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# Selection and Manipulation Methods for a Menu Widget on the Human Forearm

**Takumi Azai**

Ritsumeikan University  
1-1-1 Noji Higashi, Kusatsu,  
Shiga 525-0058, Japan  
azai@rm.is.ritsumei.ac.jp

**Shuhei Ogawa**

Ritsumeikan University  
1-1-1 Noji Higashi, Kusatsu,  
Shiga 525-0058, Japan  
s\_ogawa@rm.is.ritsumei.ac.jp

**Mai Otsuki**

University of Tsukuba  
1-1-1 Tennodai, Tsukuba,  
Ibaraki 305-8573, Japan  
otsuki@emp.tsukuba.ac.jp

**Fumihisa Shibata**

Ritsumeikan University  
1-1-1 Noji Higashi, Kusatsu,  
Shiga 525-0058, Japan  
fshibata@is.ritsumei.ac.jp

**Asako Kimura**

Ritsumeikan University  
1-1-1 Noji Higashi, Kusatsu,  
Shiga 525-0058, Japan  
asa@rm.is.ritsumei.ac.jp

**Abstract**

Mixed reality (MR) space merges the real and virtual worlds in real time and makes it possible to present and manipulate virtual objects in the real world. However, to manipulate virtual objects, menus are required, and where to display menus in MR space and how to manipulate them are often problems. For example, a virtual touch menu shown in front of a user's face cannot provide the user with touch sensation and interferes with the user's sight. In this study, we propose a method to display a menu on the user's forearm, which is always within reach of the user's hand. The user can obtain touch feeling by directly touching their forearm. An application was developed using this menu, and an informal user study at a previous conference was successful, leaving some minor points to be improved.

**Author Keywords**

Head-mounted display; Mixed Reality; Menu operation; Forearm; Gesture operation

**ACM Classification Keywords**

H.5.2. Information interfaces and presentation (e.g., HCI): User Interfaces .

**Introduction**

Due to the advent of inexpensive head-mounted displays (HMD), Mixed Reality (MR) technology, which can merge the real and virtual worlds in real time, has

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become familiar. In MR space, various virtual objects can be presented in the real world and the user can manipulate them via gesture operations. However, where to display menus in MR space and how to manipulate them are often problems. Therefore, in this study, we propose a method to display a menu on the user's forearm, which is always within reach of the user's hand. The user can obtain touch feeling by directly touching their forearm (the part of the arm between the elbow and the hand). Users are able not only to manipulate the menu items using "touch" and "drag" operations but also to switch the menu using "slide" and "rotation" operations.

### Related Work

In a study on menus in MR space, Lee et al. [4] proposed a method to select the menu by rotating the cube with AR markers. This requires not only HMD but also extra real objects just for the menu. Calaco et al. [1] used a touch menu that floated in front of the user's face. Because the menu does not provide touch feeling, it is difficult to know when the menu operation is completed.

In general, the part of the body that is most likely to come into view while at work is the hand. Therefore, it would be easy to see and manipulate objects displayed on the palm, the back of the hand, or the tip of the fingers in MR space. He et al. [3] proposed a method to display a menu centered in the palm of the hand through the AR glass. However, due to the narrowness of the display area, the quantity of information is restricted.

Harrison et al. [2] proposed a menu projected on the user's forearm, which detects the touched location on

the forearm. This system is superior in that it does not require extra objects, it provides direct touch feedback, and it uses a relatively wide area. Following Harrison's study, we developed a new style of menu on the forearm in MR space. We propose an interaction method that enables the user to manipulate more menu items.

### Our Approach

#### *Menu widget on the forearm*

In this study, we focused on the forearm, which can easily enter our field of vision and has a wider surface than a hand. The use of the forearm should be as natural as checking the time on a wristwatch. More complex information has been handled on various watch-type wearable devices, such as Sony's *wena* wrist and Apple's *iWatch*. Forearms would therefore provide an ideal location to display and manipulate menus with high flexibility. We propose "touch" and "drag" interactions for selecting and manipulating the forearm menu and "slide" and "rotation" interactions for switching sets of displayed menu items.

#### *Touch and Drag*

Just as "touch" and "drag" are the basic interactions commonly used on smartphones and tablets, these two interactions in our system function as selection and scroll. A menu item on the forearm can be selected by touching it with the index finger (Fig. 1). The scroll bar can be manipulated by dragging the tip of the finger (Fig. 2).

#### *Slide*

The gesture of rolling up a sleeve is adopted as the "sliding" interaction for the menu. By "sliding" the hand from the wrist to the elbow, the display of the menu is

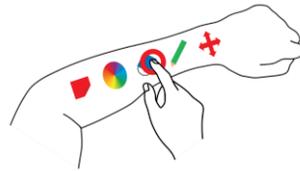


Figure 1: Touch interaction.

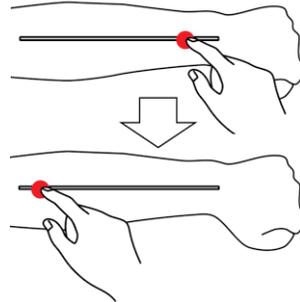


Figure 2: Drag interaction.

