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Exploring the Potential of Virtual Reality for the Elderly and People with Disabilities

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1. Introduction

Nowadays society is facing a process where life expectancy is gradually but constantly increasing. As a result, the group of elderly people is growing to become one of the most significant in the entire population (Giannakouris, 2008). This also means that the prevalence of physical and cognitive impairments is increasing in proportion. Elderly people usually suffer from vision deficiencies (yellowish and blurred image), hearing limitations (especially at high frequencies) motor impairments (for selection, execution and feedback) and slight deterioration of their cognitive skills (Lillo & Moreira, 2004). In this context, providing the elderly and people with disabilities (E&D) with accessible systems and services that could improve their level of independence and thus enhance their quality of life has become a must for ICT –Information and Communication Technologies– developers such as usability engineers and interaction designers.

Ambient Assisted Living (AAL) is one of the solutions that are beginning to address this technological challenge. The AAL concept represents a specific, user-oriented type of Ambient Intelligence (AmI). It comprises technological and organisational-institutional solutions that can help people to live longer at the place they like most, ensuring a high quality of life, autonomy and security (Steg et al., 2006). AAL solutions are sensitive and responsive to the presence of people and provide assistive propositions for maintaining an independent lifestyle (De Ruyter & Pelgrim, 2007).

Within this complex and continuously evolving framework, it is very challenging to technologically meet all users' needs and requirements regarding accessibility and usability along the development process. Accessibility is a prerequisite for basic use of products by as many users as possible, in particular elderly persons and persons with sensory, physical or cognitive disabilities. Usability denotes the ease with which these products or services can be used to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use (Wegge & Zimmermann, 2007). These aspects should be taken into account during the product design ideally from early stages, following a more interactive and iterative design-development-testing procedure. The major problem lies in the global cost of the design and development process, which can be critically increased, since AmI

solutions involve complex features such as ubiquity, context awareness, smartness, adaptiveness and computing embedded in daily life goods.
The continuous advance of ICT is gradually increasing the ability of the E&D to perform daily activities independently, decreasing the amount of effort required for completing sensitive tasks. In this sense, Virtual Reality (VR) –at a broader scope, Virtual & Mixed Reality (VMR)– is growing to become a very useful tool for the empowerment of a large number of people. The potential usefulness of VR for these persons were already summarised in four main points almost two decades ago (Lanier, 1992; Middleton, 1992):

- It offers them the possibility to perform tasks and experience situations that they might not otherwise because of any physical or cognitive limitation, since VR can transform the sensory information that they cannot perceive into other modalities.
- VR can present a world where people may learn in a simplified way, applying afterwards the skills acquired to more complex real environments.
- VR technologies can be adapted to a wide range of individual senses and capabilities of the user. E.g. blind users can receive more audio information; visual information can be reinforced for deaf users, etc. Also, individual abilities of the users can be assessed so that the adaptation is optimal for them.
- VR allows people with special needs to interact with other users in the same conditions.

At present, costs of emerging VR technologies are being constantly reduced while becoming adaptable to a wider range of environments and individual requirements. Therefore they may offer significant opportunities to support user interaction in technological environments, while helping to reduce the existing usability gaps. As a consequence, VR has become the central research issue for a new generation of technologies that may be used to help E&D.
Since many years, the two research groups responsible of this book chapter – Fh-IGD and LST-UPM– have been advancing in the potential of ICT to overcome access limitations to environments and services, particularly addressing the convergence of VR, domotics and accessibility. As a natural step in this collaborative process, both groups are exploring the convenient application of VR technologies in the process of designing and developing accessible solutions for the E&D. An overview of this complementary work is depicted below.

2. State of the art

Probably the main advantage of VR is the possibility to create realistic environments. The experience of feeling immersed in a virtual scenario helps the user to overlook that s/he is actually in an artificial testing environment, allowing the assessment of the user experience under more natural circumstances. Another important benefit is the capability for controlling the type, number, speed and order of stimulus that are to be presented to the user of the virtual scenario, which enables the specialists to improve their interventions by personalising the environments, adapting them to the special conditions of each user. In the same way, trial and error methods can be easily applied into virtual environments; VR may then be used to analyse the user's behaviour in potential dangerous situations without any risk. Finally, by selecting different sets of stimulus to be presented to the user, the level of complexity of test exercises can be gradually increased, so the specialist is able to individualise the treatment or training scenario.

At the moment, the most significant domains for using VR applied to E&D are training, learning, rehabilitation, leisure or even tele-operation. Most of these systems are designed to establish a flexible and efficient *interface* between user and specialist, allowing the latter to define activities, measurements and protocols to quantitatively evaluate the user's progress. In contrast, a major weakness of VR is that nowadays there are still few applications that cover all the expectations created. Anyway, there are remarkable products coming out from laboratories that seem rather close to predictions. Some of them are analysed next.

2.1 VR applied to people with physical, sensorial and cognitive disabilities

VR technologies can be a great help for people with dysfunction or complete loss of specific interaction functions such as motion or speech. Techniques are progressing, and today certain applications and devices, which were used at first only to interact with VR, are now useful in the real world as assistive technologies (e.g. VR gadgets for transforming sign language into speech).

Furthermore, VR can be applied to rehabilitate specific disorders of people with motor limitations by training exactly those functions that can be improved. In this field of motion rehabilitation, force feedback devices like haptic interfaces and exoskeletons are commonly used (Ghedini et al., 2008). These devices are mainly robots able to apply controlled forces upon the user, to enable perception of the virtual environment by means of touch. The therapy may be adapted by calibrating the forces, hindering or facilitating the patient's motion for a specific exercise. There are several types of robots for this purpose, depending on the functionality required or the interaction mode. Some of them allow either 2D or 3D movements, some are wearable, others are in contact only with the part of the body that is going to be rehabilitated, etc.

People with physical disabilities can also use VR to perform the same complex tasks as non-handicapped people. VR may provide an adaptable mechanism for taking advantage of a convenient physical ability of one person to operate an input device for a computer program and, therefore, go around his limitation. E.g. there are systems based on data gloves that allow users to record custom-tailored gestures and map these gestures into actions (Micelli et al., 2009). In this way, people with vocal impairments could even enhance their communication skills by mapping specific hand gestures to speech phrases.

Another area of use is creating simulations for people with sensory impairments like blind or deaf people. In these applications the focus is helping them to learn the use of new tools like a walking stick or sign language. VR systems are also used for testing the usefulness and accessibility of products and environments before they are actually built. Virtual buildings can be designed in advance and displayed through a head mounted display to a wheelchair user who will move around and check for potential obstructions or non-accessible places (Pithon et al., 2009).

Educational inclusion for children with sensorial disabilities is also an important research goal for VR developers. The overall objective of virtual learning environments is to allow students to interact physically and intellectually with a new generation of instructional materials, and the focus of a significant number of researchers is to offer the same opportunities to users with disabilities to access and take advantage of all these resources. For example, there are virtual environments for visual impaired or blind children, which focus on the creation of mental structures of navigable objects using only spatial audible information and no visual information; there are also virtual environments for the education and training of children with spatial problems caused by movement limitations; hearing impaired children can also benefit from virtual environments by helping them to improve in structural inductive processes and flexible-thinking ability (Sik Lányi et al., 2006).

One type of application is the improvement of training results for people with cognitive impairments. Here, VR environments provide a safe and completely controlled surrounding that removes many stresses caused by natural human interactions and thus allows a gradual development of social abilities that are impossible to attain through real-life interactions. Work in this area includes the development of special VR scenarios for children with autism to promote creative activity (Parés et al., 2005). An interactive environment with stimuli of different modalities like visual, aural and vibrotactile was created for autistic children without verbal communication abilities, looking forward to providing these children with a reproducible and ordered environment in which they can expand their underdeveloped sense of agency, an essential factor of the autistic condition. It means that autistic children are unconscious of their ability to influence their environment. A virtual environment with clear input-reaction mappings can isolate this problem and provide a space where sense of agency can be developed.

Finally, therapeutic leisure is one of the most extended applications of VR for all kind of users, still offering long-distance research paths. Its ease of use and adaptability makes it a feasible option for E&D. This way, impaired participants have the experience to control over their environment and success in activities that are usually inaccessible to them (Yalon-Chamovitz & Weiss, 2008).

2.2 VR applied to the elderly

VR appears to provide varied and motivating opportunities for the rehabilitation of elderly people with chronic diseases, like stroke patients. In stroke rehabilitation, animal studies have suggested that, through the use of intensive therapy –which implies the repetition of individual movements hundreds of times per day–, a significant amount of the motor control lost by the stroke can be recovered. Human therapy approaches supplement this approach with keeping patients informed about their progress. Since sessions with therapists usually only cover a small set of motions and significant recovery requires more effort, patients are required to stick to an extensive home exercise regimen. However, only a fraction of the patients actually perform these exercises as recommended. Here, VR games are investigated for improving rehabilitation involvement by increasing patient motivation and quantifying recovery progress, with a focus on supporting the re-development of proprioception (Alankus et al., 2010; Cho et al., 2010). In the case of brain damage, VR approaches not only include direct rehabilitation work but also give the opportunity for tele-rehabilitation (Flores et al., 2008). A further use of VR in healthcare is the involvement of so-called *virtual humans* in elderly assistance scenarios. In this framework, simulated doctors or healthcare workers are being used to let a system communicate with patients. Similarly, VR representations of patients are being used by healthcare personnel for bed-side soft-skills training (Cabrera-Umpierrez et al., 2006).

