An Omnidirectional Virtual Desktop Environment Using HMDs and Its Evaluation

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Abstract. This manuscript attempts to expand work space with the basic idea of omnidirectional virtual desktops. HMDs are used to expand work space. Users wear the HMD and look around to see it. Application windows can be placed all around the user virtually and their positions are represented in the world coordinate system. Their positions are transformed in the HMD coordinate system then these windows are shown on the HMD screen. Our system requires less room to work as compared with multi-display systems that take up much more room. From a pilot experiment in target search tasks, the result showed that users tended to look for the target in a spiral way and locate them in about 19 seconds.

Keywords: Omnidirectional virtual desktops, HMDs, augmented reality, evaluation, user interface.

1 Introduction

In an environment of desktops and laptops, computer screens are the one of important components for user interface. They often influence usability of those computers. Especially the size of computer screens is a major factor in usability. Larger computer screens (or work space) improve the performance of computer work because users can put more relevant documents and icons on the screen at a time to come across quickly. It is now around 24~27 inches for desktops. As regards the size of computer screens, A. Kimura et al. [1] expanded work space with large displays. They designed their large display systems to organize work and view medical images. Larger displays however take up more room to be put. To expand the work space, this manuscript employs head mounted displays or HMDs, which require less room to work, and conducts a pilot experiment in performance of our prototype.

2 Omnidirectional Virtual Desktop

This manuscript attempts to expand work space with the basic idea of omnidirectional virtual desktops as shown in Fig. 1. HMDs are used to expand work space. A HMD

C. Stephanidis (Ed.): HCII 2014 Posters, Part I, CCIS 434, pp. 434–439, 2014.

used in our system is a video-mixed type equipped with a built-in head tracker. Users wear this HMD and look around to see work space. The orientation of the user's head is traced by that head tracker and work space synchronously goes around before the user's eye. The user feels as if he/she was in a spherical computer screen. The user can still do his/her daily routine in it using a mouse and a keyboard as he/she usually does on the usual desktop.

Fig. 2 shows a brief demonstration of our system. This user wears the HMD to get in an omnidirectional virtual desktop environment. Fig. 3 shows images of that user's view. In the figure, (a) he runs a notepad and places it in the center and then (b) he looks to the right side to use a calculator.

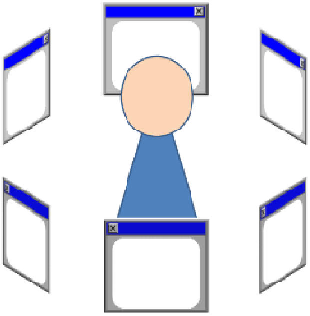

Fig. 1. An omnidirectional virtual desktop

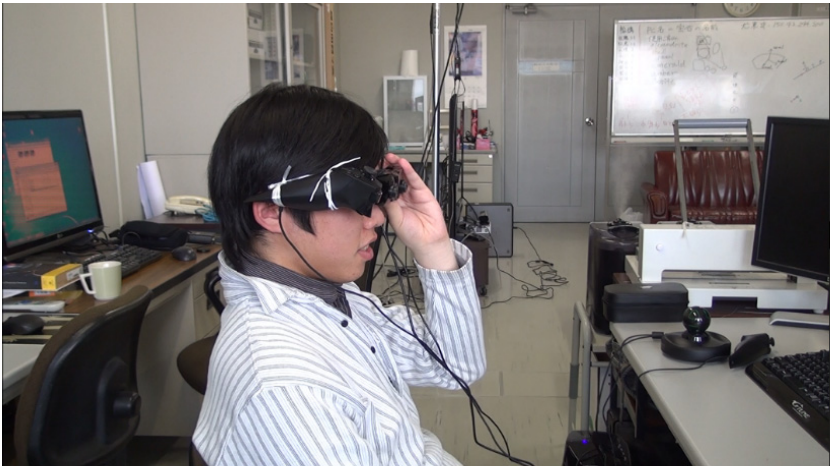

Fig. 2. An overview of our system

(a) The user runs a notepad. (b) The user uses a calculator.

Fig. 3. User's views

3 System Design

3.1 How it Works

Application windows can be placed all around the user virtually and their positions are represented in the world coordinate system. Their positions are transformed in the HMD coordinate system then these windows are shown on the HMD screen.

Let (w_u, w_v) be the position of an application window on the HMD screen, $\boldsymbol{w}(w_x, w_y, w_z)$ be the one in the HMD coordinate system, and $\boldsymbol{W}(W_x, W_y, W_z)$ be the one in the world coordinate system. These three representations of that window's position are converted each other by the following equations.

$$\boldsymbol{w}^T = \boldsymbol{R} \cdot \boldsymbol{W}^T \tag{1}$$

$$(w_u, w_v) = \frac{-f}{w_z}(w_x, w_y) \tag{2}$$

, where f represents the focal length of the HMD screen and $\boldsymbol{R}$ represents the rotation matrix of the HMD. In our system, f is the constant of 192 dpi and $\boldsymbol{R}$ is updated by the head tracker in real time.

The above equations updates the position of the application window on the HMD screen (Fig. 4) whenever if the user drags that window by the mouse or the user looks around.

