

# Tap-Tap Menu: Body Touching for Virtual Interactive Menus

Takumi Azai  
Ritsumeikan University  
azai@rm.is.ritsumeikai.ac.jp

Syunsuke Ushiro  
Ritsumeikan University

Junlin Li  
Ritsumeikan University

Mai Otsuki  
University of Tsukuba

Fumihisa Shibata  
Ritsumeikan University

Asako Kimura  
Ritsumeikan University

## ABSTRACT

Virtual and mixed realities make it possible to view and interact with virtual objects in 3D space. However, where to position menus in 3D space and how to interact with them are often problems. Existing studies developed methods of displaying a menu on the hand or arm. In this study, we proposed a menu system that appears at various body parts. By placing the menu on the body, it enables the user to operate the menus comfortably through kinesthesia, and perceive tactile feedback. Furthermore, displaying the menu not only in the hands and arms but also in the upper legs and the abdomen, the menu display area can be expanded. In this study, we developed a modeling application and introduced a proposed menu design for that application.

## CCS CONCEPTS

• **Human-centered computing** → **Gestural input, Mixed / augmented reality, Virtual reality**

## KEYWORDS

Gestural input, Mixed reality, Virtual reality, Head-mounted display, Menu

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## 1 INTRODUCTION

The emergence of new, inexpensive head-mounted displays (HMDs), virtual reality (VR), mixed reality (MR), and augmented reality (AR) technology in the market, has made them relatively familiar to most users. These technologies make it possible to view and interact with virtual objects in three-dimensional (3D) space via gesture operations [1, 2]. The method of interaction, however, is far from refined. Menus are required to facilitate interaction with these objects. However, the location of the display of these menus in the field of view, and the method by which the user should interact with them, remains undetermined.

A general method is to display the menus floating in the air. Calaco et al. [3] used a touch menu positioned in the center of the user's field of view. However, this menu did not provide tactile feedback, making it difficult to know when a menu operation was completed.

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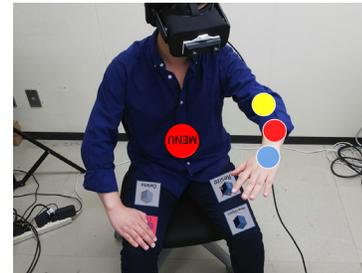


Figure 1: Concept image of the Tap-Tap Menu.

Grubert et al. [4] proposed a method to perform tasks such as menu operation using a smart watch or a smartphone in the AR space. The use of these devices resulted in the provision of tactile feedback, reduced workload, and provided an indicator of task completion. In addition, users could choose the position of the menu by moving it around freely. However, it was necessary to introduce a separate device in addition to the HMD.

Methods that employ the user's body as a menu display area have also been proposed. He et al. [5] presented a method to display a menu centered in the palm of the hand. This method was compared with the other methods of displaying the menu. Most participants preferred the palm-based menu because it was easier to use and see. Furthermore, we had previously proposed a method of displaying the menu on the user's forearm [6], which provided a wider surface area than that of the hands. Such a menu on the body can provide tactile feedback without introducing real objects. In addition, smooth operation is achievable through kinesthesia.

Employing the user's arm or hand as a menu display area has many advantages, but there is a display area limitation. Furthermore, when all the menu items are placed on hands or arms, the menu becomes complicated. To address this problem, we propose the Tap-tap Menu (Fig. 1) that is displayed on various body parts. Our system can provide tactile feedback without introducing a real object, and smooth menu operation through kinesthesia. In addition, distributing the menu functions on different body parts alleviates the limitations of display area, and facilitates easy-to-understand menu operation.

In this study, we focus on the hands, forearms, abdomen, and the upper legs, which are easy to touch and see. We implemented the modeling application and considered the menu layout depending on the characteristics of each body part

## 2 TAP-TAP MENU

### 2.1 Displaying the Menu on the Body

Based on the discussions in Chapter 1, the following requirements need to be met by an ideal menu in the 3D space.

- (a) Operation without real objects
- (b) Ease of movement
- (c) Tactile feedback during operation
- (d) Smooth operation
- (e) High visibility
- (f) Wide display area

In the case of the menu on the palm or the forearm, requirements (a) and (b) are satisfied because users can move the menus and there is no need to introduce real objects. Because tactile feedback can be obtained by touching the body part directly by hand, requirement (c) can also be satisfied.

