Virtual Worlds to enhance Ambient-Assisted Living

Daniel Cascado, Salvador Jesús Romero, Santiago Hors, Ángel Brasero,
Luis Fernandez-Luque, José Luis Sevillano

Abstract— In this paper we discuss about the integration of Ambient-Assisted Living (AAL) with virtual worlds. The integration of sensors from the AAL environment (e.g. vital signs, motion sensors) in the Virtual World can enhance the provision of in-world eHealth services, such as tele-rehabilitation, and taking advance of the social nature of virtual worlds. An implementation of a virtual world integrated in an AAL environment for tele-rehabilitation is described in this paper. At this time, all of the system's modules have been developed and we are currently integrating them in a fully functional version. The system will be tested with real users during 2010 in the Sport Medical Unit of The University of Seville. This paper describes the architecture and functionalities of the system.

I. INTRODUCTION

Ambient Assisted Living (AAL) is a discipline that combines different Information and Communication Technologies (ICT) to help people in their daily life, especially senior citizens and people with chronic diseases. An AAL system is composed of a set of devices integrated in a user environment providing different services to assist the users. Typical AAL systems include services such as emergency (e.g., fall detection), health services (e.g. vital sign monitoring), etc.

In the recent years, the advancement of the Internet capabilities has made it possible to create more complex applications such as virtual worlds (VWs). VWs are 3D simulations of an earth-like world where users are represented by an avatar (i.e. graphical representation of a human being). VWs have gone one step further in online social interaction and interactivity. Users can interact with objects, or with other users by means of text

chat, voice or even video. VWs offer an immersive experience that allows interacting with other users using text, voice and video. Social interactions can be made in different virtual places as parks, buildings, etc. In order to start a conversation, users just need to get closer to each other.

The integration of medical and motion sensors from the AAL system in VWs, makes the realization of rehabilitation exercises inside the VW possible. In addition, healthcare professionals can supervise the physical exercises which take place in the VW. Besides, vital signs and information from the motion sensors can be displayed to both professionals and patients in the VW. Data from medical sensors, such as heart rate, can be displayed in the VW to be discussed by healthcare professionals and patients.

Moreover, VW adds a social component which makes users become an active part of the VW. VWs have been found to reinforce user's auto-esteem, and to reduce technological frustration [1]. Socialization can be enhanced by means of exploring the VW, and the interaction with other users. Users can make activities together, such as rehabilitation exercises and shared applications. In this way, the capabilities of the system are not only the sum of capabilities of system, but also the sum of capabilities provided by the users [2].

In this paper, we propose the integration of AAL services in VWs. We propose to use health monitoring services and low-cost motion sensors for supporting tele-rehabilitation in the VW, allowing group exercises in order to enhance sociability and motivation.

Daniel Cascado-Caballero, Salvador Jesús Romero, Santiago Hors-Fraile, Ángel Brasero-Moreno, and José Luis Sevillano-Ramos are with the Robotics and Computer Technology Laboratory of University of Seville, ETS Ingeniería Informática. Avda. Reina Mercedes s/n. 41012, Spain (e-mail: danic@atc.us.es)

Luis Fernandez-Luque is with the Northern Research Institute Tromsø, P.O. Box 6434, Tromsø Science Park, N-9294 Tromsø, Norway (e-mail: luis.luque@norut.no)

II. PREVIOUS WORK

There are several VWs available online, such as Second Life [3] with thousands of users connected per day. There are also open source virtual worlds platforms. For example, Open Simulator [4], a

virtual world compatible with Second Life, and Open Wonderland [5], an open source VW developed in Java focusing on collaborative work.

The health-related experiences with VWs are mainly devoted to medical education and health promotion. Thomson [6] proposes a virtual hospital for training about hospital logistics implemented in Second Life. A similar approach is shown in Second Health [7], devoted to training medical and administrative staff into the handling of patients. Moreover, in Gorini [8] a discussion about using VWs for mental health is shown, where professionals take care of patients in private VWs. Gorini points out the positive effects of this type of therapy, although she warns about the risks of addictions and privacy.

One of the first approaches to use external devices in VWs came from adding new interaction devices like joysticks, haptic devices, and even affective devices [9]. However, adding new devices, such as game controllers, normally requires to develop new software. In that regard, Syamsuddin [10] proposes a generic interface layer, and an interaction information format for all types of devices and VWs.

The combination of AAL and VWs is studied in [2], where some interesting considerations are made about organization and implementation. One of the first examples of this approach is CAALYX [11], which uses Second Life to provide a virtual place where patients can see their vital signs in the VW by means of the information gathered by health sensors. The project Smart Condo [12] deploys a sensor network to locate user's position and movements in order to create an animation of them in the VW, as well as for further studies by medical professionals.

III. Virtual Valley

Virtual Valley is an example of a virtual world integrated in an AAL environment for tele-rehabilitation. In [13] we describe the spaces inside the virtual world. As explained in the next section, Virtual Valley is based on Open Wonderland virtual world platform and integrates low cost motion controllers (e.g. Wii Remote) and medical sensors from the AAL environment.

