Feasibility in human machine interfaces for elderly people

R. Raya, D. Torricelli, E. Rocon, R. Ceres, A. Frizera, J.L. Pons

Abstract— **One of the main challenges of social policy in European Union is to promote the autonomy of elderly people. Investments in assistive technology and rehabilitation are producing improvements in the quality of life of elderly people. However, the effectiveness of assistive devices is often limited by the human machine interfaces. Actual assistive devices are beginning to go beyond the conventional interfaces as keyboards, mouse or switches. The aim of this paper is to study the key points of feasible human-machine interfaces focused on applications for elderly. Although a general form to identify these keys does not exist, a wide range of international standards has been developed to define the general principles of user centered design and good practice in user interface design. Moreover, some case studies are analyzed to evaluate the feasibility from a practical point of view.**

KEYWORDS: Feasibility, interfaces, elderly people, usability.

I. Introduction

Ideally, getting a job or education and moving freely are activities that everybody should be able to do. In this sense, public investments are growing, especially in the field of Assistive Technology (AT), which can be defined as "products, devices or equipment, whether acquired commercially, modified or customized, that are used to maintain, increase or improve the functional compatibilities of individuals with disabilities". This definition of ISO 9999 can be extended for AT for elderly people.

The study "Access to Assistive Technology in the European Union" [1] describes the current state of the rules and the way in which the provision of AT for people with disabilities or elderly is organized in European Union (EU). It says that 20.000 assistive technologies related products represent a market volume of over 30 billion euro. Accordingly, in the future a greater demand for technologies will exist. Finally, the study concludes that the market remains unstructured and manufacturing demonstrates a trend towards delocalization outside of the EU. It stresses that although offer of products is diverse, poor information, advice or publicity exist. Moreover, producers are highly specialized and their resources and capacity to invest in product are restricted [2].

These troubles appear once the AT product has been created and the complexity to exploit a product may be influenced by fails in planning, research or development phases, during which the group of work should be interdisciplinary in order to create the most suitable AT solution for the end-user. Moreover, users should participate in all stages of the process together with technicians and clinical experts. However, many projects are technology driven, rather than being guided by real needs.

The interaction between human and AT is the core of technology aids. The interface is the medium through which communication flows between user and device. In this work, the feasibility of the product is evaluated from human-AT interface point of view dealing to identify the key factors according to user needs. As an example, the design of conventional keyboards or mouse can introduce barriers for the use of computer by elderly people. The adaptation of these interfaces to seniors or the invention of alternative interfaces, make the improvement of interaction between elderly and computer possible, meaning that the devices are closer to the needs of the end-user. Adapted mobile phones are another example. They have the same functionalities of general mobile phones but they have easier interfaces for elderly [3]. In short, if a new user-centered design is carried out, the end-user is the main actor and the final product will have more chances of success.

In order to evaluate the key factors of usable interfaces, we need some objective considerations. In the last decade diverse standards have been generated to establish some rules of design. Mainly, the International Organization for Standardization (ISO) and International Electro technical Commission (IEC) have developed wide concepts of usability, effectiveness or feasibility related to human-machine interfaces. This work will use these standards as an objective tool to evaluate and illustrate the importance of the interface on the assistive device.

II. Methods of evaluation

International Organization for Standardization (ISO) has developed over 17000 International Standards on a variety of subjects and 1100 new ISO standards are published every year. Related to Assistive Technology and concretely to human machine interfaces, standards define concepts, classifications and useful terminology. In this section, we propose some standards to evaluate the feasibility of elderly-AT interfaces.

According to [4], standards related to usability can be classified into:

1. The use of the product, [5]

Manuscript received January 31, 2008.

R. Raya (rraya@iai.csic.es), E. Rocon, R. Ceres, A. Frizera, J.L. Pons are with the Bioengineering Group of the Spanish National Council for Science Research.

D. Torricelli is with the Department of Applied Electronics, University Roma TRE, Rome, Italy (e-mail: d.torricelli@uniroma3.it).

