Generic user interface for people with Disabilities: Application to smart home concept

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Abstract - Intelligent homes or Smart Homes, or as defined in Europe as domotics, consist on acting on the user environment to make it more accessible by adding automated controlled systems used through a common user interface which is defined as an environmental control system. The Smart Homes concept is not only limited to home environment, but also to hospital, school, outside and so on.

In this paper we will describe our adaptation to the concept of the software architecture developed for the Smart Home Project, which is an extension of our work in the field of Manus robot Human Interface adaptation to the users with disabilities. . In term of tasks we could say that Smart Homes are dedicated to control systems in the environment, such as doors, windows, lights, TV, VCR and so on, and that assistive robotics is mainly dedicated to manipulate objects, such as gripping object from the floor, drinking, eating and so on.

I. Introduction

We assist today to a considerable increase of people with disabilities due essentially to the improvement of medical care. The handicap is at the same time an individual problem with an important alteration of the quality of life, and a social problem which could increase in the future. We have focused our research mainly on the persons having four limbs impairment due essentially to a spinal cord injuries or muscular dystrophies. Elderly people are also considered

People having motor disability have, very often, maintain their intellectual capacity. If they have an adapted environment, disabled people could work, learn, and live. The assistive technological aids (wheelchairs, robots, environmental control systems, etc.) are dedicated to reduce the handicap by a compensation of the motor capabilities and by favoring a better socio-economical integration of the disabled people[Mok 01 a].

The aim of our work is to develop generic and unified user interface, independent from the controlled systems objects (effectors are defined in our case in XML[Fek 03 b]), or from the communication protocols, which must be flexible and personalized for each end user. This implies to experiment existing and emerging technologies to fit the needs of people with disabilities.

To meet this target we should have a consistent knowledge of users' needs and taking into account their specific types of handicap, their restricted possibilities, and also their acceptation level of technologies. This requires multidisciplinary competencies on several research areas, such as computer sciences, networking, robotics, domotics, and also on ergonomic to provide standard functionalities which allow efficient usability of assistive technological aids.

II. User needs analysis

Usually our environment became not adapted for people having lost the ability to use their proper lower limbs to walk or their proper arms to perform daily living task, as such opening a door, eating, or even having access to a computer. To compensate their incapabilities the disabled people have often recourse to access to the environment such as, electrical wheelchair to compensate moving function, a robot manipulator to move objects in their environment, environmental control systems to control the home environment and communication systems to improve their ability to communicate with people or to get information by the use of a computer. Consequently the user is confronted to several **heterogeneous** systems, imposing **several user interfaces**, providing multiple and **complementary functionalities**, and forming a whole complex environment that we describe as being a smart environment.

This situation is usually described in the literature and by some industrials as the Smart Homes concept that is not necessary limited to home environment, but also to hospital environment and outside (school, train station, leisure places, etc.).

Human-Machine interaction in this system appears not only by the **user interface**, but it is also dependent on **hardware level** of the interface, on its associated modalities (voice, gesture..), and on the wireless and wired **networks** protocols which control the devices (Fig. 1).

