Usability Evaluation of Virtual Environment for Early Diagnosis of Dementia

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Abstract

Virtual Technology (VT) plays a vital role in many areas. It is a promising tool in healthcare and offers opportunities and solutions for early detection of dementia. Dementia is associated with loss of brain function from the process of ageing. This serious illness needs early diagnosis if medical treatment and healthcare services are to be deployed in time. We developed a new prototype called Virtual Reality for Early Detection of Dementia (VReDD), and have applied psychology theories in an attempt to make an early diagnosis of dementia. In this paper, we will focus on the usability of user satisfaction for young participants to see the complexity and effectiveness of the prototype as a first step prior to the implementation the experiment with elderly, those with a mild cognitive impairment and Alzheimer patients. These preliminary findings show that the prototype is reliable and suitable to be used with elderly people.

Keywords: Virtual Environment, spatial memory, topographical disorientation, dementia

1 Introduction

One of the biggest fears in the process of ageing is associated with brain memory which leads to dementia. There are currently 510,000 in people living with dementia in England for year 2010 and expected to double over the next 30 years [1]. People aged over 65 are likely to have dementia and probability for women is slightly higher compare to men [1].

Topographical disorientation is the incapability to navigate in the environment [2]. Cognitive processes including memory, attention, spatial skills or visual perceptual skills are usually the expression of topographical disorientation [3]. This is a general symptom of dementia of the Alzheimer’s type that can occur in the early stages of the disease [4]. Alzheimer’s disease patients will usually get lost in unfamiliar places in the early stages of the disease and may become disoriented in familiar places in the later stages [5].
Virtual environments (VE) allows a more or less complete functionality without requiring all the functions to be located in the same physical space to an integrated workspace [6]. VE as defined by reference [7] as interactive, virtual image displays enhanced by special processing and by non-visual display modalities. VE can also be defined as computer simulation environment with sense of presence that can be experienced [8]. A VE can be successful in providing a high level of sensory richness in immersing the user within a realistic 3D world [9]. With Virtual reality (VR) technology, a VE lets the user freely explore the 3D space. VE known to experimental research conditions that are easy to identify, control, and replica [10].

VR can be applied in many applications including gaming, entertainment, training, education and health. This technology offer specific attributes that are well-suited to the needs of many medical applications which include exposure, distraction, motivation and interaction [11]. VR is rapidly becoming a popular application in healthcare. Its promising technology offers opportunities to create new products in everyday situations. This software is thought to be more effective of everyday life situations than paper and pencil treatment procedures or other limited software [12]. Werner et. al. developed Virtual Supermarket to examine the feasibility and the validity of the virtual action planning supermarket for the diagnosis of patients with mild cognitive impairment (MCI) [13]. Tippet et. al. designed and developed virtual city to examine the ability of MCI participants to navigate effectively through the VE [14].

This paper focused on the development of virtual environment and usability evaluation of user acceptance and satisfaction for young participants. The results of user acceptance and satisfaction were then analysed and discussed.

2 System Design

2.1 Virtual Environment

A prototype simulation was developed using a 3D authoring tool called Virtools. VReDD consists of three modules: VR Practice, VR Park and VR Games (see Figure 1 and Figure 2). VR Park and VR Games both have five levels from easy to complex (see Figure 3).
Figure 1: Overview of VReDD

Figure 2: Main Menu of VReDD

Figure 3: Five levels in one of the module VR Park
**VR Practice**

The VR Practice is the training module. In this module, users have the opportunity to practise cursor keys using keyboards. This module has been developed to meet the needs of the target users who are aged over 45 and who may need some time to practice with cursor keys so they can use the application easily.

**VR Park**

The scenario settings for this module are in a park. There are five specific target destinations including playground, art gallery, garden, rest area and picnic area. Users experience walking through a park in the city where there are tall buildings to be seen, trees all around and various other things.

**VR Games Land**

In this module, the location is surrounded by tall buildings and houses. Inside the park, there are five different and specific types of giant games available, such as giant chess, giant board games, lawn bowls and mini golf.

Figure 3: Procedure in VReDD

Figure 3 represents a procedure done in VReDD. First, users’ information are recorded in the system. A unique user ID is given to each user. Then, in the VR simulation, users are able to see one of the two environments. The users are allowed to repeat the exercise of reaching the target destination three times by following the red ribbon attached to the path. Next, the user is tested on their ability to recollect given path. All data are collected and recorded during this phase. Lastly, all data were exported to the system to be analysed.
Figure 4: Procedures of experiment in VReDD

Figure 4: Interface with red ribbon attached to the path
2.2 Data Collection

Data are collected during the testing phase. There are five attributes needed to diagnose early detection of dementia: correct path, incorrect path, correct sequences, incorrect sequences, timing and scores.

Path
During testing, users are allowed to move freely to the target destination. All the movement are captured and recorded for data analysis.

Path Sequence and Path Squares
Users are required to reach the target destination in the correct path sequence. The data from path-tracking will show correct and incorrect sequences and path squares.

Timing
During testing, the amount of time taken to complete the journey from the starting point to the target destination was recorded.