2. The user interface and interaction

3. The process used to develop the product

4. The capability of an organization to apply user centered design

The function of these standards is to coordinate national standards facilitating information exchange. Therefore, they are an authoritative source of advice for designers. Moreover, they allow the product to relate to other products and to assure quality and consistence. However, these standards are not widely used. Some problems may be that a unique architecture of ISO for elderly people and assistive devices is required or that existent ISO standards could result expensive. Some standards related to elderly-AT interface are described in the following paragraphs.

SO 9241 [5] is a multi-part standard which deals with aspects about interaction between people and computers. The standard addresses a number of guidelines referred to ergonomics requirements and characteristics of computer equipments. Part 11 defines usability and explains how to identify the information required for specifying or evaluating usability in terms of measures of user performance and satisfaction.

ISO/IEC FDIS 9126-1 [6] provides detailed metrics for quality in use and deals with important factors during product development as functionality, reliability, usability, efficiency, maintainability, safety and portability. It defines functionality as a set of other factors as suitability, accuracy, interoperability and security. Reliability is defined as maturity, fault tolerance, recoverability. Usability is described as understandability, learn ability, operability and attractiveness. Efficiency is described as time behavior and resource utilization. Maintainability is defined as analyzability, changeability, stability and testability. Finally, portability is described as adaptability, install ability, co-existence and replace ability.

The technical specification "ISO DTS 16071: Guidance on accessibility for human-computer interfaces (2002)" describes guidelines and recommendations for the design of systems and software that aim at enabling users with disabilities greater accessibility to computer systems (with or without assistive technology). It includes low vision users, hearing impaired users, deaf users, users with physical and cognitive impairments, and elderly.

ISO 14915 describes software ergonomics for multimedia user interfaces and IEC TR 61997 defines guidelines for the user interfaces in multimedia equipment for general purpose. Finally, ISO 13407 describes the human-centered design processes for interactive systems.

ISO 9999:2007 "Classification of technical aids for persons with disabilities" establishes a classification of assistive products especially addressed, or generally available, to persons with disability. The ISO 9999 classification is used in storing and distribution systems in order to keep the general view over the equipment in centers for technical aids.

These standards will help us to extract concepts which represent feasibility of an elderly-AT interface. However, the variety of interfaces makes difficult to identify the keys to feasibility. For this reason, a classification of interfaces is proposed in this paper, focused on the kind of interaction between the two actors:

- Mechanical. The interaction takes place by movement of both parts.
- Biometric. The machine interacts with the body by measuring biological signals.
- Human expressions. Set of signs which define a language.

Mechanical interfaces are the most conventional, e.g. a joystick or a mouse. These are used for common applications or in some cases adapted for elderly people. Biometric is a field where numerous efforts are being put. Electromyography (EMG), Electrooculography (EOG) and electroencephalography (EEG) are techniques which measure electrical activity produced by muscles, corneal-retina and brain respectively. The information obtained from these signals is analyzed to infer the intention of the user to control the device. The last group describes all the techniques which obtain information on user intentionality from human expressions, i.e. voice, gestures or postures. Voice recognition, eye tracking are methods widely studied offering reliability and introducing new concepts of interfaces.

Some relevant literature deals with the topic of elderly and assistive technology. Abascal et al. analyses how new technologies introduce important social and ethical risks for elderly people focused on mobile technologies, [3]. Jorge et al. exposes that varying illness, disabilities and personality traits for each individuals unique needs is too complicated to design, [7]. Mikkonen et al. tries to find out the key service needs of elderly people, [8]. Hirsch et al. identifies implications for product, interface, and interaction design and opportunities for new products and technologies, [9].

III. Feasibility of elderly-AT interface

The term *feasibility* is strictly related to the concept of *suitability* and generally used to describe something that can be "achieved successfully". In the field of disability, and, in particular considering the elderly-AT, feasibility is a wide concept which depends on the user's context not limited to the interface characteristics.

