THE DESIGN OF A MOBILE NAVIGATION SYSTEM BASED ON QR CODES FOR HISTORIC BUILDINGS

CHUN-HUNG LIU, CHANG-FRANW LEE
Graduate School of Design, National Yunlin University of Science and Technology, Douliou, Yunlin 640, Taiwan, R.O.C
Department of Digital Media Design, Kao Fong College, Chung-Ji, Pingtung 908, Taiwan, R.O.C
chliu@kfut.edu.tw, leecf@yuntech.edu.tw

Abstract. Due to the rapid development of mobile and compact electronic devices such as PDAs and smart phones, designers and developers now have to consider user mobility and the dynamic context of use in the design of interactive systems. In this study, literatures associated with mobile navigation systems in museums and historic buildings are first reviewed in order to understand the features, advantages, and drawbacks of current mobile navigation technology. The feasibility of applying QR codes in the navigation of historic buildings is then discussed, and the mobile navigation principles mentioned in previous literatures are applied in our proposed system. A number of common problems are encountered in the navigation of local historic buildings or museums. Visitors (1) cannot understand what makes an exhibited item a work of art; (2) do not know where to start or how to get started; (3) feel rushed by guides during the guided tour; and (4) find that the audio guide is not clear enough. Managers of historic buildings or museums are generally concerned about (1) the high cost of constructing a mobile navigation environment; (2) possible damage to devices; and (3) the cost of device maintenance. This study attempts to solve the above issues by constructing an affordable digital navigation environment that enables users to clearly understand each exhibited item and its location.

Keywords. Mobile navigation; QR code; historic buildings.

1. Introduction

When visiting a historic building or a relic, one usually does not fully understand the history of the building or the object if an introduction is not provided. In
this situation, navigation becomes particularly important. For many historic buildings, printed introductions are usually available; if resources are abundant, tours led by a professional guide can be reserved in advance. However, for historic buildings located in areas with scarce resources, providing printed guidebooks is impossible, and building a digital navigation environment is certainly out of the question. However, thanks to the advances in wireless network technologies and the prevalence of handheld mobile devices, interaction with exhibits using personal mobile phones is now possible. In this paper, a mobile navigation system based on QR codes is proposed and the feasibility of applying it to the navigation of local historic buildings is tested. We attempted to construct an affordable system that requires no extra investment in human or material resources on the part of the museum and allows visitors to get a better understanding of historic buildings and their contents.

Most people would like to know more about the historically significant places that they visit. However, at some historical buildings listed as cultural heritage sites by the United Nations, one will find that only printed introductions are provided. If no admission fee is required, the introduction is likely to be very vague and printed on a piece of A4-sized paper. As shown in Figure 1, this kind of printed information often disappoints visitors. At some historical sites where an admission fee is required, the introduction may be provided on full-color printed brochures, as shown in Figure 2. However, visitors still have to shift their attention back and forth between the brochure and the exhibits and cannot concentrate solely on enjoying the experience. In this basic navigation environment, visitors are required to (1) search for the corresponding description on the brochure and (2) switch their attention between exhibits and the text.

Figure 1. A printed introduction to the Cathedral of Saint Barbara (a cultural heritage site).

Figure 2. A full-color brochure for St. Vitus Cathedral (a cultural heritage site).
In this paper, we propose a mobile navigation model that allows (1) users to have a better understanding of the content of exhibited objects and (2) administrators to use the most effective navigation mechanism available at the lowest cost.

2. Related Research

The focus in this section is to explore the previous work of mobile digital navigation researchers and use this information as a reference when implementing the proposed system.

2.1 CONSIDERATIONS FOR PDA NAVIGATION

Yu et al. (2003) conducted a thorough review of studies related to the applications of mobile digital navigation systems. We examined the original papers and added some of our own ideas in order to discuss the issues that should be considered when developing mobile information carriers. These issues will be the reference for the subsequent implementation of a prototype system.

Spasojevic and Kindberg (2001) proposed that in the design of navigation between the physical and virtual, four factors should be considered:

1. Basic affordances: handheld devices, wireless connectivity, sensor capability (1-2 m Infrared and RFID, 1-10 cm barcode), screen properties, and input models.

2. Attention to artifacts: the attention that a user pays to a particular exhibit or web page. Does the user really look at a particular web page? If so, does he only glance at it or read some text on it? Is the user interested in the exhibit or the device?

3. Path through physical and virtual space: the sequence of points in physical and virtual space upon which a user’s attention is focused as he visits the museum, as shown in Figure 3.

4. Higher order effects: this relates to models of higher order effects such as informal learning. The literature is placed on exploring whether technology
aids can really enhance learning and how to allocate users’ attention as they visit an exhibition. However, these issues were not substantially dealt with by Spasojevic and Kindberg (2001).