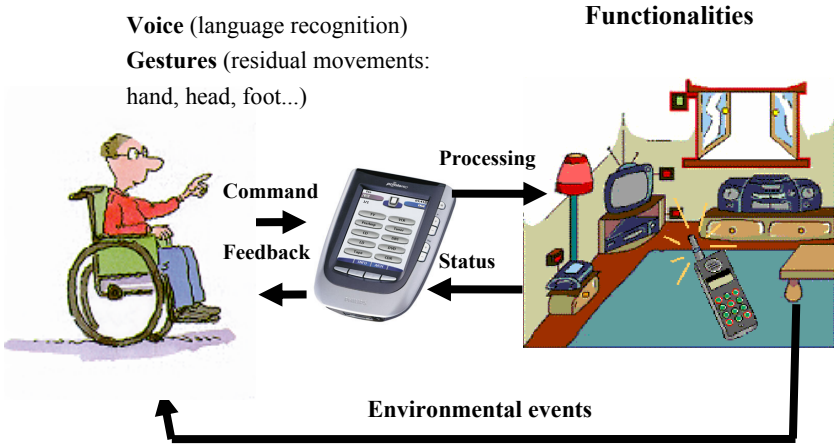

Figure 1: Smart Home environment

III. Constraints

The main problem met by people with disabilities is situated at the Human-Machine level. Users have to use a non-adapted input interfaces and learn many complex sets of commands to control the environment (TV, Tel., robot, etc.) [Hei 99 b] [Mok 97]. Regarding human-machine interface evaluations showed that the actual configuration of input devices presents learning difficulties for some people. These difficulties come from the fact that device configurations are frozen. This is why there is the necessity of a configurable/adaptable architecture function of input devices.

However, Various types of environment control peripherals exist on the market. Some are marketed and others are at the stage of prototyping. These control devices can not correspond to the residual motor capacities of the users heavily handicapped. Small numbers of these interfaces can satisfy the greatest number of possible handicapped users. However people with disabilities use to handle several type of interfaces and systems mainly when using computer, this systems are running on different OS (exploitation systems) and on different hardware plate form (PC, MAC, PDA, etc.), it is easier for this people to use the same system for controlling other output devices (Smart Home).

The case of our system, the research prospects of our team is to offer to persons with disability multiple proposals “choices” of physical interfaces (devices) which could be connected to varieties of hardware platforms, running on different OS, personalize and adapt the whole to each user using spatial tools which permits choosing any configuration of these input devices in function of output devices and the users capacities and choices[Abd 03 c].

The user interface has a crucial role of managing various equipment’s functionalities. Among equipment we distinguish several types of products: electrical devices (white goods), household equipment (brown goods), data-processing equipment (grey goods), and also mobile devices (mobile phones, pocket PCs, wireless devices, etc.). The diversity of these products brings a wide range of heterogenic networking protocols necessary to manage the whole smart environment (radio: Bluetooth & 802.11, Infrared, Ethernet, Power Lines Communication: X10, X2D, etc.).

In this paper we described our research strategy which mainly consists on dissociating the user interface from the controlled system and from the communication protocol. The objective is to allow focusing on the user interface which must be personalised for each user having disabilities without having a huge background of the controlled device. XML input and output devices description allow us to consider the real smart environment as communication objects using several networking protocols.

IV. Software architecture

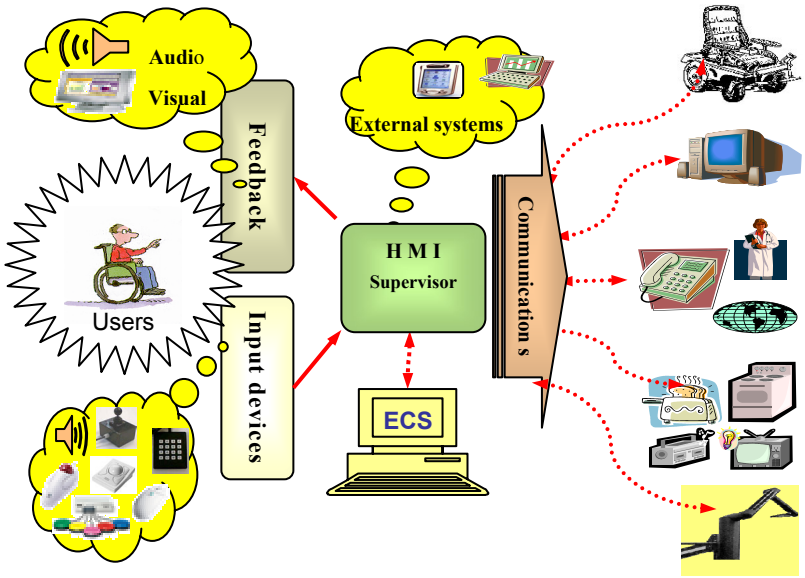

Figure 2: Modular software architecture

The aim of our work is to build generic, adaptable, configurable and unified user interface to control the Smart Home, independent from characteristics of output systems (protocol, device, environment, etc.) which must be flexible and personalized for each end user. The design of Smart Home is based on a modular architecture components[Mok 03 a], this work is based on our experiences in the control of Manus assistive robot[Abd 01 a], the concept has been adapted to the smart environment to control various systems. This modular software architecture offers several advantages to the developers and consequently to the users as adding or developing any input device driver doesn’t require high

