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Teleportation of Objects between Virtual Worlds: Use Case: Exer-gaming

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Abstract

The Internet and virtual worlds are increasingly become a part of our daily lives. Currently these two are not capable of exchanging information, largely because of the lack of a global accepted standard for information exchange. Interaction between the real world and virtual worlds is mostly limited to classic mouse and keyboard devices, and exchange of information between different virtual worlds is virtually non-existent. We present a Use Case in the Metaverse1 project to increase motivation for continued physical exercising for the elderly by connecting real-world devices to virtual worlds, and allow information exchange through the teleportation of virtual objects from Second Life to our custom virtual biking world created in the Logos3D engine. We show that the principle of exchanging information between real and virtual worlds is simple, but the solution is non-trivial and requires not only a globally accepted standard to facilitate information exchange. From the results of a focus-group study, we show that a virtual environment does have the capability to increase motivation for exercising and that users do respond to a virtual exercise coach.

Unlike the Internet, virtual worlds lack standard frameworks for composing information-exchange processes. Virtual worlds typically run on self-contained, 'homebrew', systems and are not submissive to a W3C authority that streamlines the automation, sequencing, and management of complex computations and information exchange. To date, there are no global accepted standards for the exchange of information among real and virtual worlds and between virtual worlds.

To drive pre-competitive research on embedded and distributed software-intensive systems and services in virtual worlds, Information Technology for European Advancement (ITEA 2) installed the Metaverse1 project to help to provide a standardized framework, interfaces, and metadata definitions that enable interoperability between virtual worlds (e.g., Second Life, World of Warcraft, IMVU, Google Earth) and the real world (e.g., sensors, actuators, robots, social and welfare systems, banking, insurance, travel). Additionally, ITEA's 'Metaverse for all' strives to be a leverage point for the e-inclusion of minorities in society (Metaverse1 profile, 2008).

We used the Metaverse1 project and our Use Case, Serious Gaming for Ambient Assisted Living, to illustrate what is needed to start to bridge the gap between virtual worlds and the real world. Within the Use Case we focused on the transition of a health-exercise service from the physical world to a hybrid version between virtual worlds and discuss the impact this transition had on the operation and interfacing of the devices and the associated embedded software and hardware. The goal was to create an exercise environment that would increase motivation of elderly people to start and continue with physical exercises. To accomplish this we built an interactive virtual world using the Logos3D (About Logos3D, n.d.) engine and a Virtual Exercise Coach in the form of an on-screen avatar. To add an element of entertainment and to show the possibility of inter-virtual world object teleportation, we showed that we were capable of teleporting objects from Second Life into the Logos3D world.

A small focus-group validation study showed that the basic premises do seem to hold and that we may conclude that a system using a virtual world and a virtual coach, like our vrBiking system, can indeed contribute to a higher level of well-being through exercising. Apart from health or commercial settings, interoperability between virtual worlds could lead to new concepts for (serious) gaming, for example, World of Warcraft invading Second Life.

1. Prior Art

On the question of exchanging information between the real world and virtual worlds and between two or more virtual worlds, we need to identify two separate situations. The first is information exchange between real world devices, i.e. sensors and actuators, and a virtual world, and second the information exchange between two or more virtual worlds.

1.1 Real world and virtual world exchange

Sending information between real world devices and a virtual world is something we do every day when we interact with our computers, smart phones, or gaming consoles. We use mouse, keyboard, touch screen, Web cam, and other input devices to send information to programs, Web sites, and virtual environments. At the same time, feedback from the virtual world is less advanced, primarily restricted to visual and auditory feedback.

Almost all input devices are a variation mouse and keyboard or a simulated version of these. Certain devices take interaction to the next level like the Nintendo Wii (Wii Homepage, n.d.) or the Microsoft Kinect (Microsoft Kinect, n.d.) These systems replace unnatural ways of interaction with relative (body) movement and positioning to control and navigate software programs (Ashbrook & Starner, 2010; Fu, et al, 2010).

