Assistive housing: Case study in a residence for elderly people

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***Abstract*— The ageing of the population increased the needs of elderly people for assistance and care in specialized structures. They become increasingly dependent. Adequate environment have to be provided to fit with their special needs and constraints. This paper presents a case study of assistive housing in a residence for elderly people. The technical assistance like home automation, task reminder and personal assistant is provided in order to enhance the independence of elderly people. The paper focuses on the use of the TV as an interaction mean to use proposed services. The graphical interface deployed on the TV was evaluated by elderly people and resulting ergonomic recommendations. This research activity is ongoing work within the Nuadu project.**

Keywords-component: Elderly people, technical assistance, home automation, evaluation

I. INTRODUCTION

By 2030, 25% of the European population will be over 65 [1]. As the population grows older, people become increasingly dependent as their vision/hearing/mobility and/or general health deteriorates. Most European countries are now facing an urgent requirement to provide adequate environments for these citizens and allow them to be an integral part of society. Current solutions to support dependent people, whether they are elderly people or people with disabilities, are often insufficient and costly, as they require the help of qualified personnel. The use of technological tools can both help these people restore their autonomy, and reduce the need for constant presence of personnel around them, and potentially the need for specialized homes and institutions taking care of them. This achieves two fundamental objectives:

- Improving considerably the quality of life of dependent people, who, thanks to the use of these tools, become much less dependent and much more autonomous, which they are craving for
- Allowing the society to provide improved care at reasonable cost.

Our role is to provide scientific data on the usage of Information and Communication Technologies in daily living for dependant people. Within this framework, we are participating to the ITEA European project called Nuadu [2] in order to contribute to achieve the above objectives. Nuadu addresses the technical challenges of providing networked "healthcare and wellness" services that offer improved "quality of life" for users and more cost effective and efficient solutions for service providers.

In this paper, we address the problematic of assistive housing of dependent people through a case study in a residence for elderly people, fitting into Nuadu pilot sites. The remainder of the paper is organized as follows: Section 2 presents the main problematic of maintaining elderly people at home and highlights their needs of technical assistance. Section 3 explains the importance of potential usages of the TV for elderly population. Section 4 depicts briefly the general system architecture divided into three layers. The evaluation results are presented in section 5 followed by the conclusion of the paper.

II. PROBLEMATIC AND NEEDS ANALYSIS

The number of elderly person is increasing significantly and their life span is stretched out. This assessment has as effect the rise of need to take care in specialized institutions and hospitals or to be dependent to a third party. In order to avoid the congestion of those healthcare structures, actual research is focusing on extending the maintaining at home of elderly people thanks to information and communication technologies. However, this represents a long term objective. Keeping elderly people in specialized residences having adequate structures and tools to take care of them and to enhance their autonomy and independence represents an intermediary solution instead of keeping them at their personal home or hosting them in hospitals or healthcare structures. The goal of Nuadu project is to allow dependent people keeping some autonomy and to enhancing their independence, by implementing technical assistance within their living environment (home, residence for elderly people…). Nuadu consists on the introduction, in those environments, of technological tools able to interact with different users (dependent people, nurses …) using suitable and adapted application like a personal assistant or a remote control. The dependent person could ask or receive automatically information to help taking medicine for example, but also to control his environment. In fact, taking into account special needs and individual diversities while creating technological tools, avoids the marginalisation of some users like elderly people [3].

In order to achieve that, we have to deal with the acceptance of technical assistance and New Technologies (NT)

by dependent users. Caradec [4] defines 3 logics determining the acceptation of NT by elderly people: utility logic, identity logic and evaluation logic. Author shows that accepting a tool isn't static but rather progressive regarding the user age and memorable events. Proposed tools should be flexible and able to suit elderly need evolutions and expectations. From another hand, we have made, within Nuadu Project, an exploratory study to depict user requirements and expectations and to understand the situation of NT in elderly people activities [5]. This study highlights the need of some services like a tasks reminder (drink water, take medicine…) and environment control. It shows that the TV represents the main activity for elderly people.

III. USAGES AND POTENTIAL IMPACT

To define eventual usages of the proposed assistance system, we consider the TV as an interaction tool since it is largely used by elderly people. It could be used to host additional services like medicine reminder, personal assistant, advanced home automation, etc. That represents a diversion of TV usages and functionalities which should be relevant for dependant people. Indeed, the television is a familiar element in the environment of the dependent people (old and/or disabled). This equipment is used in almost all houses and which can be used easily by a person confined to a bed. Besides, a person has more visual and auditive comfort with a usual interface than with a new one. In fact, the authors in [6] argue that object considered as ordinary (and/or usual) are preferred than object associated with handicap, dependence or invalidity image. That's why we consider relevant to insert this element to allow a feedback of the home automation system or for additional services and applications. The TV is considered as an interaction tool; for example, the person can use its remote control to change channels, to control his home appliances as well as to see the state of the different services of its house (opening/closing the doors, shutters, windows, light, etc). The aim of this display system is to allow the person being more autonomous without human assistance to do some tasks like answering a phone call, knowing the state of its environment, knowing who rings at the door, etc. This system allows also for the person to answer directly on television or to do it with another usual interface (like PDA or remote control). The PDA represents an additional interaction tool which can host equivalent services on TV.

