Developing virtual vending and automatic service machines for brain injury rehabilitation

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ABSTRACT

Two different approaches for developing virtual environments (VE) for brain injury rehabilitation are described and discussed. The two VEs are built with the VR software World Up in the form of virtual vending and automatic service machines. The result from the first approach is a virtual cash dispenser that has been tested on five patients with brain injury. Improving the VE according to the test results was found to be quite hard, since it is implemented in a way that makes it difficult to update the code. In the second approach independent programming modules were identified and isolated. The modules were used to build a VE in the form of a train ticket machine. The second approach seems to provide a fast and understandable way of building virtual vending and automatic service machines for brain injury rehabilitation. There might also be the possibility to add a graphical user interface on top of the modules so that, for example, an occupational therapist with no programming experience could build an arbitrary virtual vending machine.

1. INTRODUCTION

Brain injury rehabilitation is a long and difficult process that includes training of so-called instrumental activities of daily living (IADL). IADL training involves activities like preparing meals, doing housework, using a cash dispenser etc. and it is often used by occupational therapists when helping people with brain injury to manage their daily lives. Among other things, daily life means encounters with different vending and automatic service machines. On a regular day an average person might use a cash dispenser, a train ticket machine, a coffee vending machine and a parking ticket machine. A person with brain injury might not be able to use any of these machines, which limits this person's ability to perform his or her daily activities. Therefore, IADL training with VEs in the form of vending and automatic service machines could constitute a complement to conventional brain injury rehabilitation techniques.

2. PROJECT DESCRIPTION

The Department of Rehabilitation, Lund University Hospital and the Division of Ergonomics at the Department of Design Sciences, Lund University are presently co-operating in a long-term project (Davies et al, 1999; Lindén et al, 2000). Each department brings its own unique areas of competence to the project: the Division of Ergonomics is specialised in human computer interaction and development of VEs for various applications, whilst the Department of Rehabilitation has expertise in the practical and theoretical aspects of rehabilitation of people with brain injury.

2.1 Overall Project Goals

The main goal of the project is to determine whether a VE tool can be a useful component for the rehabilitation of people with acquired brain injury and an effective tool in everyday life. More specifically the project aims to

- find the optimal interface between a VE and the user;
- to investigate transfer of training of practical tasks learnt using a VE to the real world; and
- to develop at least three practical applications of VE for rehabilitation

Among these three applications are a virtual cash dispenser and a virtual train ticket machine that were developed using two different approaches.

2.2 Aim

The aim of this paper is to describe the two approaches used for developing virtual vending and automatic service machines for brain injury rehabilitation. Also, the results of an evaluation made with the VE developed with the first approach is presented and discussed.

3. METHOD

Desktop VR was used for both the approaches mainly because of the cost and availability of such computer equipment in the hospital environment (Lindén et al, 2000). Also, Brown, Neale and Cobb (1999) have shown that people can learn well using desktop VR.

The vending machine of the first approach was developed with World Up, an object-oriented VR developer's kit in which VEs with complex behaviours can be created. The behaviours are implemented with BasicScript, which is a scripting language syntactically similar to Visual Basic. The main reason for choosing this VR software was that it works on ordinary personal computers, such as those found in a rehabilitation hospital. When the VE is complete it can be distributed to the hospital using the freely distributable World Up player.

Five voluntary brain injury patients participated in the evaluation of the virtual cash dispenser. The test group consisted of two men and three women and their age ranged from 28 to 58. Three of the test persons reported having problems using a cash dispenser and one test person had never used one. The task of the test was to make a withdrawal of 100 SEK five times in a row with the virtual cash dispenser. After the test an interview consisting of ten questions was made with the subject. Three video cameras were used to capture facial expressions, body language and hand movements of the subject when using the virtual cash dispenser. The monitor signal was converted into an analogue video signal and mixed with the video camera signals using a video quad splitter (Fig. 1). This was to provide an overall display on one screen to facilitate analysis. Also, a microphone was used to record comments from the subject.

Figure 1. *Experimental set-up.*

For the second approach the vision was to find a way to build virtual vending machines with World Up in a fast and understandable way. The idea was to identify and implement generic parts of vending and automatic service machines so that independent modules of code could be written. In this way an arbitrary machine can be put together in a fairly simple manner with World Up, which will hopefully save a lot of time and effort. To find the recurring features of vending and automatic service machines 18 different types of machines were studied. From this study it was concluded that most vending and automatic service machines of today can be described with the following six modules: slot, coins and notes, buttons, credit card, credit card reader and light emitting diodes. Most vending machines also have some sort of device for output of money, ticket and receipt. However this device is fairly uncomplicated and does not need to be described by a module.

4. THE FIRST APPROACH: THE VIRTUAL CASH DISPENSER

The result of the first approach is a VE in shape of a cash dispenser (Wallergård et al, 2001) that has been tested on five brain injury patients (Fig. 2). It is an exact replica both in function and appearance of the cash dispenser of Sparbanken Finn, which is one of the bigger banks of the Lund region.

Figure 2. *The first approach: the virtual cash dispenser.*

The implementation of the virtual cash dispenser was made in three steps:

1. Made a simple 3D-model of the cash dispenser
2. Took photographs of the cash dispenser and put them on the 3D-model as textures, which is a common technique in VR modelling.
3. Programmed the behaviour of the virtual cash dispenser, i.e. the user dialogue, animation of objects, user interaction etc.