A further area of use of VMR solutions is in the development of products and services tailored to elderly people with cognitive issues, in order to support them in their daily lives. An example for this is an augmented reality approach for helping elder drivers with spatial recognition problems though a GPS navigation system suited for the needs of elderly people (Kim & Dey, 2009). Existing navigation systems, while helping with orientation and navigation, tend to increase the in-vehicle information load, creating problems with divided attention between the information display on the navigation system and the road itself. The solution realised is the projection of navigation information directly onto the windshield, thus requiring no switching between looking at the road and the navigation system since they are both integrated. As in-vehicle augmented reality displays are being seriously considered by car manufacturers as a display option, this system has potential to be used in field once the underlying technological issues of creating reliable high-quality images on the windshield have been solved. Evaluations show that augmented reality displays are preferred by elderly and younger drivers alike, supporting them to understand context-sensitive information and reduce cognitive load.

Further usage of VR solutions in product development takes place in the development of mobile services for the elderly, for instance through avatar-based VR simulation systems (Asghar et al., 2009). Real world sensors help to map user movement and interactions to the virtual scene, running simulating services in parallel, so as to support the adaptation of the final products to the elderly requirements.

Another area of research for elderly people is the improvement of their access to real environments through the use of VR interfaces (Pittarello & De Favieri, 2006) by adding a semantic description of different zones and objects in the environment. This description is then mapped onto a 3D simulated environment used for navigation and object descriptions, providing a different level of assistance based on user skills and/or cognitive deficiencies.

A main area to consider is the wide range of solutions developed in the AAL field, such as the creation of VMR development and simulation environments for debugging AAL solutions. Some of these initiatives (Arca et al, 2009; Maly et al, 2009; Schäfer et al., 2009; Schätzlein et al., 2009) are developed in the framework of the VAALID project, so they will be described in more detail in a later section.

3. Experimenting with VR & accessible domotics

The Life Supporting Technologies group (LST-UPM) has a long experience in research on the application of ICT solutions towards the *accessible digital home*. The emergence of accessible and adapted spaces –and particularly the development of domotics and environment control systems– holds a key role in supporting the independent living of the E&D. Since almost two decades, concepts such as Universal Design (Connell et al., 1997) or Design for All, Assistive Technologies (Tiresias, 2010) or Web Accessibility (WAI, 2010) have been exploited in this group to advance in the development of accessible approaches to domotic installations, taking advantage of a fruitful, direct and continuous cooperation with the E&D. As a result of this research line, a dedicated smart home infrastructure was arranged as the Laboratory for Domotic Usability Evaluations at the University premises, providing a preliminary testbed to assess user experience of E&D and their carers in a controlled home environment. In this framework, emerging VR technologies appears as a potential next step to offer significant opportunities to support user interaction, helping to reduce the existing usability gaps in such technological environments (Stanney et al, 1998). The idea of integrating VR into domotic spaces as a new environment control modality has implied for a long time the exploration of a very testable research area with promising perspectives for supporting independent living (Meisel et al, 1993). Following these arguments, this section describes an innovative VR-based interaction strategy which was fully integrated within an accessible domotic platform (Jimenez-Mixco et al., 2009), providing an evaluation framework to analyse and extract those applications with better acceptance for the users by making use of a multimodal approach to adapt the interaction mechanisms to their needs, skills and preferences.

3.1 Configuration of the smart home demonstrator

The core of the smart home demonstrator is an accessible domotic installation, which is composed of several home appliances (lights, window blind, door, water tap and heating) and environment sensors (presence, smoke, gas, flood and temperature) connected through an EIB[1] gateway. An open architecture platform derived from an OSGi[2] middleware allows software-based environment control, while a set of accessible web-based interfaces enable both local and remote, secure, personalised access to domotic services (Conde-Alvarez et al., 2006).

A new virtual environment has been aggregated to the demonstrator trying to replicate the real appearance of the laboratory, using Multigen Creator[3] for 3D design and EON Studio[4] for interactivity. Users may interact with the system through a combination of different displays and devices: 6 m^2 Stewart retro-projection screen for stereoscopic glasses[5]; Trivisio AR-vision-3D stereoscopic binocular display[6]; 5DT HMD 800 head mounted display[7]; 5DT Data Glove 5 for detecting finger motion[5]; Intersense InterTrax 2 tracking system with 3-DOF[8]; stereo sound system and different models of tactile screens, mice and keyboards.

The design and implementation of the VR-based solution followed the Design for All philosophy by taking into account concepts such as usability, adaptability, multimodality or standards-compliance, going through the following phases: (1) graphical design of the virtual elements for a realistic 3D representation; (2) compilation of individual components into the simulated lab; (3) integration and configuration of multimodal –visual, tactile, acoustic and haptic– interaction devices; (4) incorporation of animation and interactivity to the virtual scene; (5) development of a bi-directional communication interface between the virtual and real environments based on web services; and (6) deployment of the VR solution over most web browsers, by taking advantage of EON Reality's web plug-in. The resulting architecture of the system is represented in Fig. 1.

3.2 Virtual design considerations

One of the key factors that support accessibility is the provision of multimodal user interfaces. Multimodality –as the possibility of using in parallel more than one interaction modalities for communication between user and system– has been implemented in four modes: whereas *visual* and *acoustic* modalities are used for system outputs, inputs are achieved through *tactile* and *haptic* methods. Acoustic input (i.e. voice recognition) was left out for future platform versions. A more detailed description of each modality is included below:

[1] http://www.knx.org
[2] http://www.osgi.org
[3] http://www.presagis.com
[4] http://www.eonreality.com
[5] http://www.stewartfilmscreen.com
[6] http://www.trivisio.com
[7] http://www.5dt.com
[8] http://www.isense.com

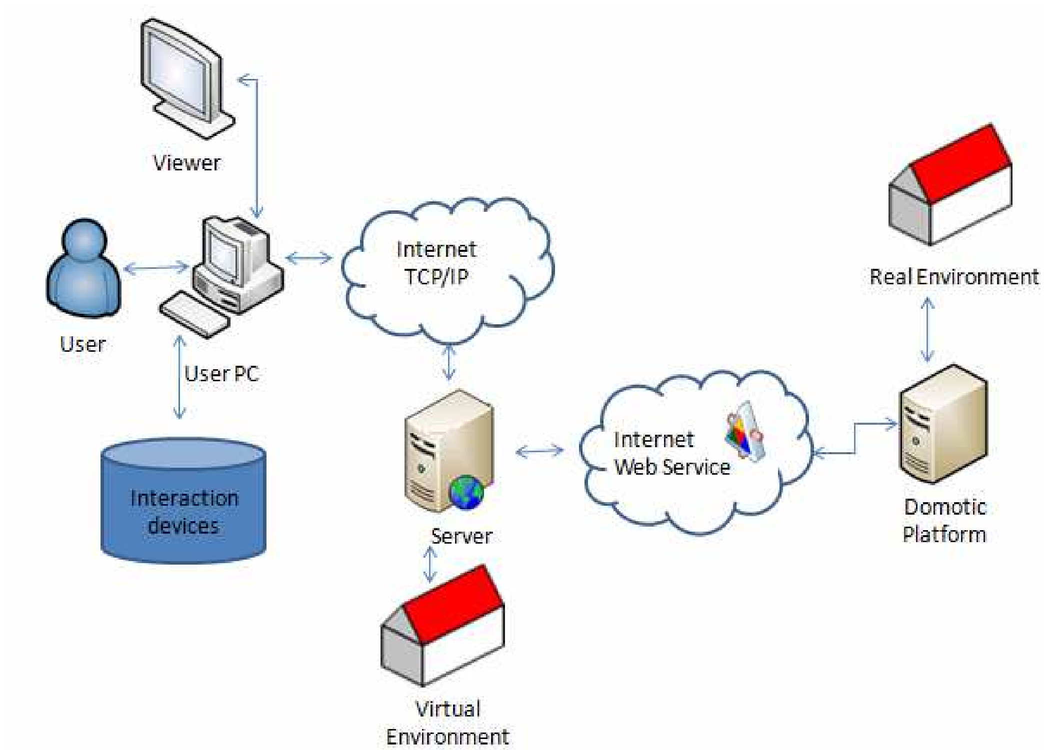

Fig. 1. System architecture of the VR demonstrator

- *Visual:* The 3D representation of the virtual lab and its components gives the main feedback to the user: virtual doors have been provided with open/close motion; lights change their colour to differentiate between on/off status, conveniently updating the overall light condition of the virtual environment; water pours from the tap when open; etc. Interaction options are highlighted through a helping tool, both textual and graphical, to facilitate user's navigation along the scene. Moreover, the user has also the possibility to visualise the real living lab at any time through an integrated web camera. The different screens and VR displays allow the customisation of the 2D or 3D visualisation scenario.
- *Acoustic:* In addition to the visual helping tools, acoustic messages guide the user in the navigation and interaction with the scene. For instance, when the user faces an interactive device–e.g. the door–, a voice message informs about the different interaction possibilities –i.e. open/close–. Virtual elements are also complemented with acoustic signs to increase the user's immersion feeling, like the sounds of the window blinds that are raising or some water pouring from the tap. This modality is implemented through a stereo sound system, either integrated in the virtual scenario or through personal headphones.
- *Tactile and haptic:* These two modalities allow the user to navigate in the virtual scene and control its elements. Navigation provides the user with a feeling of presence into the virtual environment, as s/he can move all over the scene (forward, backward and around), collide with the virtual objects, observe in any direction, make zoom and even change the point of view. The different interactive devices of the scene (e.g. lights, doors, webcam) can be controlled too, changing their status through a combination of these modalities. Complete tactile interaction is possible by pressing keyboard buttons, moving and clicking the mouse or touching the tactile screen. Haptic communication is

