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A Framework for Improving User Experience in Ambient Assisted Living

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Keywords
User experience, universal accessibility, adaptive interfaces, iterative design, elderly, disabilities

Disciplines
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Comments
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Abstract

Ambient Assisted Living (AAL) refers to the integration of all kind of computerized devices into a home environment in order to provide their residents with a better quality of life. Information and Communication Technologies (ICTs) can empower the growing elderly population by providing them with a longer independence, security and a lifestyle enhancement. In order to solve the problems of accessibility to elderly users who might have cognitive, physical or other limitations, interchangeable or adaptive interfaces are required. Looking into the future, adaptive interfaces with intelligent agents, known as assistive environments, can act as a substitute for care and benefit elderly users by increasing their level of activity and quality of life. This paper proposes a framework for improving the user experience by designing adaptive interfaces to support elderly people living in smart environments. This framework has been developed through experience of designing user interfaces for elderly and disabled users gained while conducting the EU-funded EASY LINE+ project (no. 045515).

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1. Introduction

Ambient Assisted Living (AAL) seeks to extend the time the elderly population can live in their own house by increasing their autonomy and by assisting them in carrying out their daily household tasks. Therefore, ICTs such as distributed, ubiquitous and wearable computing are integrating into people's home and offer support to those who need it the most. People with disabilities and elderly people who need assistive aids could profit from an environment that will adapt to their abilities.

Novice users feel often frustrated, insecure and even frightened when they have to deal with a complex system whose behaviour is incomprehensible, mysterious and intimidating. After all, the success of any software depends heavily on its interface. But, designers forget sometimes that users are not mainly computer professionals, especially the elderly who are not familiar with new technologies. Human-Computer Interaction (HCI) has been developed to provide tools, techniques, design practices and methodologies in order to look at how users behave at an interface and what users require from a system.

User experience (UX) is the result of good interaction design. It is described as the quality of experience a person has when interacting with a specific design. There are four main factors that will affect the user experience when interacting with a system:

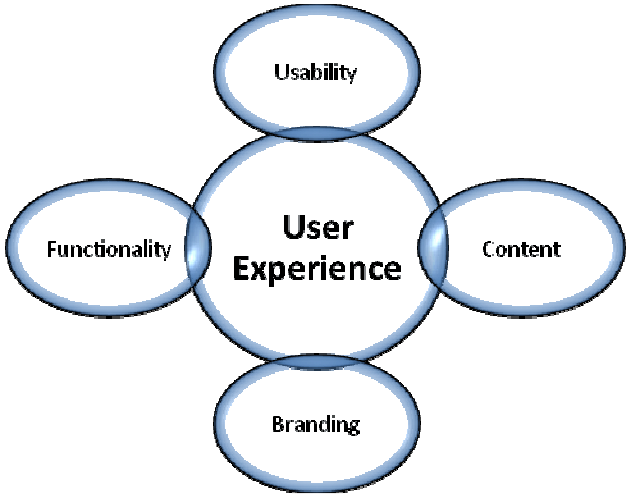

Figure 1: UX's factors

- **Usability**: refers to the ease of use of the system.
- **Functionality**: refers to all processes and behaviour of the system.
- **Content**: refers to the system's structure and content.
- **Branding**: refers to all design-related components (graphics, colours, etc.) of the system's interface.

If accessibility barriers are detected as the early stages of the system's development, ICTs can offer a great improvement in assisting elderly persons living independently in their home for a longer period of time. The design of interfaces capable of providing the best UX requires a particular methodology that bears in mind the user's capabilities. The User-Centred Design methodology explained below is considered one of the best techniques to solve accessibility issues.

2. Understanding User-Centred Design methodology

User-Centred Design (UCD) is a design concept where relevant information about end users is put at the centre of the system's design and development processes. Why is it so important to involve the user? Well, thanks to the users' involvement, designers have a better understanding of their needs and expectations... it provides them with new insights (Black, 2006) which will contribute positively in terms of user acceptance of the final product. However, involving users often means spending time to arrange meetings, but at the end, it is worthy since more often designers would rather go beyond user's expectations than to fall below them (Dix *et al.*, 2004).

The UCD process goes through a cycle of several stages that will facilitate the completion of the system's usability objectives. UCD methodologies are based on the ISO 13407 international standard (cf. figure 2) which provides guidance on improving UX by involving users in the design and development of interactive systems.