IV. GENERAL SYSTEM ARCHITECTURE

Our strategy is based on a framework-oriented research rather than application-oriented research. We aim generally at proposing a generic framework of technical aids and services to assist users in their living environment and able to host additional services or applications. We propose general system architecture divided into 3 main layers: Device layer, Supervision Layer and Presentation Layer. They are respectively explained as follows.

A. Device layer

Indeed, concerning home automation functionalities, each appliance is controlled through the X10 power line communication protocol. A device has an X10 receiver plugged to the electrical network which is tied to the local supervisor through an X10 modem. From a logical level, each appliance is considered as a service having the respective functionalities and displayed by a presentation layer. Thus, a given service is represented by two main parts: the first one is the logical part containing the program code and the presentation layer, and the second one is the hardware part if need exist. A proposed model of a service is explained in [7]. All appliances and hardware components belong to the device layer of the general system architecture (Figure 1). Infrared motion detectors and other sensors are considered in the device layer. They are deployed in order to perceive the environment context. That significantly helps context definition and management to determine the actual user situation allowing either the personalization of service provision and also being aware of critical situations requiring immediate assistance or intervention.

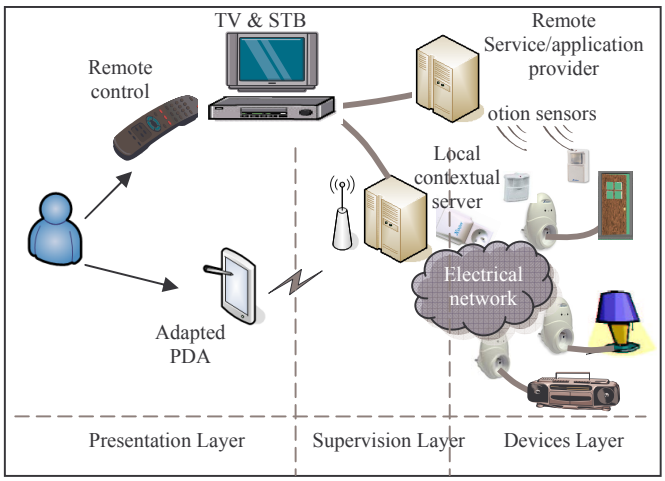

Figure 1. General system architecture

B. Supervision layer

To host local services, a local contextual server is used as a service provision platform and ensuring service discovery and selection mechanisms. The OSGi [8] java based technology is used to play the role of the service container since it represents a widespread standard technology offering a basic service dependency and life cycle management and service administration functionalities. A context management engine is set up over the service platform to deal with sensors and to perform service delivery. The whole of those modules represents the supervision layer.

C. Presentation layer

The end user interacts with the system through the presentation layer. Our objective is to provide end-user with comfortable and adapted interfaces as much as possible. That's why we propose two different means of interaction. The first one is a PDA wirelessly connected to the local server. The second one is the TV monitored via a remote control. The graphical display on the TV is made by a Set Top Box (STB) connected to the TV from one hand and to the local and remote servers from the other hand. It concretely performs presentation layer of existing services like home automation control,

agenda, medicine reminder, etc. In this paper we focus mainly on the TV as an interaction tool and we address the graphical user interface used to display services. As a first step, the interface is developed basing on web technology and is interpreted by a web browser. The development of the Human Machine Interface is done with the assistance of ergonomists in order to fit with user requirements and restrictions. A first version of this interface is done. In the next section, we present the evaluation framework and tools for this interface and preliminary results.

V. Residence Case Study and Evaluation

Within the framework of Nuadu Project, different pilot sites have been being deployed not only to host infrastructures for validations, demonstrations and evaluations, but also to make user needs and usages analysis. Among them, a French pilot site has been proposed; it is about 3 floors elderly home care units residence called "La Roselière" located in the east of France at Kunheim. This residence is lodging up to 80 independent to severely dependent residents for 3 types of stays: permanent, temporary or daily. 50 professionals are working in the establishment: institution or private doctors, care givers and medical aids, nurses, housekeepers, kinesitherapists. As mentioned, a first study based on questionnaires and interviews was realized in order to define the needs of elderly people and their carers, the difficulties and expectations concerning a technological tool allowing their assistance in their daily life and to make easy the daily work of their carers. Data were collected in 4 elderly home care units and at home and our study population included:

- 23 retired people over 60 (from 63 to 99) divided in 3 groups: autonomous and independent people living at home, people with impairment and living at home with human assistance, dependant people living in old people's homes.
- 25 Health professionals (experienced and inexperienced, from 20 to 60) divided in 2 groups: professionals working at home and professionnals working in old people's homes. They were nurses, caregivers, etc.