A. User's context

The context around the user consists of several groups of influence as depicted

Fig 1, forming the *context of the user*. ISO-9241 defines it as users, tasks, equipment and the physical and social environments in which a product is used. In elderly-AT interfaces, the context of the user acquires special significance because users are a specific group with

possible impairments or difficulties to use the device. Moreover, actors as clinicians, pathology, researchers or market, play an important role in conception, design, and commercialization of the interface.

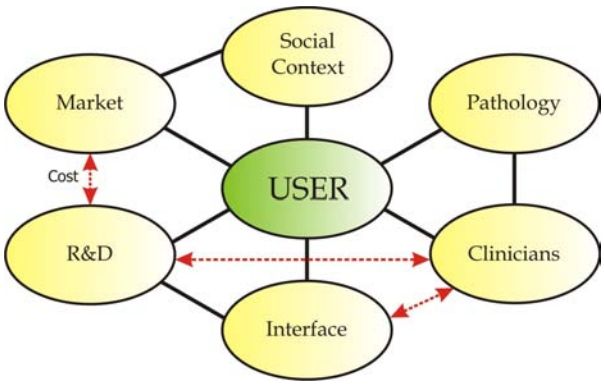

Fig 1. User's context

The user

Understanding the user's needs is the essential input to the design process. Therefore, the participation of users provides relevant data based on their experience and expectations. Users should take part in development and test process providing an interesting feedback to improve details of the prototype. This is an iteration process which should be repeated until a desired outcome is achieved.

Pathology

The study of the nature of the disease allows developing interfaces more adapted to user's needs. Pathology should not be considered only from a physiological and functional point of view, but also under its capacity of influencing user perception and experience, that represent the key factors for satisfaction and usability in general.

Social context

The social context reflects the relationships of the user with the society, intended as family, friends and work community. The quality of this relationship is strongly influenced by the opportunity of freely acting/reacting to the environment. From this point of view, the psychological acceptance of the technological aid plays a crucial role. Often happens that an assistive device that fulfils most of the functionality requirements is doomed to be rejected because of psychological and social involvements.

Clinicians

Professionals who assist elderly may focus the solution on the real needs of the users no matter what is technologically feasible. In this sense, multidisciplinary is essential since the first step of the project. Usability of a technical aid from the clinician/care giver point of view should be also taken into account, particularly when a long term external support is envisaged.

Market

The most limitations for the diffusion of AT solutions are nowadays related to the cost. Whereas technology becomes increasingly sophisticated, investments addressed to commercialize products for elderly people do not reach the same level. Through advertisement of companies, customers and their social environment can know assistive products.

Research & Development

Designing a technologically feasible solution is a task for researchers and engineers. The biomedical engineer or researcher should be more and more aware of the multidisciplinary nature of the problem in order to create a useful interface.

None of the groups listed above should be neglected in the design process. For instance, focusing on economy, the main conclusion could be "an economic product tends to be more successful". However, in some areas, purchasers are willing to pay a premium for well-designed products and systems, so this assertion is not always the main rule to follow. Moreover a device may fulfill the user's needs and to be economically feasible but not having into account social context what might put at risk the acceptance of device.

The red lines in

Fig 1 represent critical relations that often lose importance during some stages of the process. The relation between market and R&D facilitates the post commercialization, taking into account mainly the relation between technology resources and cost. Clinicians and researchers or engineers should work together (multidisciplinary). Finally, clinicians should be familiarized with the interface because, in many cases, elderly people will learn using it through them.

Elderly-AT Interface

As the user should represent the hearth of the design strategy, the interface is the direct object of the design process, because of its role of transportation channel of information and rehabilitation effort. For this reason, an accurate and detailed analysis of the key points of the interface design will be carried out in the next section.

B. Interface characteristics

This section refers to the development process of the interface before commercializing. ISO 9241 describes *usability* as the key factor for the interface success. It is defined as "the extent to which a product can be used by specified users to achieve specified goals with *effectiveness*, *efficiency* and *satisfaction* in a specified context of use". This definition could be the first step in order to assess whether the interface complies with the standards specifications. In fact, this standard helps us to realize certain aspects that seem obvious but during product development often lose relevance. However, what do effectiveness, efficiency and satisfaction represent in

elderly-AT interfaces? We expose our perspective gathering several key terms. Explicit references to commercial solutions will be presented to connect the theory analysis and the technical practice, with respect in particular to the classification of section II.

