DESIGN AND DEVELOPMENT OF AUGMENTATIVE AND ALTERNATIVE DIGITAL HOME CONTROL INTERFACE

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Abstract: This paper describes a Digital Home Interface capable of adapting layouts, styles and contents to device capability, user preferences and appliances' features; designed with a combination of web technologies, standard languages for abstract interface definition and AAC systems. The Home Automation architecture is characterized by devices' independence, combining eXtensible Markup Language and Cascading Style Sheet, web technologies standard languages for abstract interface definition and two basic Augmentative and Alternative Communication systems with a Java based platform. This paper includes the result of a preliminary experiment, conducted with 4 users with cerebral palsy that are daily users of Augmentative and Alternative Communication systems in October 2011.

Keywords: Home Automation, Universal Remote Control, Augmentative and Alternative Communication, User Interfaces, Design for All, Accessibility.

Introduction

An inquiry of the National Statistics Institute of Spain shows that 74% of the Spanish population with disabilities (2.8 millions) suffers some kind of limitation performing daily basic activities (DBA), while about 1.39 million cannot perform DBA at all without the assistance of specialized personnel (Instituto National de Estadistica, 2008) . In this context the most vulnerable people are those who, in addition to mobility problems, could have speech

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and cognitive limitations. This is, for example, the case of people affected by severe cerebral palsy. Social and health professionals routinely refer to the ability or inability to perform DBA as a measurement of the functional status of a person. This measurement is useful for assessing the elderly, the mentally ill, those with chronic diseases and others, in order to evaluate what type of social and healthcare services an individual may need. Limited mobility and mental diseases usually cause a situation of reliance on other people for self-care, housework and, in general, DBA. In Spain more than the 70% of the Spanish population with disabilities suffers some kind of limitation performing Daily Basic Activities at home. Digital Home Systems could mitigate disabled people's difficulties to carry out those activities, giving the opportunity to manage home appliances through a single control. Digital Home Systems have to provide specific and adapted control interfaces based on Augmentative and Alternative Communication languages in order to be an efficient solution to the problem and to allow most vulnerable groups of people with disabilities to reach the highest level of autonomy.

In this context, the user's home becomes a vital area. The installation of a Digital Home System can make the technology useful for those people with particular necessities, with the purpose of adapting the environment to people needs, improving user's autonomy and making it easier to perform DBA in a private environment despite the user's capability conditions, as long as the systems are designed with accessible parameters. Opening a window, turning on the TV and switching over to your favorite channel, setting the heating to 22 degrees, switching on the light, opening and closing the door or checking the alarms' status are only some examples of Digital Home utilities. Digital Home Systems can minimize users' effort avoiding movement's necessity to control different devices into a house and, if they are conveniently designed, can mitigate difficulties of disabled people for being autonomous, improving their quality of life (Heins, Leroy, & Leo, 2011; Romich & Zangari, 1989; Zangari, Lloyd, & Vicker, 1994). At the Universidad Politécnica de Madrid there is a specific laboratory called Smart House Living Lab, a house where all the appliances and devices are connected through a domotic bus, making this lab a real Digital Home. In the context of this Smart House Living Lab these developments have taken place.

This paper aims at describing the design and the development of a web-based Digital Home Interface, enhanced with Augmentative and Alternative Communication standards in order to accomplish the “Design for all” objective. The designed interface is capable of adapting layouts, styles and contents to device capability, user preferences and appliances’ features. Considering the difficulties of users affected by cerebral palsy to use conventional input devices, the UI has been designed to be compatible with assistive technology (Berry & Ignash, 2003; Miesenberger, Karshmer, Penaz, & Zagler, 2012) such as alternative keyboards, touch screens, electronic pointing devices, joysticks, trackballs, switches or head controlled mouse (Manresa-Yee, Ponsa, Varona, & Perales, 2010).

Materials and Methods

Digital Home is an important scenario in the Information and Communication Technologies (ICT) field, and nowadays it is present in different commercial Home Automation. Most of the existing interfaces in the Digital Home market are not designed with accessibility and “Design for All” properties and, above all, are not compatible with assistive technologies typically used by people with disabilities. If Digital Home Systems pretend to become a solution for people with severe cerebral palsy, they have to provide support for Augmentative and Alternative Communication (AAC) systems, like Blissymbolics (Archer, 1977; Blissymbolics & Process, 2004) or Picture Communication Symbols (PCS)(Fuller & Lloyd, 1991; Mayer-Johnson, 2012; Mizuko, 1987), with their rules and schemes, to create specific interfaces and controls (Heins et al., 2011; Zangari et al., 1994).

