Open Source Virtual Worlds and Low Cost Sensors for Physical Rehab of Patients with Chronic Diseases

Salvador J. Romero, Luis Fernandez-Luque, Jose L. Sevillano, and Lars Vognild

[1] Robotics & Computer Technology for Rehabilitation Laboratory, University of Sevilla, Spain
[2] Northern Research Institute, Tromsø, Norway
{luis.luque,lars.vognild}@norut.no

Abstract. For patients with chronic diseases, exercise is a key part of rehab to deal better with their illness. Some of them do rehabilitation at home with telemedicine systems. However, keeping to their exercising program is challenging and many abandon the rehabilitation. We postulate that information technologies for socializing and serious games can encourage patients to keep doing physical exercise and rehab. In this paper we present Virtual Valley, a low cost telemedicine system for home exercising, based on open source virtual worlds and utilizing popular low cost motion controllers (e.g. Wii Remote) and medical sensors. Virtual Valley allows patient to socialize, learn, and play group based serious games while exercising.

Keywords: Tele-rehabilitation, Virtual Worlds, Open Source, Low-Cost.

1 Introduction

Most patients with chronic diseases depend on exercising and rehab to stabilize the progression of their disease and increase quality of life [1]. However, many of them suffer motivation problems which could lead into poor compliance to perform the physical exercises suggested by their healthcare professionals. Patients become more sensible to depression when they are no longer able to go out from their homes. They cannot go to the health center for rehabilitation anymore, and have to exercise at home. They stop having a sense of group belonging and tend to feel isolated.

Many of the solutions proposed or adopted to confront this problem are based on computer applications. Usually, a system based on a PC and medical sensors is installed in the patient's house, to help doctors monitor and supervise the patient´s rehabilitation [2]. For the exercises, systems use to have some hardware, like intelligent clothes or a bike [3]. They also provide communication tools, such as videoconference.

In recent years, virtual worlds like Linden Research's Second Life have become really popular. They have shown to be a great tool for collaborative works, learning and e-health [4-6]. An increasing number of companies, universities, and educational centers have presence in Second Life. Users can attend virtual lectures, interact with applications and 3D objects, and socialize with other users. They can see if other people are around and can start a conversation with them. These features make virtual worlds a natural and attractive social platform.

2 Virtual Valley

We are taking advantage on innovations in virtual world technologies, game-based low-cost solutions for motion tracking [7], and medical sensors in the development of our approach; a social-oriented virtual world controlled by sensors, where the patient can learn, exercise, and interact with others from home.

Although Second life is a good option to reach as many people as possible, due to sensible data we manage and requirements of restrict access, we need to deploy the virtual world in our own servers. For that, there are open source clones and alternatives to Second Life, e.g. OpenSimulator and Sun Wonderland [8]. We have decided to use Wonderland, as we explain in the following section.

2.1 System Architecture

Virtual Valley implements a client-server architecture, running a Glashfish server on the server side, the Wonderland server and other complementary software (Fig.1).

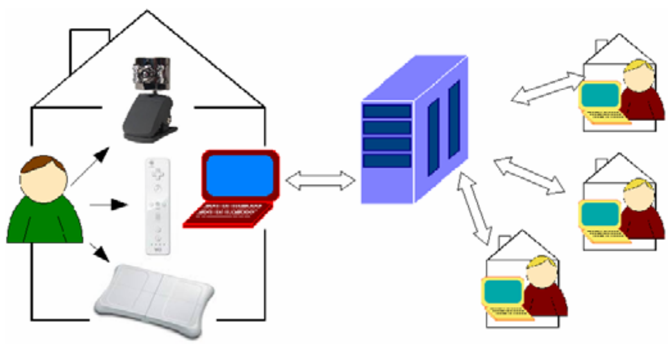

Fig. 1. System architecture

Wonderland is a Java open source software for virtual worlds. It is able to run Java and X11 compatible applications embedded inside the virtual world, which users can interact with through their avatars. This feature provides a straightforward way to develop custom multiuser applications inside the Virtual World, and makes Wonderland very flexible. Another interesting feature of Wonderland is the voice bridge technology, which allows the user to have a voice chat at any moment. The user just speaks through her microphone, and nearby avatars can hear her.

On the client side, a PC is running the Wonderland client, controlled and receiving input from sensors, such as the Wii Remote controller and the Nonin Pulsioximeter. The communication protocols of these Bluetooth sensors are publically available. There is a growing set of libraries and APIs[1] which allow applications to interact with them easily. We are using WiiGee [9] for gesture recognition with the Wii Remote and Bluecove to enable Bluetooth communications.

Thanks to the voice bridge technology and the use of motion controllers and sensors, a keyboard and mouse are not necessary.

[1] *Windows*: GlovePie, *OSX:* Darwiin remote; *Linux*: Cwiid driver; *Multiplatform*: Wiiuse (C), Wiimotelib (.Net); MoteJ, Wiimote Simple, WiimoteJ, Wiigee (Java), WiiFlash (Flash!).

2.2 Functional Design

The virtual world shown to the user is a 3D representation of a Valley, where several buildings can be found: 1) the Learning Center, 2) the Virtual Gym, for exercising; and 3) the amusement garden, which is basically a game oriented virtual gym.

