Towards Interactive Museum: Mapping Cultural Contexts to Historical Objects

Ki-Woong Park
CORE Lab., KAIST
373-1 Guseong-Dong
Daejeon, Korea
woongbak@core.kaist.ac.kr

Sung Kyu Park
CORE Lab., KAIST
373-1 Guseong-Dong
Daejeon, Korea
skpark@core.kaist.ac.kr

Jong-Woon Yoo
CORE Lab., KAIST
373-1 Guseong-Dong
Daejeon, Korea
jwyoo@core.kaist.ac.kr

Kyu Ho Park
CORE Lab., KAIST
373-1 Guseong-Dong
Daejeon, Korea
kpark@ee.kaist.ac.kr

ABSTRACT

In this paper, we present Interactive Museum Interface (IMI) which runs on a wearable computer. It allows people to efficiently and intuitively interact with historical objects in museums. Based on the IMI, the historical objects can be mapped to virtual icons containing cultural contexts as if making a shortcut icon in Desktop. A visitor can collect interesting contexts by pointing & selecting the virtual icons in the museum. In the IMI, the detection of users' pointing objects is a challenging issue because the virtual icons are widely dispersed in the physical space. In order to devise IMI pointing device, we performed simulations of G-sensor modules to extract system parameters like as the sensor threshold and the maximum density of virtual icons. Based on the simulation results, we designed and implemented IMI framework which includes a wearable platform and a ring-type 3D pointing device.

Keywords

Interactive Museum, Virtual Context Icon, Gesture-based Interface

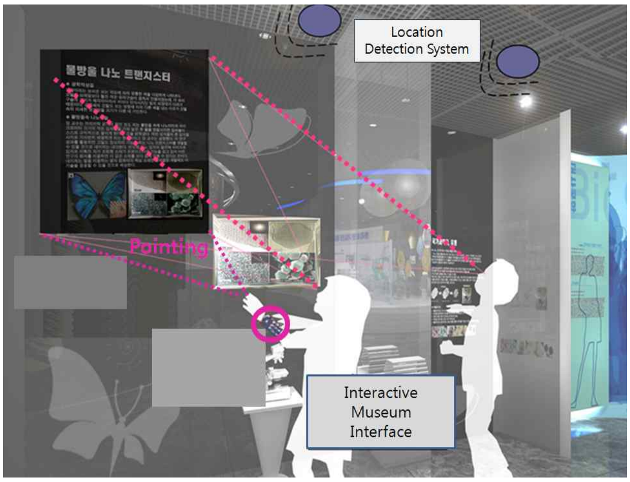

Figure 1. Concept Scenario of Interactive Museum Interface

1. INTRODUCTION

Recently, there has been an increasing interest in developing mobile interface for museum guides and sightseeing. Many museums still present their exhibits in a rather passive and non-engaging way. The visitor has to search through a booklet in order to find descriptions about the objects on display. However, looking for information in this way is a quite tedious procedure. Moreover, the information found does not always meet the visitor's specific interests [1, 2]. Novel devices equipped with appropriate software can facilitate visually-impaired people in autonomous orientation and in exploring the surrounding environment. In this paper, we present an interactive museum interface (IMI) which runs on a wearable computer platform. It allows people to efficiently and intuitively interact with historical objects in museums. Over the interface, the historical objects can be mapped to virtual icons as if making a shortcut icon in Desktop. A visitor can collect interesting contexts by pointing to the virtual icons in the museum. Figure 1 shows the concept scenario of the interactive museum interface. The 3D museum space which includes various exhibitions [3] and those abundant spatial resources are mapped to a certain context. The visitor can select the exhibitions in the museum using a gesture-based 3D pointing device. And then, he can intuitively collect the context by just drag-and-drop into his/her wearable platform rather than searching through a booklet in order to find descriptions about the objects on display.

In the IMI, the detection of users' pointing direction is a challenging issue because the virtual icons are widely dispersed in the physical space. In order to develop the 3D pointing device, we performed simulations of G-sensor modules to extract system parameters like as a sensor threshold and the maximum density of virtual icons for a certain space. Based on the simulation results, we designed IMI framework with a ring-type 3D pointing device. As a next step, we have implemented the prototype of IMI system which includes a wearable platform, and a ring-type 3D pointing device and deployed UWB-based location tracking system.

