Remote Museum Guidance using Augmented Reality Vehicle

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Abstract

In this paper we propose a augmented reality vehicle systems that provides mobility support and enables museum curator to present guide tour to museum visitor from outside exhibition hall. In museums, exhibition guide tour is widely conducted as a strong support for exhibition appreciation activity. Effectiveness in exhibition guide tour is based on its interactivity caused by face to face discussion between visitors and curator. However, it has strong restriction in space and time for curator, museums are not able to perform exhibition guide tour frequently. Therefore, we propose the systems that experts in exhibition theme can perform such guide tour through personal mobility and network and provide more opportunities to present guide tours for museum visitors.

Index Terms: H.5.1 [INFORMATION INTERFACES AND PRESENTATION (e.g., HCI)]: Multimedia Information Systems—Artificial, augmented, and virtual realities; H.4.3 [INFORMATION SYSTEMS APPLICATIONS]: Communications Applications—Computer conferencing, teleconferencing, and videoconferencing

1 Introduction

Recently in museums, activities for providing opportunities of experience and communication to visitors become more important. A guided tour is the most popular service to offer an experience to promote greater understanding of exhibits through communication between visitor and curator. Nevertheless, it is difficult to perform guided tour frequently because of the restriction in space and time for museum curators. Information technologies have contributed widely to this problem by applying mobile terminal as museum guide such as audio guide. Audio guide is in widespread use all over the world but the lack of interactivity and multimedia expression drive many researches in development of next generation museum guide. In following chapter, we describe several related effort of using information technology or robot technology for guide tour application.

2 Related Research

2.1 Exhibition Support using Information Technology

There are many attempts to utilize personal digital assistant for museum guide tour application [4] [7] [3]. These cases are suitable for presenting personalized information to each user. However, one issue is that users are forced to keep focus onto information displayed on the surface of mobile terminal and kept from appreciating exhibit itself. Another issue is that it is hard to have conversation among group of visitors, since each person is concentrated on operating own terminal.

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2.2 Exhibition Support using Robot Technology

Besides information technology, robot technology is began to apply on museum guide tour [8] [1] [5]. The largest advantage of using robot as a guide is in the presence of robot its own. The presence of robot can attract museum visitors. Robot can physically navigate group of visitors and indicate directly to attention point of certain exhibit by its body. Although robots are effective for spatial navigation of visitors, it does not have an advantage in presenting multimedia content related to exhibit compared with mobile terminal. On the other hand, visitors are forced to follow all the guidance that robot performs. It is difficult to make together both guide tour performed by robot and spontaneous appreciation of visitors.

3 System Design

3.1 concept

Considering backgrounds mentioned in previous chapter, we decided to develop remote guide tour system using personal mobility. Fig.1 illustrates the application image of our concept.

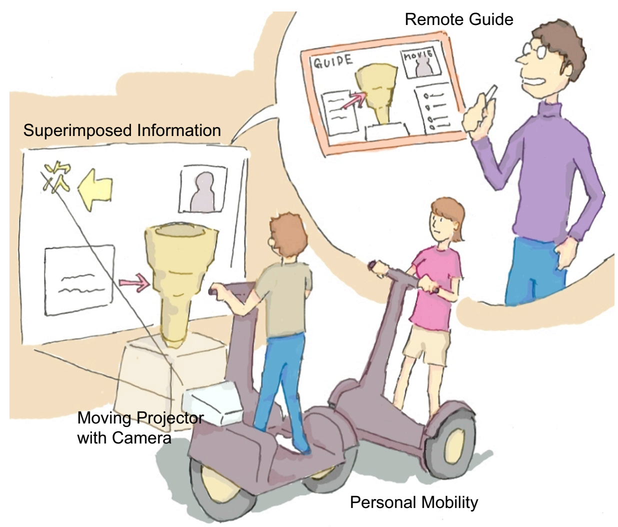

Figure 1: Concept Image of Proposing System

User can move freely inside exhibition hall by driving the personal mobility. The Personal mobility is equipped with a robotic pan-tilt projector. By using this projector, the person who performs guide tour from remote site can present spatial navigation indication or additional multimedia content onto real world. With a help of robot technology and information technology, proposed system enriches appreciation of exhibition. Furthermore, the system can also release curator from restriction of space and time.