This paper describes a Digital Home Interface included in a line of work called “ICT applications for people with special needs” of the Life Supporting Technologies research group. The developed Digital Home Interface is based on web technology. Ubiquity, accessibility properties and spread use of internet are the main reasons for basing this interface on this particular technology. Moreover users do not need dedicated controllers, but only common ICT devices which support various modalities, principally for internet applications (Lee, Helal, & Lee, 2006). Making the user interface

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easy to use and accessible for people with communication disabilities is the main objective of the project. In this way it is important to create the interface's pages according to the Web Content Accessibility Guidelines versions 1.0 or 2.0 (WCAG) with a minimum level of compliance AA (Caldwell, Cooper, Reid, & Vanderheiden, 2008), which provide strategies, guidelines and resources to make the web accessible to people with disabilities. Individuals living with a disability are able to use their own assistive devices such as Braille terminals, mouse emulators, screen reader or speech recognition software, when web interfaces are correctly built and maintained.

Design and implementation

The Digital Home Interface explained in this paper employs a set of web languages and standards, refined by AAC systems to achieve user adaptation. The UI is been designed following the WCAG v2 (Caldwell et al., 2008) and the recommended guidelines described in Poulson et al. (Poulson & Nicolle, 2004). Moreover, the UI design is based on the traditional design approach of AAC boards for users affected by severe cerebral palsy.

The Home Automation architecture is characterized by devices' independence; the user interface has to adapt the accessed pages modifying layouts, styles and contents according to device capability, users' preferences and appliances' features. This Digital Home Interface combines XML and CSS web technologies (eXtensible Markup Language and Cascading Style Sheet), standard languages for abstract interface definition (URC, Universal Remote Console) (Whitepaper, 2005), and two basic AAC systems (Blissymbolics and PCS.) with a Java platform (CEAPAT, 2012). The result is an accessible, multimodal, multi-language and dynamically adaptable user interface. The Digital Home interface consists of three different interconnected modules (Figure 1 show the detailed schema).

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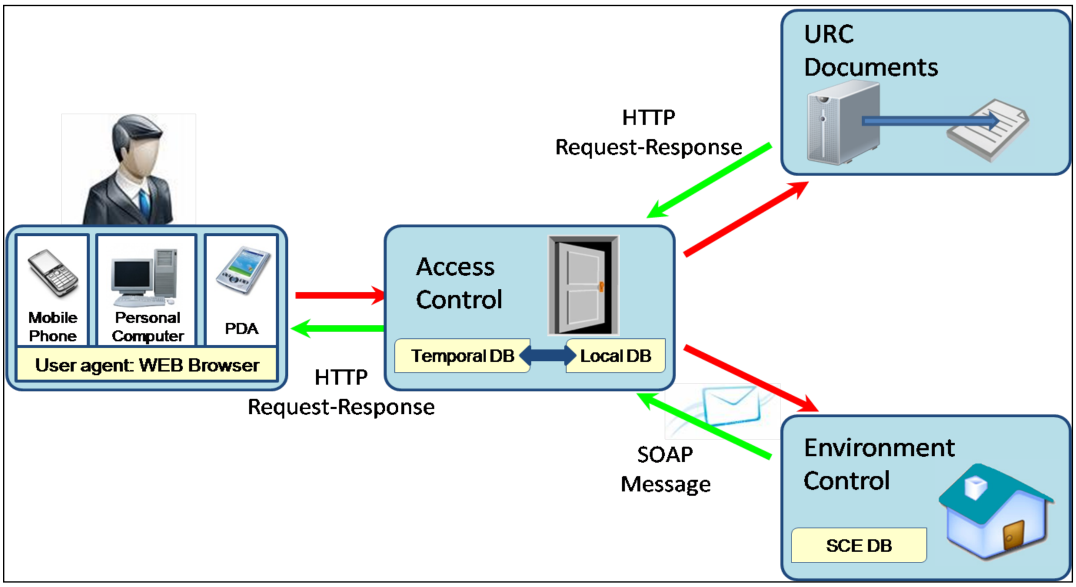
- Access Module: that manages user's personal details, how to access and how to create a new user profile.
- Environment Module: that controls the interactions between user interface and devices;
- URC Module: that holds information about devices and services, stored in XML documents.