implemented by detecting commands from hand-based gesture recognition (using the VR glove) as well as by aligning user perspective along with head or arm real-time orientation (through the 3-DOF motion tracker).

Furthermore, the integrated system has been designed according to various guidelines and recommendations in order to make it accessible and user-adapted (Tiresias, 2010; ETSI, 2008):

- Users are able to select any of the input and output devices available as any input device –such as mouse, keyboard, tactile screen or data glove– can perform the same tasks effectively.
- The virtual environment provides object descriptions that are meaningful to users (when interactivity is enabled). Visual objects that are primarily decorative and contain little or no information need not be described.
- Users can easily activate a graphical menu to personalise different interaction features (e.g. acoustic signals).
- Users are provided with both acoustic and visual feedback when they interact with the elements in the scene (including alerts).
- Users are allowed to change the point of view and make zoom in the scene so as to find the most comfortable perspective.
- Every interaction has been implemented with at least two modalities: e.g. users can turn on/off the light either by touch (tactile screen, keyboard, mouse) or haptically (data glove), whereas feedback is obtained both graphically (screen, VR display) and acoustically (stereo system, headphones).
- Immersiveness can be adapted according to user preferences, from selecting specific visualisation devices (e.g. head mounted display instead of 2D screen) to simulating the own user's hand in the virtual scene. The inclusion of a virtual avatar is under consideration for further research.
- Users can combine the different interaction devices and modalities as they wish, to achieve the most usable solution for them. At present, most VR interfacing devices are wired, presenting tough usability concerns. Emerging wireless gadgets are to provide a relevant step forward in this sense.

3.3 Outcome of the experiment

The proposed solution has resulted in a running living lab for testing VR applications in the smart home domain, especially devoted for the E&D. It can be accessed locally or remotely through the Internet, and enables both real and simulated control of the domotic platform. Furthermore, it supports multimodal interaction, by means of specific VR devices, such as head mounted display, position tracker or data glove, and commonly used interaction gadgets (e.g. mouse, keyboard, tactile screen). This approach permits that users move around and interact with home appliances in a virtual environment, allowing them to check and change online the status of real devices directly through the 3D virtual elements (Fig. 2). To keep consistency between both real and virtual environments, status and orders for each device are shared by means of continuous feedback through an Internet connection and a typical web browser. Because of the collection of displays and interactive devices included, users may play around with different interaction modalities and degrees of immersion. Also some visual and acoustic guidance and help tools have been provided, to facilitate navigation within the interface and make it more intuitive.

Fig. 2. Views of the LST-UPM living lab: real picture (left) vs. virtual representation (right)

In addition, by adjusting a number of configuration elements on the user interface, the same interactive application may be validated for different settings and user profiles. In case the virtual environment is disconnected from the real lab, the application can be used by elderly or cognitive disabled to learn how to manage domotic installations in a non-threatening environment, while those with physical impairments may exploit the system to find the most convenient combination of modalities and interaction devices. By keeping both labs interconnected, confident users can go one step further and take the application directly as a ubiquitous remote control of the smart home, enabling them to check, both indoors and outdoors, the status of any home alarm or change in advance the temperature of the heating system. Moreover, carers, relatives or informal assistants are able to monitor in a non-intrusive way the real environment of any person requiring external supervision.

A preliminary evaluation phase has been carried out to validate the system in terms of performance, reliability and usability. 25 volunteers were able to assess combinations of the different displays and interaction mechanisms, both in simulated and real running modes. The results have been satisfying in terms of system usability, supporting the interest in VR technologies applied to smart home interaction. Although a complete validation plan was arranged to assess the whole system considering several user profiles from the E&D, professional assistants and informal carers, unfortunately some last-minute logistic problems made it postponed until the new living lab –which is actually under construction– becomes available, expected by the last quarter of 2010.

4. VR & AAL environments: the VAALID project

Nowadays, an innovative area of research and development is usability testing to make sure that special needs of the E&D are taken into account in the design and deployment of AAL environments. Conducting such tests in a VR environment can save time and money whereas improving the quality of products and services. In this sense, the above-described living labs resulted in a useful tool for interaction designers and usability engineers to immerse users in a virtual environment and assess, through the application, their experience in terms of interaction devices, modalities and reactions within smart home environments. Based on this assessment, designers would be able to develop new interaction concepts with users, improve existing solutions, and explore the potential of innovative AAL products and services. The preliminary encouraging results allowed envisioning multiple possibilities of VR on the process of providing the E&D with more adapted access to domotic-related applications.

However, current solutions have important limitations, especially as they require a significant amount of implementation effort to finally address the assessment of user experience in just one single environment integrating a pre-defined set of products and services. This section presents an approach proposed in the context of the European-funded VAALID project (VAALID, 2010) that extends the key concepts applied in these living labs, providing an easier method to create virtual environments and implement interactivity, enabling dynamic changes of environment conditions and characteristics, and allowing a thorough evaluation of user performance with real time interaction techniques. A dedicated toolkit has been developed in order to enable real rapid prototyping and validation of accessible and usable AmI solutions, by integrating VR tools and appropriate user interfaces. This approach will bridge the gap between planning AAL scenarios and their refinement and assessment in reality from the very beginning in the development process, reducing the global design and development effort.

4.1 The VAALID concept

VAALID is a European research project that aims to develop advanced computer aid engineering tools that will allow ICT developers, especially those ones that design AAL products and services, to optimise and make more efficient the whole process of user interaction design, and to validate usability and accessibility at all development stages, following a User Centred Design (UCD) process. The VAALID platform makes use of VR technologies to provide an immersive environment with 3D virtual ambients, specifically created for each possible use scenario, where AAL users can experience new interaction concepts and techno-elements, interactively. The usage of VAALID tools will make feasible, both economically and technically, the Universal Design of AAL solutions which have the potential of being acceptable by most persons since their needs are taken into account proactively during the development phases.

The methodology proposed to address AAL solutions (Naranjo et al., 2009) is based on a UCD approach, drawing together the practical, emotional and social aspects of people's experience and bringing on the needed innovation that delivers real user benefit. For that reason, UCD is particularly useful when a new product or service is to be introduced, as it is the case of AAL solutions. The methodology consists of four iterative phases (concept, design, development & validation), where both usability engineers and interaction designers must participate, while involving AAL users –i.e. the E&D– all along the process:

- *Concept.* First, AAL solution requirements must be extracted, including the functions that the proposed solution provides and how it reacts and behaves, as well as the constraints that should be considered in the design process.
- *Design.* Once the requirements are well-identified, developers define the specifications of the AAL solution, taking into account all significant facets that may have influence on the development process. Low-fidelity virtual prototypes of the AAL solution, including 3D virtual AAL-enabled spaces, are built to reflect all aspects of the conceptual design, and further evaluated by users. Design iterations are driven by users' feedback in terms of acceptance and accessibility issues until requirements are met.

- *Implementation.* This phase involves the creation of real and fully-functional high-fidelity AAL prototypes, with the aim of transforming the validated conceptual design into a concrete and detailed solution. The components developed at this stage must be tested against its accessibility features, and improvements or corrective actions must be addressed accordingly.
- *Validation.* Finally, the implementation of AAL solution prototypes are evaluated and assessed, detecting usability issues both automatically and with real end-users.

This methodology allows virtually simulating each aspect of an AAL product/service and validating it before the real implementation. The whole process involves both virtual and mixed reality elements. The simulation in the design phase requires mainly 3D virtual environments to reproduce the conceptual design of the solution; the implementation phase goes a step further and adds the possibility to use mixed reality elements, so that both real functional prototypes can be tested within virtual environments and product/service virtual mock-ups may be integrated in a real living lab scenario for final assessment.