However, feedback devices remain less diverse. If we exclude the classic visual and auditory feedback devices, such as monitors and speakers, feedback is almost exclusively limited to vibration actuators (Marks, 2006; Dijk, et al, 2009). Other more natural feedback mechanisms, such as olfactory (Kaye, 2004) and complex haptics (Nijholt et al, 2010; Faust & Yoo, 2006) are harder to construct and usually fail to feed back a realistic sense of interaction (GauthierDickey, 2010). And although research has shown that more realistic feedback modalities enhance the user's participation (Richard et al, 2006; Lee & Spence, 2008), little effort seems to be spent by hardware and software developers in this area.

1.2 Exchange between virtual worlds

Communication between virtual worlds is almost non-existent. Most work has been done for the US Department of Defense in the development of the High Level Architecture for Simulation (Dahmann, 1997, 1999). Currently available immersive virtual worlds however, are all closed off environments that offer no or limited possibilities to communicate outside that environment. Most virtual-world communication occurs on a low abstraction level and concerns specific hardware and network requirements to support large and complex systems (Jordan et al, 2010). When, for instance, an avatar or an object in Second Life moves from one virtual region to another, these regions might reside on different physical servers (Ferreira & Morla, 2010). This means that protocols must be in place to take care of the transfer of all relevant information from one server to the other (Hu et al, 2008). It can even be taken one step further by creating an object in Second Life, exporting this to an XML-based file and then importing it into Open Simulator (Open Simulator, n.d.), thereby recreating the exact same object. However, the transport of objects between these worlds is possible only because the data structure and the way the environment and objects are created, stored, and rendered are exactly the same. Therefore, one can argue that this does not comply with true, preferably real-time, inter-virtual world exchange of objects. Other virtual information exchange involves multiple users within the same environment (Jana et al, 2008) and can be the mapping of information from one object to another within the same virtual world or allowing another user to receive a copy of an object.

True inter-virtual world exchange of information is rare and many problems need to be overcome before this can become commonplace. Horn et al. (2009) have proposed a novel system architecture to facilitate the interoperability of the real world and virtual worlds, but do not go into details of how such architecture might be realized.

To accomplish a true "Metaverse", we need an internationally accepted standard of virtual object geometry, capability, interactivity, and exchange. At the moment there are several encoding systems for describing 3D virtual objects. The best-known and most widely used systems are the X3D format (web3D Consortium, n.d., Daly & Brutzman, 2008) and the Collada format (Collada – Digital Asset & Exchange Schema, n.d., Arnaud & Barnes, 2006). Each of these methods has the potential to function as common language between virtual worlds to facilitate true real-time exchange of objects. However, the problem is that there are almost no open virtual worlds available to communicate between. The engines upon which these virtual worlds are built have the capability to communicate, but once a virtual world is built, it usually becomes a closed-off proprietary entity that seldom allows import or export of virtual objects. It is the economy that is playing the delaying role in creating, accepting, and implementing a global virtual object-exchange standard. Interactive virtual worlds have a real and measurable economic impact on our society and manufacturers of these virtual worlds generate hundreds of millions of dollars of income per year (KZero Worldswide, n.d.). To date, however, it is not in the interest of the developers to invest time and money in creating more accessible virtual worlds, as that would remove part or all control they have over the virtual assets and the real, and paying, users (Zyda, 2007).

Finally, another problem is the existing Internet network infrastructure. Connecting virtual worlds involves the exchange of large amounts of information. Continued use of the virtual world systems requires a realistic feedback time between real world devices and virtual worlds, and between virtual worlds themselves (Bainbridge, 2007; Chen et al, 2009). At the moment, this infrastructure is not reliable enough to handle large data streams. High latencies are one example of a problem caused by an inadequate network. Latencies above 50ms are noticeable to humans and can cause users to abort a session out of frustration (Bainbridge, 2007). Network security and low bandwidths are other problems that need to be solved for undisturbed multi-virtual world use (Chen et al, 2006).