2.1.1 Other issues relating to basic affordances (physical and mental affordances)

On the basis of the practical experience of implementing a digital navigation system at the National Palace Museum (NPM), Lai et al. (2004) pointed out that the battery life of PDA devices is not long enough if the screen backlight remains ON during navigation. For long-term navigation, they added an external battery to each PDA. Additionally, compared to common audio navigation devices, PDAs are more delicate and fragile. To avoid damage from accidental bumping or dropping the device, they put a protective cover on each device, adding even more extra weight. Although the navigation device can be worn around a user’s neck to alleviate the burden, Fleck et al. (2002) pointed out that PDAs are costly, and even if they are borrowed from the museum, users still have a sense of insecurity, fearing that they are responsible for any damage if the devices fall to the ground. In this study, the navigation devices (mobile phones) are owned by the users. The museum is not responsible for lending, managing, and maintaining the devices. As long as users’ mobile phones can be connected to the wireless network, they can be used for inductive navigation in a local network environment. This kind of application is expected to be a future tendency.

2.1.2 Interaction with companions

In the study of attention allocation, some scholars have mentioned the importance of interactive sharing with companions. Woodruff et al. (2001) pointed out that when visiting a cultural heritage site, what visitors expect to obtain first is not educational information but the experience and perceptions of their companions. Interaction with companions is important for visitors, and wearing headphones makes them feel isolated. Woodruff et al.’s (2001) empirical result showed that of the five pairs of visitors, four chose to listen to the narration using a speaker, and only one chose to wear the headphones. Fleck et al. (2002) observed visitor behavior in a museum (the Exploratorium), discovering that adult visitors tend to discuss the scientific knowledge behind the exhibits. For instance, while one “reads” the description, the other can “do” the visit. Visitors were pleased to help and discuss with each another.
2.1.3 Mapping the physical space

On the basis of the characteristics of interpersonal interactions, Woodruff et al. (2002) further developed a navigation system for historic exhibits. This system (1) uses images of the exhibition hall as media that connects the virtual space and the physical exhibits; (2) provides succinct descriptions (in 2-3 sentences) to maintain the balance between the requirement of attention and fulfillment of navigation; and (3) allows visitors to hear and interact with their companions through the use of headphones. The single-sided wireless headphones allow visitors to chat with companions in a low voice without the worry of disturbing other visitors. Indeed, Aoki et al. (2002) discovered that companions enjoy sharing ideas using this mechanism.

2.1.4 Synchronous and asynchronous transmission of information

Semper and Spasojevic (2002) mentioned that museum learning is a process that ideally consists of three stages: (1) before the visit, visitors should log onto the Internet to get familiar with the exhibits; (2) during the visit, they can use handheld devices to browse the content and obtain additional information about the exhibits; and (3) after the visit, they can reflect, analyze, and extend what they have learned from the exhibits. Through this process, as illustrated in Figure 4, their learning effectiveness can be enhanced.

![Figure 4. The framework of using portable devices and a wireless network to extend the museum experience. (Semper and Spasojevic, 2002)](image)

3. QR Code Features and Construction of a Prototype Digital Navigation System

This section introduces the features of QR code and explains how to apply them to building a prototype navigation system for historic buildings.
3.1 FEATURES OF QR CODES

Both the Exploratorium (Fleck et al., 2002) and the NPM (Lai et al., 2004) use RFID-based navigation systems. The cost of a RFID reader is almost equivalent to that of a QR code scanner (camera), and most modern mobile phones are already built with a camera. Compared to a bar code, a RFID tag is much more expensive. A passive tag costs about 1 USD (Jao, 2006), but a QR code costs less than 1 NTD.

Integrative application of camera phones and two-dimensional bar codes is one of the programs currently promoted by governmental agencies in Taiwan. Two-dimensional bar codes can store text and graphics data. Consumers can capture the bar codes using the camera on their mobile phones and retrieve further information from the Internet. Compared to RFID, this is a much cheaper and faster mechanism for mobile commerce (Chi, 2005). Therefore, integrated application of mobile Internet, phone cameras, and QR codes seems feasible.

3.2 PROTOTYPE DESIGN

The proposed mobile navigation system for historical buildings in Pingtung is mainly an integrative application of existing wireless technology, QR code, and mobile phones.

Weng and Tai (2007) mentioned that integrating a QR code decoder into a camera phone makes the phone a portable and compact bar code scanner. Such integration not only saves the cost of a real scanner but also reduces the cost of generating bar codes. For museum administrators, QR codes are easy to make and mobile phones can be used as navigation devices, which the museum is not responsible for maintaining. Thus, the sense of insecurity mentioned by Fleck et al. (2002) and the risk of damage mentioned by Lai et al. (2004) will no longer be issues.