It supports physical rehabilitation, education, socialization and sharing of knowledge between users (i.e., patients and health professionals) in a virtual world with controlled access.

Virtual Valley provides an environment for socializing and interaction between the different users, using live chat, audio and multiuser interactive applications. Education is achieved through the integration of multimedia material, such as images, videos, presentations and interactive applications.

In the virtual world, we integrate activities designed for physical rehabilitation. Virtual places include multiplayer game areas designed for specific rehabilitation exercises. These games will request users to do physical exercises in the real world to interact with them. Users' movements are registered by sensors integrated in the AAL environment at their homes. Then, the sensor data are sent to the virtual world in real time. Consequently, users can follow the progression in their exercises through the feedback provided by games (e.g., the user has to move her arms in order to move the avatar's arms).

The data of the exercises and user's health are stored in a database, making it possible to follow the progression of the patients by health professionals. These data include: gender, weight, and height; patient's performance in the exercise (using motion sensors); as well as other parameters that depend on the specific illness: expiratory flow rate, continuous SpO_2 readings, glucose levels, etc.

Health professionals can adapt the rehab exercises for each patient depending on their personal needs. The same data can also be displayed in the virtual world, for example to show the patient's evolution. In addition to following the rehabilitation program, they can use the collected data for research purposes and to validate new rehabilitation exercises.

IV. System Architecture

As detailed in Figure 1, the user's AAL environment incorporates fitness devices, medical sensors, and other devices controlled by VW platform software. The client of the VW runs in a

PC connected to the patient TV. The client connects to the server using Internet.

The Virtual Valley client application can be accessed from a web browser and starts as a Java Web Start application. In this way, health professionals can access the virtual world from their standard PCs and would control their avatar with a simple mouse and keyboard.

As explained in the following subsections, to provide such VW integration with AAL environment, two components are required: A) the Virtual World platform, and B) AAL devices.
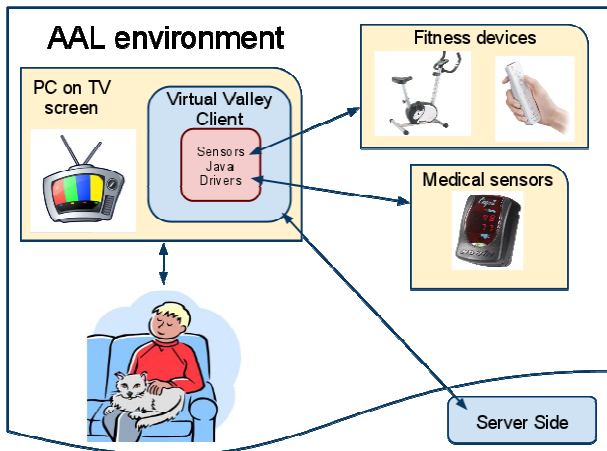

Figure 1: AAL Environment

A. Virtual World Platform

Open Wonderland is an open source virtual world platform developed in Java. Its architecture is built with a relatively small core with additional modules that can be developed to add extra functionality (Fig. 2).

One of the main modules included in Open Wonderland is the X11 shared application module, which allows running any X11-based application (described below). Other modules provide communication features, such as the voice chat module.

Applications can be integrated and used inside the virtual world. Those applications, called in-world applications, can be either: A) X11 shared applications, which are common Unix desktop applications, such as a web browser, a PDF viewer and a game: and B) custom-built Open Wonderland modules, developed to provide virtual elements (e.g., a virtual fitness device) that reacts to the users. For example, these applications can be multiuser serious games for physical exercises.

B. AAL devices

AAL devices, such as motion sensors, provide the interface between the users, the VW and the AAL system.

The integrated devices in our system are connected using Bluetooth and the java library Bluecove (Fig. 2). The controllers of these AAL sensors are developed in Java, and used by an Open Wonderland module. The Open Wonderland modules read data from the devices as input to in-world applications.

As shown in Figure 1, there are two categories of devices, control devices (e.g., fitness devices with motion sensors) and medical sensors. The first category monitors the user behavior to generate input, while the second monitors vital signs.
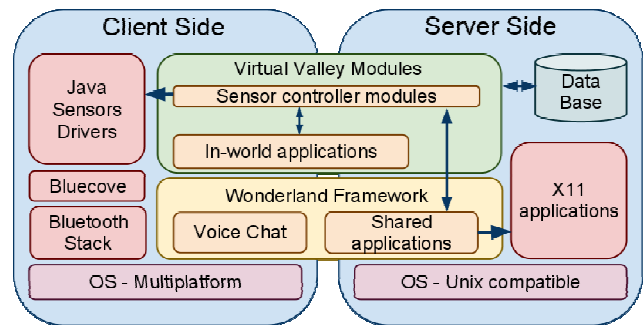

Figure 2: Virtual Valley Software Architecture

1) Control Devices

This group comprises sensors like computerized fitness devices, electronic pedometers, mobile phones [14], video cameras, and video-games motion controllers.

Figure 3: An example of a WiiRemote monitoring a fitness device.

