Graphical Menus using a Mobile Phone for Wearable AR Systems

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Abstract— **In this paper, we explore the design of various types of graphical menus via a mobile phone for use in a wearable augmented reality system. For efficient system control, locating menus is vital. Based on previous relevant work, we determine display-, manipulator- and target-referenced menu placement according to focusable elements within a wearable augmented reality system. Moreover, we implement and discuss three menu techniques using a mobile phone with a stereo head-mounted display.**

Keywords- graphical menu; mobile phone; menu placement; wearable AR

I. INTRODUCTION

For several years, augmented reality (AR) systems, especially wearable AR systems, have become increasingly popular. Within such systems, user interaction is required for efficient control. Bowman et al.[11] have addressed system control tasks among various 3D interaction techniques in 3D space. In terms of the control of commands, as well as the presentation of information, graphical menus represent basic and significant methodology. For desktop and VR environments, much research on menus has been conducted. However, to date, research has not been sufficient for application in wearable AR systems due to a lack of focus and design.

Regarding wearable AR configuration, user interfaces are required for interaction within systems[2]. Further, in order to interact with augmented or virtual objects in AR space, control interfaces are necessary for selection and manipulation. Although designed for manipulation, many interfaces are designed either dependently within systems and/or expensively for popular use. To overcome such vulnerable points, mobile devices represent suitable manipulators within wearable computing systems[3]. Thus, we believe mobile device sensors are becoming rich enough for compatibility in hand-held interfaces. Particularly, such devices are sufficient enough to generate various inputs, e.g., touch, gesture, camera, etc., enabling wireless communication in wearable computers. In addition, mobile phone users are increasing; therefore, people do not need to purchase specific interface controlling AR systems.

The remaining content of the paper includes related work and a methodological description. In section III, we explain designing three graphical menu concepts in order to effect a wearable AR system. Afterward, in section IV, we introduce system structure that functions with a mobile phone. In section V, we describe our demonstration and implementation results of the graphical menus by using a mobile phone. Finally, we concluded the paper by addressing the future direction of such research.

II. RELATED WORK

Various techniques have developed to interact with menu items running command on system. In spite of both VR and AR technologies deal 3D space, efforts on applying 2D user interface into 3D space have conducted for ease of use and accuracy gain. Tinmith system used glove-based menus and 3D interaction for wearable AR modeling[10]. It depicted traditional 2D style menu on both bottom sides of the HMD screen and selected a menu item by pressing an appropriate finger against the thumb on the gloves. Hoang[5] used 3D models as menu items for wearable AR modeling with Tinmith 2D style menu. Using static screen-fixed way has a stable characteristic but it is hard to say pretty harmonized to real world.

Along the 3D space structure, our hand is a feasible tool for presenting information and selecting input. In TULIP[8] system on virtual environments, up to 16 menu items are selectable by using pinch glove through finger and thumb interaction. Sasaki et al.[1] introduced skin color detection based hand-menu system to move TULIP concept into AR environments. Using our body, especially hands as menu presenter and selector, possesses merits having a sense of intimacy. On the other hand, representing item numbers with whole fingers has limitation at once. In Tangible Spin Cube[9], it showed possibility to relieve such problem by drawing augmented 3D ring items on hand-held cube interface. In spite of multi-modal feedback, the interface was early prototype so it is hard to apply in practical use.

Detected objects also have used as general reference of presentation, though it was mostly applied to annotate visual information not a complex menu system. In mobile AR, almost Mobile AR browsers[15][16][17] locate accessible tags at contextual target position by using location-related sensor data. The location-related annotation on screen helps user to aware multiple objects situation and concentrate at desired target object. By reason of screen size, the users are hard to be immersive through mobile display. However, HMD-based wearable AR configuration will lead us to different result.

