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Ambient Assisted Living Spaces Validation by Services and Devices Simulation

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Abstract— **The design of Ambient Assisted Living (AAL) products is a very demanding challenge. AAL products creation is a complex iterative process which must accomplish exhaustive prerequisites about accessibility and usability. In this process the early detection of errors is crucial to create cost-effective systems.**

Computer-assisted tools can suppose a vital help to usability designers in order to avoid design errors. Specifically computer simulation of products in AAL environments can be used in all the design phases to support the validation. In this paper, a computer simulation tool for supporting usability designers in the creation of innovative AAL products is presented. This application will benefit their work saving time and improving the final system functionality.

I. Introduction

Nowadays, age-specific disorders are more and more usual in current society. This is because the increase of life expectancy of people. Patients that are suffering these kind of illnesses requires specific devices and systems to empower them in their daily life activities. The current technological approach to support senior citizens is the creation of intelligent environments that reacts to the users needs providing the needed specific care at the concrete place. These spaces aimed to improve the level of independence, promote the social relationships, leverage the immersion in the environments and encourage the psychological and physical state of the person. The idea of creating smart spaces to cover the assistance needs of senior citizens was promoted by the definition of Ambient Assisted Living (AAL) environments [1]. AAL is the solution that appears in the horizon since the related technologies and applications to be developed will be focused on the main characteristics of Ambient Intelligence [2], that suppose that intelligent services available in the ambient must be natural, invisible, non-intrusive and cannot be an obstacle to the interaction between the user and the environment

The design of accesible products and services for AAL environments is an absolute prerequisite that will allow the inclusion of elderly persons and persons with disabilities in our modern information and communication society [3]. In this way, the improvement of accessibility and usability of current Information and Communication Technologies (ICT) to ensure a better adoption and acceptance by the elderly population and people with disabilities, functional limitations that are main the target of AAL spaces.

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The design of these kind of systems suppose a very demanding challenge to industry which should create devices and services that must cover the needs of very specific customers. In this way, the systems developed require high usability capabilities and the user acceptance of a wide spectrum of senior citizens. To produce interactive systems with high usability and user acceptance, it is necessary to involve end-users throughout the whole development process. This idea is covered by the Human-Centred Design (HCD) methodology [4].

Nevertheless, although there are significant efforts in political and industry side to board this problem, it is not trivial to create effective and efficient AAL product and services. The user interaction in AAL services is very complex. Then, the design of AAL products and services is a very demanding challenge to usability engineers. AAL designers are pushed to build electronic environments that are sensitive and responsive to the presence of people and provide assistive propositions for maintaining an independent lifestyle. This requires to them the ability to develop new and innovative modalities of interaction that must be, of course, accessible and usable. In this scenario, it is crucial to provide tools to engineers that help them in the design of AAL products.

One of the most serious problems in the design of innovative products is the early validation of them. The earlier the prototype errors are detected, the less cost overruns will suppose to the companies. The high complexity of AAL products usually suppose multiple design iterations that require the creation of a large quantity of prototypes that can make the product non-viable. In summary, the on-design time validation is crucial to create cost effective AAL products.

To provide a better validation by using ICT technologies it is possible to design and provide simulation tools that enables engineers to discover errors and interaction problems among devices and services deployed in AAL environments that are interacting with senior citizens or people with disabilities.

In this paper a simulation tool thought to validate AAL environments on-design time is presented. The tool combines the use of 3D simulation of prototypes for enabling the interaction simulation of devices and services with AAL users. This will allow usability engineers to validate their product ideas with different users in different environments without the necessity of creating physical prototypes, saving resources and reducing the time to market.

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II. Supporting validation in Human Centred Design

To produce innovative and successful products it is needed to involve end-users, in our case Senior Citizens, throughout the whole development process. To do that we propose a methodology based on Human Centred Desing that leads the AAL solutions development to a better position to ensure accessibility and acceptance of those services.

HCD is an approach that supports the entire development process with Human-centred activities in order to create applications which are easy to use and provides added value to the intended users. This approach is particularly useful when a new product or service is to be introduced, as it is the case of AAL solutions, because Human-centred design draws together the practical, emotional and social aspects of people's experience bringing on the needed innovation that delivers real user benefit. Despite the benefits, using HCD in the ICT industry is still confined because of cost and benefits. When systems become more complex, HCD evinces not only inefficient but also ineffective with respect to improving accessibility as there aren't available supporting tools. Designing and evaluating with manual approach is a time-consuming endeavor, imposes a high work load on the designers and may lead to completion of the design search with premature, suboptimal solutions.