One of the key points of a usable interface is user's *satisfaction* both short terms, for example, comfort, pleasure, and long term, health and well being. Regard to satisfaction, technological acceptance appears to remind that sophisticated devices can result difficult to use and generally additional functionality often increases interface complexity, decreasing the accessibility. From this point of view, it is recommendable to keep the simplicity of the interface as much as possible. A useful rule to get an accessible interface is to be intuitive, so that, the functionality is similar to natural tasks. As a result, the interface results easy to use. Cognitive problems play a relevant role because seniors may have difficulty understanding unfamiliar tasks while their previously learned skills may become more interference than assistance [10]. ISO/IEC 9126-1 provides a list of sub-terms for satisfaction:

- *Understandability*
- *Adaptability*
- *Install ability*
- *Attractiveness*

In this sense, interfaces based on human expressions fulfill understandability, adaptability because they extract information from natural movements and they are usually intuitive. Iriscom, [11], Tobii, [12], or SMI HED, [13] are examples of commercial interfaces based on human expressions. Concretely, these systems measure the point of gaze what is called "eye tracking". They are non-invasive so users can interact with computers and machines almost without modify their normal behaviour. Also the visual interface HEADdev, [14], uses computer vision techniques applied, in this case, to head tracking. This interface is an alternative to standard mouse resulting more natural and easy to use. In fact, a standard mouse can be difficult to use because the correspondence between hand movements and the corresponding effect on the screen is not so natural and even simple clicks can be quite challenging. This means it is essential to establish a trade-off between targets to reach and amount information which seniors have to comprehend.

Efficiency is another key factor which can be defined as the ratio between the output and the input of any system. Therefore, it is related with the resources used to get a goal. ISO/IEC 9126-1 describes this term as:

- *Time behavior*
- *Resource utilization*
- *Complexity*

Technology resource utilization is a good measurement because can represent the complexity of the interface what could put at risk the understandability or install ability. The Audio-Visual Walker for Movement Disorders developed by Technion (Israel Institute of Technology) is an example of efficient interface. It modifies the user's perception to improve his/her gait, [15]. The interface is wearable because consists of a pair of glasses through which a virtual tiled floor is seen. Furthermore, an auditory feedback cue, adapted to the patient's own steps, is provided through micro earphones. The goal of this device is to aid elderly people with Parkinson's disease, senile gait or stroke among others. The results show that the walking abilities of patients with movement disorders are improved by visual and auditory cues. Therefore, this interface offers a non-pharmaceutical, non invasive, gait therapy. Its design is small and light and thus portable, key factors for wearable interfaces. In addition, it is comfortable and social accepted because seniors usually wear a pair of glasses (adaptability) and presents a high efficiency because with a relatively simple technology it is got a great performance.

This project gathers other key factors of efficiency, as:

- *Co-existence*
- *Replace ability*
- *Portability*

The co-existence can be considered as a measurement of social and technological acceptance because represents the degree of compatibility between user and machine. Replace ability could measure the capability of the interface to substitute some skills. Portability represents the quality of being light enough to be carried. Generally, wearable interfaces should have these three characteristics.

Other example of efficient interface is Emotiv Epoc, created by the electronic-game company Emotiv System [16]. The device is a brain computer interface (BCI) belonging to a new generation by evolving the interaction between humans and electronic devices where conscious instructions are not necessary. The interaction takes place by expression, intuition and perception. The biometric interface is based on EEG, observing each person's individual electrical brain activity so it is a biometric interface. The attractiveness plays an important role because immediate target market of this product is focused on the electronic games industry (attractiveness, social acceptance). This is an example where the context of use can determine the success of the interface because the video games for elderly have increased the sales in last years. Moreover, recent video games are destined to improve mental agility and even slow the onset of dementia and Alzheimer's disease. Other biometric interface is Myomonitor (by Delsys [17]) which is a medical solution suited for real time EMG viewing on a desktop computer. Its lightweight design is ideal for elderly patients and it is ultra-portable because it offers the freedom to monitor muscle performance with a wireless transmitter.