The outline of this paper is listed as follows: Section II introduces an application scenario of IMI and its components. The design flow of 3D-pointing device is described in section III. In section

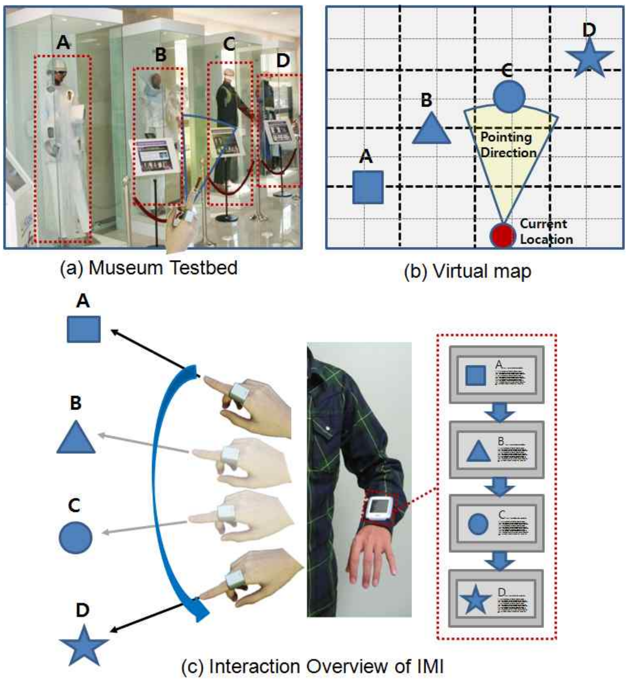

Figure 2. Virtual & Interaction overview of Interactive Museum Interface

IV, we summarize our related works and conclusion is given in section VI.

2. INTERACTIVE MUSEUM SYSTEM

2.1 Application Scenario

In order to realize IMI system, we designed a prototype based on gestural input and mobile display output. Figure 2(a) shows our museum testbed which includes several physical objects. The location information of these objects is managed by the Virtual Map Manager (VMM) which contains the virtual map of the testbed as shown in Figure 2(b). As described in the previous section, the physical objects are mapped to virtual icons as if making a shortcut icon in Desktop.

When a visitor visits the museum, he/she can give a searching glance at around objects by scanning gesture (Figure 2-c and Figure 3-a). And the visitor can select interesting contexts by pointing & selecting the virtual icons in the testbed (Figure 3-b). Finally, the visitor can collect the contexts into his/her wearable platform by taking the drag-and-drop gesture (Figure 3-c). The gesture detection in our interface utilizes a three-axis accelerometer [4] and a three-axis magneto-resistive sensor [5]. The sensor produces signals that are interpreted as events by the gesture detection processing module of the wearable platform. The movements are detected by an accelerometer and, depending on the direction and speed of such movements, they are translated into suitable actions/events (selection, scan or drag-and-drop) on the gesture interface.

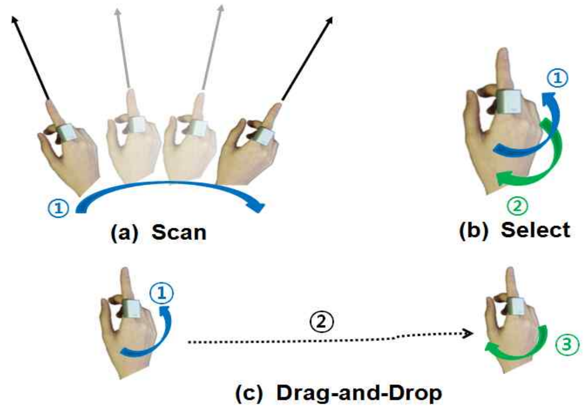

Figure 3. Basic Interactive Museum Interface

2.2 System Components

The overall system of IMI is composed of four components: 3D Pointing Device, Location Tracking System, and Virtual Map Manager.