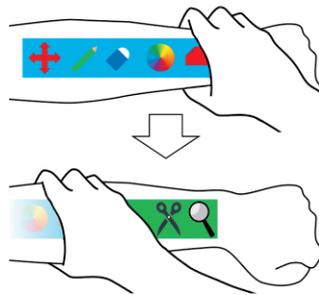


Figure 3: Slide interaction.

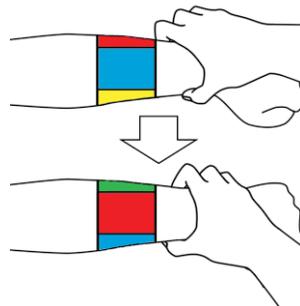


Figure 4: Rotation interaction.

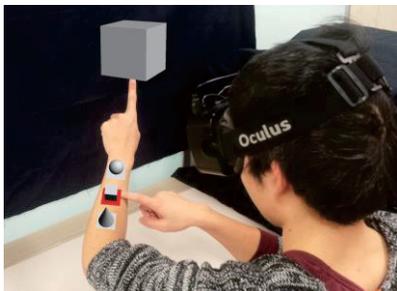


Figure 5: Concept image of our modeling application.

switched to an under-lying layer (Fig. 3). This motion-command makes understanding the concept of the layer structure of the menu-sets intuitive for the users.

**Rotation**

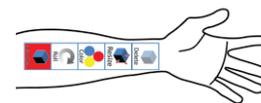
A “rotation” gesture, just like changing the camera’s mode or adjusting the volume of a music player, was adopted as an interaction to switch the selected menu, or adjust the parameter (Fig. 4).

**Implementation**

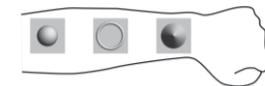
A real world image is acquired via a stereo camera (Ovrvision Pro), and the image information and a menu widget, which are virtual objects, are presented with HMD (Oculus Rift DK 2). The positions of the palm, fingers, and forearm are acquired using a small motion tracker (Leap Motion) attached to the front of the HMD. In addition, Unity 5.3.5 was used for the development environment.

**Application**

We implemented an application incorporating the method proposed in this study. In this application, virtual 3D objects can be placed freely within MR space (Fig. 5). The layout function and the rotation and scaling functions of the object are switched by touching the menu items. The main menu is displayed on the front of the forearm (palm side), and a submenu for manipulating the object is displayed on the back of the forearm (Fig. 6). The specific operation methods are as follows. When placing a new object, the placement function panel should be touched first on the front menu side of the forearm. Then, a submenu of thumbnails of the primitive objects is shown on the backside of the forearm. A new object is created by



(a)



(b)

Figure 6: Menus arranged on the front and back of the forearm: (a) main menu and (b) submenu.

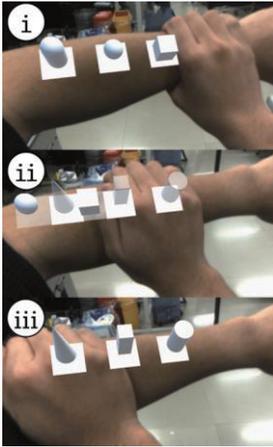


Figure 7: "Slide" interaction for switching the menu items.

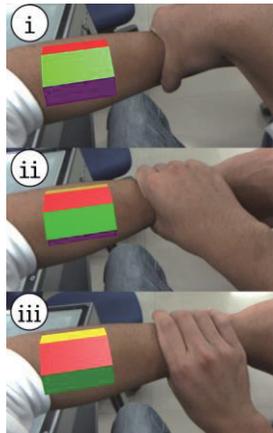


Figure 8: "Rotate" interaction for the color palette.

touching one of the thumbnails. In this step, the user can switch to different sets of thumbnails using the "slide" interaction (Fig. 7). The color of the placed object can be changed using the "rotation" operation on the color palette on the forearm table (Fig. 8). Specific menus are prepared to rotate, delete, or change the size of the objects. Objects can also be moved using a pinch action in this application. Using the above functions, it is possible to create various shapes of models in various colors and sizes.

### Results of the User Study

Approximately 30 people tried out this application at a domestic conference, and the following comments were obtained. "The method of displaying the menu on the forearm in MR space is interesting and looks good." "The purpose of this interaction is clear and easy to understand."

However, there were comments about the method's unsatisfactory precision. There was also a negative opinion as follows, "In the current system, the menu operation can only be performed in the state where the forearm is in view. However, in that state most of the field of vision is covered by the forearm."

### Discussion

The informal user study of our system achieved favorable ratings for its concept and understandability. The unsatisfactory precision is thought to be due to our use of Leap Motion. In response to that comment, we will use motion trackers covering a wide range, such as RealSense and Kinect.

As for the vision interference caused by the forearm, we are planning to extend the menu so that it can also

be operated relying on "somatosensory." Users should be able to manipulate the intended part of the forearm menu without looking at the forearm directory. This problem may be solved by attaching a sensor to the forearm.

### Conclusions and Future Work

In this study, we proposed a menu widget using the forearm in MR space. This menu widget can be manipulated using "slide" and "rotation" gestures to manipulate supplementary information in the limited forearm area in addition to the "touch" and "drag" interactions.

In the future, we would like to improve the precision of the movements and decrease the amount of visual interference. Further, we aim to develop a more convenient interface, such as an extension of the interaction using not only the forearm but also the palm and the back of the hand.

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