Research and Development for Assessment of Cognitive Function with Immersive Virtual Reality System

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1 Background

Cognitive function is very important for our social life. Cognitive dysfunction often disturbs healthy life of patients. In addition, it is difficult to predict the problems patients face in their actual daily life. Therefore, assessment of cognitive function is required in this ageing society. Such assessments aim to evaluate negative influences caused by a variety of cognitive dysfunctions. Conventionally, such assessments have been performed primarily based on neuropsychological tests. The effectiveness of these assessments has been proved to date, nonetheless, it is also known that these tests cannot directly predict the problems patients face in actual daily life. This is because the tests are performed on the desk. Also, the execution of the tests often burden the patients.

Recently, it has been proposed that virtual reality (VR) technology could be utilized for the assessment of cognitive function, as it is possible to perform the assessment under more realistic environment than conventional paper-and-pencil based assessments. There are some preceding studies that reported assessments of cognitive function using VR technology. For example, a virtual cooking system [1], a virtual shopping system [2] and a virtual system of supermarket [3] have been reported. Since 2008, a 2-D virtual shopping test (VST) system has been developed at Kobe University, Japan [4] [5] [6]. In the VST, the user executes shopping and some other tasks. This system uses the virtual shopping mall created with computer graphics. VST adopts a touch panel screen as its user-friendly interface (Fig. 1). This user interface helps the user (mostly elderly people) to operate the system easily (Fig. 2). It has been revealed that this system is effective for assessment of higher cognitive function [7].

In this study, we developed a prototype of 3-D VST, which is a development of the past 2-D system. We selected immersive display system named “CAVE” as equipment for presenting 3-D images. There are two reasons why we selected a 3-D environment. First, reality is one of the most important elements of the assessment of cognitive functions with VR. We assume that the more realistic VST becomes, the better test we can execute. Second, we try to test if CAVE is useful for the assessment of cognitive function. In order to utilize CAVE as a device presenting VR, we need a new user interface instead of a touch screen. User interfaces used in such assessment systems should be intuitive and easy to use. Therefore we put emphasis on the user interface in this development.

Fig. 1. 2-D VST with a touch screen

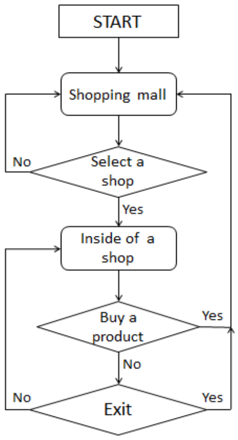

Fig. 2. Flowchart of VST

2 Method

2.1 Immersive Display System “CAVE”

CAVE is one of the most immersive display systems which was developed at Illinois University, USA in 1991. Standard CAVE is composed of a cube-shaped room whose walls are 3-D screens. The number of screens depends on each CAVE system. We used a four-screen CAVE system for this research (Fig. 3). Four means front, left and right walls and floor. User stands in the room composed of 3-D screens wearing stereoscopic glasses and holding a controller called “wand” (Fig. 4). Wand has some buttons and a joystick. Tracking cameras set around the ceiling capture tracking markers attached on glasses and wand. API for CAVE named “CAVELib” automatically computes their position and direction in real time. Using the data, stereoscopic image for the user’s eyes is projected on the wall of screens.

Fig. 3. Four-screen CAVE

Fig. 4. The stereoscopic glasses and the wand

2.2 Outline of the Prototype of VST

On 3-D VST, users perform shopping in virtual shopping mall projected on screens (Fig. 5). Because the scene of the shopping mall is projected on the walls surrounding the user, he/she has a feeling as if being in a real shopping mall. There are some differences from the 2-D VST except for the form of presentation. While insides of the shop and products are represented simply by pictures in the 2-D VST, users can enter the virtual shops in the 3-D VST. In the virtual shops, users can grab products as if they do in real shopping. Finishing tasks in a shop, users go out from the exit.

Fig. 5. A scene of 3-D VST

2.3 User Interface

Expanding 2-D system into 3-D system needs changes of its user interface. For patients, it is difficult to operate the system with buttons and a joystick of the wand. Therefore, we developed a new user interface using tracking systems of CAVE. Users can control their action in the virtual shopping mall with the wand's position. On the floor, a red circle is shown. While standing on the circle, yellow balls appear around the user. These balls are navigating balls. The user touches navigating balls by the wand to move in the VR space. Unique actions are assigned to each ball. For example, the ball in front of user corresponds to going straight on and the ball on the right of user corresponds to turning right. When the user wants to pick up a product, he can do it that by directly touching the product with the wand. At the entrance and exit of shops, bright red balls are shown. The user can go into and out of shops by touching these balls. The data of the position of user's head is obtained from the tracking markers attached on the glasses. These data are used for distinction of standing in the red circle or not. The same type of data of the wand is used for distinction of touching objects. This interface is considered to enable more intuitive operation which helps users (Fig. 6).

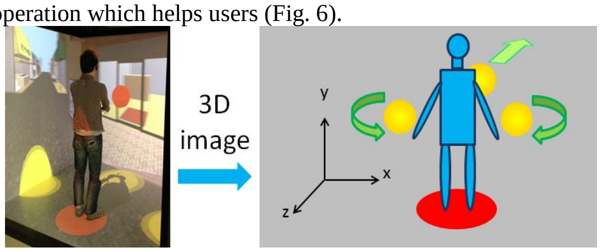

Fig. 6. The red circle and the navigating balls

3 Results

We had two male subjects in their twenties experience this system and asked their opinions. Both of them could utilize the user interface without problems. However, according to their opinions about the use of interface, below issues were found.

- It takes time to get used to the CAVE system and the user interface.
- Touching the balls to navigate might not be intuitive.
- Sometimes unexpected touch on the navigating ball occurs.

From these comments, when aged persons or patients of cognitive impairment use the system, the possibility is high that they cannot operate the system as they want, and this problem could hinder a proper assessment.

4 Conclusion

We developed the prototype of 3-D VST. This system does not yet contain the following functions which are in the 2-D VST.

- Output a log of tests
- Play sounds
- Set the difficulty of task

3-D VST would be effective because it includes shopping function of core system of VST. In addition, 3-D VST has some strength such as the details of inside of the shops and carrying of the products. So, the reality is considered to be largely improved.

However, some users point out the difficulty of user interface. Therefore, it is important to aim further development of useful user interface. We also have to add more functions and evaluate the effectiveness for practical use.

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