3.2 Methodology

In order to guide visitor who is driving personal mobility from remote site, it is important to consider about the navigation method.

If the visitor is guided through only oral communication with remote guide, guide is required to give frequent instruction to visitor. Visitor may be confused which is the right direction to keep her/his eye on. To avoid this kind of problem in spatial and viewpoint navigation, we decided to make use of moving visual information of the projector for navigating visitor's location and direction of eyes.

3.2.1 Spatial Navigation and Viewpoint Navigation

At first, we measured direction of eyes of visitor who is riding personal mobility to examine how it changes when heading toward an object. Subjects are asked to wore wearable eye-mark recorder(NAC EMR-9) and ride personal mobility(Segway PTi2) to move toward 3 exhibits that are placed in different distance, 8.0, 18.0∼20.0 and 32.0[m]. This experiment is conducted to 5 subjects from graduate student major in computer science. Fig.2 is the result of measurement. Despite of different distance or heading speed every subject move their direction of eyes from heading direction to exhibit in 6.0∼7.0[m] distance.

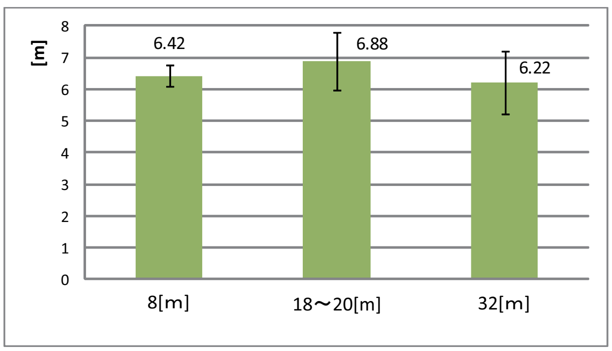

Figure 2: View-point Transition in Moving

From this result, we decided to divide navigation phase into two. Those are spatial navigation phase and viewpoint navigation phase. In the first phase, the system project directional arrow on floor. As the personal mobility get close to certain distance, the system moves to the next phase to project indication toward exhibit Since the moving projector mounted on personal mobility requires 2.0[s] to upward the direction from projecting ground, the projector is set to start moving in accordance with distance $d_{\text{boundary}} = 2.0|\vec{v}_{\text{segway}}| + 6.0[m]$. $\vec{v}_{\text{vehicle}}$ is heading speed of personal mobility. Additionally, head movement of subjects is also observed when they move their direction of eyes toward exhibit.

3.2.2 Evaluation Value of Visitors Viewpoint

Projection quality must be evaluated to obtain well observable image projected onto exhibit surface. So that evaluation function is required to describe spatial relationship among projector, object and observer. Evaluation function of projection point is derived by extending the fuction defined in our previous research [2]. Firstly, resolution of projected image become coarse when projecting distance becomes large. This relation is described in equation $QV_{\text{Dis}} = \text{Const.}/\text{distance}$. Secondly, projected image become distorted when projecting angle become sideways. This relation is described in equation $QV_{\text{Rot}} = \vec{n} \cdot \left(-\vec{dir}_{\text{Proj}}\right)$. Where $\vec{n}$ is normal vector of object surface and $\vec{dir}_{\text{Proj}}$ is vector of projecting direction. Thirdly, however, projection distance and direction are ideal, if heading direction of visitor is apart from projecting direction, visitor may lose site of projected information. So that we assume that the heading direction is nearly equal to visitor's direction of eyes and evaluated that gap between projecting direction and personal mobility's heading direction is remain in the range of ± 50 [deg] . It is a field of view where person can notice displayed information. QV_{Eye} is defined to describe this relation.

$$QV_{\text{Eye}} = \begin{cases} 1 & (-50 < \theta_{\text{Eye}} < 50) \\ 0 & \text{else} \end{cases} \tag{1}$$

$$\theta_{\text{Eye}} = \arccos\left(-\vec{dir}_{\text{Eye}} \cdot \vec{n}\right) \tag{2}$$

$\vec{dir}_{\text{Eye}}$ is heading direction of personal mobility. Considering all elements related to projecting condition mentioned above, Final equation of evaluation function combined with the result in [2] is defined as,

$$QV_{\text{Guide}} = QV_{\text{min}}^3 \cdot QV_{\text{Dis}} \cdot QV_{\text{Rot}} \cdot QV_{\text{Eye}} \tag{3}$$

$$QV_{\text{min}} = \min\left(QV_{\text{Dis}},\ QV_{\text{Rot}}\right) \tag{4}$$

The more QV_{Guide} become larger, the more ideal position for visitor to see the projected information.