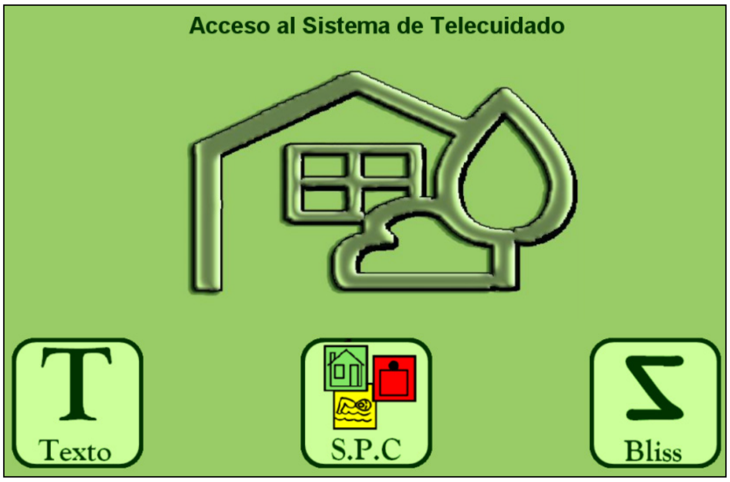
The interface is based on HTTP request-response protocol with typical client-server network architecture characteristics. When the user tries to access to the Digital Home Interface, a connection request is sent to the Information Server that houses the Access Control module. This module handles the interactions between the user and the interface, in order to show the information according to the user's needs and preferences.

Figure 1. Control Interface structure



To obtain all the data about the different rooms (devices and services) and about the system status, every HTTP request invokes a Web Service between the Access Control module and the Environment Control module. When the user decides to manage a specific device, the Access Control retrieves the corresponding URC documents to collect the device's information, which includes how to control it and how to represent it. Once the Access Control has obtained the necessary information, it starts creating the web pages that will compose the final user interface by filling a fixed XML document structure and, afterwards, converts them to XHTML pages through a XSL transformation (Guo, Guo, Chen, & Yang, 2005; W3C, 2012). To control text and layout, a set of different pre-defined CSS is used, whose selection is made depending on user preferences or log-in method. Users can choose which kind of AAC system to use for the interaction (Blissymbolics, PCS or Text) by simply selecting the corresponding button in the initial page (see Figure 2), using the most suitable method, either traditional or through an assistive technology. Now the interface is set with the user's favorite language and the system starts to create dynamically the subsequent web pages with the language's specified characteristics.

Figure 2. Home Page



In the second step users have to log-in themselves through a username and a password. The interface log-in page is an AAC application that adapts itself to the AAC system chosen, so as to make the user interaction easier. Moreover, as it is WAI-compliant, this application is compatible with all kind of assistive technologies used to navigate through the system. In the access page, users can select an image looking through a list of all possible users' pictures, which identify him/her in a unique and absolute way; besides, they have to combine 3 different groups of images to compose the personal password (see Figure 3). These images are simple collections of colours, animals and numbers, so as users can easily remember them. When in the log-in screen a user chooses the personal image and a combination of pictures, the interface puts the relative text into the boxes in order to perform the access. Previously each user had to set the image and the password during an initial register phase. In this case some users may need the support of an assistant to fill in the registration form.

Figure 3. Username and Password in PCS Mode

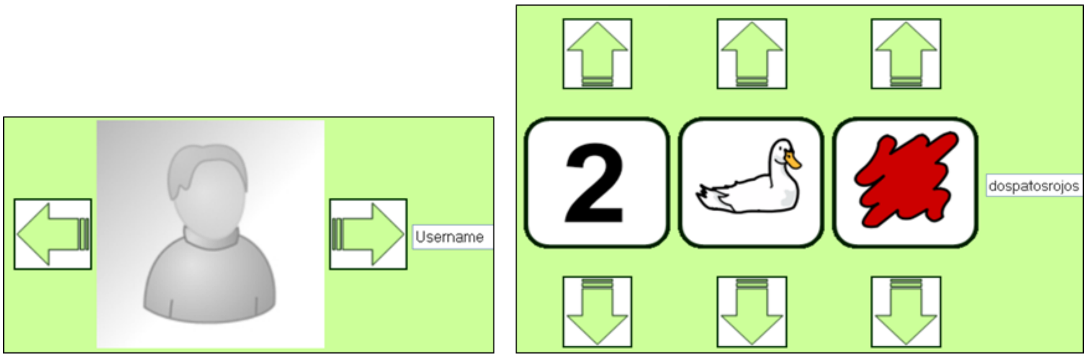
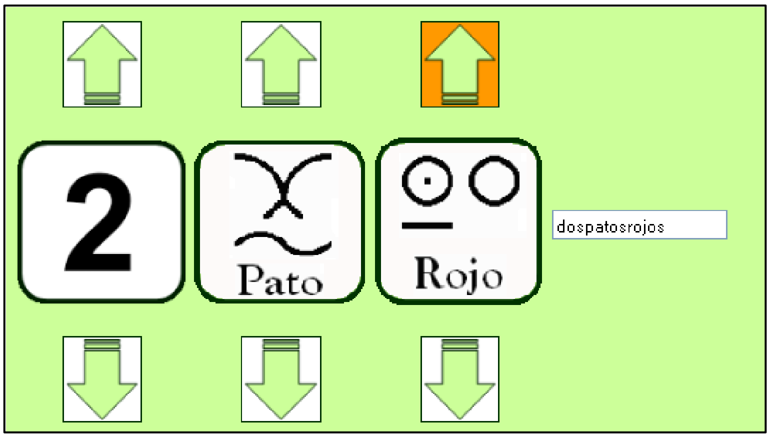
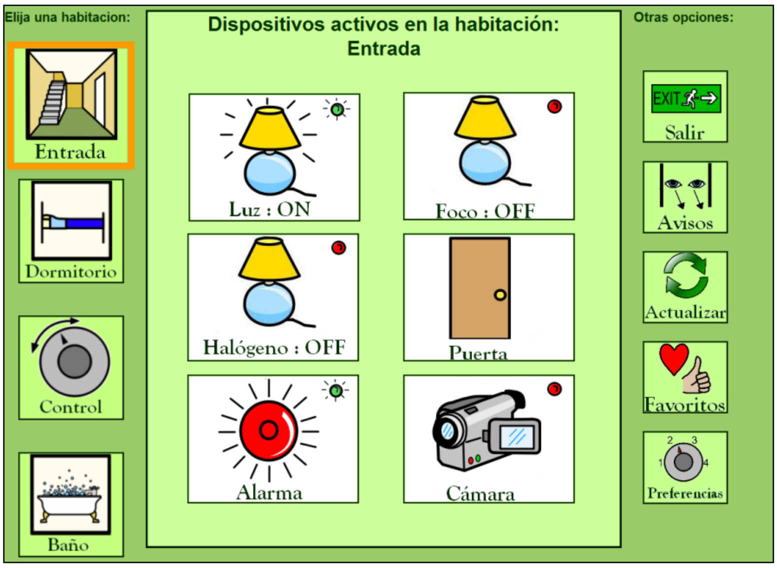


