Virtual Window Manipulation Method for Head-mounted Display Using Smart Device

Shu Sorimachi
Kansai University
Osaka, Japan
k527911@kansai-u.ac.jp

Kota Kita
Kansai University
Osaka, Japan
k097619@kansai-u.ac.jp

Mitsunori Matsushita
Kansai University
Osaka, Japan
mat@res.kutc.kansai-u.ac.jp

ABSTRACT

In this paper, we propose a virtual window manipulation method used for information search while utilizing a head-mounted display (HMD). Existing HMD operation methods have several issues like causing user fatigue and processing input tasks inefficiently. Such problems are difficult to solve simultaneously. Therefore, we propose using head tracking cursors and smart devices. The suggested method aims to operate a head tracking cursor by swiping input on the smart device. In this paper, we compared the operability of this new method and the classic hand tracking one based on the results of user experiments. As a result, it was confirmed that operability of the proposed method is deemed to be high.

CCS CONCEPTS

• **Human-centered computing** → *Mixed / augmented reality*.

KEYWORDS

augmented reality, manipulation method, visibility of visual information, hmd

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1 INTRODUCTION

In recent years, Augmented Reality (AR) technology has been developed. And, the information search under the real environment using AR is tried. The text or image of the search result is displayed superimposed on the real environment in the form of a two-dimensional window on the device. This virtual window manipulation method includes hand tracking and gaze selection. However, problems are pointed out in these. For example, Hansberger et al. [2] have the problem that the hand tracking is an operation with a raised arm, which makes the user physically burdened (Problem 1) and unsuitable for use in the presence of a person around it (Problem 2). Points out. Also, Choe et al. [1] pointed out that the gaze-pointing method requires more time to determine the input state than the selection method using the physical button, and the task efficiency decreases (Problem 3). These problems can be solved by using an auxiliary tool such as an elbow rest or by using an input device such as a mouse, but this causes the problem that the user's action range is restricted. So, in this research, we assume the situation where the user wears HMD and searches information continuously at multiple points under real environment, and examines the intuitive virtual window operation method with small physical burden.

2 PROPOSED METHOD

In a situation where information is being searched in a real environment, the user can intuitively select and browse additional information such as a shop menu or the history of a tourist spot without being distracted from the subject matter in front of them (a shop or a tourist spot themselves). This feature is also desirable in the case of information search within AR. However, the three problems mentioned previously cannot be solved simultaneously using existing operation methods. Therefore, in this study, three goals were taken into consideration: (1) to establish an operation method causing small user fatigue, (2) to achieve space saving while applying the method, (3) to enable a smooth input operation within a small amount of time. To satisfy these requirements, this paper proposes an operation method that combines cursor movement associated with the user's head tilt and the fine cursor movement related to touching a sensor on a smart device.

3 IMPLEMENTATION

Figure1(a) shows an overview of the proposed system, and Figure 1(b) shows an example of a screen displayed on an HMD device. In this implementation, we used Microsoft HoloLens as an HMD and Nexus 7 as a smart device. In the proposed system, the user selects an object operating a cursor displayed at the center of the HMD screen. The user can move the cursor to any location by swiping the screen of the smart device held. After an input operation is completed by the user, the cursor becomes input-acceptable for 0.5 seconds, and returns to the center of the HMD screen if there is no new input in the meantime. The cursor and the virtual window are displayed using double spherical coordinates centered on the user as shown in Figure 1(c). When the cursor moves to the inside sphere, consequently, the virtual window moves to the outer spherical coordinates. In addition to moving the cursor, the user can perform four types of operations: (1) selecting an object, (2) moving a window, (3) scrolling across a window, and (4) deleting a window. The operations required for each operation are (1) single tap, (2) long press and then swipe, (3) two finger swipe, and (4) double tap.