The device used in our system is the Nintendo WiiRemote, which is an inexpensive gaming control that combines different motion sensors (e.g. accelerometer, gyroscopes), infrared camera

for pointing and Bluetooth communications. We use that device as a user control and also to monitor the fitness devices (see Figure 3).

We developed java modules to integrate the WiiRemote using a customized version of the open source Wiigee library, which provides a wide range of functionalities (e.g., reading of accelerometer data, infrared camera and gesture recognition). Additionally, we created new libraries to use the WiiRemote Infrared camera to control the mouse pointer on the screen.

We implemented a module based on the library IRGlance to use the WiiRemote infrared for controlling fitness devices. For example, we integrated several LEDs in a rowing machine. Then, the movements of the LEDs are tracked by the WiiRemote infrared camera and sent to the Virtual World to control the avatars.

2) Medical Sensors

This group comprises pulse-oximeters and glucometers. For instance, the Nonin 9560 OnyxII pulse-oximeter, with Bluetooth communications. We have created a Java library that receives the raw data from the Nonin and provides an API to read the pulse and oxygen blood saturation in the PC, providing continuous monitoring.

TABLE I
LIST OF IMPLEMENTED FEATURES

Virtual Valley Modules	
Anaerobic exercise game	
Gesture based mobility game	
AAL device server	
Mouse and keyboard emulator	
Devices and custom supported features	
Nonin PsO$_2$	Continuous readings of PsO$_2$.
WiiRemote	Buttons, gestures, accelerations and IRcamera pointing.
Wii board	Pressure, weight.
Wii motion plus	Angles.
Nunchuck	Acceleration, buttons.
Provided by Open Wonderland platform	
Voice chat and Desktop integration	

V. CONCLUSIONS AND FUTURE WORK.

Virtual Valley, the ongoing project presented in this paper, is an example of combination of AAL and Virtual Worlds to provide tele-rehabilitation services for a community of patients. One of the main characteristics of Virtual Valley is that it has been developed using low cost devices and open source software.

Virtual Valley is a virtual world based on Open Wonderland that we adapted for using health sensors, motion sensors, integrated in an AAL environment. This paper describes some of the features of Virtual Valley, as well as its possibilities in a medical context.

At this time, all of the system modules have been developed (Table I). We are currently integrating them in a fully functional version. The system will be tested with real users during 2010 in the Sport Medical Unit of The University of Seville. We also have an active collaboration with researchers from the Northern Research Institute-Norut (Tromsø, Norway). Some of the ideas described in this paper will be further explored as part of the project IsActive [15].

REFERENCES

[1] Steg, H., et al., Europe Is Facing a Demographic Challenge – Ambient Assisted Living Offers Solutions. In: VDI/VDE/IT, Berlin, Germany, 2006.
[2] Hong Sun et al., Towards Building Virtual Community for Ambient Assisted Living.Parallel, Euromicro Conference on Distributed, and Network-Based Processing, vol0, p556-561. IEEE Computer Society, 2008.
[3] Second Life: http://secondlife.com Accessed 25/06/2010
[4] Open Simulator http://www.opensimulator.org Accessed 25/06/2010
[5] Open Wonderland: http://www.openwonderland.org/ Accessed 25/06/2010
[6] Thompson, C. W., Hagstrom, F., Modelling health care logistics in a virtual world. IEEE Internet Computing, 12(5), 100-104, 2008.
[7] Second Health: http://secondhealth.wordpress.com/ Accessed 25/06/2010
[8] Gorini, A., Gaggioli, A., et al., A second life for ehealth: Prospects for the use of 3-d virtual worlds in clinical psychology. J Med Internet Res, vol 10(3), 2008.
[9] Dzmitry Tsetserukou, et al., iFeel_IM! Emotion Enhancing Garment for Communication in Affect Sensitive Instant Messenger. Human Interface and the Management of Information. Designing Information Environments, pp628-637, ISBN: 978-3-642-02555-6. Ed. Springer-Verlag, 2009.
[10] Muhammad Rusdi Syamsuddin, et al., Research on VRI: Virtual World and Real World Interface, International Symposium on Ubiquitous Virtual Reality, pp. 72-75, 2009.
[11] Boulos Maged, Rocha Artur,Martins Angelo, et al., CAALYX: a new generation of location-based services in healthcare. International Journal of Health Geographics, v6, p9. 2007.
[12] Stroulia, E. et al., Software engineering for health education and care delivery systems: The Smart Condo project: Software Engineering in Health Care, SEHC '09. ICSE Workshop on, pp.20-28, May 2009.
[13] S. J. Romero, et al., Open source virtual worlds and low cost sensors for physical rehab of patients with chronic diseases, in Electronic Healthcare, P. Kostkova, Ed. Berlin, Heidelberg: Springer Berlin Heidelberg, vol. 27, ch. 12, pp. 76-79, 2010.
[14] J. Bravo, R. Hervás, et al., Visualization services in a conference context: An approach by rfid technology, j-jucs, vol. 12, no. 3, pp. 270-283, 2006.
[15] IsActive: http://www.is-active.eu/ Accessed 25/06/2010