Score
Scores are then calculated based on path sequences and path squares. The scores show the percentage of performance done by users.
2.3 Information System

An information system has also been developed to keep the users information and data collected. The text file produced by VReDD is then be transferred to the system to be recorded and analysed. Figure 6 and 7 shows interfaces of the system.

Figure 6 : Main Menu of Information System

Figure 7 : Interface results of the system
3 Methods

3.1 Design

The participants were students of University of Bradford following different courses. A total of 11 participants (8 female and 3 male) from age 18 to 35 were recruited for this experiment.

3.2 Instruments

VR System

VRREDD operates on a standard PC and simulates a fully textured of two various scenes: VR Park and VR Games. The participants are allowed to repeat the exercise of reaching the target destination three times by following the red ribbon attached to the path. Then, the participants are tested on their ability to recollect the given path and they must find the destination themselves. Each level gets progressively harder, with more complex navigation required.

Feedback Questionnaire

The questionnaire features several questions, the answers to which will produce a score of between 1 and 5. The questionnaires assess the participant’s learned controls quickly, moved easily, clear instructions, system control, preferred more freedom and looking around easily.

Procedure

Each participant was trained to use the arrow keys using the module VR practice. After the training the participant will carry out the real experiment. The users will be allowed to repeat the exercise of reaching the target destination three times by following the red ribbon attached to the path. After this, the test phase begins where the participant sees the VE without the red ribbon and they have to make their own way to the destination with the cursor keys. This terminates either when the participant completes all levels or when the participant takes longer than 5 minutes to reach the destination on the test phase at any level. When this is complete, participants will commence on word memory test where they have to try to remember 60 words in any particular order.

4 Usability Evaluation and Results

Usability evaluation of any system is essential to ensure systems meet both design specifications and user requirement criteria. Usability can be defined as ease of use, usefulness including such quantifiable characteristics as learnability, speed and
accuracy of task performance, error rate and satisfaction [15]. This section only focused on user satisfaction based on the questionnaire given.

To evaluate the usability of our prototype system (VReDD), we undertook a user evaluation study with 11 participants. The questionnaire was based on participants’ responses on five-point Likert Scale (strongly agree, agree, undecided, disagree, strongly disagree). The responses are summarised in Table 1.

Table 1: Feedback results from questionnaires

<table>
<thead>
<tr>
<th></th>
<th>Agree</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of Participants (%)</td>
<td>Number of Participants (%)</td>
</tr>
<tr>
<td>1. Learned to move quickly</td>
<td>11 100</td>
<td>0 0</td>
</tr>
<tr>
<td>through application</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Moved easily</td>
<td>11 100</td>
<td>0 0</td>
</tr>
<tr>
<td>3. Clear instructions</td>
<td>11 100</td>
<td>0 0</td>
</tr>
<tr>
<td>4. Control using arrow keys</td>
<td>11 100</td>
<td>0 0</td>
</tr>
<tr>
<td>5. Feel disoriented</td>
<td>0 0</td>
<td>11 100</td>
</tr>
<tr>
<td>6. Looking around easily</td>
<td>11 100</td>
<td>0 0</td>
</tr>
<tr>
<td>7. Preferred more freedom</td>
<td>6 55</td>
<td>5 45</td>
</tr>
<tr>
<td>8. Fast speed of movement</td>
<td>10 91</td>
<td>1 9</td>
</tr>
<tr>
<td>9. Comfortable using application</td>
<td>11 100</td>
<td>0 0</td>
</tr>
<tr>
<td><strong>10. Overall satisfaction</strong></td>
<td>11 100</td>
<td>0 0</td>
</tr>
</tbody>
</table>

In the experiment, users learned to move through application using the cursor keys from the keyboard. In response to question 1, they do agree 100% and a possible explanation was because they were asked to use VR Practice first before going through the testing modules. The users are required to move through application without any help from researchers using control keys from the keyboard. All participants reported that they can move easily through the application. Since the general purpose of this research is for Dementia people, instructions must be simple and clear. From the results, it shows that they all agree to the clear instructions given throughout this application. From the study, it was found that all the participants were able to use the control keys for navigation and interaction without any problem. Disorientation is one main issue arises in health and safety implication for using VR. The overall response to this question was very positive as they do not feel disoriented while using the application. All participants agree that it was easy to look around in the application. Of all 11 participants, six of them responded that they would prefer to have more freedom. This may be because users are limited to walk on the path without going to the grass and other places. The reason for limited movement was not to let users feel disoriented or getting lost while using the application. Only one participant responded the speed of movement was too fast. For both questions of
overall satisfaction and comfort using application, the overall response was 100% which is positive. The findings demonstrated that the application is reliable and suitable to be used by the elderly participants.

5 Conclusions

The results of this study demonstrate the usability of VReDD. The finding is important as a first step prior to the implementation to the elderly people with Alzheimer disease. To date, we have carried out the experiment with healthy elderly and young participants. In future work, experiments need to be conducted with elderly Alzheimer patients and data will be analysed to see the comparison and discriminate between elderly, those with a mild cognitive impairment and Alzheimer patients. The ability of this prototype to track and record all the movements of users will be easier to analyse. Furthermore, using VReDD will save time and reduce health and safety risks.

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References