In order to permit developers to apply this methodology across all the stages of the design cycle –and thus allow rapid development of AAL solutions and further assessment with users–, the VAALID platform is structured in two complementary frameworks: Authoring and Simulation. The *Authoring Framework* provides the ICT designer with the appropriate components to deal with the three main pillars of an AAL solution: users, environment and services. In particular it involves the creation of user profiles, the modification of AAL-enabled 3D spaces (including sensors, networks and interaction devices and functions), the creation of virtual user-interaction devices (which may be embedded in daily life objects) and new service concepts. The designer may then interconnect these individual components to create different evaluation scenarios so as they can be validated afterwards as integrated simulations. The *Simulation Framework* is based on the *instant**reality***[9] framework (from the Fh-IGD group in Darmstadt, Germany) to run the 3D environment in the available VR infrastructure and activate the different virtual devices and services, providing the ICT designer with a number of tools to assess how the user interacts within the virtual scenario.

From the VAALID usage perspective, target users can be divided into three main groups:

- *Primary users*: designers of AAL solutions that will use VAALID as a professional instrument. This group includes interaction engineers –who design the structure of the simulation, building the seniors' profile and defining the interaction modes with the environment– and usability engineers –who plan the interface between AAL services and senior citizens, through the study of their interactions with the VAALID system–.
- *Beneficiaries (or users, by default)*: the main target group of users who will benefit from the results of using VAALID tools:
    - Elderly people over 60 years old that may have light hearing/sight problems, mobility impairments or the typical declined cognitive and physical abilities related to age
    - Young people with hearing/sight/mobility problems
    - Any other group of users that may profit from accessible AAL solutions
- *Secondary users*: all those users that may benefit indirectly from VAALID, using it as a consultancy service:

[9] http://www.instantreality.org/

- Architects, construction planners, care centres, suppliers of interaction devices, public administration, interior designers and other stakeholders who work for companies that buy and develop AAL services.
- System designers, who implement AAL solutions validating usability and accessibility of their products, like sensors, actuators or control software.

4.2 The VAALID Authoring Framework

The main purpose of the VAALID Authoring Framework (Villalar et al., 2009) is to support interaction designers and usability engineers in building the core elements that compose an AAL simulation context. It follows the Rapid Application Development (RAD) methodology (Mackay et al., 2000), enabling a quick iteration between the design, execution and refinement phases for each individual element that will be integrated and afterwards executed within the Simulation Framework. One AAL simulation is created from a conjunction of several models (or *Templates*) which are stored together in a so-called *Project* – i.e. the basic component of the VAALID data repository–. Every simulation scenario is saved as a single Project that, according to the VAALID modelling framework, is basically composed of three main models: User Model, Environment Model and AAL Service Model. Each of these elements is created by editing pre-existing characteristics described as properties and behaviours. Properties are defined through *ontologies* (Mocholí et al., 2010) that represent static features of a single model; behaviours are described as *workflows* (Fernández-Llatas et al., 2010) that define how the element relates with others by means of interaction. Through this kind of information the designer can build models in a rapid way trying to cope with the user requirements.

The Authoring Framework workspace is then divided into three tools, one for each type of model (Fig. 3):

- *User Model Builder:* The User Editor defines the user (i.e. E&D) profile in terms of interaction capabilities –physical, sensory, cognitive– according to pre-defined ontological templates. This information is collected during the design phase and may be refined while testing the AAL solution. With this tool, the designer may create a new User Model, import or export an existing one from/to the VAALID library and remove the User Model associated to the current Project.
- *Environment Model Builder:* The Environment Model holds a virtual representation of one specific place, similarly to the living lab experiences described above. This tool allows importing VRML files from any CAD or 3D animation software as the start-up for the 3D simulation environment where users will be finally immersed. Pre-existing 3D objects can be added –defining their relative position and dimensions– and deleted from the Project to complete the desired environment. These objects are the interactive devices of the scene (i.e. sensors, actuators and a combination of both), which are the basis for defining the interaction between users and AAL services. The tool enables the characterisation of these objects by means of defining their properties and behaviours through the appropriate ontology and workflow editors using a graphical language.
  Environments, devices and workflows can be imported and exported from/to the VAALID library for being reused in other Projects.
- *AAL Service Compositor:* This editor creates an AAL Service Model, which describes the potential interactions between users and objects in the scene. It is essentially composed of a workflow that defines how to process information coming from environment

sensors (i.e. active or passive user inputs) to consequently activate the relevant actuators (e.g. security systems, lighting, automatic phone calls), including those devoted to give feedback to the user. Services can be also imported and exported from/to the VAALID library.

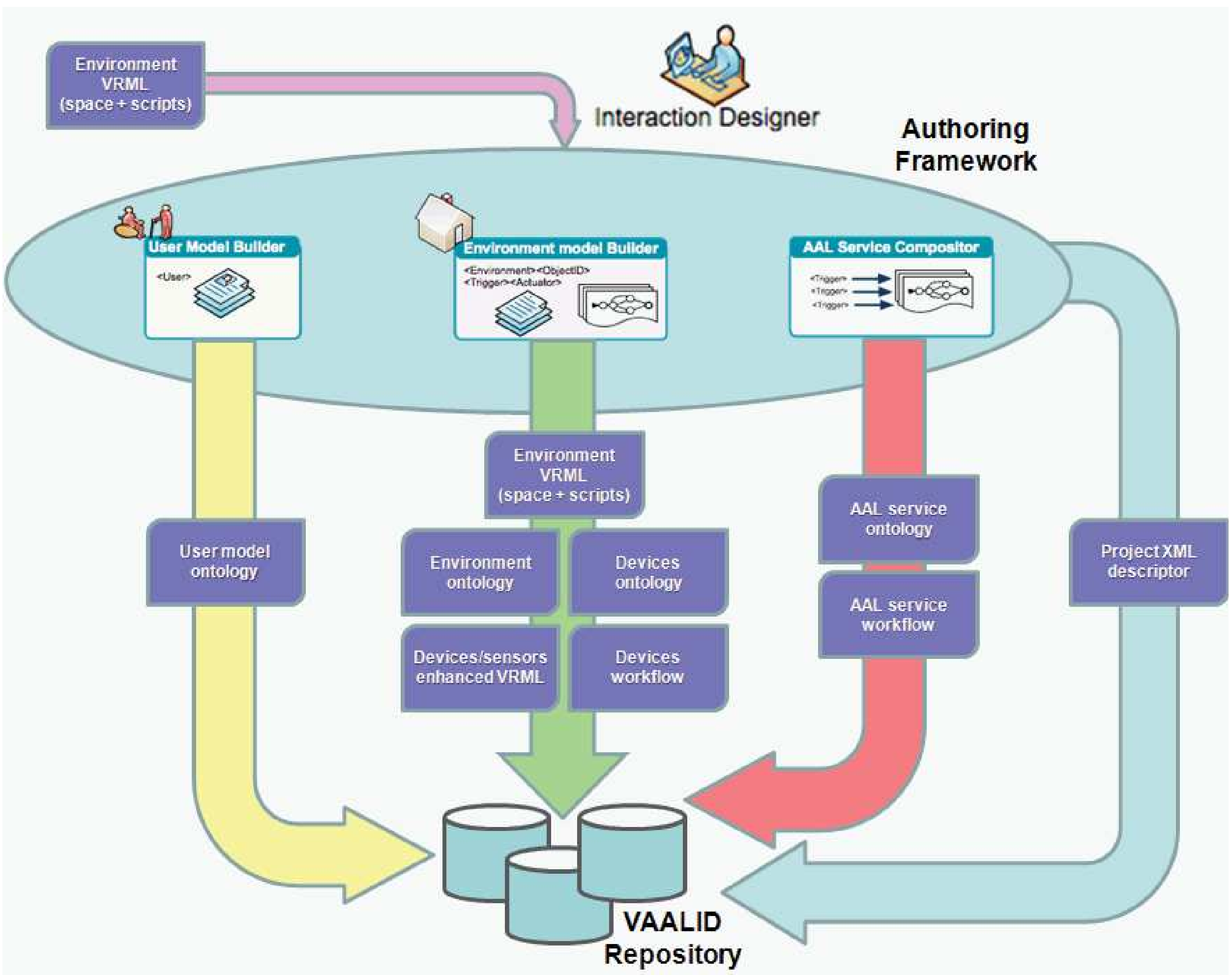

Fig. 3. Structure of the VAALID Authoring Framework

Finally, there is a *Project Editor* that integrates these three tools in a common framework in order to manage all the files involved in each simulation scenario as one single Project. Projects can be saved and opened in the traditional way and is the input element for the Simulation Framework.

Regarding implementation facts, the Authoring Framework (Fig. 4) is based on the architecture and look-and-feel of Eclipse[10] so that a highly-familiar user interface could help developers in rapidly getting managed with the tools. The development framework can then be personalised, configured to fit the needs of each designer, providing help hints whenever required along the development process. The following technologies have been integrated to create the Authoring Framework: Eclipse RCP as main IDE; GForge for cooperative software development; SWT for user interface components; Java3D/VRML97 for 3D management; Protégé, Jena & Jastor for ontologies; jBPM for workflows.