In order to discuss budget and human resource constraints, three sites listed as either historical heritage sites or historical buildings by the Taiwan Ministry of the Interior (MOI) were selected: the Air Force Hostel (Sun Li-jen’s Residence, currently named the Museum of Ethnic Music), the Golden Catholic Church, and the Hsiao Family’s Old House. In these buildings, no wireless networks have been established. Thus, considering the cost of 3G connections and users’ willingness to use them, text-only QR code and QR code that require Internet access were simultaneously provided (as shown on Figure 5).
The first room in the Hsiao Family’s Old House (Theme)

| Internet access | Text-only (No Internet access required) |

*Figure 5. Two types of QR codes: one (left) requires internet access to provide graphics, audio, and text descriptions, and the other (right) requires no internet access but provides text-only descriptions.*

### 4. Results

Before devising the prototype system, we reviewed related studies on digital navigation in order to better understand the issues, methods, and factors considered by previous researchers. Our solutions and results are as follows:

#### 4.1 SOLUTION TO ATTENTION ALLOCATION ISSUES

In conventional paper-based navigation models, visitors need to switch their attention between the brochure and exhibits. Unlike RFID-based systems, the proposed QR code-based system does not have the capability to identify all the objects within a certain distance. However, it requires only a quick scan of the barcode to show the content of an exhibit of interest. Issues such as unexpected jumps to the next exhibit will not occur. Thus, the proposed navigation method resembles the method that requires manual input of the number corresponding to an exhibit of interest, but does not really require manual input. Compared to paper-based navigation and manual input of corresponding numbers, our method demands less user attention. In addition, the additional audio navigation helps visitors concentrate their visual attention on exhibits by minimizing the need to switch focus between the virtual and physical spaces. Linearity is one drawback of audio navigation. Users may not fully understand the significance of an exhibit. However, if the narration is too long, users can also select the text mode as a means of understanding the content (Figure 6).

*Figure 6. The QR codes attached to a column in the Golden Catholic Church.*
4.2 SOLUTION TO ISSUES REGARDING BASIC AFFORDANCE

PDA battery life is always an issue that museum administrators are concerned with when providing PDA-based navigation. During prolonged navigation, the PDA battery will be quickly drained by the screen backlight. Thus, an additional battery should be attached to increase the battery life of the PDA. However, this also increases the weight of the PDA. A neck strap may be needed to help the user alleviate the burden of the PDA's weight. Despite the assistance of neck straps, users still have a sense of insecurity. As mentioned by Fleck et al. (2002), users fear that they are responsible for any damage to the PDA. This issue can be addressed if visitors’ mobile phones are directly used as navigators.

4.3 SYNCHRONOUS AND ASYNCHRONOUS MAPPING TO THE PHYSICAL SPACE

The proposed mobile navigation system provides not only synchronous information during the visit but also asynchronous information that “corresponds to the physical space” of a website, as suggested by Woodruff et al. (2002) (Figure 7). Visitors are allowed to preview or review the exhibition content available on the website. By browsing the virtual exhibits corresponding to the physical ones, they can get a deeper understanding of the exhibits after the visit.

![Figure 7. A website that provides asynchronous information relating to the exhibits.]

4.4 THE SYSTEM IS AFFORDABLE

Using personal mobile phones as navigators provides the following benefits for a museum: (1) funds do not need to be allocated for the purchase, maintenance, and management of navigation carriers (mobile phones are owned by visitors themselves); (2) it is not necessary to educate visitors about how to use the navigators (they know how to use their phones better than anyone else); (3) availability is high (almost everyone carries a mobile phone); and (4) the exhibits in local cultural or historical organizations usually remain unchanged for a long period of time. If any QR code is damaged, it can be
easily printed with normal printers. These benefits are helpful for local cultural and historical organizations with access to limited funds. Their navigation services will not be temporarily terminated if carriers or QR codes are damaged.

5. Conclusion and Discussion

In this paper, we attempted to extend the systematic applications of QR codes. The proposed system is only a conceptual prototype. Practical application of this system is expected in one or two years. In terms of carriers, some problems regarding the use of mobile phones as issues have been encountered: (1) the screen size is small; hence, the readability of the information is reduced; (2) the coverage of local wireless networks is limited (Although a 3G connection may be a substitute, there is still a limited number of subscribers to such plans); and (3) in Taiwan, unlike in Japan, QR code decoding software has not been widely installed on mobile phones (Manual installation of the software is required).

Some problems associated with attaching QR codes to historical and cultural exhibits have not been resolved. In our experiment, the selected historical and cultural organizations permitted us to attach QR codes to the building or beside the artifacts. Some artifacts or exhibits are located outside the building or on the ceiling. For instance, some windows in the Golden Catholic Church are located on the ceiling of the hall. If QR codes were attached beside these windows, they would be out of the identification range. One of the feasible solutions is to add an easily recognizable pattern to each QR code. Visitors would be able to recognize the QR codes by the pattern and retrieve more information relating to an exhibit.

Like the NPM, many national museums have tested various technologies, such as RFID and Tablet PCs. However, local historical buildings do not have the human or material resources to consider this option. Therefore, the proposed system is intended to provide navigation services at a low cost. For historical buildings suffering from a lack of funds, this system can be a feasible and sustainable solution.

References