This first approach is characterized by code that is hard to reuse for similar applications since it is not divided into independent modules. Also, it is difficult to update the functionality of the virtual cash dispenser since it is hard to identify the different parts that need to be re-written. The virtual cash dispenser has been tested on five brain injury patients and the main results are as follows:

- the textures of the virtual cash dispenser were perceived as somewhat unclear
- one of the subjects had big problems with object interaction
- all the subjects had problems perceiving the computer screen of the virtual cash dispenser as a display

The test results indicated that the interface of the virtual cash dispenser was in need of improvements. However, altering the programming code was found to be not so easy. A lot of code had to be rearranged or rewritten.

5. THE SECOND APPROACH: THE VIRTUAL TRAIN TICKET MACHINE

To overcome the problems of the first approach a second approach was tried. The idea was to identify and implement generic parts of vending and automatic service machines so that independent modules of programming code could be written. The results of the second approach so far is a collection of programming modules implemented in World Up and a virtual train ticket machine made with these modules (Fig. 3). The virtual train ticket machine is an exact replica both in function and appearance of the train ticket machine of Skånetrafiken, which is the public transport provider for the Skåne region in the south of Sweden.

Figure 3. *The second approach: the virtual train ticket machine*

Every module has a set of properties that describes the behaviours of the module. For example, the coin slot has a property called AcceptedCoins which is a list containing the coin types that are accepted by the machine.

The modules communicate with an object called Main, which is responsible for the overall decisions (Fig. 4). For example, it decides when it is time for the vending machine to change state.

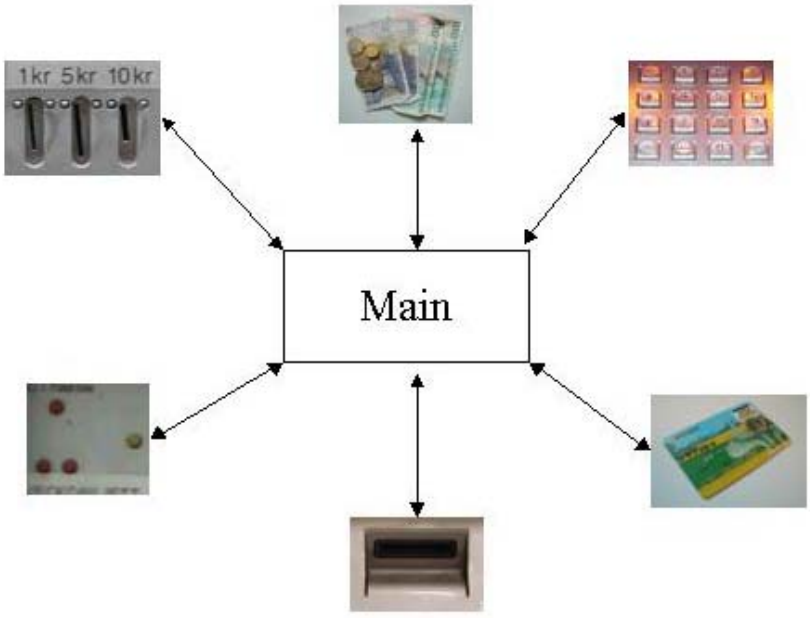

Figure 4. *The modules and the Main object*

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Once the modules were ready the virtual train ticket machine was implemented in three steps:

1. Made a simple 3D-model of the train ticket machine
2. Made textures of drawings found on the Skånetrafiken homepage and put them on the 3D model
3. Implemented the behaviour of the train ticket machine by connecting the six modules

The virtual train ticket machine has not yet been evaluated but tests with brain injury patients are currently being planned.

6. DISCUSSION

The second approach seems to provide a fast and understandable way of building virtual vending and automatic service machines. The virtual train ticket machine took considerably less time to build compared to the virtual cash dispenser. Another thing speaking in favour for the second approach is the results from the evaluation of the application made in the first approach, which indicate that it must be easy to update the programming code. Designing usable VEs is an iterative process made in several steps and therefore it must be possible to make changes without having to rewrite vast amounts of code. This can be done with the second approach whose independent modules facilitate changes in the code.

An idea for the future is to give persons without programming skills access to the second approach by giving it an easy-to-use drag-and-drop interface. That would make it possible for e.g. an occupational therapist to create virtual vending and automatic service machines for their patients to use in the rehabilitation process. Consider for example the following scenario:

Per, who is suffering from attention and memory problems as a result of a brain injury, has just begun his rehabilitation program. He frequently uses different food and coffee vending machines at work and therefore he wants to practice this activity. His occupational therapist starts the training by letting him practice on a real coffee vending machine. However, Per also wants to be able to practice this activity at home. Therefore, his occupational therapist uses a special program to construct a virtual coffee vending machine that looks and behaves exactly like a real one. The program has a graphical user interface that makes it easy to combine different pre-defined programming modules. She puts textures in the shape of photographs on the 3D model with simple drag-and-drop operations. With the ready virtual coffee vending machine it is now possible for Per to practice at home, at his own pace, as many times as he wants.

Another field of application for a program like this could be industrial design. A design team could use it to try different designs on a vending and automatic service machine by altering both its appearance and functionality in different ways.

Although the VEs described in this papers seem to provide usable training environments for brain injury rehabilitation some issues need to be investigated further. For example, we would like to examine the role of textures for this type of VEs. Are there differences between photographic and computer generated textures when it comes to usability? How true to reality must a virtual vending machine be in order to provide a usable training environment?

The Virtual Cash Dispenser can be downloaded from *http://www.eat.lth.se/staff/mattias/virtual cash dispenser.html.*

6. REFERENCES

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