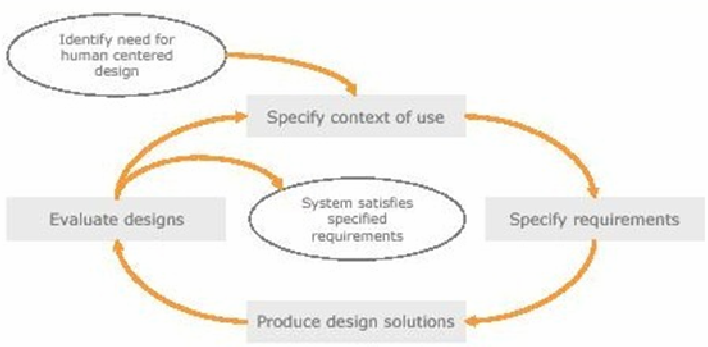

Figure 2: the ISO 13407 standard (*Source: upassoc.org*)

This figure outlines the four key activities involved in any UCD project:

1. **Understand users and specify the context of use**: also known as "early focus on users", identifying users' requirements is the initial step that will contribute in developing a successful product. It is important to get involved with users as early as possible in the design process.
2. **Specify user and socio-cultural requirements**: no need to implement extra features or functionalities into a system if the users are not going to use them to accomplish tasks. It is better to stick to the users' requirements and build products that will suit the user's goals.
3. **Produce design solutions**: create interactive design solutions and prototypes.
4. **Evaluate design against user requirements**: testing will help identify usability issues and evaluate the system's accessibility. If necessary, iterations will be made in order to continuously enhance the system's interfaces.

Until the product being developed delivers upon users' requirements, the cycle is being repeated. As a rule, UCD methodologies consider and integrate users' requirements since the beginning of the system's lifecycle. The major characteristic of UCD methodologies is the active participation of real users.

In summary, providing a great UX is an ongoing process. User-centred design is about understanding users, especially if they have special needs such as elderly or disabled people and those needs must then reflect on the system's interfaces. As a result, UCD will benefit both the users (development of innovative user-friendly

systems, higher acceptance of the final system, better satisfaction etc.) and the designers (reduced cost and development time, reduced maintenance etc.).

3. Designing adaptive interfaces to bring accessibility into AmI systems

The massive diversity of people's impairments makes it difficult to design user interfaces that will suit all of those people's needs. It seems unthinkable to assume that Human-Machine Interfaces (HMI) can fulfil any user's requirements. The concepts of "Design-For-All" and "Universal Design" or UD (Mace, 1998) look for attempts to accommodate the widest definition of users in terms of abilities, needs and preferences in design.

3.1. User requirements

Before starting the user interface's development, learning about the stakeholders, their environment and the tasks they want to achieve is a significant phase to the success of the system. As the requirement analysis is the most important stage in the software lifecycle, designers need to conduct this investigation since the early design stages to understand the users' cultural and emotional context where the system will be present in order to obtain more satisfactory results (Saffer, 2007).

Requirements analysis is a time consuming process but completely necessary and worthy. There are a number of techniques to improve requirements gathering for assistive system design but the common user-centred methods for requirements gathering are listed in the table below:

Table 1: The most popular UCD methods

Method	Description	Cost	Output	Sample size	When to use
Focus group	Users are invited to share their thoughts and ideas about a project	Low	Non-statistical	Low	Requirements gathering
Usability testing	Users are asked to perform a series of tasks while a moderator takes notes	High	Statistical & non-statistical	Low	Design & evaluation
Card sorting	Users are asked to sort into groups an unsorted pack of index cards which are related to the system	High	Statistical	High	Design
Participatory design	Users are actively involved in the design decisions. They become co-designers	Low	Non-statistical	Low	Design

Questionnaires	Users answer a pre-defined set of questions	Low	Statistical	High	Requirements gathering & evaluation
Interviews	Interaction between interviewer and user	High	Non-statistical	Low	Requirements gathering & evaluation

However, involving users is not always easy and it tends to be particularly difficult to recruit elderly and disabled people in the design process of a system. Although, their participation is imperative since it is more complex to generate interfaces for this particular group of individuals. There are alternative techniques used in UCD to keep the users in mind throughout the system's design: the Personas concept is one of them. Personas are fictive characters invented to provide designers with valuable insights and help them simplify design decisions (Casas *et al.*, 2008). They are a valuable tool to help in the creation of user profiles and guide decisions about the system features, interaction and design.

Once designers have collected data about their potential users, they must model this information into user profiles. Since a home system seeks at being universally usable, it will have to accommodate a diverse set of users and being adjustable in order to fulfil their needs in case they change through time. A set of rules has been established to help practitioners enhance their user modelling techniques (such as the guidelines for adaptive interfaces created by Kules (2000)).

As it is difficult to develop an interface that will adapt to every single user, a user modelling technique can be applied with the intention of creating an accurate and parameterized user model (or profile) that can be adjusted to define how the user interfaces should display information in the most comprehensible way for the user (Casas *et al*, 2008). Accordingly, the interfaces will compare parameters like hearing, vision, mobility, cognitive capacity and so on with the data contained within the user profiles and will be able to know the user's current state and make a decision on how to interact with him/her (Abascal *et al.*, 2008).