[10] http://www.eclipse.org

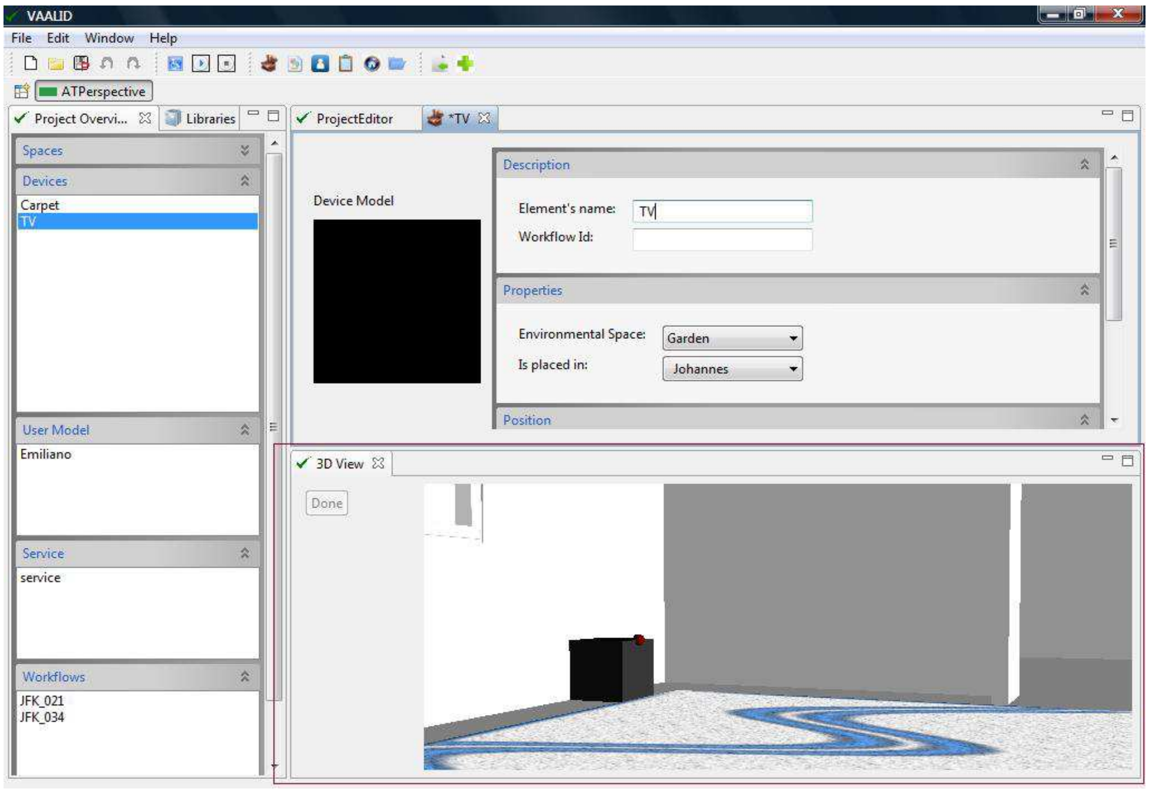

Fig. 4. Screenshot of the Authoring Framework prototype

The Authoring Framework will be deployed as open source software so, in case of success, a kind of development community may grow around it in the near future. This community may be oriented to: (a) the development of additional tool functionalities, by simply integrating new Eclipse-based plugins; (b) the creation and exchange of individual elements though the VAALID library; (c) the cooperative reuse and refinement of VAALID Projects due to the import and export facilities.

4.3 The VAALID Simulation Framework

The purpose of the VAALID Simulation Framework is to provide the possibility to perform AAL system evaluations and validations at earlier stages of development in a fast and cost-effective fashion, thus saving development time and cost while incorporating end-users into earlier stages of development. The Simulation Framework takes care of displaying the virtual AAL solution to end-users for validation and evaluation purposes. It consists of several components which simulate different aspects of the virtual solution (Fig. 5).

From an AAL system designer perspective, the core component is the *Simulation Control Panel* (SCP) as it lets the designer setup, configure, run, manipulate and analyse a simulation session. This module is integrated with the Authoring Framework and distributes the different output files (3D environment, workflows and ontologies) among the other components of the Simulation Framework architecture. It has the control for executing and stopping all these components, each of which simulates an aspect of the developed solution. Besides, the SCP includes an *Accessibility Verifier* which allows performing preliminary checks for the early detection of accessibility constraints depending on the user profile (e.g. using acoustic outputs for hearing impaired users will automatically raise an alarm for the AAL designer before the simulation starts).

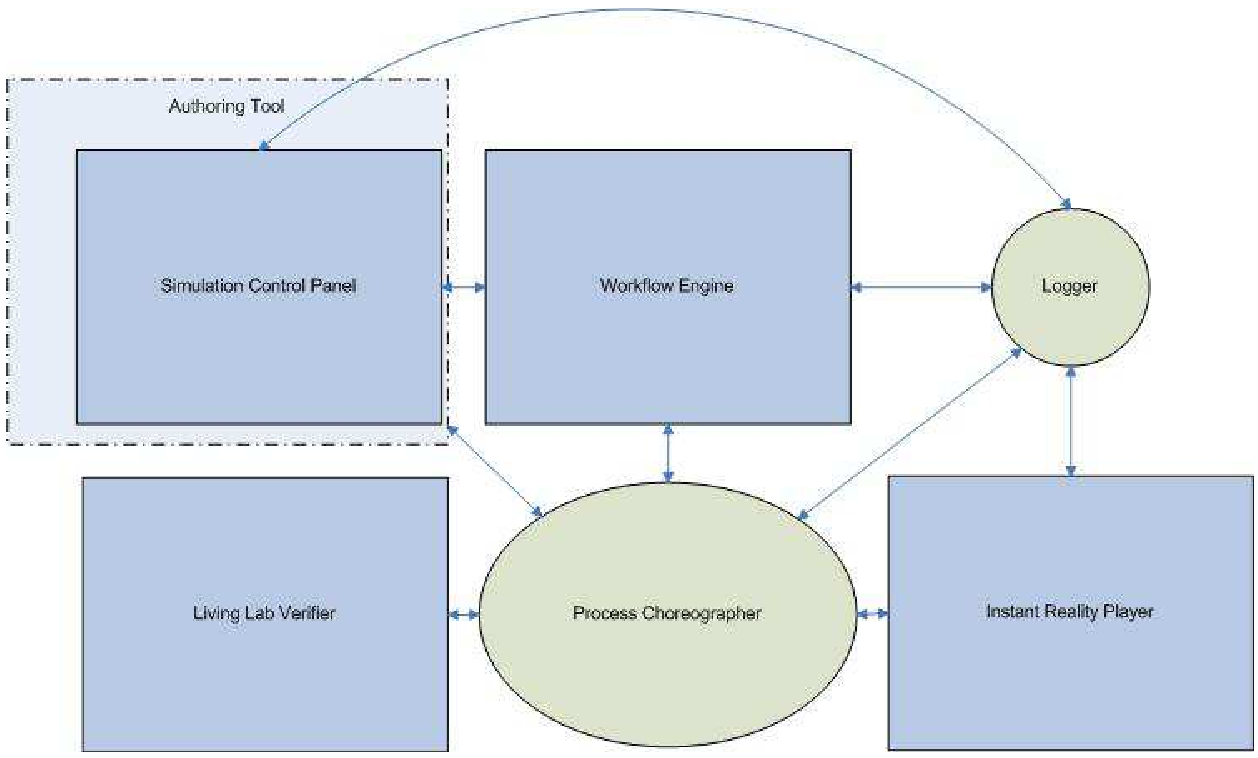

Fig. 5. Architecture of the VAALID Simulation Framework

The *instant**reality*** player is a complete VMR system, which is used for rendering the 3D-model of the simulated AAL environment, coming as a VRML file from the Authoring Framework. At the same time it provides the connection framework for the interaction devices used to navigate through and interact with the scene. The *instant**reality*** player allows the use of common 2D-displays and modern 3D-displays as well as CAVE or other multi-projector display systems.

In parallel, the *Workflow Engine* (WE) executes the different workflows created with the Authoring Toolkit to simulate the functionalities of all functional components within the scene, like TV screens, stereo systems, ambient displays, doors or windows. The other main feature of the WE is the simulation of AAL services such as health monitoring, personal security services or daily life support services which make use of the simulated devices' functionalities. Once the simulation is running, the SCP can be used to intervene in the execution of these workflows and change some system functions in real time.

The WE is connected to the *instant**reality*** player through the *Process Choreographer* component. This module facilitates the communication between the Simulation Framework components by coordinating the exchange of the XML-structured messages previously defined.

The *Living Lab Verifier* module enables the AAL designer to replace simulated devices and sensors with their real counterparts, thus including real-world components into the simulation environment. Following this process iteratively with every simulated device, in the latter stage of the development cycle for the AAL solution the simulation environment is fully replaced by a real laboratory for final solution testing.