Figure 4. Password in BLISS Mode



Once users have accessed the main interface, they can control all the existing devices of the different rooms using compatible assistive input technology. Using the conventional devices (e.g.: mouse and keyboard) is not mandatory for the correct management of the system interface.

Figure 5. Enter room control in PCS Mode



The main page layout is divided in three parts. The left column shows all the available rooms. The current room is highlighted with a different border style and size. The centre part shows all active devices into the selected room. Every device is identified by an image and a state indicator, both in written and graphical way, to make the interface clear. Users can control directly the devices or verify the state of the appliances; for example to switch on or switch off the light or to verify if the gas tap is closed in order to avoid a gas leak. The right column shows the menu, where users can personalize their profile or verify warnings in case of alarms such as gas leak or flooding. In this case, users assume a passive role, as the alarms are automatically managed by the system.

User experience study

A preliminary experiment has been conducted with 4 users with cerebral palsy that are daily users of AAC systems in October 2011. The users were 2 women and 2 men, with ages between 19 – 28 years. All the users were capable of pointing to a symbol in a tactile screen, placed in their most convenient position, so they could reach it easily. The experiment was conducted in two phases. Before starting the test, the purpose and procedure of the experiment was explained to the user and his tutor or familiar who accompanied the user, and they signed the consent form. Then the user was asked to do two simple tasks through the interface: turn on the bedroom light and open the kitchen blinds. In the second phase of the test, a short interview was conducted in order to gather the users' opinion. The questions were: 1) Are you familiar with the symbols presented? 2) Imagine I am one of your friends at school. Tell me what you like and don't like of what you have seen and interacted with. 3) Would you like this system for controlling your house? The results of the experiment, although cannot be considered very relevant because of the limited number of users, gives some insightful information. Only the interface that used the Pictogram Communication Symbols could be evaluated because the users were not familiar with Blisssymbolic system, and didn't know what to select when looking at the Bliss based interface. With the PCS interface, users had a success rate of 75 %, and all of them were familiar with the symbolic system. The main results of the interviews shows that users like the structure of the web interface, and the symbols they could recognize, while they dislike some of the symbols that were not familiar to them, as were made ad-hoc for the project. This shows the importance of familiarity of the user with the symbols used. Finally all the users would like a system like the one presented to control their home. The feedbacks of the users will be used to upgrade and improve the Interface.

Conclusions

The evolution of ICT makes possible an improvement of quality of life. Design systems following "Design for All" recommendations are the way to make the technology accessible for every group of people. The use of standards such as URC meets all the requirements to facilitate the control of accessible and usable home automation environments. It allows the development of adaptive user interface. The result is an accessible Digital Home interface compliant with the WCAGAA accessibility level adapted to the needs of users of AAC (Bliss or PCS) systems. Digital Home Interface is being incorporated into the Smart House Living Lab, so that users with cerebral palsy can use it in a real environment, simulating DBA.

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