To sum up, user involvement is essential in any design of systems aiming at supporting vulnerable people with any kind of disability. Establishing a close working relationship with the end-users throughout the design process is the best way to design and implement successful systems.

3.2. Interfaces' requirements

Once the requirements of the end-users have been defined and the user profiles have been created, the design team can elaborate a design concept; storyboards are used to show how the interfaces will look like but what they can do too. They are helpful to represent graphically the interfaces' behaviour while the user is interacting with them. Prototypes can be drawn to help evaluate design alternatives at any stage of the development process. During the conceptual phase, the basic elements can then be explored and tested with users (thanks to low fidelity prototypes). When designing the actual screens, the layout and more detailed interaction issues can be evaluated

and tested. High fidelity prototypes are used to provide a "preview" of the final application. Scenarios are as well a useful tool in order to help designers incorporate in the final product all the possible situations with the different kinds of user. The central characters of scenarios are the Personas. They help acknowledge the requirements of a successful system.

When creating interface, designers should always keep in mind the 5Es of usability:

- **Effective**: the system must allow users to complete their tasks fully and accurately.
- **Efficient**: the system must allow users to complete their tasks with minimum of effort.
- **Engaging**: users must have a pleasant and satisfying experience when using the system.
- **Error tolerant**: the system must be bug-free, minimise the risk of errors and help users recover from mistake.
- **Easy to learn**: users should not have any difficulties interacting with the system as it must be consistent and predictable.

3.3. Iterative design cycle

The iterative design methodology consists in a design cycle where prototypes are elaborated, refined and tested until complete satisfaction of users' requirements. During this iterative development, designs are tested with end-users and when any problem is identified, a new iteration of the design is produced and tested again. The iterative design cycle is summarized in the figure 3 below: first, designers analyse user's requirements, then produce a design, develop the piece of software, implement system's functionalities and features and finally test the product with end-users.

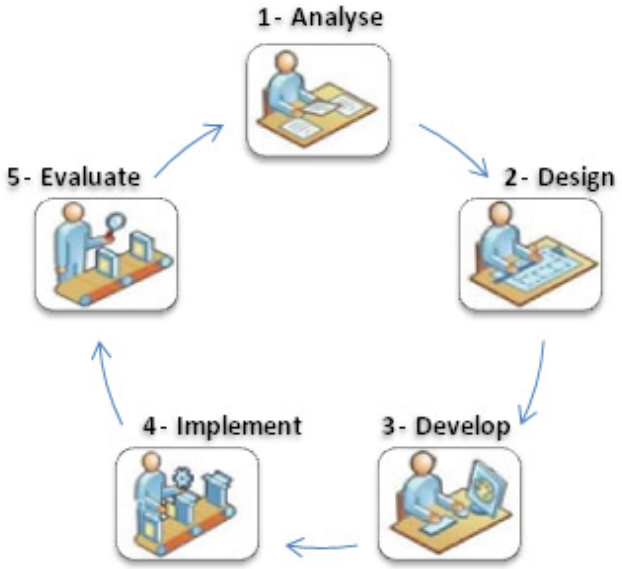

Figure 3: Iterative design cycle

Thanks to its repeating cycle of design and testing, iterative design is known to be a validated methodology that will consistently produce successful results. By redesigning the interfaces based on usability issues spotted during user testing this will contribute positively in improving accessibility. During the first testing, the major usability problems will be found and rectified. The more iterations designers make, the better the user experience will be. Figure 4 shows a conceptual graph of the relation between design iterations and interface usability. Thanks to additional iteration, interface usability and accessibility increase, until the design potentially reaches a point where it plateaus. However, from time to time, it happens that new iterations bring new usability problems. Only testing will be a way to fix those issues.

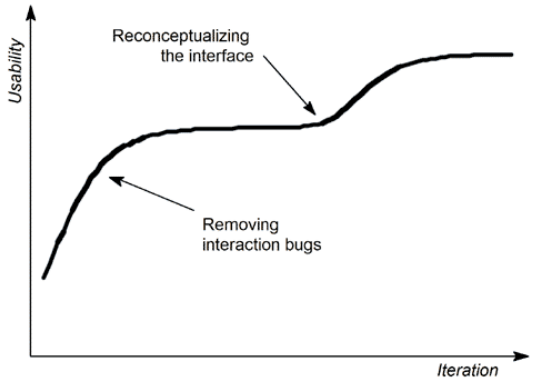

Figure 4: Iteration design improvements (*Source: Nielsen, 1993*)

3.4. Usability testing

Over the years, designers have created several evaluation techniques that look at identifying usability issues of a piece of software. Heuristic evaluation, cognitive walkthrough, feature inspection, consistency inspection, standards inspection are usability inspection methods used to examine and criticize user interfaces as opposed to testing. However, the best way to get feedback on an interface look-and-feel is to ask the users directly by conducting usability testing.