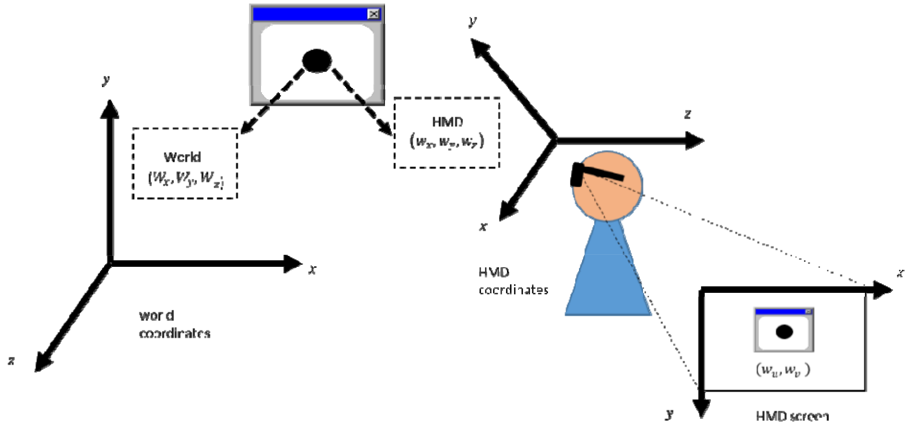

Fig. 4. Three coordinate systems and coordinate transformation

3.2 Hardware

A HMD used in our system is shown in Fig. 5. This HMD is a glasses-like device that has a stereo camera and a head tracker. The spec is specified below.

Fig. 5. A HMD used in our system

- HMD:Vuzix Wrap920AR
  Twin high-resolution 640 x 480 LCD displays
  31-degree diagonal field of view
  Two discrete VGA (640 x 480) video cameras
- 6-axis head-tracking sensor: Razer Hydra
  Ultra precise sensor for 1mm and 1 degree tracking

4 Pilot Experiment and Results

A pilot it in performance of our system was conducted. There were four subjects with the ages of 23~24. All were right-handed. Each subject was asked to look at the specified start position and search a target, which was shown at a random position on the omnidirectional virtual desktop. The elapsed time to locate the target and the angular movement of the subject's head were recorded. Table 1 shows the elapsed time.

Table 1. Elapsed time

Subject	Time (sec)
A	19.46
B	11.88
C	20.69
D	27.08
Average	19.78

Fig. 6. shows the angular movement of the subject's head during the task. The red circle represents the start position and the red star does the target position. From the figure, all the subjects looked around in a spiral way, it subjects A and C did it counter clockwise and the others did it clockwise.

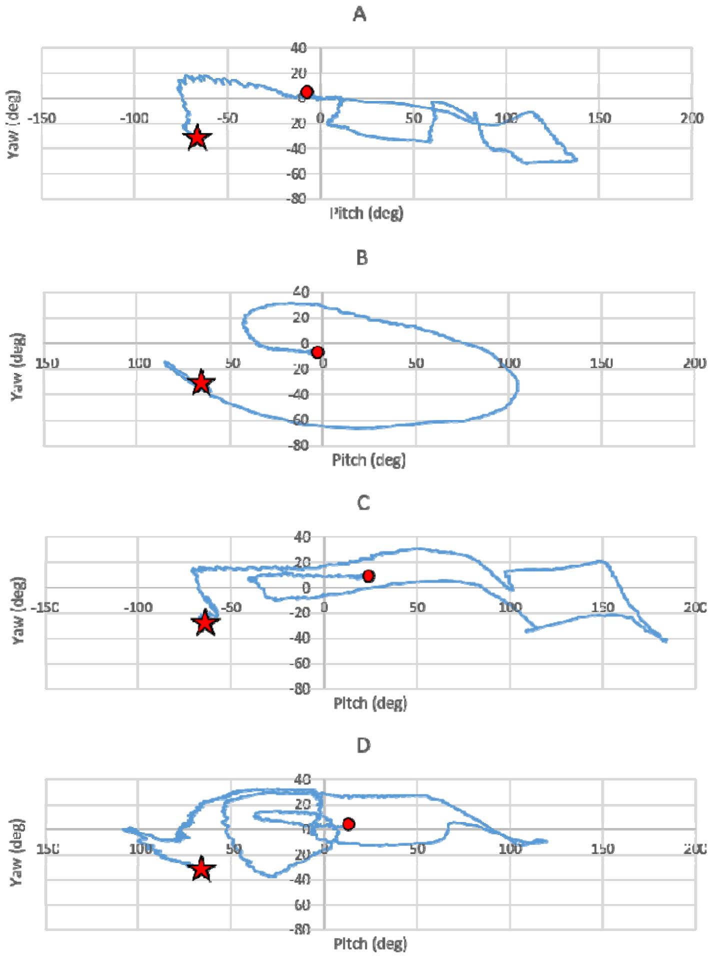

Fig. 6. Angular movement of the subject's head

5 Conclusions

In this study, an omnidirectional virtual desktop system was designed and implemented with HMDs. The user wore the HMD and got in the surrounding work space. Our system required less room to work as compared with multi-display systems that took up much more room. From a pilot experiment in performance of our system, it was shown that users tended to look for targets in a spiral way and locate them in about 19 seconds. In the future work, we are going to conduct further experiments in common tasks such as manipulation of mouses and application windows.

References

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