The *Learning Center* building is intended to aid patients to learn how to deal with their illness. The info is shown on walls, like in a museum. It can be slides with text and images, videos, websites and interactive applications. The learning center has a conference room, where a person controlling an avatar can give a talk. By moving her avatar after a microphone, she can be heard in the whole room. The speaker is able to show slides, applications or live videos on a couple of blackboards nearby.

The *Virtual Gym* building (Fig. 2) is dedicated to exercise and rehabilitation. Inside the building there are 3D items, called animatics, which resemble a treadmill, with a large screen in front of it. When an avatar steps on the animatic, the view is centered on the animatic screen. There is then displayed the exercising program, adaptable to each user's needs, that the user has to perform using the sensors. There is another conference room used for group exercising leaded by a physiotherapist.

Avatars perform predefined movements, the same in all cases, to show that a user is exercising. This might help patients to get over their shames and socialize with others, including healty users (e.g. relatives).

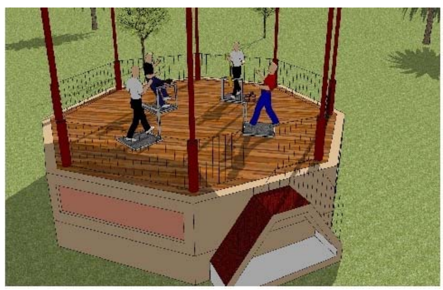

Fig. 2. Screen captures of a prototype. From left to right, Virtual Gym and Music Hall.

The *Amusement Garden* is similar to the virtual gym, but oriented to games and group activities. The technique of disguising rehabilitation exercising with serious games has been successfully tried in several occasions, e.g. [10]. The avatar will use a modified animatic to fit the context of the game. Several of these activities are: 1)*Garden scout*: The avatar rides an animatic which resembles a bike, a scooter or similar. As she performs her exercises, the animatic-bike moves around the garden; 2) *Sailing the Fjord:* Similar to the previous one, but group oriented; 3) *Music hall* (Fig. 2). Avatar takes places in an orchestra of animatic-instrument. When they exercise properly, their instruments sound.

3 Discussion and Future Work

Virtual Valley represents the convergence of traditional telerehabilitation and new ways of communication and social interaction. Based on previous experiences [2], our hypothesis is that this kind of social-oriented approaches can help encouraging and motivating patients to exercise and keep doing rehabilitation.

We have done a study of the art and tested the most promising technologies. The Virtual Valley System has been designed with the active implication of healthcare professionals of the University Hospital of North Norway, Tromsø The system is currently being implemented, and we estimate that a working version for evaluation by users will be ready by the third quarter of the present year.

Thanks to the use of state of the art low cost sensors and open source software, we are in condition to build an affordable system that we can install in most patients' houses. The open source community is active in these areas, and the success that low cost game and medical sensors are achieving in the market, guarantee a continuous development of software, hardware and APIs which will support our project. The virtual world can be expanded easily, and new applications, activities and buildings can be added as needed. Other sensors can be used and more function added to those we already use, like precise 3D tracking.

Acknowledgments. This project is a part of the MyHealthService project from the Tromso Telemedicine Laboratory, co-funded by the Research Council of Norway. The project has been partially supported by the Fidetia and the Telefonica Chair on Intelligence in Networks from the University of Sevilla (Spain).

References

1. W. H. Organization: Global Strategy on Diet, Physical Activity and Health, Facts Related to Chronic Diseases, `http://www.who.int/dietphysicalactivity/publications/facts/chronic/en/index.html` (Cited: 4 7, 2009)
2. Burkow, T.M., Vognild, L.K., Krogstad, T., Borch, N., Ostengen, G., Bratvold, A., Risberg, M.J.: An easy to use and affordable home-based personal eHealth system for chronic disease management based on free open source software. Studies in health technology and informatics, vol. 136 (2008)
3. Wang, Z., Kiryu, T., Tamura, N.: Personal customizing exercise with a wearable measurement and control unit. Journal of NeuroEngineering and Rehabilitation 2(1), 14 (2005)
4. Hansen, M.M.: Versatile, Immersive, Creative and Dynamic Virtual 3-D Healthcare Learning Environments: A Review of the Literature. EdD, MSN, RN: JMIR (2008)
5. Gorini, A., et al.: A Second Life for eHealth: Prospects for the Use of 3-D Virtual Worlds in Clinical Psychology. JMIR (2008)
6. Galego, B., Simone, L.: Leveraging online virtual worlds for upper extremity Rehabilitation. In: IEEE 33rd Annual Northeast Bioengineering Conference, NEBC 2007 (2007)
7. Smith, B.K.: Physical Fitness in Virtual Worlds. Computer 38(10), 101–103 (2005)
8. Project Wonderland, `https://lg3d-wonderland.dev.java.net`
9. WiiGee: A Java-based gesture recognition library for the Wii remote, `http://www.wiigee.org`
10. Consolvo, S., Klasnja, P., Mcdonald, D.W., Avrahami, D., Froehlich, J., Legrand, L., Libby, R., Mosher, K., Landay, J.A.: Flowers or a robot army?: encouraging awareness & activity with personal, mobile displays. In: UbiComp 2008: Proceedings of the 10th international conference on Ubiquitous computing, pp. 54–63 (2008)