User Interface Framework for Ambient Intelligence Platforms

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Abstract. Nowadays, the new technological advances make possible to offer different services in a complete personalized way, covering the needs of heterogeneous user groups. In the case of elderly users, the acceptance of technology is a key aspect in their motivation to use certain services, and in consequence, the adaptability of the user interfaces is a critical requirement to achieve this goal. This paper presents the intelligent and adaptive user interfaces of a system devoted to offer AAL services, especially designed for increasing elderly users's acceptance, and developed as part of AmIVital project innovative technological platform.

Keywords: Ambient Intelligence (AmI), Ambient Assisted Living (AAL), Adaptative Interfaces, elderly users, multimodal interaction.

1 Introduction

Ambient Intelligence (AmI) paradigm aims to improve citizens' quality of life through an innovative utilization of ICT, where individuals are surrounded by networking and computing technology, unobtrusively embedded in their environment. User empowerment, efficient and distributed services, user-friendliness technology, and support for intelligent human interactions are key aspects of the AmI vision. The Ambient Assisted Living (AAL) concept applies this model to the provision of various services for elderly and people with special needs, helping them to better manage diverse situations in their daily lives. AAL services should include invisible, but always present technology; natural, simple and effortless interaction with users; device-independent and reactive user interfaces; and continuous, autonomous and ubiquitous service adaptation.

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This paper presents the intelligent and adaptive user interfaces developed as part of an innovative technological platform, which enables the creation of new AAL applications and services within a personal environment, for the care, monitoring and support of citizens with special needs in relation to their health and welfare status. The system has been developed within the framework of AmIVital research project [1], partially funded by the Spanish Ministry of Industry, Tourism and Trade.

AmIVital project introduces an adaptable User Interface Framework which is able to support the provision of a variety of complex AAL health and social services for elderly people (e.g. chronic obstructive pulmonary disease (COPD), heart failure (HF), and stroke assistance and management). The services have been built combining basic components: videoconferencing, vital signs and parameters monitoring (electrocardiogram, blood pressure, glucose, weight, and oxygen saturation), alerts, agenda, calendar and reminders. Each component, as well as the global services, includes a user interface that has been designed to be highly adaptive to the offered application, the specific user needs, and particular context situation.

2 Methodology

The methodology used for the design and development of AmIVital user interfaces, the "Interaction Framework" design method, comprises a combination of the principles stated in the User Centred Design [2] and Goal Oriented Design [3] methods. The whole process has followed an iterative approach that embraced three main phases: User Requirements Definition and Analysis, Framework Interaction Design and Development, and Design and Implementation of the User Interfaces.

In the first phase, User Requirements Definition and Analysis, all users' and functional requirements were elucidated and the concept of each service was defined. The work started with the examination of the available social and medical solutions to

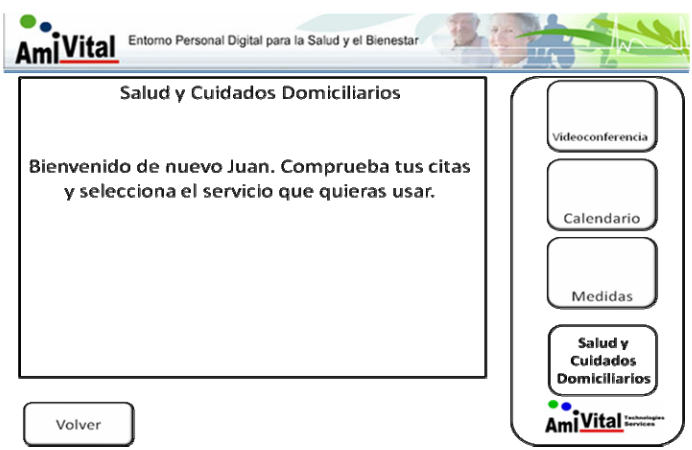

Fig. 1. This figure shows the functional blocks organization in the second version of AmIVital user interface prototype, taking into account that the user device is a tactile screen

assist the final target group, elderly chronic patients. Then, a selection of the different AAL services to be included into the system was done, following a Service-Oriented Modeling Analysis (SOMA) [4][6]. Finally, for each of the planned AAL services, particular user needs were identified, analyzed, and subsequently refined with the correspondent interaction requirements, such as simplicity and easiness to use, short curve of learnability, adaptation to personal routine, multimodality, guidance for use, and error prevention and recovery.