▪**3D Pointing Device**: It is used to exploit spatial resources. A visitor can point to any objects in the physical space and input simple commands like point, select, scan operations. We have devised IMI pointing device. We explain it more detail in following section.

▪**Location Tracking System:** It keeps track of the location of users and physical objects in 3D physical space. This system is essential because the absolute location information of users and physical objects are critical to find the target object that users point to with 3D pointing device. We have utilized an Ultra-Wideband (UWB)-based location tracking system whose typical accuracy is 6 inches (15cm).

▪**Virtual Map Manager (VMM):** The role of a VMM is to manage virtual icons and the mapping information of the physical space. It contains virtual maps for a certain region like Figure 2-b. When a visitor points to certain object, the VMM automatically finds which virtual icon is mapped to that object.

3. TARGET SELECTION TECHNIQUE

3.1 Ray-based Target Selection Technique

Target selection that identifies which object is pointed by the visitor is the main issue of the IMI system. A sequence of the target selection operation to realize the scenario consists of three phases: First, a visitor can pick interesting contexts by taking selection gesture. Second, the visitors' location and pointing gesture are recognized by the location tracking system and gesture detection module. Finally, on recognizing the selection gesture, the virtual map server responds the information of the pointing object to the visitor's wearable platform.

To realize the target selection mechanism, we have taken a ray-based minimum angle selection approach which is described in Figure 4. When a user points to a physical object with 3D pointing device, a ray from a user toward a pointing direction in a virtual map is casted. Then the closest physical object is selected

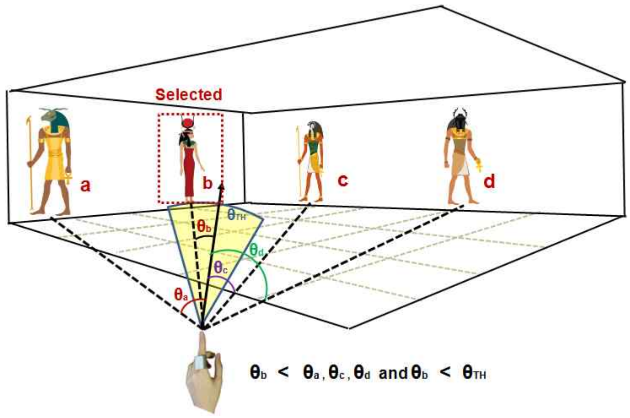

Figure 4. Ray-based target selection mechanism

if an angle between a ray and the selected icon is smaller than θ_{TH}. If a minimum angle is larger than θ_{TH}, no physical object is selected. The reason why θ_{TH} is needed is that we have to find an empty space or an empty physical object which is not mapped a virtual icon. If not, we can't find an empty space when one virtual icon is mapped in a space.

3.2 System Parameters Extraction

In this study, the detection of users' pointing objects is a challenging issue because the virtual icons are widely dispersed in the physical space. Beside the pointing accuracy of the pointing device is affected by both human factors and device factors. The human factors are something like the hand trembling and miss alignment. And the device factors are the variation of a value from a sensor and the error of a location tracking system. Among them, device factors impress the pointing accuracy significantly comparing the human factors. Therefore, we mainly focus on the device factors when designing the pointing device.

3.2.1 Simulation of Pointing Accuracy

We performed simulations to measure the expected pointing accuracy with varying the threshold angle (θ_{TH}), and the number of the virtual icons. In the simulations, we assumed that the average location error from the location tracking system [6] is 6

