Using Exercise Cycle as a Haptic Input Device in a Virtual Environment

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Abstract. Virku (Virtual Fitness Centre) is a study, in which an exercise cycle is used for navigating in a virtual environment. The cycle acts as a haptic bodily user interface between the user and the simulation. The simulation takes the terrain of the virtual environment into account in order to provide better feedback of the environment for the user. We have found out in usability tests that this kind of interface enhances the user's feeling of immersion in the virtual environment.

1 Introduction

Virku (Virtual Fitness Centre, see Figure 1) is a research and development program in which a prototype of a fitness game played with an exercise cycle in a virtual environment has been produced[10]. Virku includes also a Fitness Monitoring Program for testing the user's fitness level and for supporting long term fitness monitoring and training.

The purpose of our research is to study bodily user interfaces and the use of a computer game to enhance motivation to keep fit. In this paper, we will concentrate on the bodily user interface and especially on how to use an exercise cycle as a haptic input device in a virtual environment.

2 Background

2.1 Bodily user interface

With the bodily user interface we mean an interface, which allows the user to interact with the interface using other methods than the traditional input devices, such as a mouse or a keyboard. The user can also react with other senses along with his visual or aural perception.

Bodily user interface is not a very defined term and there are sometimes difficulties in determining, whether an interface is a bodily user interface. A

Fig. 1. Virtual Fitness Centre

fitness computer game is a good example for illustrating these difficulties. We do not usually consider a bicycle racing simulation played with mouse to be using a bodily user interface. We could, however, replace the mouse with a handle-bar. Does this make the interface a bodily one? What if we make the user sit on a bicycle seat and give him pedals for controlling the speed of the cycle in the game?

In our research, we have used (somewhat vaguely) the term bodily user interface for an interface in which the user uses his whole body for controlling the system. In Virku, the user moves the pedals with his leg muscles and steers the bicycle with his hands. Whole body weight can be used for example for riding uphill in order to gain more power for the pedaling.

Bodily user interfaces are clearly useful for fitness purposes since they force the user to move, instead of only sitting in front of the computer. We also show in this paper that a haptic bodily user interface helps the user feel more immersed in a virtual environment.

2.2 Haptic user interface

We usually get information from the computer systems by seeing and hearing, and input information by manipulating a mouse and/or keyboard with our hands. These modes of communication neglect our other senses, touch, taste and smell. Of these three, smell and taste are more difficult to include in human-computer interaction, but this does not necessarily have to apply to touch.

According to Tan [8], the term "haptics" refers to sensing and manipulating through the sense of touch. He divides haptic sensations into two categories: sense of touch and sense of posture, both of which are important in a bodily user interface. The sense of posture can be especially effective in a fitness application, like Virku, in which whole body is used for controlling the interface.

In a virtual environment, haptics are an important part of the immersion, the feeling of "being there". In our terms, haptics are a part of the bodily user interface. Its purpose is to enhance the virtual environment's resemblance to natural environment and thus make the whole experience more vivid, enjoyable and captivating.

2.3 Other bicycle simulators

Using a bicycle as an input device has been studied, for example, with the Peloton simulator[1], which was developed as a virtual environment for athletic training and competition. There are also virtual reality systems, which use a bicycle as their input device, such as Jeffrey Shaw's Legible City [7] and the Diamond Park [11]. Legible City can be considered as an art installation and Diamond Park as a study of social virtual reality.

Other bicycle interfaces with simulators are commercially available and their purpose is usually to improve the users' fitness. These include RealBitz.com, WebRacing and CompuTrainer. RealBitz [6] uses a movement sensor, which is attached to the user to sense the speed of his movements. WebRacing [12] supports the use of VR helmet and it has a multiplayer game, which can be played via the Internet. CompuTrainer [2] adds the possibility to design one's own training courses.

Virku differs from these systems by taking the terrain of the virtual environment into account in its haptic response and by allowing the user to navigate anywhere in its virtual world. In the user's point of view, the purpose of Virku is to help him improve his fitness [5].

In Virku, it is possible, but not required, for the users, to compete with each other or against a clock. Instead, they can also enjoy the game just by cycling around the generated landscape and enjoying the nature and the views. This is an important difference between the commercial, more competition-oriented games played with exercise equipment, and Virku.