Finally, the *Logger* is connected to the Process Choreographer, WE and *instant**reality*** player, capturing all the communication messages between the components as well as all user inputs to the simulated scene through the *instant**reality*** player. The aggregation of these collected data is available in the SCP after the simulation run has been ended and lets the AAL designer analyse key indicators of the simulation (e.g. task completion, time between events, number of events of a kind) and perform semi-automatic analyses of the extracted information.

This way, the Simulation Framework provides a complete system for performing fast and effective early evaluations with end-users and thus supports the AAL solution designer in moving through UCD cycles much faster at earlier stages of development. It covers the entire process from simulation configuration to post-simulation analysis while providing the designer with complete control over the simulation while it is running.

4.4 Further research on accessible VMR interaction

The interaction with VMR for testing AAL environments poses an extra challenge to the Simulation Framework. Developing interaction modalities which deal with the impairments of elderly people, a challenging enough task by itself, is now complemented with a 3D virtual environment. This adds another layer between the elderly test person and the simulated environment which should be evaluated. The key to overcoming this problem is to generate a sense of immersion for the user, so that the inevitable gap between real and virtual environment can be neglected and the evaluation results of the test in VR can be transferred meaningfully to the real environment. It should be noted here that the Simulation Framework is meant for quick feedback in early UCD cycles, so as more detailed feedback still requires real-world implementation. However, these first results regarding the feasibility of an AAL service for elderly people can meaningfully complement the early stages of AAL solution design and lead to a stronger involvement of end users in the development process.

For the interaction in the VAALID system, the end user can navigate through the scene and manipulate the environment using different simulation control devices, which range from standard input devices like a space mouse or a gamepad to specialised devices more suited for elderly people like wheelchairs, which serve the needs of the elderly in the VR setting. This wheelchair allows elderly people to sit down in front of the environment, thus eliminating the strain of standing or the fear of falling down. The interaction with the wheelchair is quick and intuitive, since there already exists a clear mental model for its function even among technology-averse people. An aversive response to the wheelchair as stigmatising was not confirmed in tests. On the contrary, the fact that one could sit down in front of the wall and have an easy-to-learn interface was regarded as beneficial.

While there are clear limits to the use of VR technology among the cognitive disease spectrum –patients with epilepsy, for example, should not be confronted with a virtual reality environment–, the VAALID system aimed at an extensible interaction system which allowed the incorporation of a variety of different input modalities for simulation control, both in terms of navigation and interaction.

For interaction, an abstraction was used which lets the elderly user interact with the system in an intuitive fashion (Kamieth et al., 2010). A virtual hand (Fig. 6) can be moved through the scene and be used to touch, grab and interact with objects and devices within the scene. Opening doors, windows, controlling televisions and touch screens for example, can be implemented with the virtual hand abstraction. For first evaluations of AAL scenarios, this metaphor allows a clear and intuitive way for interaction that facilitates end-user immersion within the scene and thus helps in closing the gap between VR and reality, supporting the transferability of results from VR testing to real world test outcomes.

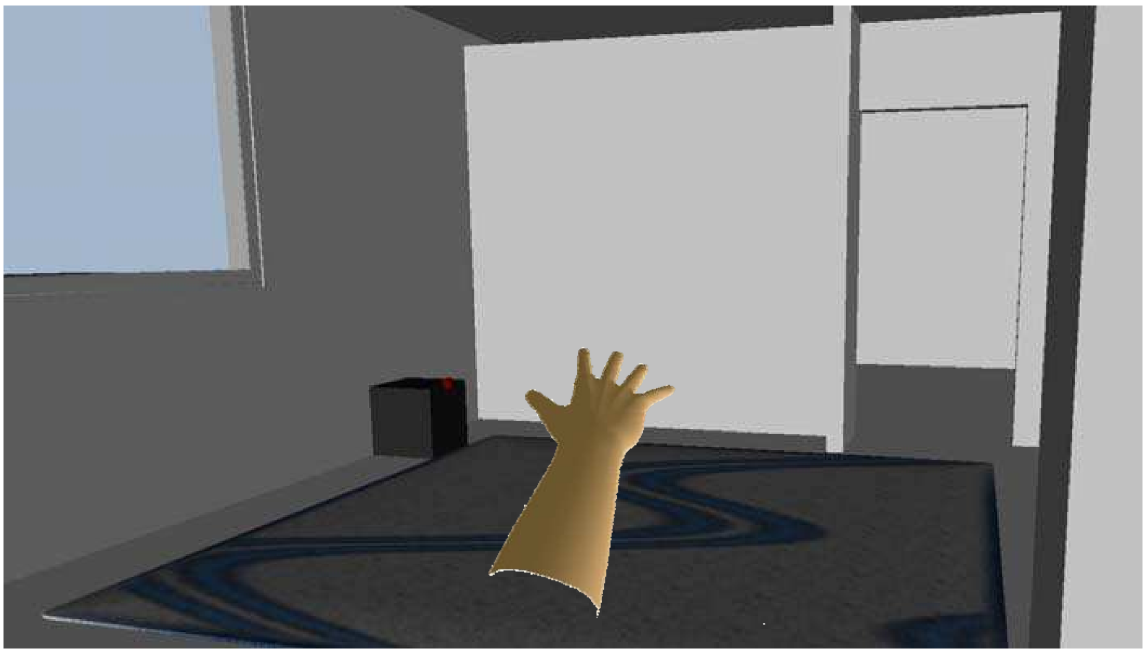

Fig. 6. Virtual hand used for interacting with the simulated environment

For transferability of results –an important issue in the development of AAL solutions–, the question of end-user immersion is crucial. Some authors argue that, in the development of a feeling of presence, scene realism is of secondary importance (Nunez, 2004). Instead, the support of user expectations needs a high degree of consideration. Thus, the analysis of end-user expectations –in this case, the expectations of elderly people in VR environments– requires extended research for the realisation of better scenario simulations. Especially the manipulation of cognitive load leads to an improvement of a feeling of presence. Based on these findings, further research would include the testing of this concept with elderly people. However, the question of presence is also being approached in the sense of earlier research focusing on realism and the coverage of different sensory channels.

The literature suggests that immersion is made up of two main components which can be called *Depth of information* and *Breadth of Information* (Steuer, 1995). The term *Depth of information* refers to the quality of the signals presented to the user (for example, the sound quality or the resolution and colour depth of the displays used for the simulation). The term *Breadth of information* refers to the variety of sensory data sent to the user during the simulation. This means that the more senses are stimulated during a simulation, the higher is its breadth of information. In this area the main focus in the research community has usually been on visual and auditory stimuli with an even stronger focus on visual display. This focus has shifted in recent years toward incorporating haptic systems too, which provide the user furthermore with data in the form of touch.

The VAALID approach takes these requirements for immersion into account. At the pilot site in Fh-IGD, either the HEyeWall (a high-resolution 3D-projection wall) or the CAVE (a small room in which five walls are 3D-projector displays) is being used, providing state-of-the-art solutions in the area of immersive visual displays. Furthermore, the VRML-standard used for the description of the simulation environment allows a complex modelling of directional sound sources, which provide the illusion of moving past sound sources through a change in sound volume and direction. To increase the sense of immersion in the dimension of *breadth of information*, the VAALID system incorporates haptic interaction devices like the Novint Falcon[11], which enables the user to interact with the scene through a natural mapping of hand movements to VR interactions. Apart from the abovementioned wheelchair device, a pressure board is also used for travelling through the scene, which allows a natural mapping of stepping on a board to travelling through a scene.

Along the VAALID lifetime, the project is exploring the feasibility and accessibility of integrating other simulation controls to the platform (Fig.7), either based on the Nintendo Wii remote controller[12], head/hand trackers, infrared data gloves, visual hand controls or smart phone accelerometers. The most suitable simulation controls will be extensively assessed during the final pilot tests, with the aim of finding the most adapted solutions for each user.

Fig. 7. Testing VR using a wheelchair and Falcon (left), smart phone (centre) and infrared data gloves (right)

5. Discussion & conclusion

Accessibility and usability concepts are currently considered within a limited range of ICT applications and services, mostly constraining its usage to research and development activities and presenting significant reserves when dealing with production and deployment phases. Although the seven principles of the Universal Design or Design for All are well-known and applicable to a wide variety of domains, business stakeholders are still highly reticent to apply them in practice. This lack of commitment with the elderly and disabled community, in particular when designing AAL solutions, is mainly due to the high costs involved in the iterative design-development-testing procedure and the considerable effort in time and resources needed to meet user's needs.