Kim et al.[7] experimented multimodal menu presentation and selection for immersive virtual environments. They classified the menu as three presentation types according to location in VR space. White et al.[6] conducted a menu design and evaluation in detail for tangible augmented reality. There are four menu placement techniques and coordinate system. Two of classifications are very similar and useful to apply menu in 3D space. However, Kim's work was focused in VR environments with gesture or voice interaction using burdensome hardware to general user. Also, in order to follow White's work, user has to carry the manipulator printed tangible fiducial marker. We focus to reclassify the menu placement considering wearable AR contexts in end-user's view and verify it from real implementation.

III. GRAPHICAL MENUS

Refer to the section II, menu placement dominates a crucial portion of the visual display. Therefore, we identify three focusable elements to locate menus in wearable AR systems. First is display which covers whole screen by HMD. The second element is manipulator (in this paper, we use mobile phone) to deliver input to system. The last element is the target object which desires to control at certain situation. All elements are possible to be centered of users' attention in system running cycle so they are feasible to be a criterion for menu location. We propose three menu placements: display-referenced, manipulator-referenced, and target-referenced. These terms refer to how menu locates relatively to certain coordinate system.

A. Display-referenced

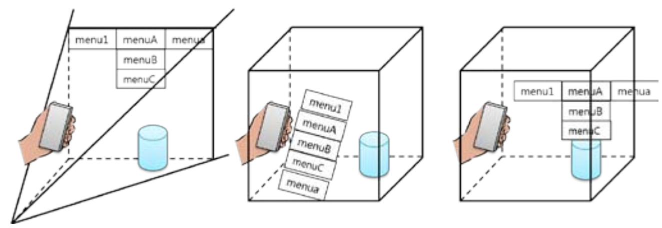
The display-referenced menu is view-fixed way overlaying to user's view point as shown in Fig. 1(a). This is approach to apply existing menu representation on 2D desktop UI into 3D space. There is almost separated between menu and augmentation space from system running and ending. It is independent on the context such as image sequences and manipulator. Therefore, the system requires 2D coordinates to manage this menu interface without any tracking via image sequence.

B. Manipulator-referenced

This menu overlays the device-fixed items to control system(Fig. 1(b)). According to configuration of wearable computer devices, it might be a different result but here we introduce a concept with a single device using mobile phone. This menu type is an immersive environment to browse menu for the item selection by corresponding interaction with visualization space to user. Therefore, when the mobile phone is showing in the 3D space covered by FOV, the system detects and tracks the phone for drawing 3D menu around it.

C. Target-referenced

The target-referenced menu is object-fixed way to stay at controllable target object as shown in Fig. 1(c). The wearable AR system can be run regardless of place, so there are various real and virtual objects in the 3D space covered by FOV. Whenever the selection of a desired object is done after the objects detection, its 3D pose is required to drawing the menu having 3D coordinate. With this menu, the users' eyes do not need to be separated from the target. Therefore, it is fast way to aware the alteration of value by menu item selection. For menu attached on a real object, combination of object detection and tracking is necessary in real-time. In case of a virtual object, a relative coordinate of the object from world coordinate is enough for menu attachment. This step will requires less computational load than real object tracking.



(a) (b) (c)

Figure 1. Three menus on focusable location: (a) display-referneced, (b) manipulator-referenced, and (c) target-referenced.

IV. SYSTEM STRUCTURES

In order to realize proposed graphical menus, we provide the system for realizing proposed menus and it contains a wearable computer and a mobile device. The main device, a wearable computer, primarily processes tasks including tracking and rendering parts. On the other hand, the mobile device mainly takes charge of interaction with menu structure. Beyond the task of control target selection between single object and system itself, here we minutely describe one cycle procedure to handle a command from user to system crossing mobile phone to wearable computer(Fig. 2). In terms of that, the wearable computer side contains four components; menu viewer, menu browser, interaction interpreter, and communicator(receiver). On the other hand, single mobile phone side has only two components; interaction detector and communicator(sender).

A. Menu viewer

When the control target is selected, the menu viewer draws a menu layout of the target to the certain location. The rendered items represent accessible entities to user at that context. Therefore, the visual structure is maintained until the rendering information is updated from menu browsing action.