4 SYSTEM CONFIGURATION

The system diagram is illustrated in Fig.3

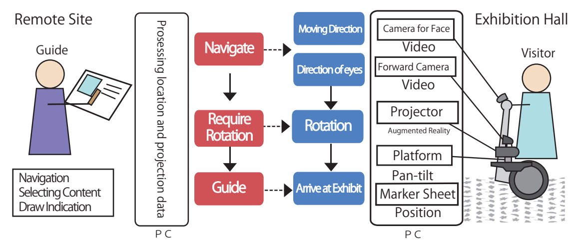

Figure 3: System Diagram

4.1 Augmented Reality Vehicle

The system for visitor is shown in Fig.4. Segway PTi2 is used for a personal mobility. Robotic pan-tilt projector is attached on the side of segway. Location and orientation of segway is measured from decorative maker sheet mat on a floor[6]. Distortion of projected image is compensated by 3D positional data from the maker sheet.

4.2 Remote Guide Tour Interface

The system for remote guide is illustrated in Fig.5. There are five user interface windows in remote guide tool. A guide can operate these tools by using stylus input. Map window is to show visitor's current location and to select next exhibit which guide wish to navigate. Image material window is to select related content image to project nearby guiding exhibit. Selected material window is to show selected image that is chosen by image material window. Guide can superimpose indication figures such as circle or arrow through AR camera window by drawing figures on the captured image transferred from AR vehicle. Communication window is to observe visitor's facial expression. This window is sat up in request of a museum curator. He said that he always observes visitors' facial expression when he perform face to face guide tour in museum hall. Guide can also make oral communication with visitor through headset via network.

It is important for guide to know in what situation visitor is. It is difficult to judge whether visitor is ready to listen for guide tour

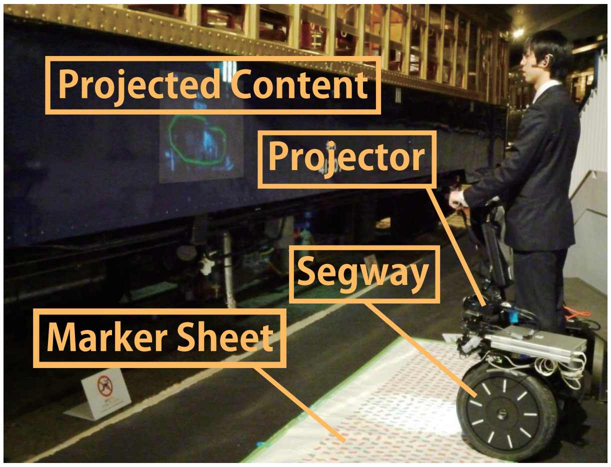

Figure 4: AR Vehicle

Table 1: Visitor's State

Value	Navigation Mode	Guie Mode
	$QV_{\text{Eye}} > 0$ / $QV_{\text{Eye}} = 0$	
$QV_{\text{Guide}} > 0$	Arrived	Guiding
$QV_{\text{Guide}} = 0$	Moving / Need to Rotate	Need to Rotate

story only from information of map window. Therefore, we designed to show what kind to instruction is required to tell the visitor. Visitor's situation displayed on remote guide tour interface is classified as shown in Table.1. Situations are defined by value of QV_{Guide} , QV_{Eye} and current action if visitor is navigated to next exhibit or visitor is now listening to guide story. According to this function, guide is able to give appropriate instruction quickly.