background of the controlled system since each action has a user oriented description in XML [Fek 03 b].

This software architecture is decomposed in three main layers (Figure **2**):

User Layer

1. *Input Devices*
   Manage user interface events according to any input device (keypad, joystick, voice recognition, etc.) selected and configured with the ECS software according to each end user.
2. *Feedback*
   Give user information about the environment (input and output devices states) via visual representation (text, icon and image) or audio (sound). This module allows using pointing devices (Mouse, Trackball, etc.)

HMI Layer (Human-Machine Interface): this layer supervises the whole system functionnalies: it converts user events into actions according to selected output devices (Manus, TV, VCR, etc.), transmit the information to the feedback module, manage multimodal aspects, manage errors situations, manage the synchronization of modules, etc.

At the same time, HMI supervisor allows coupling modalities to control a system, for example coupling voice recognition for device selection and shin control to perform according actions.

Low Level or Communication Level: deals with the specific characteristics of any output device and according to its communication protocol (CAN, infra red, radio protocol, etc.).

Networking technologies

Figure 2 shows the conceptual architecture of smart environment and attempts to outline the networking problems of heterogeneous products which are considered as communication objects in user's environment. On the software level, the supervisor plays the central role by processing various interconnections between protocols to allow the transport of the requested action to the corresponding communication object which is specific representation of the physical devices[Mok 03 a]. In term of wireless networking, which ensures the mobility of the handicapped person, several wireless communication protocols have been developed and the most popular are 802.11, called WIFI, and Bluetooth protocols. After investigation, we found that 802.11, in spite of its high portability and its significant data flow, are more dedicated to enterprise's applications than for domestic applications[Fek 03 a]. Bluetooth coupled with infra red IrDA protocol, meet better the objectives considering their low cost and their capacity to control terminals of different natures with minimum energy consumption[Mil 01]. That is way the solution adopted consisted of the design of a generic user interface independent of the communication protocols, and the build up of a communication manager (communication layer).

Toward a generic user interface

The designing of generic user interface should be independent from communication protocols, independent from output devices and without forgetting to be independent of plate-forms; that is why the design and the development have been done in target to be independent from plate-forms; it could be running in multi-hardware plate-forms (PC, MAC, PDA, etc.) and multi-software plate-forms (Windows, Linux, etc.).

The mobile design of the generic interfaces system (hardware plate-form), allows using the system in different environments (home, school, hospital, etc) and favor the mobility of user with keeping the control on the devices (in general environment).

On the hardware level too, the universal remote control (Smart Home control system) which is the mobile support of the developed interface, comprise suitable input devices according to each end user (joystick, touch screen, microphones, etc.) [Fek 03 a]. In term of communication, it is necessary that the system complies with various communication protocols compatible with available domestic equipments at home.

Environmental Configuration System (ECS) for User interfacing

Design of modular software control architecture is not sufficient to allow access to smart environment by severely disabled people. The problem is that each end user, with his deficiencies and his individual needs, is considered as a particular case that requires a typical configuration of any assistive system. Selecting the most adapted input devices is the first step and the objective is to allow the adaptation of available functionalities according to his physicals needs and his choices.

For this purpose, as shown in this Figure 4, we have developed configuration software, called ECS, which allows a non expert in computer science to configure easily any selected input device by drag and drop with the help of different menus containing activities associated to action commands of any system of the user environment.