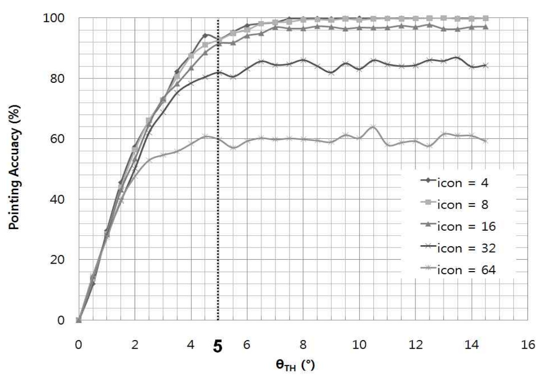

Figure 5. Pointing accuracy with the number of virtual icons and θ_{TH}

inches (15cm), and the one region space of a museum is 100 ㎡. Figure 5 shows how the pointing accuracy mutates as the number of virtual icons and θ_{TH} varies. As increasing the number of the icons, the pointing accuracy is decreasing due to the short distance between the virtual icons. θ_{TH} also affects pointing accuracy. If it increases, it is easy to point to a target icon because a selection range is extended. However, if θ_{TH} is too large, it is hard to find an empty space or an empty physical object which is unmapped to a virtual icon. Therefore, it is important to select an appropriate value of θ_{TH}. From the simulation, we have chosen an appropriate value of these parameters. An appropriate value of θ_{TH} is 5 and the appropriate number of virtual icons in 100 ㎡ room is 20. If applying these values of parameters to real system, we will obtain over 90% pointing accuracy.

3.2.2 Applying the parameters into the 3D-pointing device

Based on the results of the simulations, we applied the measured parameters into IMI 3D pointing device and a wearable platform called UFC [7]. As shown in Figure 7, it is a ring-type device for reducing an error of miss alignment. It has a three-axis accelerometer [4] and a three-axis magnetic sensor [5] for recognizing the defined gesture and the direction of the finger. It also has a ZigBee transceiver [8] for informing the recognition results to the UFC. Every time a visitor points to an object in the museum, the wearable platform displays the selected target object and context upon its screen. This feedback information helps the visitor find the correct target object. Similarly, a scanning gesture allows the user to investigate pointing object as described in Figure 2-c.

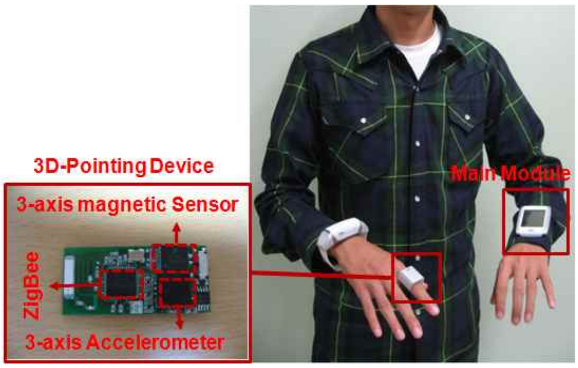

Figure 7. 3D-pointing device and wearable platform for IMI

4. RELATED WORK

Recently, numerous researches have done in devising various technologies to assist in museum's exhibition such as Interactive Museum Guide [1], an audio-augmented museum guide, called LISTEN[13], RFID-based Museum Guide [2], Electronic Guidebook [9], PDA with Semantic Web [10], Museum Guide enhanced with tangibility called ec(h)o [14], and many more. As a service aspect, Herbert Bay proposed the prototype of an interactive museum guide. It runs on a tablet PC that features a touch-screen, a webcam and a Bluetooth receiver. This guide recognizes objects on display in museums based on images taken by the webcam on the tablet PC. In order to provide blind users with a museum guide services, Giuseppe Ghiani [2] made effort to investigate how tilt-based interaction, along with RFIDs for localization, can be exploited to support blind users in interacting with mobile guides. They presented a tilt-based interaction and RFIDs for accessible mobile guides.

As a mobile technology aspect, many research efforts have been performed to achieve high usability of a mobile device. Rukzio et al. [11] proposed a framework for the development of systems which takes physical mobile interactions into account. They mean any communication between the entities user, mobile device, and physical objects in the physical world whereby every entity can exist one or more times with it. They have used typical technologies supporting these interactions that are Radio Frequency Identification (RFID), visual marker recognition, Near Field Communication (NFC), or Bluetooth. They have made mobile interactions with various services, which were inadequate and inflexible in a mobile device for small screens, fiddly keys and joysticks as well as narrow and glutted menus, easier and more convenient. Valkkynen et al. [12] presented a user interaction paradigm for physical browsing and universal remote control. The paradigm is based on three simple actions for selecting objects: pointing, scanning, and touching for choosing tags with readers. Therefore, these paradigms should be supported for any tagging technology. They have provided an optimal support for natural interaction with physical objects. And they can control augmented physical objects with tags and get information from them. All of the previous works, however, used augmented physical objects with tags. Therefore, they can only interact with specified objects that have augmented tags. Compared to the previous work, we can use more abundant spatial resource because the physical objects do not need augmented tags for the interaction in our mechanism.