2. The vrBiking Use Case Background

Many of the newer interaction devices are used in interactive gaming solutions developed for academic research (Beaton et al, 2010; Beckhaus et al, 2005), hobbyists (Exergame Lab, 2010), and the consumer market (Stach et al, 20009). Most of these solutions focus on the possible health benefits of interactive exercise games, because of considerable attention and societal worries about obesity and lack of physical fitness (Buttussi et al, 2007). Several studies showed that exercising with video games increases motivation and perseverance to exercise (Warburton et al, 2007). When social aspects are added to these games, i.e. people racing against each other, and the software takes different levels of physical fitness into account, the motivation to play and exercise increases even further (Mueller et al, 2007; Stach et al, 2009). Other studies showed that motivation is the key element to make inactive people enjoy exercising (Rhodes et al, 2007). This becomes even more important when we look at elderly people, who often suffer from a stronger lack of motivation to exercise and reach their physical limits much sooner than younger people do (Ekkekakis & Lind, 2006).

Interactive video games can be effective to increase motivation and continue physical exercise, thereby alleviating some of the increasing fitness problems in our society. Currently available virtual exercise environments, however, are almost exclusively proprietary systems that focus on one specific real-world device that functions with one specific virtual world, e.g. Wii Fit (WiiFit Plus, n.d.), EA Sports Active (EA Sports Active, n.d.), and the PCGamerBike (PC Gamer Bike, n.d.). Using more generic and open virtual worlds like Second Life with real-world devices is not common and has not generated usable systems. This is largely caused by a lack of an accepted global information-exchange standard that allows hardware manufacturers to create input devices, which are usable in any virtual world.

The MPEG-Virtual standard (MPEG-V) that the Metaverse1 project attempts to establish, should enable providers and consumers to carry out transactions between real and virtual worlds, creating a virtual market that will not only have entertaining or educational elements, but also offers ways to make the "Metaverse" an economical success. At the same time, the Metaverse1 project wishes to avoid e-Exclusion, which can be caused by geographic location, language, access to technology, access to networks, inexperience, perceived lack of skills, or even undue fears of new media (Bianchi et al, 2006).

Within the Metaverse1 project we create a Use Case that tried to create a more motivational physical exercise environment for the elderly by placing the user in a state-of-the-art virtual world and providing feedback using a Virtual Exercise Coach in the form of an on-screen avatar. We also wanted to create a setting in which it was possible to transport virtual objects from one virtual world to another. Our goal was not to create a prototype with fully implemented standardized data formats, but to show, using a proof-of-concept that information exchange between real worlds and between virtual worlds is easy to achieve provided the right structure is present and to show that such a system has the capability to (further) increase the motivation of users.

3. Experimental setup

We started by connecting exercise hardware and custom software. For this we used a Tacx i-Magic home trainer system (Tacx, n.d.) with steering frame. The Tacx system connected to a computer using a USB connection and the open source LibUSBDotNet driver (SourceForge – LibUsbDotNet, n.d.). For the Virtual Exercise Coach (VEC) we added the Haptek avatar software (Haptek software, n.d.) to create the exercise coach. Furthermore we added a bio-sensor module so we could add biophysical sensors for measuring e.g. heart rate, respiration, and brain waves. Finally, we added the Logos3D virtual world. To connect all these systems we created a custom computer program written in C#, called vrBiking, which processed all the real and virtual world data.

Although we first planned to use Second Life as the virtual world in which the user would ride his/her bicycle, it became clear at an early stage that Second Life was not a workable platform for interfacing in real-time with real-world devices. There is no real-time communication method available in Second Life that allows the 20-30 updates per second we needed to create a realistic link between the home trainer and the visual feedback from the virtual world (Claypool & Claypool, 2007). Next we tried OpenSim as this offers more access, but even using available OpenSim access libraries, e.g. WinGridProxy (WinGridProxy, n.d.), the update rate of the application remained comparable with that of Second Life and was deemed not usable for our application.

We decided to opt for a completely custom made and 100% controllable virtual world made specifically for our vrBiking application using the Logos3D engine (Fig. 1).