The development of computer-aided supporting tools to be used by Interaction Designers and Usability Engineers can overcome these limitation. In particular, the use of interaction simulation systems in all the stages of the HCD process shown in the Figure 1.

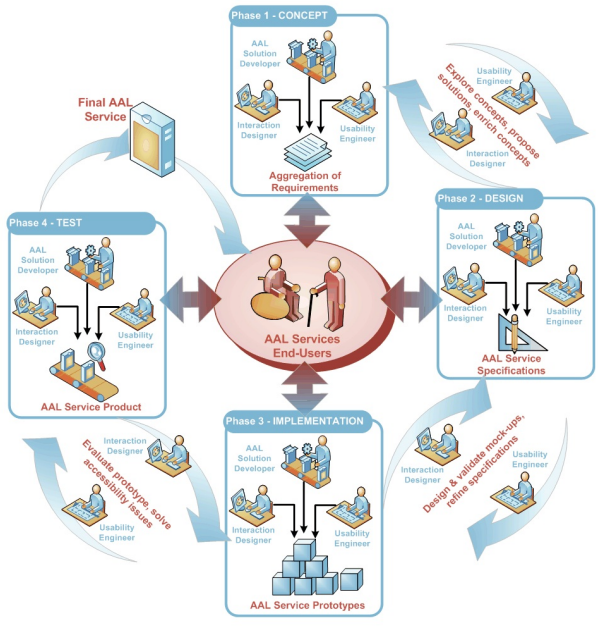

Fig. 1. Human Centred Design Process

The HCD process with its process steps, is described in the ISO/DIS 9241-210(former ISO 13407). The HCD Process is an iterative process divided in four stages:

- The *Concept Phase* is in charge of analyzing, understanding and specifying the context of use of the product. The context of use should describe the characteristics of the users, key goals and constraints, tasks and organizational, technical and physical environment in which the system will be used. The main purpose of this phase is to elaborate the AAL Solution Requirements, including both functional and non-functional requirements. The first ones specify the functions the proposed solution provides and how it reacts and behaves; the second ones define which constraints to take into account when designing the solution.
  In this phase an usability engineer could use a simulation environment to present to Seniors a wide range of real situations and elicit Senior reactions to identify Senior needs and goals.
- The *Design Phase* is thought to produce design solutions of the intended User Interface. The main purpose of this phase is to define the AAL Solution Specifications that will be used by the development team to implement the solution in the next phase. The conceptual design of the AAL solution addressing all aspects is created and reflected in low-fidelity prototypes, which are evaluated by Senior Citizens. Design iterations are driven by seniors' feedback until requirements are met. In this phase simulation environments could be used by usability engineers to immerse Seniors in the AAL solution by means of the virtual prototype to experience with the new interaction devices, new interaction modes and elicit Senior reactions to identify early acceptance and accessibility issues.
- The *Implementation Phase* main purpose of this phase is to build the AAL Solution Prototypes. The key design activity is transforming the validated conceptual design of the AAL solution into a concrete and fully detailed design including high-fidelity prototypes that become really coded and fully functional
  In this phase a simulation environment can be useful to test the developed components against its accessibility features making use of the library of virtual seniors and providing improvements or corrective actions to the interaction designer.
- The *Test Phase* is aimed to evaluate and validate the developed concept with end users. This phase validates the final implementation of AAL Solution Prototypes to ensure it satisfies business, market and user requirements.
  Usability engineers could use simulation environments to test final implementation, first detecting usability issues with the automated tool and then with real Seniors.

The use of simulation can be very useful for help usability engineers in all the Phases of AAL Spaces design. This problem was boarded in the VAALID European Project [5]. VAALID project intends to provide a set of tools for interaction and usability engineers. The Project provides a

modelling framework that allows to interaction designers to define AAL Services and devices [6]. VAALID also provides a Choreography module able to execute the interaction among real and simulated services and devices [7]. Nevertheless, to perform a validation it is needed a tool that allows to usability engineers to understand how the designed products works by using virtual simulations.

In the next section, the VAALID simulator control panel will be presented to be used by ussability engineers in all the phases of HCD for AAL environments definition and implementation.