5. CONCLUSION

We have presented Interactive Museum Interface (IMI) which runs on a wearable computer. Our work aims to allow people to efficiently and intuitively interact with historical objects in museums. In order to devise IMI pointing device, we performed simulations of G-sensor modules to extract system parameters like as the sensor threshold and the maximum density of virtual icons. Based on the simulation results, we designed and deployed IMI framework which includes a wearable platform called UFC and a ring-type 3D pointing device.

6. REFERENCES

[1] H.Bay, B.Fasel and L.Gool, "Interactive Museum Guide",UbiComp 2005, September 1114, 2005, Tokyo, Japan.

[2] G.Ghiani, B.Leporini, F.Paternò, and C.Santoro, "Exploiting RFIDs and Tilt-Based Interaction for Mobile Museum Guides Accessible to Vision-Impaired Users"ICCHP 2008, LNCS 5105, pp. 1070–1077, 2008.

[3] G. Broll, S. Siorpaes, E. Rukzio, M. Paolucci, J. Hamard, M. Wagner, A. Schmidt, "Supporting Mobile Service Usage through Physical Mobile Interaction," In proc. the 5th IEEE International Conference on Pervasive Computing and Communications (PerCom'2007)

[4] Freescale Semiconductor, 3-axes accelerometers, MMA7260Q,http://www.freescale.com/

[5] Honywell, Magneto-resistive sensor, HMC1053, http://www.ssec.honeywell.com/

[6] Ubisense, http://www.ubisense.net

[7] J.Lee, S.H Lim, J.W Yoo, K.W Park, H.J Choi, K.H Park, "A Ubiquitous Fashionable Computer with an i-Throw Device on a Location-Based Service Environment", In Proc. 21st IEEE Symposium on Pervasive Computing and Ad Hoc Communications, Vol. 2, pp. 59-65, May 2007.

[8] IEEE 802.15.4 Specification, "Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low Rate Wireless Personal Area Networks (LRWPANs)," IEEE Specifications, October 2003.

[9] M. Fleck, M. Frid, T. Kindberg, R. Rajani, E. O'Brien-Strain, and M. Spasojevic (2002), "From Informing to Remembering: Deploying a Ubiquitous System in an Interactive Science Museum",[Online]. Available: http://www.hpl.hp.com/techreports/2002/hpl-2002-54.pdf

[10] C. Shih-Chun, H. Wen-Tai, F. L. Gandon, and N. M. Sadeh, N.M.(2005), "Semantic Web Technologies for Context-aware Museum Tour Guide Applications", 19th International Conference on Advanced Information Networking and Applications, 2005, Volume: 2, pp. 709- 714

[11] E. Rukzio, S. Wetzstein, and A. Schmidt,"A Framework for Mobile Interactions with the Physical World," Wireless Personal Multimedia Communication (WPMC'05), Aalborg, Denmark, 2005.

[12] P. Valkkynen, I. Korhonen, J. Plomp, T. Tuomisto, L. Cluitmans, H.Ailisto, and H. Seppa, "A user interaction paradigm for physical browsing and near-object control based on tags," In proc. Physical Interaction Workshop on Real World User Interfaces, in the Mobile HCI Conf. 2003, Udine, Italy, 2003.

[13] Zimmermann, A., Lorenz, A."LISTEN: A User-adaptive Audio-augmented Museum Guide", Springer User Model User-Adap Inter (2008) 18:389–416 Ec(h)o

[14] Ron W., Marek H. "ec(h)o: Situated Play in a Tangible and Audio Museum Guide", ACM DIS 2006