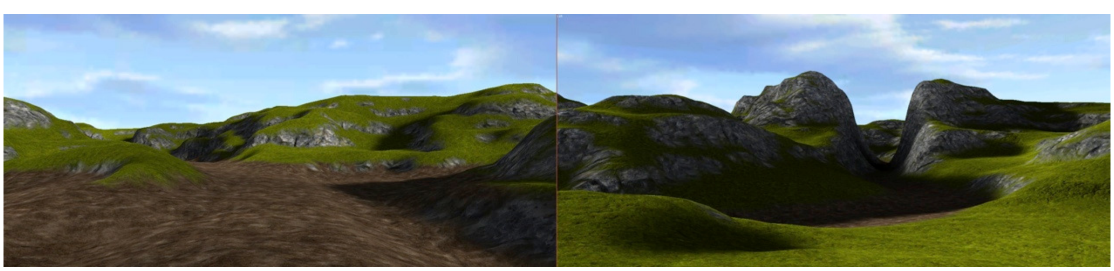

Figure 1: Screenshots of the virtual world used in vrBiking.

Logos3D is an advanced 3D graphics engine developed by IC3D Media, which delivers high performance and a graphically rich 3D experience. Logos3D is built upon a highly optimized set of functionalities written in ASM and C++, accessible through a C# interface. Therefore, it was relatively easy to setup communication between real world devices and software and the Logos3D virtual world.

Our application was built in three distinct layers (Fig. 2). The outer or application and device layer contained the real and virtual world applications and devices. These entities operate in their own environment, but are all capable of at least one-way communication with the middle or Translation layer. In our case the communication was handled through both software libraries (DLL's) and socket layers.