The core interaction framework was designed and developed in the second phase. This included a set of decision rules that, based on the previously identified user requirements and the environmental data acquired, define the best possible user interface at each time. At this stage, all functional elements of the interaction framework for each offered service were depicted (Fig. 1), as well as the key and secondary paths (Fig. 2).

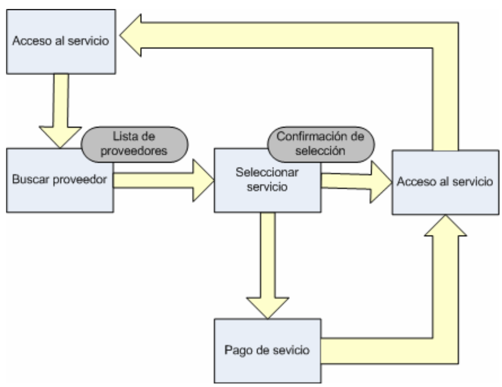

Fig. 2. This figure illustrates the key path of Videoconference service

Finally, the last phase involved the design and development of the actual user interfaces for each of the offered AAL services, including the number and position of the main functional elements of the graphical user interfaces (GUI), and multimodal functionalities such as the dialogs for voice interaction, and the vibration rules for haptic interaction. It also comprised the definition of the "look and feel", that is, the graphical aspect and the behavior of the data and functional elements in each application. The design took into account several accessibility guidelines especially focused on elderly user [5].

3 Results

Following the previously described approach, three different versions of the user interface were designed in an iterative way, including progressive and increasing complexity and functionality. Intermediate designs, obtained as outcome of each iteration step, have been tested and used to refine and improve the next one.

3.1 First Version Prototype

The first version of the user interface included the basic functionalities for the final services (agenda, reminders, videoconferencing and monitoring), and two basic environment adaptation rules, related with the user position and type of required monitoring. The main goal of this interface was to provide a rapid prototype that could be used for evaluating the acceptance of the basic set of the offered services.

The prototype interface was focused on implementing the basic functionalities of the final services, reducing the adaption possibilities to a few options (i.e. automatic selection of the type of monitoring for each user, and reminders displaying according to the user's behavior). This simple design facilitated the implementation of the interfaces, as the requirements were quite limited, and made possible the use of well known interaction devices, a television set and a remote control (Fig. 3).

Fig. 3. This figure illustrates two examples of the first prototype of AmIVital user interface, showing colors, visual elements and position of the interaction elements

Table 1. Validation of 1st prototype. Distribution of services per participants and age.

Participant	Service distribution	Participant's age
1	Videoconference with 2 vital signs monitoring, personal alarm and reminders	69
2	Videoconference with 4 vital signs monitoring, reminders, personal alarms	75
3	Videoconference with 3 vital signs monitoring, reminders, personal alarms	81
4	Videoconference with 3 vital signs monitoring, personal alarms, calendar	67
5	Videoconference with 3 vital signs monitoring, personal alarms, calendar	72

The resulting first prototype was tested with five users, in order to assess the usability and acceptability of the user interface design. Additionally, the ability of the design to introduce additional functionalities was also evaluated. Participants in the validations were senior citizens living independently in their own houses with different levels of chronic illness or disabilities (Table 1).

The obtained results were quite useful. Initially, four of the five elderly participants who had previously indicated their difficulties for controlling a computer based services were quite concerned and reluctant to use the system. However, their appreciation improved during the introduction of the system once they confirmed that the user interaction was based on a television set, a device which they were very familiar with.

All participants praised the simplicity of the design and the short learnability curve, and they also positively appreciated the introduction of visual elements or metaphors that facilitated the access to the different offered services. Nevertheless, in general, the system obtained low acceptance rates. This was mainly caused by the low level of adaptability and personalization of the application at that stage, as well as the reduced interaction possibilities provided by the remote control, especially critical when the number of offered services exceeded three and the time to access to a specific application suffered some seconds of delay.