3 Virtual Fitness Centre and Research Objects

In Virku, the bodily user interface is an essential part of the interaction between the user and the exercise cycle. In our research we used a Tunturi T6 cycle [9],

which can be used both as an input and an output device. The T6 cycle uses an asynchronous RS interface to move data in and out of the cycle. It is capable of increasing its resistance according to commands sent from a computer via the serial line, and it can tell the computer its resistance, torque and the heart rate of the user. We can use this information for modifying the training session so that the training will be optimal. The user navigates in the virtual world entirely with the exercise cycle. The cycle has two buttons for steering, and the torque of the pedals affects the movement speed.

The visual part of the virtual environment is presented on a computer monitor or it can be projected with a data projector onto a large screen. We use SimCore[3], a commercial 3D engine, to render the scenery. The scenery depicts a rural environment from the northern Finland generated from digital map information. Virku uses a multichannel sound system, which creates an illusion of threedimensional sound. The user gets feedback from the game also in the form of resistance. The resistance is increased when the user rides his bicycle uphill and decreased when riding downhill.

Virku is designed to be usable in a fitness centre or a gym. Typically, these are environments in which head-mounted displays can not be comfortably used, because of sweat, humidity and heat. With the traditional fitness devices, VR equipment is not needed, so the users would also have to put them on or remove them every time they wanted to use some other training device in the gym. This is why we did not want to use intrusive equipment. Therefore, we could not use, for example, stereo images of the landscape. So, the bodily user interface has to enhance the immersion in order to compensate for the possible loss of visual realism.

The Virtual Fitness Centre also includes a fitness monitoring program to assist the user in long term exercising. It gathers information from the exercise sessions and uses it to give training recommendations for the user. The purpose of the fitness monitoring program is to support the overall concept of enhancing the users' motivation for adhering to a certain training programme, whereas the purpose of the game is to help the users with short term motivation.

4 Evaluation and results

We applied the Human-Centred Design (HCD) approach in the development of our system. The Human-Centred Design is an iterative approach to design where an active involvement of the users and a clear understanding of the user and the task requirements are emphasised [4].

We tested the fitness game with nine people, seven women and two men. They were especially familiar with computer games or virtual environments. All of them trained at least somewhat actively (minimum once a week). The tests were conducted in the Usability Laboratory of VTT Information Technology. We arranged an environment, which consisted of the exercise cycle, a computer and a large screen onto which the scenery was projected with a data projector. The users were asked to ride through a predetermined course in the virtual

environment after which they were allowed to explore it themselves. The test data was gathered by observing the users and interviewing them.

The users felt that they were exercising rather than playing a computer game. They liked the game and felt thet it was more entertaining than using an exercise cycle without a game. The interface was natural and intuitive to use; the users knew immediately how to navigate in the virtual environment with the exercise cycle. They also told that they had a feeling of immersion. At times, some users' behaviour suggested that there was a feeling of riding a bicycle in a natural environment. Some users, for example, were afraid to ride down a ridge (see Figure 2), or they stood up on the exercise cycle to see better over obstacles in the terrain. In the interviews, they told that the immersion was due to the combination of a large, impressive and realistic visual system and the bodily user interface. The experience of the bodily interface was achieved by both the haptic response and using the whole body to control the navigation.

Fig. 2. A view down a ridge

One problem with the haptic interface is that the resistance does not adjust according to other terrain features than the slope. Useful bases for adjusting the resistance would be at least surface and vegetation. This is an important feature to improve in a cross-country bicycle simulation, and it will be dealt with in the next version of the game.

We must keep in mind that following a fitness program is a long task. Therefore, we can not expect to gain long term results until we have conducted a prolonged field test study. The first impressions of the users, however, suggest, that this kind of system motivates them in adhering to a training program. The reason is that a fitness computer game adds entertainment value and naturality to the exercise session compared to traditional exercise cycling.

5 Conclusions

In conclusion, we found out that the bodily user interface was a tremendous addition to the virtual environment and the game. Users can feel immersed in the environment without any intrusive VR equipment and stereo imagery. It seems to us, that in this kind of application, a haptic bodily interface is at least as effective as the traditional approach with the head-mounted displays.

6 Future work

We will continue to develop the interface and the game during this year and the next; at the time of this writing we are about halfway through our research and have another fifteen months ahead. The improvements will include at least developing a multiplayer game in a local area network, in which many users can train together in a common session. The haptic response will be improved by taking into account other terrain features such as the surface and vegetation. We will also consider other extensions to the bodily user interface and implement them if they seem appropriate. The Human-Centred Design approach will be used in this work; design solutions will be tested with the users.

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