The idea is to describe environmental equipments by the use of XML standard () and generate automatically all available functionalities which could be displayed in an interactive graphical user interface (Figure 4).

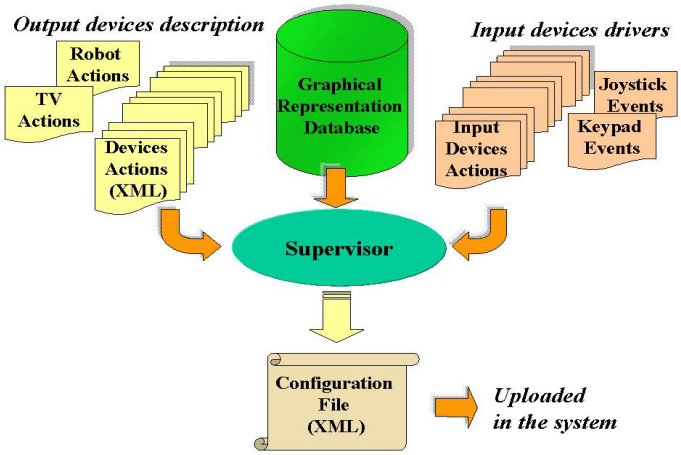

Figure 3: Input devices configuration tool

According to each user needs, and to the selected input devices, the ECS offers the mean to associate graphically selected actions to the input device events (buttons, joystick movements, etc.).

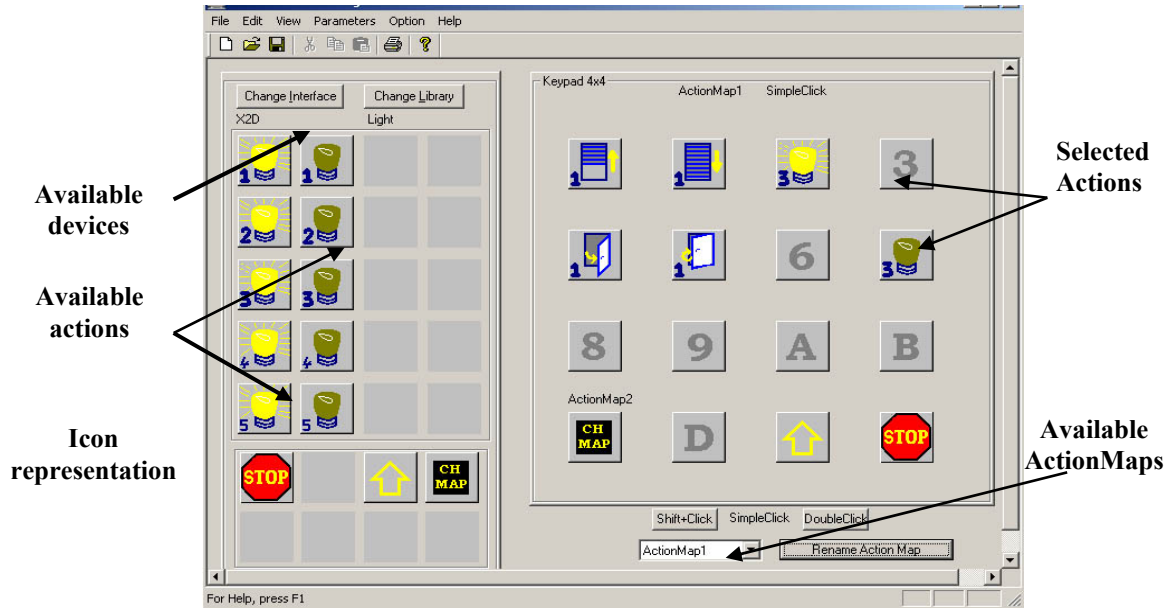

Figure 4: Keypad configuration

V. Conclusion

The Smart Homes context is not only limited to home environment, but also to hospital, school, outside and so on. The integration of assistive technological aids in the user environment, such as an electrical wheelchair, a robot or a laptop portable computer, aims to provide an accessible environment composed of different communication systems and forming a smart environment. The situation of the user with disabilities in this environment and his interaction with several systems is the key parameter to favor the use of assistive technological systems dedicated to elderly people and to people with disabilities.