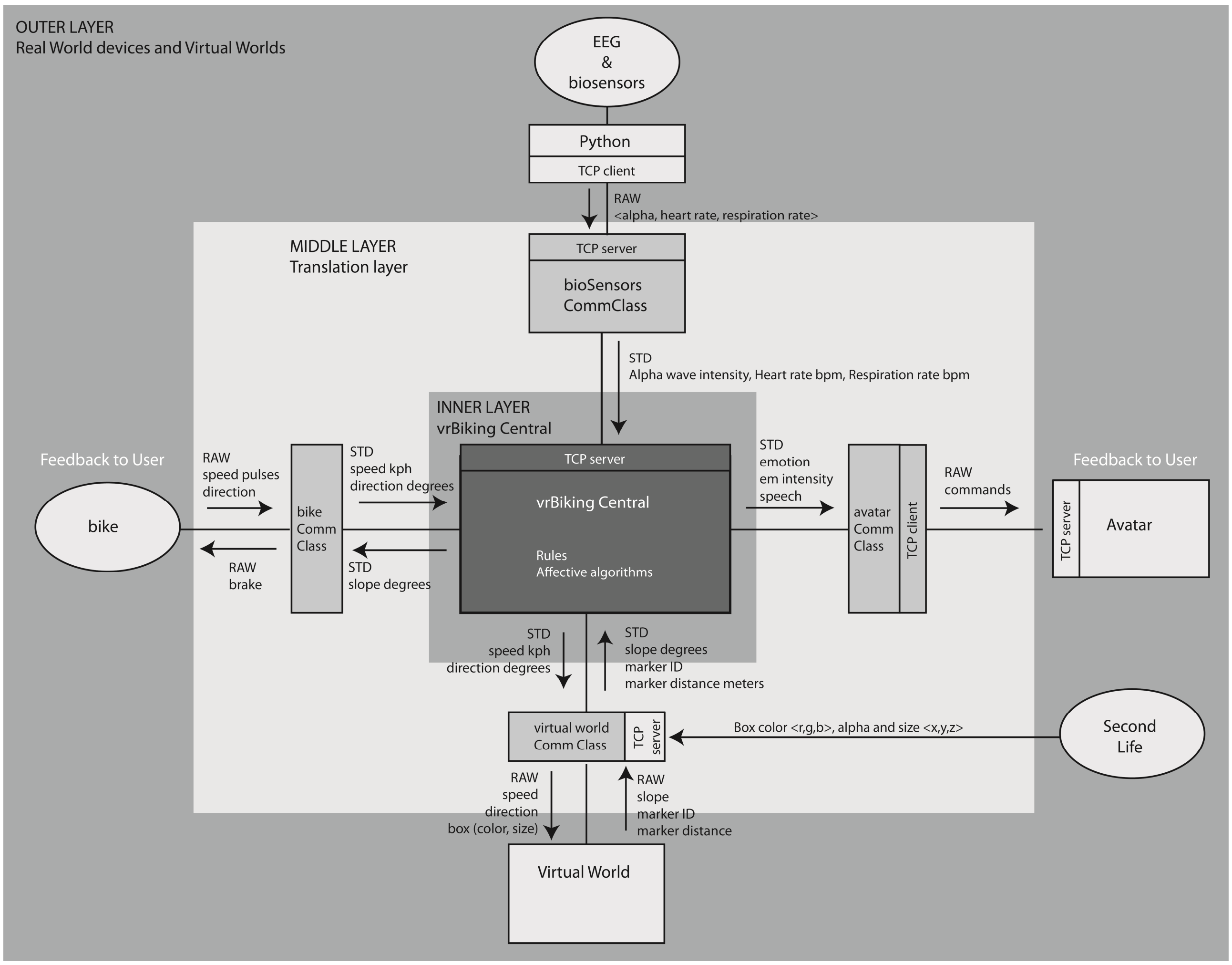

Figure 2: Architecture of the vrBiking application.

The Translation layer accepted any standard and non-standard data coming from the outer layer or standardized information from the inner layer. For each component in the outer layer we wrote a small program that converted raw device and application specific information into a standard-like format. To communicate back to the outer layer, standardized information from the inner layer was converted back to the proprietary format of the device or application.

The inner layer, vrBiking Central, only handled our standard-like information. Here incoming information from the Translation layer was gathered and fed into algorithms that created a response of the system to be sent back through the Translation layer and to the various feedback mechanisms, e.g. bike friction, virtual world changes, and avatar responses.

With the basic setup of our system ready, we turned our attention to communicating between two different virtual worlds. To do so, we decided to try to teleport virtual objects from Second Life into the Logos3D virtual world. In Second Life, we created a simple script (Fig. 3) that analyzed the object to which it was attached, so we could determine what sort of primitive object it was. Once the script had determined that it belonged to a cube, it extracted the dimensions of the cube in three dimensions and its color.

```
key requestid;
string NUM;
default
{
    touch(integer num_detected)
    {
        list myList = llGetPrimitiveParams([PRIM_TYPE]);
        if(llList2String(myList,0) == "0"){
            list myList1 = llGetPrimitiveParams([PRIM_COLOR,0]);
            list myList2 = llGetPrimitiveParams([PRIM_SIZE]);
            requestid = llHTTPRequest("http://000.000.000.000:9001/#" +
llList2String(myList1,0) + "#" + llList2String(myList1,1) + "#" +
llList2String(myList2,0) + "#",[HTTP_METHOD,"GET"],"");
        }
    }
}
```

Figure 3: Sample Second Life script for the teleportation of a cube primitive.

Once the user in Second Life clicked on or touched the object, these parameters were sent over a socket connection to the vwCommClass module of our vrBiking program. Once it received and checked the data stream, it transformed and transmitted the object description to the Logos3D virtual world.

The Logos3D virtual world then accepted the translated parameters of the cube and recreated a cube with the exact same physical parameters, in our case size and color, and dropped the cube in front of the virtual bicycle on the screen, while at the same time introducing some randomness in drop distance and horizontal displacement; in effect teleporting the object from Second Life into our Logos3D virtual world (Fig. 4).