On the other hand, the adoption of VR technologies seems to confront with the purpose of designing services for the E&D, as rather few initiatives have been carried out in this field regarding accessibility requirements. Most of them deal with people with cognitive disabilities (dementia, autism, schizophrenia, Down's syndrome, etc.), proposing simple virtual worlds where users get immersed in order to learn some tasks, acquire some habits or recover some capabilities under a controlled scenario. Nevertheless, VR has been proven to offer significant advantages for persons with all kinds of disabilities. It can present virtual worlds where users can be trained or learn in a controlled environment, and then apply the skills acquired to a real context. VR technologies can be adapted to a wide range of individual requirements and, at the same time, user's abilities and experience can be assessed in order to reach an optimal adaptation. Particularly, the multimodal approach

[11] http://www.novint.com/
[12] http://www.nintendo.com/wii/

inherent to VR and the low-effort interaction techniques followed can make VR-based interfaces especially valuable for users with disabilities or special needs. The conjunction of these facts may enhance the variety of accessible solutions for addressing the specific impairments and preferences of each person, especially in terms of interaction limitations. This involves not only physical, but also cognitive disabilities.

The work described in this chapter brings together all these issues into a technological approach that will have a beneficial impact for all the involved parts: the ICT designers will be able to evaluate the suitability of the proposed solutions with a significant reduction of the global design and development effort; business stakeholders will have a cost-effective solution and therefore new market opportunities; and finally, the E&D will be provided with new services to improve their quality of life, and even better, they will be able to active and critically participate in the creation process of these services.

This chapter has explored the most promising technologies and applications in the field of VR applied to the E&D. It presents the outcomes of assessing user experience through innovative approaches, bringing together VR and other technologies such as environment control systems. The objective is to develop a convenient framework to evaluate the accessibility and usability of AAL solutions, focusing on their adequacy to increase quality of life and improve autonomy of different target users. The possibility of performing assessment phases during the design process of AAL solutions –before building up real living labs– has key benefits such as saving of time and costs. In addition, users can participate in a controlled environment, since VR technologies assure safe and secure interaction. This does not mean that evaluation in a real living lab has to be avoided, but that any further interaction experiment will be enriched by the results obtained in the preliminary design process.

The suitability of different multimodal interaction mechanisms integrated with VR has been studied, including visual, acoustic, tactile and haptic modalities. Besides, several potential functionalities of the solutions are explored, such as training, cognitive therapy or domotic control. Considering the collected data, preliminary results show that users feel comfortable in using the VR devices and defined the experience as realistic, although there are valuable suggestions to improve the user interaction (e.g. allow sensitiveness calibration). From a technical point of view, this can be taken as a good starting point for future work with VR-based applications, although further research is required concerning its suitability for elderly users.

The current research work aims at giving answer to a number of open issues such as: (a) the adequacy of VR for enhancing user experience for the E&D; (b) the chances of VR as widespread usable human-computer interaction method; (c) the convenience of VR for a daily handling of smart home environments. In this sense, the addition of other modalities, like natural language voice recognition or augmented reality, or new interfacing devices coming from the emerging generation of intuitive wireless gadgets for entertainment or telecommunication, might be the starting point for definitely spreading VR technologies while fostering their key role in improving accessibility for people with special needs.

The next evaluation phase of the VAALID project (which will involve dozens of designers and beneficiaries in three European pilot sites until April 2011) as well as the imminent finalisation of the new LST-UPM living lab will certainly help to clarify some of the above open topics. Conclusions will feed –and will be afterwards expanded by– the VERITAS project (VERITAS, 2010), the next collaboration initiative where both research groups are engaged. VERITAS aims at developing an extensive list of VMR tools for supporting accessibility testing at all stages of development of five application domains (automotive, smart living spaces, workplace design, infotainment, personal healthcare and wellbeing), moving ahead in the convergence between VMR and accessibility of environments, services and devices.

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7. References

Alankus, G.; Lazar, A.; May, M. & Kelleher, C. (2010). Towards customizable games for stroke rehabilitation, *Proceedings of the 28th ACM Conference on Human Factors in Computing Systems (CHI 2010)*, pp. 2113-2122, ISBN 978-1-60558-929-9, Atlanta, Georgia, USA, April 2010, ACM, New York, NY

Arca, A.; Villalar, J.L.; Diaz-Nicolas, J.A. & Arredondo, M.T. (2009). Haptic Interaction in Virtual Reality Environments through Android-based Handheld Terminals. *Adjunct Proceedings of 3rd European Conference on Ambient Intelligence (AmI09)*, pp. 259-263, ISBN 978-3-902737-00-7, Salzburg, Austria, November 2009, M. Tscheligi et al. (Eds.), ICT&S Center, University of Salzburg

Asghar, Z.; Hickey, S. & Kazmi, S. (2009). Developing mobile services for specific user groups using virtual environments, *Proceedings of the 8th International Conference on Mobile and Ubiquitous Multimedia (MUM '09)*, article no. 17, ISBN 978-1-60558-846-9, Cambridge, UK, November 2009, ACM, New York, NY

Cabrera-Umpierrez, M.F.; Ramirez, C.M.; Sevillano, A.; Arredondo, M.T. & De Smedt, A. (2006). Medical Educational e-Platform through Virtual Reality technologies, *Proceedings of IEEE Mediterranean Electrotechnical Conference (MELECON 2006)*, pp. 453-456, ISBN 1-4244-0087-2, Benalmadena, Malaga, Spain, May 2006, F. Sandoval et al. (Eds.), IEEE

Cho, S.W.; Ku, J.H.; Kang, Y.J.; Lee, K.H.; Song, J.Y.; Kim, H.J.; Kim, I.Y. & Kim, S.I. (2010). A Pilot Study for Development of Shoulder Proprioception Training System Using Virtual Reality for Patients with Stroke: The Effect of Manipulated Visual Feedback, In: *IFMBE Proceedings, XII Mediterranean Conference on Medical and Biological Engineering and Computing (MEDICON 2010),* 29, 4, R. Magjarevic et al. (Eds.), pp. 722-724, ISBN 978-3-642-13039-7, Springer Berlin Heidelberg, Germany

Conde-Alvarez, E.; Rodriguez-Ascaso, A.; Montalva, J.B. & Arredondo M.T. (2006). Laboratory for domotic usability evaluations, *Proceedings of the I Workshop on Technologies for Healthcare and Healthy Lifestyle (WTHS'06)*, ISBN 978-84-611-1311-8, Valencia, Spain, April 2006

Connell, B.R.; Jones, M.; Mace, R.; Mueller, J.; Mullick, A.; Ostroff, E.; Sanford, J.; Steinfeld, E.; Story, M. & Vanderheiden, G. (1997). *The Principles of Universal Design*, Version

2.0, January 1997, Raleigh, NC: North Carolina State University, The Center for Universal Design, USA

De Ruyter, B. & Pelgrim, E. (2007). Ambient Assisted-Living Research in CareLab. *Interactions*, 14, 4, (July + August 2007) pp. 30-33, ISSN 1072-5520, New York, NY, USA

ETSI EG 202 487 (2008): *Human Factors (HF); User experience guidelines; Telecare services (eHealth)*. Version 1.1.2 (February 2008)

Fernández-Llatas, C.; Mocholí, J.B.; Sánchez, C.; Sala, P. & Naranjo, J.C. (2010). Process choreography for Interaction simulation in Ambient Assisted Living environments, In: *IFMBE Proceedings, XII Mediterranean Conference on Medical and Biological Engineering and Computing (MEDICON 2010),* 29, 4, R. Magjarevic et al. (Eds.), pp. 757-760, ISBN 978-3-642-13039-7, Springer Berlin Heidelberg, Germany

Flores, E.; Tobon, G.; Cavallaro, E.; Cavallaro, F.I.; Perry, J.C. & Keller, T. (2008). Improving patient motivation in game development for motor deficit rehabilitation, *Proceedings of the 2008 International Conference on Advances in Computer Entertainment Technology (ACE '08)*, 352, pp. 381-384, ISBN 978-1-60558-393-8, Yokohama, Japan, December 2008, ACM, New York, NY, USA

Ghedini, F.; Faste, H.; Carrozzino, M. & Bergamasco, M. (2008). Passages: a 3D artistic interface for children rehabilitation and special needs, *Proceedings of 7th ICDVRAT with ArtAbilitation*, pp. 185-189, ISBN 07-049-15-00-6, Maia, Portugal, September 2008, University of Reading, UK

Giannakouris, K. (2008). Ageing characterises the demographic perspectives of the European societies. *Population and Social Conditions*. Eurostat, Statistics in focus, 72/2008, ISSN 1977-0316

Jimenez-Mixco, V.; de las Heras, R.; Villalar, J.L. & Arredondo, M.T. (2009). A New Approach for Accessible Interaction within Smart Homes through Virtual Reality. In: *Universal Access in Human-Computer Interaction. Intelligent and Ubiquitous Interaction Environments*, C. Stephanidis (Ed.), LNCS 5615/2009, pp. 75–81, ISBN 978-3-642-02709-3, Springer Berlin Heidelberg, Germany

Kamieth, F.; Hellenschmidt, M. & Dähne, P. (2010). Interaction Framework for Evaluation of Barrier-free environments, In: *Ambient Assisted Living 2010*, A. Hartmann et al. (Eds.), article nº 76, VDE VERLAG GMBH, ISBN 978-3-8007-3209-8, Berlin, Offenbach, Germany