Usability of these systems is very important and it depends on each handicapped person, the ability to adapt any assistive aids according to the needs of each individual will allow the acceptance or not of the system. This concept of user personalisation input devices was validated during Manus robot evaluation. The evaluation which had been done in the rehabilitation hospital of Garches involved 21 persons having four limbs impairments who participated to the evaluation using different input devices with different configurations. The ECS system contributed to decrease significantly the duration of the learning phase, and improved the usability of the system[Abd 03 a].

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VII. References

[Abd 01 a] Abdulrazak B., Mokhtari M., Grandjean B., « Toward a New High Level Controller for Manus Robot: The Commanus Project » Proc ICORR 2001, IOS Press, 7th International Conference on Rehabilitation Robotics, pp 221-226, INT-Evry, France, April 2001.

[Abd 03 a] Abdulrazak B., Mokhtari M., Rodriguez R., Grandjean B., « ***Manus Quantitative Evaluation*** » Proc ICORR 2003, 8th International Conference on Rehabilitation Robotics, pp.35-38, Daejeon, Korea, April 2003.

[Abd 03 c] Abdulrazak B., Mokhtari M., Grandjean B., « ***Assistive robotics for severely disabled people: The Commanus project*** » AMSE, Journal of the Association for the Advancement of Modelling and Simulation Techniques in Enterprises, special edition HANDICAP, 2003.

[Fek 03 a] Feki M.A., Mokhtari M., Abdulrazak B., «***Application of warless communication in smart homes for disabled and elderly peoples***», Proc AAATE'2003, 7th Conference of the Association for the Advancement of Assistive Technology, Ed. IOS Press, Dublin , Ireland, August 2003.

[Fek 03 b] Feki M.A., Mokhtari M., Abdulrazak B., « ***XML Modelisation of Smart Home envirement*** », Proc ICOST 2003, 1st International Conference On Smart Homes and health Telematics, "Independent living for persons with disabilities and elderly people", France, September 2003

[Hei 99 b] Heidmann J. : ***« Evaluation ergonomique du robot télémanipulateur MANUS sur site et a domicile*** », undergraduate validation report in ergonomy, Juin 1999.

[Mil 01] Miller M. Discovering Bluetooth. Editor:Suzanne Goraj. Edition Sybex, 2001.

[Mok 01 a] Mokhtari M., Abdulrazak B., Grandjean B., « ***Assistive Technology For The Disabled People: Should It Work ? The French Approach*** », HWRS-ERS Journal, An International Journal of Human-friendly Welfare Robotic Systems. Vol.2, N°2, P26-32, 2001.

[Mok 01 a] Mokhtari M., Abdulrazak B., Grandjean B., « Assistive Technology For The Disabled People: Should It Work ? The French Approach », HWRS-ERS Journal, An International Journal of Human-friendly Welfare Robotic Systems. Vol.2, N°2, P26-32, 2001.

[Mok 03 a] Fki M.A., Mokhtari M., Abdulrazak B., « ***Human-smart environment interaction in case of severe disability*** » Proc HCI'2003, 10th International Conference on Human-Computer Interaction, Crete , Greece, June 2003.

[Mok 97] Mokhtari M., « ***Interaction Homme-Machine pour la compensation du handicap moteur (Application à l'analyse quantitative de la télémanipulation)*** », thèse de doctorat en informatique de l'université Pierre & Marie Curie, Décembre 1997.

[Tru 99] Truche C., Mokhtari M, Vallet C., « **Contribution to the development of an open software architecture for the robotic Manus arm** » Proc AAATE'99, 5th European Conference for the Advancement of Assistive Technology in Europe "Assitive Technology - Added Value to the Quality of Life". Ed. IOS Press, pp 302-307, Dusseldorf, Germany, November 1999.