Requirement (d) can be satisfied by kinesthesia. Mine et al. [7] showed that the users can work in the VR space easily and efficiently kinesthesia. The Tap-tap Menu is operated by touching various body parts. Therefore, smooth operations are possible through kinesthesia.

In this study, to satisfy requirements (e) and (d), we used the hands, forearms, abdomen, and the upper legs, all of which are easy to touch and view as menu display areas. Furthermore, by expanding the display area of the menu to body parts other than the hands and arms, it is possible to satisfy (f).

## 2.2 Implementation

We implemented the Tap-tap Menu system in both the VR and MR spaces. A head-mounted display (Oculus Rift CV 1) was used for the VR and MR space presentation. For the MR, a real-world image was acquired via a stereo camera (Ovrvision Pro). The positions of the body parts were acquired using a motion tracker (Kinect for Xbox One). In addition, Unity 5.6.2 was used for the development environment.

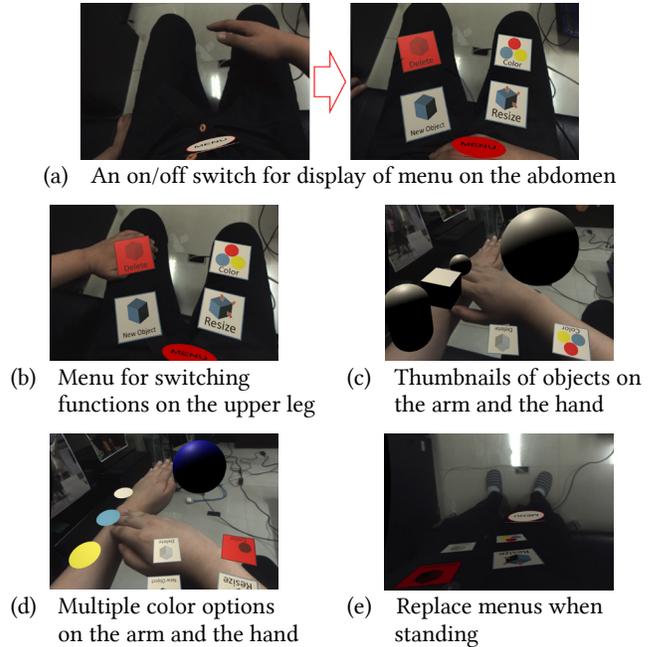
## 2.3 Application

We developed a 3D modeling application using the Tap-tap Menu system as a testbed (Fig. 2). In this application, virtual 3D objects could be placed freely within the 3D space via gesture operations. We implemented the following functions: (i) object creation/deletion, (ii) scaling, and (iii) object color adjustment.

As mentioned previously, we used the hands, forearms, abdomen, and upper legs as menu display areas, and assigned the functions based on the characteristics of each part. The on/off switch for the menu was put on the abdomen, which is a bit difficult to view but can be touched easily (Fig. 2(a)). Menus for switching the functions (main menu) were placed on the upper leg, which can be easily seen and accessed in the sitting position (Fig. 2(b)). In addition, menus which are frequently used; such as thumbnails of objects, and the color palette (sub menus) are put on the hands and arms, because users can easily see and operate them while working (Figs. 2(c) and (d)). It is difficult to reach the upper legs in the standing position, and the menus on the upper legs are swapped with those on the abdomen (Fig. 2(e)).

## 3 CONCLUSION

In this study, we proposed the Tap-tap Menu that is displayed on various body parts in 3D space. By using the Tap-tap Menu,



**Figure 2: Examples of Tap-tap Menu layout in a modeling application.**

users can obtain tactile feedback without introducing real objects. Further, it enables smooth operation by kinesthesia. We used the hands, forearms, abdomen, and upper legs as menu display areas, which are easy to touch and easy to view. The menu functions were positioned depending on the characteristics of each body part in the 3D modeling application.

In our future work, we will propose a method for using other parts of the body parts as menu display areas. Furthermore, we will conduct comparative experiments with the forearm and the palm menu, and will investigate the utility of the Tap-tap Menu.

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