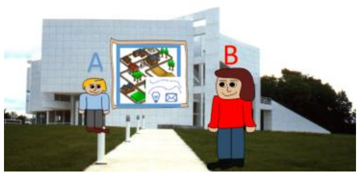

Figure 3. Interactive screens across the museum show contextual information that is relevant to the profiles of the visitors who are near the screen. In this example, User A and User B are near a screen placed outside the Visitors Center at New Harmony. The screen shows a map of the town.

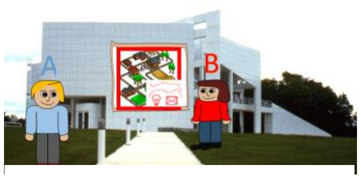

Figure 4. Visitors can interact with the screen using body movements. In this example, the information relevant to User B is moved to the foreground when she walks closer to the interactive screen.

taking ownership of it, his progressive social ideas remained long after. Thus, there are two different periods of significance associated with these two different communities: the Harmonists (c. 1814-1824) and the Owenites (c. 1824-1840).

Translated to the built environment at New Harmony, this means that the Harmonists created the footprint of the community, whereas the Owenites readapted and reused existing Harmonist structures to cater to their own needs. Currently, Historic New Harmony attempts to tell these two different narratives utilizing the aforementioned flawed traditional guided tour.

Somewhere in Time: A Traveling Alternative to the Traditional Guided Tour

We are prototyping an interactive installation, which we dubbed *Somewhere in Time*, that allows visitors to register at a kiosk (Figure 2) and select a context-based profile delineated by both period of significance and theme (e.g., "education during the Harmonist period" or "working life during the Owenite period"). Visitors then have the ability to interact with the information relevant to their profile on multiple screens placed both indoors and outdoors throughout the community (Figure 3). Visitors can interact with contextual information, which includes text, multimedia content, and maps of the museum space (Figure 4). As visitors bring their context-based profiles with them throughout their exploration of the museum spaces, visitors will have a continuous experience across the varied settings.

One question we encountered in our conceptual design of the installation, was how can we orient visitors to their specific contextual story (i.e. the one associated with their profile) across museum spaces? We thought that an interactive map would provide one solution to this problem. Thus, when we started prototyping an interactive display that would also show a map of New Harmony outside the visitor center (one of the interactive screens of *Somewhere in Time* –Figures 3 and 4), we encountered two major challenges: (1) Identity-Preserving Tracking for Multiple People, i.e. preserving the identity of each visitor across the museum, while also tracking her/his body movements (existing technologies support at most two people); and, (2) Designing a Map to Orient Visitors to Space and Time, i.e. providing visual information that allow visitors to orient themselves in both space and time (traditionally, maps are designed to provide spatial, not temporal, clues).

Related Work

At the present time, there is no museum program that utilizes technology to ensure that visitors can have a continuous experience in and between sites, as well as within multiple historic time periods.

Continuous Experience across Time

Historic museums and sites approach the problem of competing historical narratives by: 1) Focusing the majority of their exhibits and programming on a narrow time frame or, 2) Presenting different historical periods at different locations throughout the site.

The former has been done remarkably well, for example, at Colonial Williamsburg, where live interpreters act out "eighteenth century Williamsburg as it appeared on the eve of the American Revolution."[1] Though they complicate their narrative by attempting to acknowledge gender, race, and class, the stories they tell are still "of the moment;" there is no sense of how the community evolved over time, or the other narratives that could have been told had they not fallen

[1] https://www.colonialwilliamsburg.com/

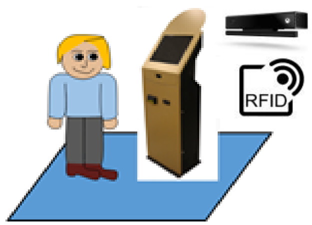

Figure 5. A museum visitor registers at a kiosk. He receives an RFID tag. A Kinect camera records a set of *salient features*.

Figure 6. When visitors approach an interactive screen, the system is able to identify who is nearby from their RFID tags.

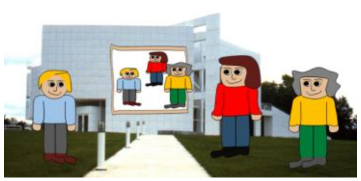

Figure 7. The combination of RFID and camera tracking limits the number of possible matches.

outside of the period. Colonial Williamsburg, and other museums like it, are stuck in time.

Alternatively, Conner Prairie in central Indiana, utilizes a "walk in time" approach to orient visitors to different periods of time. For example, at one end of the site, visitors can explore Prairietown, an interpretation of rural life in 1836; in another area of the site, visitors can learn more about the Native Americans of the area by visiting the Lenape Indian Camp perpetually set in 1816. In both cases, the visitor and the administration never get to confront the tough questions that arise when time overlaps within the same space.

Continuous Experience across Space

There have been some attempts to provide visitors with a continuous experience across space within museum buildings themselves. For example, at the National Holocaust Museum in Washington D.C. visitors are given "identification cards" that contain biographies of people who experienced the Holocaust; as visitors weave through the exhibit space on multiple floors, they are supposed to turn the pages on their booklets to follow the lives (and, all too often, deaths) of the booklets' historic subjects. Although this exhibit allows the visitor to trace a specific story throughout the museum, it is not designed for a continuous experience between indoor and outdoor spaces, as the National Holocaust Museum is contained entirely indoors.