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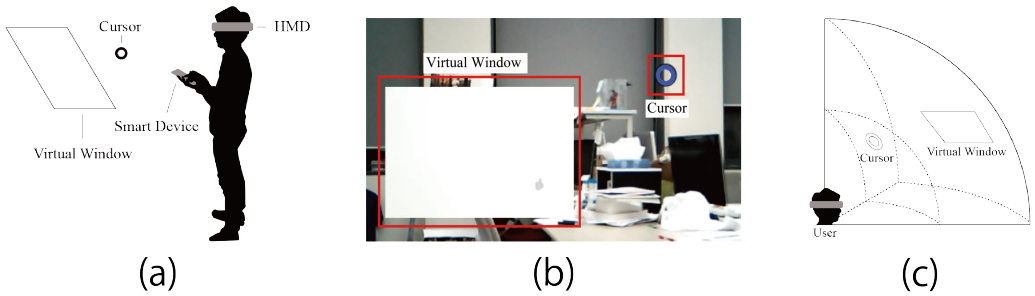

Figure 1: (a) Representation of the proposed system. (b) Virtual windows and cursors that users can see through the HMD. (c) Scheme of double spherical coordinates.

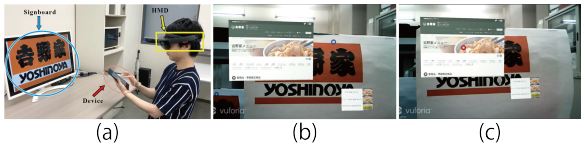

Figure 2: (a) An example of using HMD for the purposes of information search in the application. (b) Virtual windows and cursors that users can view through the HMD in the application. (c) The cursor turns red when the user moves the virtual window.

4 APPLICATION

We implemented an application to model a situation in which a user searches for information in a restaurant menu from a restaurant signboard. Signboard images were registered as AR markers using Vuforia, a library for AR application development. We presented a window with three menu items of the restaurant on the side of a recognized signboard, to avoid overlaying the view. See Figure2(a). When the user selects a window presented beside a signboard, a virtual window is generated, and a menu page is displayed in the generated virtual window. See Figure 2(b) and Figure 2(c).

5 EXPERIMENT

To evaluate the operability of the proposed method, comparative experiments using different operation methods were conducted. We used hand tracking as a comparison target as it is the virtual window manipulation method used in HMD, and a method (hereinafter, referred to as mobile AR) chosen as a comparison target because it is widely used in information search systems using AR. Ten university students participated in the experiment. The experiment was aimed to model the information search in the restaurant menu. It was performed in an environment that reproduced a street where restaurants line up by pasting the signboard images of 15 different restaurants on the wall. The experiment participants could view the menu information by manipulating a virtual window available upon selection of an object displayed beside the signboard. The participants were asked to search for specific information using all the considered methods. After completing the experiment, we conducted a questionnaire survey on the operability of each method in question. In addition to the four items corresponding to window selection, scrolling, movement, and deletion, the questionnaire was conducted on the Likert scale for five items (total six items) for the comprehensive evaluation of operability, and two items of intuition. It should be noted that the mobile AR does not allow the investigation of such operations as window movement and deletion because it is used as a browsing function only. As a result of the experiment, it was confirmed that the proposed method is significantly better than the hand tracking one in terms of overall evaluation and also considering particular operations like window selection, movement, and intuition evaluation(overall evaluation: $p = .008$, selection: $p = .004$, movement : $p = .016$, Intuitiveness: $p = .016$) however, no significant difference was observed for scrolling and deleting(scrolling: $p = .500, n.s.$, deleting: $p = .313, n.s.$). On the other hand, considering the mobile AR, it was confirmed that the mobile AR was significantly better in overall evaluation in terms of selection and scroll evaluation, and that there was no significant difference in intuition (overall evaluation: $p = .008$, selection: $p = .008$, Scroll: $p = .002$, Intuition: $p = .188, n.s.$). For items where the significant difference was not identified, it is possible that one of the factors explaining this was the instability of the system due to insufficient HMD performance. Therefore, there is a possibility of further improvement which may be achieved through improving the HMD performance.

6 CONCLUSION

In this study, we examined the virtual window operation method based on using a smart device when an HMD is attached. The experimental results confirm the usefulness of the proposed method in the cases of information search tasks. In future, we plan to make information acquisition from actual stores possible to conduct user experiments in the real environment. Furthermore, we will examine using a textile touch panel as an external device.

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