III. Simulation Control Panel

The VAALID development and simulation environment provides both tools for creating virtual simulations as well as tools for running and controlling such simulations. The tool that comprises the link between these two core functionalities is the Simulation Control Panel (SCP). This tool is being used after the modelling process in the Authoring Tool has been completed and the simulated environment has been completely created including the user model, the environment, the use of devices and sensors within the simulated scene and the simulated AAL services which should be tested and evaluated using the VAALID system. The Simulation Control Panel has been integrated into the Authoring Tool. The reason for this is to increase designer convenience when moving from modelling an environment to testing the model in a simulation and moving back to make changes. This process runs more smoothly with an integrated tool supporting both aspects within one application. The SCP is composed of the following functionalities:

- *Simulation configuration*: The designer can configure the specifics of how the simulation will be run. The Settings view lets him decide which devices in the simulation will be part of the Living Lab Verifier, thus requiring the hardware equipment, or if a virtual model of the components should be used instead. The developer can change environmental conditions, for example, whether the simulation will take place in a night- or in a daytime- setting; and choose among the different supported simulation control devices which one will suit his current evaluation purpose best, usually based on which user group is being used for evaluating the simulated AAL solution.
- *Accessibility constraint verification*: Before the simulation is being started, the user can run a so-called Accessibility Check on the environment, which is a formal test analysing until which point the simulated environment could present accessibility issues to the requirements of the chosen user model. Warnings and recommendations are provided to the designer on how the environment can be improved to match important user model criteria. The Accessibility Check will, for example, give a warning about sound alarms not being loud enough when the user has a certain degree of hearing impairment.

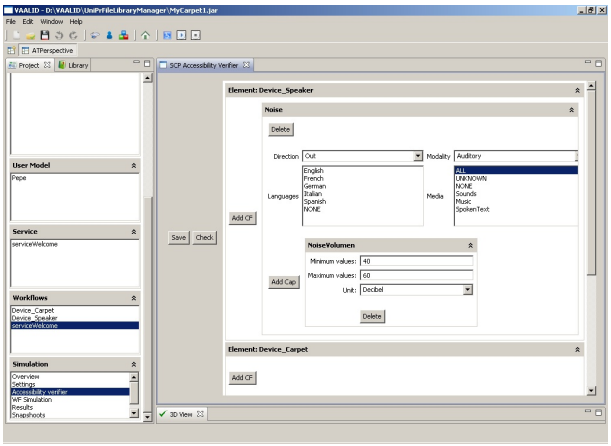

Fig. 2. Accessibility Verifier

- *Workflow simulation*: Once the simulation has started, the designer is able to check the status of the workflows that are running and trigger the predefined transitions to change its status. This functionality allows the designer to force events during the simulation that can't be activated by other means.

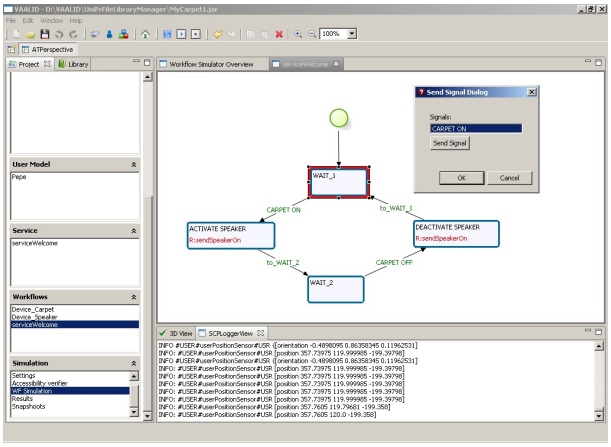

Fig. 3. Workflow Simulation

- *Simulation execution*: Once the simulation is running, the Simulation Control Panel logs the user inputs and the corresponding system reactions for later analysis. The log panel shows all the messages that are being exchanged between the components of the simulation allowing the designer to follow the results of the simulation in real time.
- *Analysis of results*: The logged data is being analysed by the Simulation Control Panel to give insights into important key features of the simulated AAL-system. The analysed log data provides the user with a high-level view on the system's functionality in a given test run and gives objective parameters for system performance. This functionality is especially practical in earlier development stages when systems are test-run by the developers themselves to receive a first-

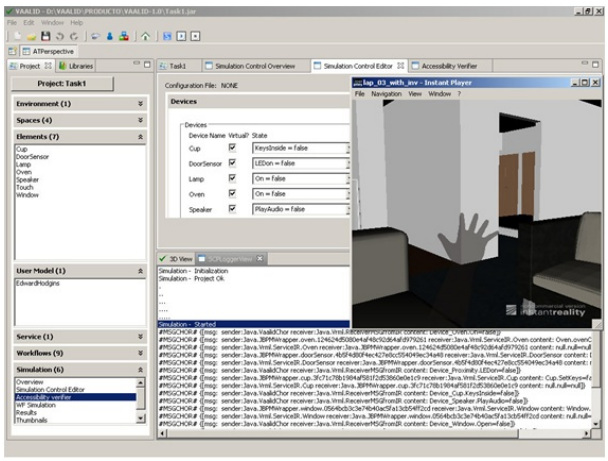

Fig. 4. Simulation execution

person experience of the developed solution. At this stage changes to the system are quick and inexpensive, so the analysis of log data requires quick and objective feedback on important system functionality parameters, which can then be easily adopted for better system performance.