B. Menu browser

Menu browser is to handle items of displayed menu in practice. Every menu has regular structure, e.g., the number of items, depth of hierarchy, and activated condition in advance. According to generated mapping function in the menu browser component, system offers diverse experiences to user. As the result, it updates rendering information for next command.

C. Communicator

To provide wireless input for item control by using mobile phone, a communication component is essential. Mobile phone sends a packet with interaction id when interaction is detected and then wearable computer is listening to receive the packet rapidly.

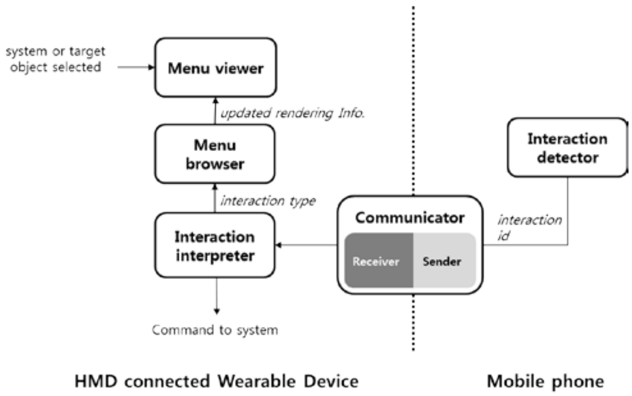


Figure 2. The snapshot of one command cycle

D. Interaction detector and interpreter

We assume mobile phone as wearable AR manipulator so the interaction detector component is being placed on users' mobile device. The role of the interaction detector is to detect proper interaction among supported interaction list. The identified numeric result helps save the communication load between phone and wearable computer. With a variety of mobile interactions, we believe almost interactions are candidate to provide input and be in the list for wearable AR system.

The interaction interpreter on wearable computer side makes a pair with the interaction detector. This component translates the interaction id from packet.

V. IMPLEMENTATION AND RESULT

A. Implementation

We use following hardware configuration to implement our prototype. In order to provide immersive AR view to user, a stereo HMD, iWearAR920 by Vuzix, is used. The mobile phone (we used iPhone 4 on implementation) as manipulator is equipped as well. Our purpose is to menu placement and its handle by using mobile phone from wearable AR consideration so we programmed the system on desktop PC not on the wearable PC.

We try to unify other factor except placement attribute. Therefore, we select the layout of the menu as fundamental list type. Also to check browsing using phone, the hierarchical structure with level was chosen. The total items in the menu are 9 with two levels. (level 0 has 3 items and 3 items for each item on level 0). Every menu has differentiated property with 2D text or color. Level 0 is visible during whole execution time while level 1 has temporary visibility by higher level menu selection.

Including the menu context, there are three menu prototypes we implemented. They present the menu on proper location and browsing it by the phone grasped in user hands.

With touch screen on the phone, the swipe (left, right, up, and down) and tap gestures are in the interaction list we implemented. Thus, the five identifiable data come and go from interaction detector and interpreter. When the user swipes the phone screen, the menu is unfolded or explored according to its layout structure and situation. Tapping is for item selection.