On the other hand, other than relying upon live interpreters, open-air museums have yet to properly address the issue of creating a continuous experience across space. Perhaps in the early 2000s, LIFEPLUS [8] came closest to this endeavor when they fitted visitors to the Pompeii historic site with a battery-powered, head-mounted display and backpack that they carried around with them at various sites. Though visitors were able to walk to different locations, their experience happened only "inside" the buildings as their head-mounted displays allowed them to "look inside" the various structures to watch fictional historic characters interact among themselves, i.e. there was no narrative or interpretive story between structures, only within them.

On-Going Work

Although the interactive map we've detailed below (*Time Travelers*) is only one element in the *Somewhere in Time* installation, because it grapples with the challenges one encounters when attempting to meld space and time into a continuous experience for visitors, it is a good model for our investigation.

Identity-Preserving Tracking for Multiple People

In order to implement an interactive, personalized map (allowing visitors to navigate both time and space), we need an identity-preserving tracking system. This, however, is an open-challenge for full-body interaction as both camera-based tracking systems and RFID readers have disadvantages.

Camera-based tracking systems are accurate enough to recognize gestures and body movements (e.g., Microsoft Kinect v.2 has an accuracy of +=1cm [14]). They are not designed, however, to preserve identities –unless they are used in combination with face-recognition algorithms. Such algorithms, however, do not offer consistent accuracy: they suffer from illumination and pose detection problems [16] which makes them difficult to use in outdoor spaces (where illumination cannot be controlled). Furthermore, they are less accurate with non-Caucasian faces [9] which would provide challenges to museums that welcome diverse visitors.

Figure 8. Four participants collaboratively design a map (*Time Travelers*) to orient museum visitors in space and time.

On the other hand, Radio-Frequency Identifiers (RFID) are specifically designed to identify all the RFID tags that are within the reach of an RFID reader. RFID tracking systems (such as those based on the Received Signal Strength Indicator [1]), can efficiently detect the room in which a person (who is carrying a tag) is, but they are not accurate enough to track people within a room or in front of an outdoor screen. Even recent approaches based on KL-divergence [7], have an accuracy of +=2 meters –this does not allow for fine-grain gesture recognition.

Our proposed solution combines these technologies and is based on the observation that museum visitors typically give each other enough space to view exhibits (e.g. most visitors do not crowd around a single panel, but rather, return to the panel once it is free). Thus, only a small portion of the people that visit a museum in a specific day will be in front of an interactive screen at the same time –for example, three visitors might be in front of one interactive screen, while fifty other visitors are in different museum locations.

Similarly to *I See You There!* (ISYT) [2], our approach merges information from a camera tracking device and an RFID system. ISYT, however, only supports two people at a time, because it still relies on an RFID tracking algorithm. On the contrary:

- Using a passive RFID sub-system (a ThingMagic Mercury6 reader and ISO 18000-6C Alien tags), our prototype retrieves only the profile of visitors (which previously registered at a kiosk –Figure 5) that are in the proximity of the interactive screen; the RFID does not track visitors' movements—Figure 6.
- Utilizing a camera-tracking sub-system (Microsoft Kinect v2), our prototype, compares "salient features" [15] of the people who are currently in front of the interactive screen with the "salient features" associated with the profiles detected by the RFID (Figure 7). The "salient features" are sets of points extracted from the visitors' silhouettes (not just from their faces). The identity information from the RFID sub-system will reduce the set of possible matches, leading to more accurate identity assignments.

Designing Maps to Orient Visitors in Space and Time

Identity-preserving tracking for multiple people is only one part of the problem space. Another is the design of the map (*Time Travelers*) itself. Although it has been done in other capacities, there is no set recipe for the design elements that must be included in a map of this kind. Thus, we are conducting a collaborative design study with potential museum visitors.

In our video-taped design sessions, at least two moderators, who are always in the room, show participants a current map of New Harmony, and then ask them to work in groups of four to design an interactive map that helps to orient other visitors in both time and space. To do this, we use a think-aloud protocol and ask participants to draw their sketches on a whiteboard (Figure 8).

Our preliminary results, culled from information gathered by twenty participants (n=20 people, N=5 groups, drawn from a population of college students) reveal two interesting patterns: (1) Participants re-purposed traditional design elements of spatial maps to represent time. For example, in lieu of a traditional timeline, eight people recommended placing symbols that represent either important events or different time periods on the map. This is very similar to "landmarks" commonly placed in spatial maps [5]; and, (2) Participants' design recommendations were based on conceptual metaphors [6]. This is similar to what was observed in [10] when designing a traditional timeline. In particular, eight people recommended using brighter colors for recent events, landmarks, or buildings, and faded colors for past ones. This is consistent with the English phrasing that "time fades away."

Future Work

The next steps will be to implement the tracking system and perform a test of its accuracy both in lab and in situ. Once the tracking system is fully implemented, it will encompass both indoor and outdoor spaces across New Harmony.

In parallel, we will use the recommendations from the co-design study to design and implement the interactive, personalized map (*Time Travelers*). We will evaluate the map which will be located outside the visitor's center at New Harmony.

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