Usability testing involves real users performing tasks with the product being tested and observing them in a controlled environment in order to identify usability issues. Testing is the core of good user experience as it allows developers and designers to spot any design issues, help them enhance the system and rectify usability deficiencies throughout the many stages of the system's design cycle (Rubin & Chisnell, 2008).

Testing is a research tool that can be conducted in a few different ways: *quantitative* and *qualitative* testing. The former describes quantifying data (such as success rates, time to complete tasks, ratings on satisfaction questionnaires etc.) that helps refine and improve known processes whereas the later focuses on revealing significant issues with the product tested. Running a usability test implies an in-depth planning in order to take the most appropriate measures and actions required without disregarding the ethical issues involved. To conduct a successful testing, it is important to follow the steps listed as follow:

1. **Set up for usability testing**: it is important to make sure everything is ready for the testing and maybe run a pilot test.
2. **Conduct the usability testing**: the usability testing needs to be lead by a trained facilitator who will interact with the participants. S/he will principally welcome the participants, explain them the purpose of the testing, make sure they give their consent about collecting data, stay neutral, take notes, decide when to help and how much to help etc.
3. **Analyse the results**: data gathered need to be studied (notes taken, comments made by participants, problems they encountered, success rates, time to complete tasks etc.) which will help formulate problem statements.
4. **Write the usability testing report**: the report should incorporate a summary of what has been tested, when and where the usability testing was held, or what has been done during the testing and so on.
5. **Implement and retest**: as part of the iterative design process, develop prototype, test it, fix it and expand it is the most successful method for developing satisfying user interfaces.

The figure below summarizes the framework proposed in this paper:

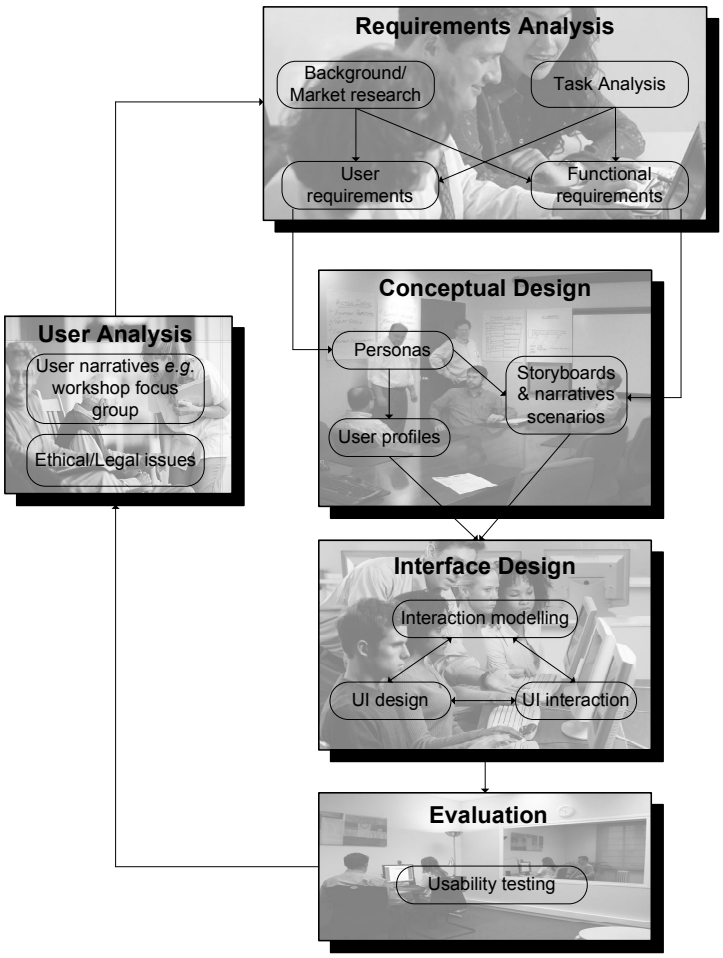

Figure 5: Proposed UI design framework

4. Conclusion

Insufficient human resources make it harder to cope with the ageing population which increases rapidly. Research and development projects keep emerging seeking at developing wellness technology applications to support elderly people to live independently in their home. The use of ICTs enables vulnerable people to preserve their independence through telemonitoring and remote health care. Yet, the difficulties they face in accessing and using information technologies for generational and technological reasons have unacceptably widened the digital divide.

Ron Mace (1998), the creator of the term "Universal Design", explained that UD was about "simplifying the life of everyone by making products, communications, and built environment more usable by as many people as possible at little or no extra cost." The application of UCD methodology into AmI system development will have a positive impact on solving the e-inclusion of elderly people by developing barrier-free accessibility ICT systems usable by the widest audience as possible.

5. Acknowledgements

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