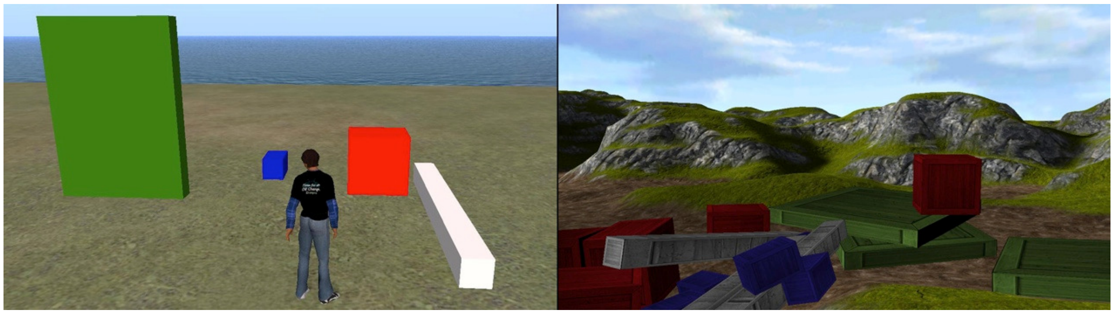

Figure 4: Left shows the Second Life environment with several objects.
Right shows the Logos3D environment with several teleported objects from Second Life.

In executing this procedure, we not only demonstrated true real-time virtual object transportation between two different virtual worlds, but also added an inter-virtual world gaming element to our vrBiking setup.

4. Validation

For a validation study we set up the vrBiking system inside the CAMeRA Game Cella' laboratory. We created an empty space in front of a large (3m diagonal) projection screen upon which we projected the virtual world. The system was placed at approximately 3 meters from the screen (Fig 5.). On the steering bar we mounted an 8" screen that displayed the avatar (Fig 5.). The projector, the Tacx system and the avatar screen were connected to a laptop running the avatar, the vrBiking, and the virtual world software.

The participants consisted of four elderly people, two males and two females with an average age of 63.2 years (sd 5.74 years). They were taken to a room adjacent to the laboratory without being able to see the experimental setup. They were given a general introduction to the Metaverse1 project without telling them about the purpose of the experiment. The participants also filled out a small questionnaire to assess their familiarity and experience with sports and state-of-the-art technology.

Figure 5. Overview of the study setup. Left, frontal view of the home trainer system. Right, rear view of the home trainer system with the small and large screens visible.

The participants were then taken one-by-one to the lab where they were told to sit on the bike and ride around in the virtual world. They were not given any specific instructions concerning how to ride or what to watch. Each participant had a maximum of five minutes to ride the bike and were free to stop at any time earlier. After the ride the participant was lead back to the adjacent room and was told not to discuss their experience with the others.

Finally a group discussion was held with one of us (Otte) using a list of 25 research questions that were specifically created to start with very general issues surrounding exercising and elderly and end up with very specific questions about the experimental setup. This focus-group technique was based upon several methods for qualitative research (cg. Flick, 2006).

4.1 Results

Most of the participants reported to having average up to extended experience with computers in general, but no experience with computer gaming. Most also did not own any state-of-the-art gadgets and had only a limited idea of what an avatar is. All did exercises at least once a week with no clear preference for exercising indoors or outdoors and alone or in a group.

In general the participants thought that exercising is very important for everyone, but especially so for the elderly. The elderly often lead a more sedentary existence and muscle tone and general fitness is felt to decrease fast. To mitigate these problems, exercising was felt as essential.

All the participants felt it was fun to use the experimental setup and be able to actually ride a bike inside a virtual world. They all reported that such a setup would make it more attractive to come back and continue exercising. All of them reported problems with the handling of the steering, in some cases it took several minutes to “get the feel” of how the system responded. These problems took away part of the fun of the experience.

All of the participants felt that our particular virtual world was not very suited for the purpose of making exercising on a home-trainer more fun. The landscape was often to dark (shadows) to clearly see what was coming up and the path was much too irregular making steering often difficult. A more open landscape with a flat cycling path would be more suited. They also remarked that going of the path did not produce any significant feedback (e.g. vibration, increase in friction) which disconnected the physical experience of cycling from the visual experience of the virtual world.