Generally, biometric interfaces reduce the learning process because the interaction is very natural and it could

be said that the interface is more transparent (easy to use).

Effectiveness is the third key of usability according to ISO 9241. It can be defined as the quality of being able to bring about an effect. ISO/IEC 9126-1 collects some terms which concretized the effectiveness:

- *Suitability*
- *Reliability*
- *Accuracy*
- *Security*
- *Maturity*
- *Stability*

Most of biometric interfaces are in research stage and they are not ready for commercialization (maturity, reliability). In many cases, these products offer a small variety of functions. Moreover, they can result invasive, and so less comfortable, because of the contact between person and machine is unavoidable.

The spanish company Technaid has created Techfilter [18]. It is a mechanical interface like a mouse which filters tremor movements caused by Parkinson or similar diseases. The device is easy to use and promotes the social integration. The system has replace ability because it allows user to do accurate movements and filter his/her involuntary movements while transmit the voluntary one to the computer. Over next years, this product will be even more useful because elderly people will be completely habituated to informatics devices.

An example of a rehabilitation device designed for elderly people is the upper limb exoskeleton for tremor suppression WOTAS, [19]. The WOTAS exoskeleton was evaluated with 10 users and validated the concept of tremor suppression through wearable robotics. Nevertheless, the users reported that the exoskeleton could not be considered as a solution to their problem since it is bulky and heavy. The users considered that the use of such device should cause social exclusion. This particular case study illustrates the process of developing an efficiency and effective device but does not satisfy user requirements. For a potential commercial exploitation, a system for mechanical suppression of tremor must fit potential user expectations in terms of cosmetics, functionality and aesthetics. Based on this, the EU TREMOR project is developing an upper limb tremor suppression device that aims to use human muscles as actuators of the system through Functional Electrical Stimulation. This will allow the development of a device that could be hide under the clothes.

All these key points are gathered in Fig 2. As a result, usability is composed of satisfaction, effectiveness and efficiency. Feasibility is a wider concept which not only depends on usability but also on other factors which depend on the user's context. Definitely, a trade-off between all these key points should be had into account to create feasible devices which can be useful for the largest number of people.

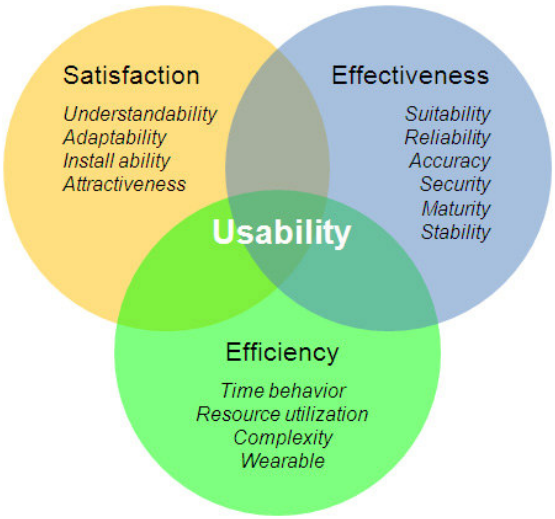

Fig 2. Interface usability

IV. Conclusions

Most of the actual advanced solutions are technology driven, rather than being guided by real needs. The growth of elderly population gives rise to the need of more feasible solutions in terms of usability and cost. To this aim, many International Standards have been proposed as an objective form to evaluate interfaces from conception to commercialization. In order to through some lights on the key factors for the design of elderly-centred interfaces, both the user's and interface's points of view have been taken into account. As objective evaluation criteria, the existent ISO standards have been analyzed and synthesized. The most relevant information has been taken out from ISO 9241, which defines usability with the three terms, satisfaction, efficiency and effectiveness. These concepts are concretized by ISO/IEC 9126-1, and they usually referred to multimedia or software applications.