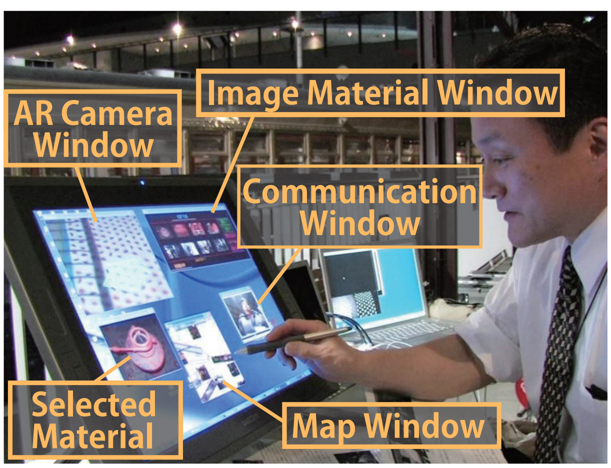

Figure 5: Remote Guide Tour Interface

5 Experiment

5.1 Experimental Field

Remote guide experiment is conducted in the Railway Museum, Japan. The Railway Museum has vast exhibition hall and numbers of historical railroad wagon, thus AR vehicle may also be good movement support. We chose three railroad wagons to perform tour guide. Fig.6 shows the exhibition hall where we used as an experimental field.

Figure 6: Experimental Field

5.2 Guide Tour Flow

The flow of the guide tour is as follows. In the beginning, remote guide selects a first exhibit to navigate. The state of AR vehicle becomes "Navigation Mode" and the projector moves to project directional arrow on the floor. Visitor is navigated to the area where QV_{Guide} gets higher. If visitor reaches inside the area of d_{boundary} the projector changes projection direction toward exhibit to navigate the attention of visitor. In this case, viewpoint navigation information is projected on surface of railroad wagon. When position of AR vehicle fullfils the condition of $QV_{\text{Guide}} > 0$, state of AR vehicle changes to "Guide Mode" and guide can see visitor is ready to listen her/his story through UI window. Then the guide asks visitor to stand still and start to tell the story and project image materials that is related to guiding railroad wagon or draw and superimpose indication figure to make visitor to focus on certain part of railroad wagon.

5.3 Results and Discussions

The experiment is conducted to 6 subjects from graduate students and one subject from museum curator. We took position and orientation log to find out whether proposed evaluation function for navigating AR vehicle worked well or not. In this case, ideal projection distance is less than 2.5[m], according to evaluation function. Fig.7,8 shows the result. The distance from guided point was in between 0.5$\sim$2.0[m]. The average view angle to guided point was less than ± 40 [deg] . As a result, developed system was able to navigate subjects to ideal position and field of view. Additionally, we made discussion with curator of the railway museum. He made a trial of using remote guide interface and he made favorable opinion to the intuitive design of operating remote guide interface. During the remote tour guide, he carefully checked the current location of visitor and made effective guidance to a visitor.

6 Conclusion and Future Work

In this research, we developed Augmented Reality Vehicle for supporting remote museum guide and conducted field experiment in the Railway Museum in Japan. The proposed system was effective for helping guide to navigate visitors using AR Vehicle. For our future work, we would like to make the system portable that can easily attached to different kind of vehicles such as wheel chair that is already widely used in public space.

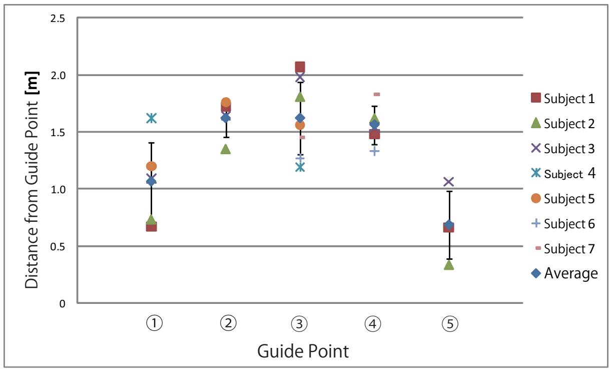

Figure 7: Distance from Guide Point

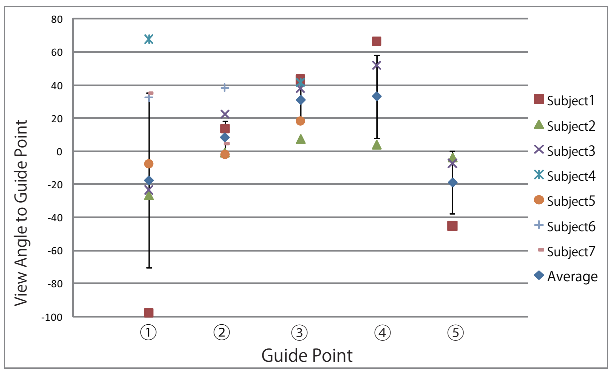

Figure 8: View Angle to Guide Point

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