All participants seemed to be immersed in the virtual world at least at some time when judging their actions, although this was hard for them to clearly report. They all however, did report that they did not look at the virtual exercise coach (VEC) except at the very beginning when they mounted the bike. The navigating in the virtual world took too much concentration, a clear indication of immersion, to have the time to pay attention to the VEC. Except for one who reported that the sound level of the coach was too low, all participants did hear the comments of the VEC and some reported that they felt the need to “do something” with the remarks of the VEC. All participants did occasionally verbally reply to the VEC while cycling, confirming that they did hear and understand the VEC comments. Because none of the participants looked at the VEC screen during the exercise, they were not able to give any comments on the emotional expression of the VEC.

Whether the VEC actually added positively or negatively to the whole experience was not clear from the participants’ reports. The fact that they heard, understood, and even reacted to the VEC does indicate that the VEC can have an effect on the user and suggests that a properly responding VEC could have a positive effect on the motivation.

Summarizing we can say that there are indications that using a home-trainer setup like our vrBiking setup does help in making the experience of exercising more pleasurable. There were indications of immersion, although this did not seem to distract from the fact that the user was physically active. Although not clear, there seem to be indications that a VEC does add positively to the experience and thus could lead to more immersion. As for possible negative effects from the used technologies, the users are sensitive to how they would expect the home-trainer system to respond to their actions (steering and tactile feedback) and deviations from the expectations are experienced as distracting and could therefore negatively affect the general immersion and the motivation towards exercising.

Although the size of the test group was too small to draw any quantative conclusions, we can, with the necessary caution, conclude that:

1. Using a virtual world to ride a bicycle can lead to more motivation towards exercising.
2. Using a VEC could enhance the immersive experience and so lead to an increase in motivation towards exercising.
3. It is not clear if an emotionally expressive VEC could lead to an increase in motivation towards exercising.
4. It is clear that experienced technical limitations do negatively affect the feeling of immersion and could lead to a decrease in motivation towards exercising.

5. Conclusions

Using our vrBiking setup we were able to show that using a virtual world connected to a computer-connected home trainer, does have a positive effect on the immersion of the users, making the users less focused on the actual physical activity. Users also indicated that using the virtual environment motivated them to use the system. Moreover we showed that the users interact with the virtual exercise coach in the form of verbal replying to the VECs responses. We suggest that proper VEC responses could therefore lead to even more motivation.

Technical limitations of connecting real and virtual worlds did pose problems that conflicted with the immersion.

When looking in general, the current developments concerning internet, virtual worlds, and real world devices, it is clear that in the near future some form of integration will take place. Before these elements can merge into a true "Metaverse" however, several issues need to be resolved.

First of all, there needs to be a global accepted standard of virtual object description and transfer protocols between different virtual worlds. Although geometry descriptions systems exist and property and interaction descriptions are being drafted, there is at the moment no global accepted standard that facilitates real-time interactive exchange of virtual objects between virtual worlds.

Second, to facilitate existing and future proprietary systems, a communication structure should be implemented and accepted, that facilitates translation of object information into standardized information that can be exchanged.

Finally, existing and new virtual worlds need to open up to allow the transportation of at least some of the virtual objects and their properties.

6. Future work

To improve our system we would like to address some of the issues that were reported in our study. This includes creating a better “connection” between the home trainer and the virtual world by adjusting the feedback of the steering and adding some tactile feedback in response to the terrain. To decrease the trouble participants had with navigating the virtual environment, we will create a flatter and easier to oversee environment.

Moreover, we want to enhance our vrBiking setup by adding emotional intelligence to our avatar (Hoorn et al, 2008) and conduct a full scale experiment to properly analyze the possible effects of the system on the motivation to exercise in multiple age groups. With this upgraded system we can then run a more rigorous and quantitative study of the effects of the virtual environment and the virtual exercise coach on the motivation for exercising for the elderly.

Finally, to address the more general problems surrounding the information exchange between virtual worlds we want try to develop a layered communication structure that would facilitate a dynamic extensibility to exchange not only information, but also functionality.

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