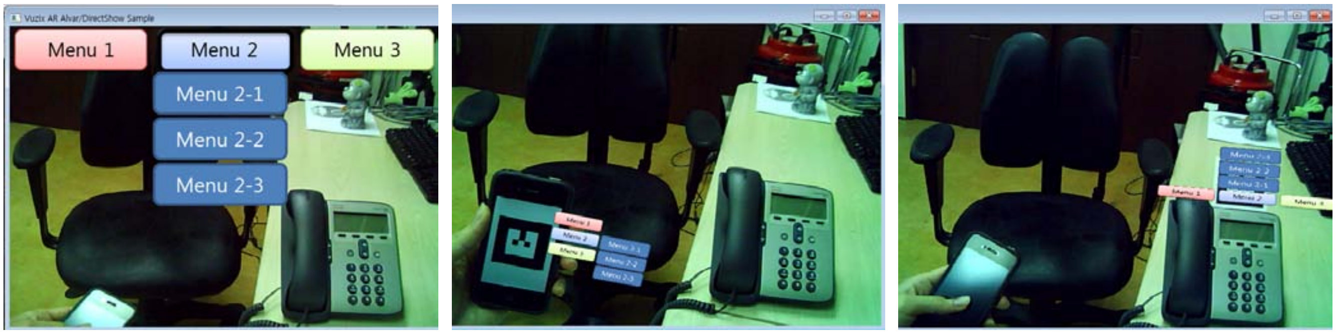
Communication between two devices used oscpack[14] based UDP socket. It process the data packed with pre-defined IP and port number from mobile phone in real time.

B. Discussion

First, display-reference is not changed the location and perspective of the menu even the movement of the users' head or position(Fig. 3(a)). As we mentioned on section II, this view-fixed style is very familiar way to desktop UI, virtual reality, and AR as well. It splits visualization space into menu and augmentation so user easy to concentrate always-fixed menu. From the viewpoint of menu expansion, it is perfectly matched to 2D layout style. Hence this property has limitation on a number of items. Though we think 3D layout with this menu but it has another visual artifacts by perspective difference because there is no use in context of real world. However, it is hard to disapprove that is looked for fast and stable performance.

Second, manipulator-referenced menu is way to placement around the phone which conducts main interactions for item browsing(Fig.3(b). This menu has most frequent position alteration inside one view-point. For rendering menu around the phone, it is necessary to track the device additionally. In our implementation, we draw the fiducial marker on the phone screen and detect it but using sensors including accelerometer and gyro together is required to overcome several tracking problem such as rotation, light condition, and distance. This menu has 3D pose from tracking result then 3D menu style is feasible. 3D menu is proper on 3D space that supports a variety of geometric menu structure and eases the restriction of the number of item by using one more space. In manipulator-referenced menu, the interaction and menu space are adjacent and then there is a few distance of eye-transition among three menus. However, differ from other menus it has limited points with current concept. The phone is always visible within field of view for menu execution and there is additional computational load for getting 3D pose in real-time.

Finally, target-referenced menu is the way to attached menu directly at the interesting object. Fig.3(c) shows the conceptual way of this menu. After the selection of a telephone by a user, the user at the situation enables to control the changeable value on the rendered menu using mobile interaction. This is an example of seamless system control using target-independent menu beyond the common AR application focused on tracking and information



(a) (b) (c)

Figure 3. Three menus on focusable location(implemented): (a) display-referneced, (b) manipulator-referenced, and (c) target-referenced.

annotation. The menu is extremely useful when the environmental structure is well established like Ubiquitous Virtual Reality environments, collaborative wearable context-aware mediated reality[12][13]. For this paper, we use fiducial marker tracking but multiple objects tracking method is also introduced. Afterward, we could apply it for realistic wearable AR concept. Further consideration for this menu is to understand target and surroundings. Even we are able to track all target objects, they are not the same feature and property. Therefore, we are prepared for classification or management for effective menu attachment around them. Also, this menu is for wearable AR system so bunch of environments can be background. We should consider the environmental context as an important factor to place the menu.

VI. CONCLUSION AND FURTURE WORK

In this paper, we explore the design of graphical menus applying mobile phone for use in wearable augmented reality system. At first, we reviewed the relative menu works to know the current status and design three different menu placements according to focusable elements for wearable AR system. We planned the system for real menu prototype with mobile phone and implemented them based on it. With the implementation result, we discuss about strength and weakness of each menu style.

On this work, we considered major constituents for wearable AR by user aside and checked with change of reference factor among whole menu characteristic. There are many other characteristics which effect on performance and usability[4]. Now we have nice testing menu system enabled mobile interaction targeting wearable AR system. With this three placement context, we are planning to apply various structural layouts and evaluate together.

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