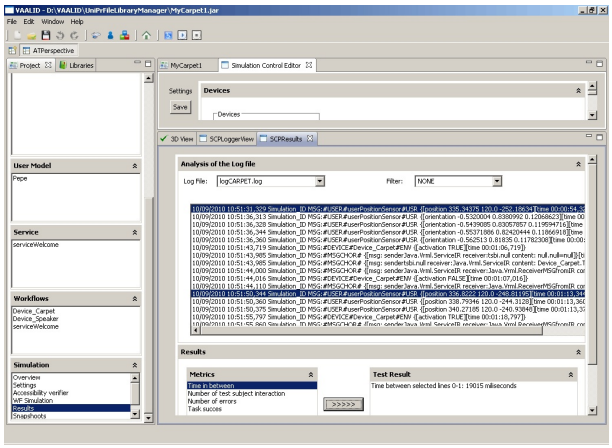

Fig. 5. Analysis of results

The application has been initially tested by 19 Usability Engineers from Spain, Greece and Germany. The usability engineers performs some direct tasks in the application. The Figure 6 shows the impression that users had of the application. The first graphic represent the overall impression of the experts before the use of the application after the presentation of the platform. The second graphic represent the overall impression of the application after the realization of directed tasks. As can be seen, the experts had a moderate first impression that was improved to a good final rating with the real use of the application.

IV. Conclusions

The Simulation Control Panel presented in this paper provides a evaluation view to usability engineers that will allow to simulate the designed processes and services and analyze their results.

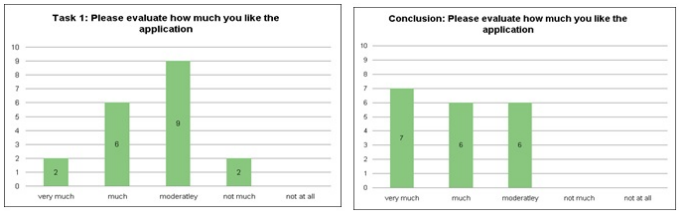

Fig. 6. Application Evaluation

Since the central target group of the SCP system are AAL system developers, using this application in the creation of new AAL solutions, the benefits to their work, such as time savings and improved system functionality are of major importance to the system. Designers have full control over the simulation, determining which devices and sensors should be part of the environment and how they are being used by and incorporated into the overall system. Furthermore, developers can decide which simulation controls to employ.

As they move from initial development stages to a more refined system, and as more hardware becomes available for real-life testing, the degree of realism of the simulation can be gradually increased, moving from a purely virtual simulation to a real-life system as the developer sees fit. This flexibility gives the developer complete control over the development process allowing him to adapt the system functionality to his momentary needs.

Currently, more specific evaluations to improve the SCP are being performed in the VAALID project framework.

V. Acknowledgments

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References

[1] Horst Steg, Hartmut Strese, Jérme Hull, and Sophie Schmidt. Europe is facing a demographic challenge. ambient assisted living offers solutions. Technical report, European Commission (Contract No. 004217), 2005.

[2] P. Remagnino and GL Foresti. Ambient intelligence: A new multidisciplinary paradigm. *IEEE Transactions on Systems, Man and Cybernetics, Part A*, 35(1):1–6, 2005.

[3] *Accessibility, usability, safety, ergonomics: concepts, models, and differences*, UAHCI'07, Berlin, Heidelberg, 2007. Springer-Verlag.

[4] Kim Goodwin. *Designing for the Digital Age: How to Create Human-Centered Products and Services*. Wiley Publishing, 2009.

[5] VII Framework Program IST Project 224309. Vaalid project:accessibility and usability validation framework for aal interaction design process, 2008-2011.

[6] Juan-Carlos Naranjo, Carlos Fernandez-Llatas, Pilar Sala, Michael Hellenschmidt, and Franco Mercalli. A modelling framework for ambient assisted living validation. In *Universal Access in Human-Computer Interaction*, volume 5615 of *Lecture Notes in Computer Science*, pages 228–237. Springer, 2009.

[7] Carlos Fernández-Llatas, Juan B. Mocholi, Carlos Sanchez, Pilar Sala, and Juan Carlos Naranjo. Process choreography for interaction simulation in ambient assisted living environments. In *Proceedings of XII Mediterranean Conference on Medical and Biological Engineering and Computing*, 2010.