Kim, S. & Dey, A.K. (2009). Simulated Augmented Reality Windshield Display as a Cognitive Mapping Aid for Elder Driver Navigation, *Proceedings of the 27th ACM Conference on Human Factors in Computing Systems (CHI 2009)*, pp. 133-142, ISBN 978-1-60558-246-7, Boston, MA, USA, April 2009, ACM, New York, NY

Lanier, J. (1992). Virtual reality and persons with disabilities, *Proceedings of Virtual Reality and Persons with Disabilities Conference*, Los Angeles, March 1992, Office of Disabled Student Services, California State University, USA

Lillo, J. & Moreira, H. (2004). Envejecimiento y diseño universal. *Anuario de Psicología*, 35, 4, (December 2004) pp. 493-506, ISSN 0066-5126 (in Spanish)

Mackay, H.; Carne, C.; Beynon-Davies, P. & Tudhope, D. (2000). Reconfiguring the User: Using Rapid Application Development. *Social Studies of Science*, 30, 5, (October 2000) pp. 737-757, ISSN 0306-3127

Maly, J.; Savall, A.; Schäfer, J. & Machate, J. (2009). The VAALID authoring tool: User Interface Concept. *Adjunct Proceedings of 3rd European Conference on Ambient Intelligence (AmI09)*, pp. 243-246, ISBN 978-3-902737-00-7, Salzburg, Austria, November 2009, M. Tscheligi et al. (Eds.), ICT&S Center, University of Salzburg

Meisel, A.H.; Meisel, H. & Marsh, C.H. (1993). Virtual Reality, Human Evolution, and the World of Disability. *Proceedings of the 1st Annual International Conference: Virtual Reality and Persons with Disabilities*, San Francisco, June 1993, Center On Disabilities, California State University-Northridge, USA

Micelli, V.; Rosiello, F.; Aleotti, J. & Caselli, S. (2009). Design of Gestural Interfaces for Simulated Smart Environments, *Adjunct Proceedings of 3rd European Conference on Ambient Intelligence (AmI09)*, pp. 231-234, ISBN 978-3-902737-00-7, Salzburg, Austria, November 2009, M. Tscheligi et al. (Eds.), ICT&S Center, University of Salzburg

Middleton, T. (1992). Matching virtual reality solutions to special needs. *Proceedings of Virtual Reality and Persons with Disabilities Conference*, Los Angeles, March 1992, Office of Disabled Student Services, California State University, USA

Mocholí, J.B.; Sala, P.; Fernández-Llatas, C. & Naranjo, J.C. (2010). Ontology for Modeling Interaction in Ambient Assisted Living Environments, In: *IFMBE Proceedings, XII Mediterranean Conference on Medical and Biological Engineering and Computing (MEDICON 2010),* 29, 4, R. Magjarevic et al. (Eds.), pp. 655-658, ISBN 978-3-642-13039-7, Springer Berlin Heidelberg, Germany

Naranjo, J.C; Fernandez, C.; Sala, P.; Hellenschmidt, M. & Mercalli, F. (2009). A modelling framework for Ambient Assisted Living validation. In: *Universal Access in Human-Computer Interaction. Intelligent and Ubiquitous Interaction Environments*, C. Stephanidis (Ed.), LNCS 5615/2009, pp. 228–237, ISBN 978-3-642-02709-3, Springer Berlin Heidelberg, Germany

Nunez, D. (2004). How is presence in non-immersive, non-realistic virtual environments possible? *Proceedings of the 3rd International Conference on Computer Graphics, Virtual Reality, Visualisation and interaction in Africa (AFRIGRAPH'04)*, pp. 83-86, ISBN 1-58113-863-6, Stellenbosch, South Africa, November 2004, ACM, New York, NY, USA

Parés, N.; Carreras, A.; Durany, J.; Ferrer, J.; Freixa, P.; Gómez, D.; Kruglanski, O.; Parés, R.; Ribas, J.I., Soler, M. & Sanjurjo, À. (2005). Promotion of creative activity in children with severe autism through visuals in an interactive multisensory environment, *Proceedings of the 2005 Conference on Interaction Design and Children (IDC'05)*, pp. 110-116, ISBN 1-59593-096-5, Boulder, Colorado, USA, June 2005, ACM, New York, NY

Pithon, T.; Weiss, T.; Richir, S. & Klinger, E. (2009). Wheelchair simulators: A review. *Technology and Disability*, 21, 1-2, (July 2009) pp. 1-10, ISSN 1055-4181

Pittarello, F. & De Faveri, A. (2006). Improving access of elderly people to real environments: a semantic based approach, *Proceedings of the Working Conference on*

Advanced Visual Interfaces (AVI'06), pp. 364-368, ISBN 1-59593-353-0, Venetia, Italy, May 2006, ACM, New York, NY, USA

Schäfer, J.; Schätzlein, F.; Maly, J.; Unger, A.; Sala, P. & Mercalli, F. (2009). Evaluation of the VAALID authoring user interface. *Adjunct Proceedings of 3rd European Conference on Ambient Intelligence (AmI09)*, pp. 239-242, ISBN 978-3-902737-00-7, Salzburg, Austria, November 2009, M. Tscheligi et al. (Eds.), ICT&S Center, University of Salzburg

Schätzlein, F.; Kamieth, F.; Röder, P.; Schäfer, J. & Burmester, M. (2009). Evaluation of interaction techniques for AAL in virtual reality with senior citizens. *Adjunct Proceedings of 3rd European Conference on Ambient Intelligence (AmI09)*, pp. 235-238, ISBN 978-3-902737-00-7, Salzburg, Austria, November 2009, M. Tscheligi et al. (Eds.), ICT&S Center, University of Salzburg

Sik Lányi, C.; Geiszt, Z.; Károlyi, P.; Tilinger A. & Magyar, V. (2006). Virtual Reality in Special Needs Early Education. *The International Journal of Virtual Reality*, 5, 4, (December 2006) pp. 55-68, ISSN 1081-1451

Stanney, K.M.; Mourant, R.R. & Kennedy R.S. (1998). Human Factors Issues in Virtual Environments: A Review of the Literature. *Presence: Teleoperators and Virtual Environments*, 7, 4, (August 1998) pp. 327-351, ISSN 1054-7460

Steg, H.; Strese, H.; Loroff, C.; Hull, J. & Schmidt, S. (2006). *Europe Is Facing a Demographic Challenge. Ambient Assisted Living Offers Solutions*. Ambient Assisted Living – European Overview Report, (March 2006) Berlin, Germany

Steuer, J. (1995). Defining virtual reality: dimensions determining telepresence, In: *Communication in the Age of Virtual Reality*, F. Biocca et al. (Eds.), Lea'S Communication Series, pp. 33-56, ISBN 0-8058-1550-3, L. Erlbaum Associates Inc., Hillsdale, NJ, USA

Tiresias web site. *Guidelines for the design of accessible information and communication technology systems*. Available online: http://www.tiresias.org/research/guidelines/index.htm (last access: August 2010)

VAALID web site. *Accessibility and Usability Validation Framework for AAL Interaction Design Process*. Research Project. 7th EC Framework Programme. Contract nº ICT-2007-224309. Available online: http://www.vaalid-project.org/ (last access: August 2010)

VERITAS web site. *Virtual and Augmented Environments and Realistic User Interactions to Achieve Embedded Accessibility Designs*. 7th EC Framework Programme. Contract nº 247765. Available online: http://veritas-project.eu/ (last access: August 2010)

Villalar, J.L. et al. (2009). *D3.1: Authoring Environment Functional Specification*. VAALID project deliverable. Version 1.0 (June 2009)

WAI web site. *W3C Web Accessibility Initiative*. Available online: http://www.w3.org/WAI/ (last access: August 2010)

Wegge, K.P. & Zimmermann, D. (2007). Accessibility, Usability, Safety, Ergonomics: Concepts, Models, and Differences, In: *Universal Access in Human Computer Interaction. Coping with Diversity*, C. Stephanidis (Ed.), LNCS 4554/2007, pp. 294–301, ISBN 978-3-540-73278-5, Springer Berlin Heidelberg, Germany

Yalon-Chamovitz, S. & Weiss, P.L.T. (2008). Virtual reality as a leisure activity for young adults with physical and intellectual disabilities. *Research in Developmental Disabilities*, 29, 3, (May-June 2008) pp. 273–287, ISSN 0891-4222

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Technological advancement in graphics and other human motion tracking hardware has promoted pushing "virtual reality" closer to "reality" and thus usage of virtual reality has been extended to various fields. The most typical fields for the application of virtual reality are medicine and engineering. The reviews in this book describe the latest virtual reality-related knowledge in these two fields such as: advanced human-computer interaction and virtual reality technologies, evaluation tools for cognition and behavior, medical and surgical treatment, neuroscience and neuro-rehabilitation, assistant tools for overcoming mental illnesses, educational and industrial uses In addition, the considerations for virtual worlds in human society are discussed. This book will serve as a state-of-the-art resource for researchers who are interested in developing a beneficial technology for human society.