The role of the user's environment, defined as persons and institutions, is revealed to be particularly significant, so that an approach based on a multidisciplinary interaction between user, clinicians, researchers and engineers should be accomplished since the very first stages of the design process. In particular the user must be present in the whole process providing a constant feedback.

Moreover, this paper discusses some technical concepts of the interfaces. Some case studies of interfaces (divided into mechanical, biometric and human expressions) illustrate how concepts as understandability, adaptability, co-existence, resource utilization, suitability or reliability among others, are implemented.

Although the wide variety of elderly's impairments and needs makes it very difficult to identify an objective solution, the exposed concepts wanted to stimulate a deeper reflection on the factors which should not lose relevance during the development process.

References

[1] European Commission. "Access to Assistive Technology in the European Union" Web access:

http://ec.europa.eu/employment_social/publications/2004/cev503003_en.html
[2] Technologies and active strategies for an ageing population. G. Eizmendi and J.M. Azkoitia. Assistive technology. Issue nº2. April 2007.
[3] Abascal, J. and Civit, A. Universal access to mobile telephony as a way to enhance the autonomy of elderly people, Proceedings of the 2001 EC/NSF workshop on Universal accessibility of ubiquitous computing: providing for the elderly pp 93-993, 2001.
[4] International Standards for HCI and Usability. N. Bevan. International Journal of Human Computer Studies, 55(4), 533-552
[5] ISO 9241. Ergonomics of Human System Interaction by ISO
[6] ISO/IEC FDIS 9126-1. Software engineering. Product quality. Part1.
[7] Jorge, J., 2001 *Adaptive tools for the elderly: new devices to cope with age-induced cognitive disabilities* Proceedings of the 2001 EC/NSF workshop on Universal accessibility of ubiquitous computing: providing for the elderly pp 66-70
[8] Mikkonen, M., Vayrynen, S., Ikonen, V., and Heikkila, M. O., 2002 *User and Concept Studies as Tools in Developing Mobile Communication Services for the Elderly* Personal and Ubiquitous Computing 6:113-124
[9] Hirsch, T., Forlizzi, Jodi, Hyder, E., Goetz, J., Kurtz, C., Stroback, J. The ELDer project: social, emotional and environmental factors in the design of eldercare technologies. Proceedings on the 2000 conference on Universal Usability. Pp. 72-79, 2000.
[10] Hanson, V.L. Web access for elderly citizens. WUAUC, Alcacer do sal, Portugal, 2001.
[11] Iriscom Sistemas, S.L. www.iriscom.org
[12] Tobii Technology. Sweden. http://www.tobii.com
[13] SensoMotoric Instruments (SMI). www.smivision.com
[14] C. Manresa-Yee, Varona, J., Ribot, T., Perales F.J. Non-verbal communication by means of head tracking. Iberoamerican symposium on Computer Graphics (SIACG, 2006).
[15] Y. Baram, S. Badarny and J. Aharon-Peretz. "Virtual reality feedback cues for improvement of Gait in Patiens with Parkinson's Disease", 10th International Congress of Parkinson's Disease and Movement Disorders, Kyoto, Japan, October 2006.
[16] Emotiv Systems. http://www.emotiv.com
[17] DELSYS. http://www.delsys.com
[18] E. Rocon, J.A. Miranda, J.L. Pons TechFilter: Filtering undesired tremorous movements from PC mouse cursor. Journal of Technology and Disability, 18-, pp. 3-8, 2006
[19] E. Rocon, J. M. Belda-Lois, A. F. Ruiz, M. Manto, J. C. Moreno, J. L. Pons, Design and Validation of a Rehabilitation Robotic Exoskeleton for Tremor Assessment and Suppression, IEEE Transactions on Neural Systems and Rehabilitation Engineering, 15(3), 367-379, 2007.