Once the first version of the TV interface had been ready, a first evaluation phase was launched.

A. Population

Our study population was identified by the medical staff of the residence. Users were selected among volunteer residents who are able to participate to evaluation phase. The study population was 5 elderly people (4 women and 1 man) with sensory and motor impairments (Table 1).

TABLE I. Population Table

ID	Age	Sex	Impairments
1	87	Woman	Sensory
2	85	Woman	-
3	80	Woman	Motor, sensory
4	85	Woman	Motor
5	85	Man	Sensory

We deployed a HMI according to application requirements (Figure 2). The item "Communiquer" (Communicate) refers to the resident contact menu to make a phone call. "Ma vie quotidienne" (My daily life) refers to a menu containing some personal information like resident agenda, personal videos, music, etc. "Ma santé" (My health) item refers to medical information management menu (e.g. medicine). The item "Mon environnement" (My environment) refers to home automation menu to control some devices like lights, radio, door, etc.

Figure 2. The menu page before evaluation

a. Data collection methods and tested aspects

We used different methods to collect data since there are different aspects to test. During this evaluation phase, we addressed mainly utility and usability aspect. In the following, we present different method deployed in each case.

1) Utility testing

We realized questionnaires and interviews in order to test the utility of proposed menus (agenda, health, environment...) according to needs and life habits of elderly people. Questionnaires were realized with "The Sphinx" software and contained 42 questions.

2) Usability testing

We assessed the usability of the deployed HMI. More precisely, we focus on potential navigational problems. Only one elderly people (ID 3) participated to this evaluation. She was the most autonomous person. The usage analysis was based on observation method. We noticed all user difficulties and remarks. In our opinion, it is clear that more elderly people have to be considered and interviewed in order to evaluate the usability of the HMI. This first exploratory study allows improving and getting the HMI that will be tested by a larger number of users (with cognitive impairments...).

B. Results

The first evaluation allowed the understanding of the user logic and differences compared with the designer logic. The results obtained couldn't be generalized since they come from only one resident. The selected person was relatively independent and interested by the integration of NT in her living space. However, this study allowed us to highlight some imperfections and/or faults regarding usability of the proposed interface. This work enabled us to make a first modification of the HMI according to the user's difficulties and needs. Thus, the HMI was modified to make it more intuitive, following are some modifications:

- The wallpaper was lightened to improve the contrast of the interface
- The actions are minimized to 3 to limit the number of successive actions necessary to achieve a goal.
- The interface privileges the pictures rather than text.
- The menu was reduced (from 4 to 3 items) following the medical staff comments.
- To grant users request and to make interface more comprehensive, some titles were modified (my environment → my bedroom, communicate → phone). They were a subject of misunderstanding.
- Some titles were cancelled (my health)
- The permanent help related to TV remote control buttons use was simplified.

The first evaluation showed that the horizontal navigation (Left-right and right-left) was more easy and intuitive than the vertical navigation (down and up). That's why we privilegied a horizontal reading of the menu for the third version of the HMI. However, the second evaluations highlighted other difficulties related to methods of navigation with the remote control. Indeed, these could disturb the user's practice of use. Our user doesn't use the navigation buttons of her remote control. Her use is limited to the numbers positioned at the top of the remote control (so easily accessible). The user declares to know by heart the position of the numbers; this facilitates the selection of TV channels. Her difficulties are related to the automatic reflexes associated with the specificities and the ownership of the remote control.

Figure 3. The menu page after a second evaluation

In order to improve the legibility and the accessibility of the HMI, we deployed a new version of (figure 3). The reading of the menu is still horizontal, but the selection of elements is based on the use of the numbers. Thus, the navigation is reduced only to one action (for example, to select the element "Téléphoner"- call - , you have just to put on the button 2 of the remote control). Moreover, the control of the selected element with the arrows and the validation of the choice with OK button are cancelled. This second feedback allows us to envisage two scenarios (with and without navigation) for the future evaluations. However, our first tests with people with cognitive impairments showed that the navigation with the numbers is easier than the navigation using the selection especially for this population. Indeed, the navigation with the keys requires just one action to execute the task, whereas the other way implies several actions (select the right element and then validate). People with cognitive impairments have also difficulty reminding the links between the different menus.

VI. CONCLUSION

This paper presents a case study of assistive housing in a residence for elderly people. Based on user needs analysis, different technical assistance was provided within a general architecture supporting different services like home automation and tasks reminder. We focused in this paper on the use of the TV as an interaction tool to interact with proposed services. Two evaluation phases of the graphical interface resulted ergonomic recommendations for interface designers. It represents an iterative human-centred and participatory design work done throughout Nuadu project in parallel of technical development of assistance tools. The first evaluation phase is formative evaluations of the HMI ("How can we improve the HMI?") and the last one will be a summative evaluations phase of the HMI ("Does the HMI help?").

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