3.2 Second Version Prototype

Based on the validation results of this first version, a second prototype of the interface was implemented, including extended functionalities and more user's adaptations than the previous one. Additionally, different options to be used as main interaction device were investigated. Aspects like easiness to use, naturalness and functionality were considered and, as a result, a touch screen was selected.

The new graphical interface design had the screen area divided in two main parts: the left side was the main interaction area showing the current service in use, while the right one (functions area) included all the buttons for accessing the different services and functionalities (Fig. 4). This design was decided in order to facilitate the interaction, based on the assumption that the majority of users are right-handed. In the function area the different applications were grouped in a personalized way, according to the importance for the user and the frequency of use (i.e. chronic patients would have on the top of the screen the services related to their illness, while other secondary applications, such as domotic control, would be placed at the bottom).

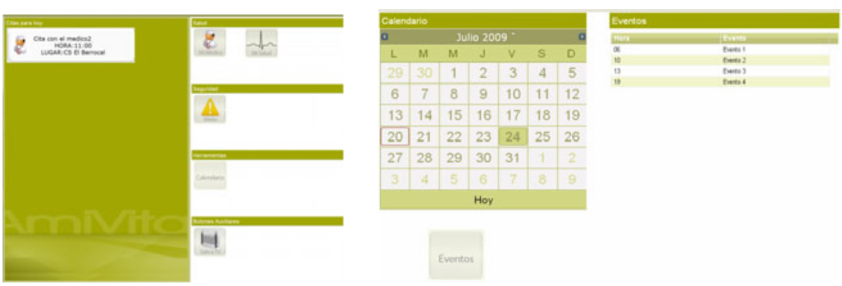

Fig. 4. This figure illustrates two examples of the second prototype of AmIVital user interface, showing colors, visual elements and position of the interaction elements

This second prototype of the interface was also validated with five end users, in order to assess the appropiate personalization of the services and applications according the user profile. Again, all participants were senior citizens living independently in their own houses with different levels of chronic illness or disabilities. The number of assessed services and their paticular combination were different for each participant, as it is shown in Table 2.

Table 2. Validation of 2nd prototype. Distribution of services per participants and age.

Participant	Service distribution	Participant's age
1	Videoconference with 2 vital signs monitoring, personal alarms, and reminders	65
2	Videoconference with 4 vital signs monitoring, domotic control, reminders, calendar, personal alarms	75
3	Videoconference with 3 vital signs monitoring, reminders, personal alarms	71
4	Videoconference 5 vital signs monitoring, domotic control, personal alarms, calendar	68
5	Videoconference with 5 vital signs monitoring, domotic control, personal alarms, calendar	76

The results showed that the acceptance of the system was very much affected by the number and distribution of elements on the screen. Users who had a reduced number of services in their interfaces gave very high rates to the system (participants 1 and 3), as well as to the selected device (the tactile screen), and the use of visual metaphors introduced to increase the usability and learnability of the interface. However, the acceptance decreased considerabily when the number of services was very high, forcing the interface to introduce scrolls or rotate menus (participants 2, 4 and 5). Addionally, results showed differences between young and old seniors. While old seniors considered the general design simple and easy to use, young seniors judged it as little attractive or low interactive. Finally, three participants appreciated the introduction of alternative interaction modalities, like sounds (participants 1, 3 and 5).

3.2 Third Version Prototype

The third and final version of the interface aimed at including multimodality access and creating a more attractive design, in order to increase the acceptance of the young elderly users and to provide alternative interaction methods. The design comprised the two well-accepted features of the previous prototypes: the TV-set navigation and the use of visual metaphors in the graphical user interface (GUI). Once again, a GUI was the basic interaction method, but in this case, the design also supported multiple interaction devices (i.e. PC, touch screen, TV set with remote control, Wii remote control, or web camera that detects the user's hand movements). Moreover, alternative interaction methods have been implemented into the final system, such as Text-to-Speech Technology (TTS), included as a support in some applications like the reminders, and Voice Recognition (ASR), as a secondary interaction method for the final users. These multimodality features were especially devoted to tackle the technophobia problems experienced by older seniors, by helping them to establish a natural dialog with the system and, therefore, increasing its acceptance (Fig. 5).

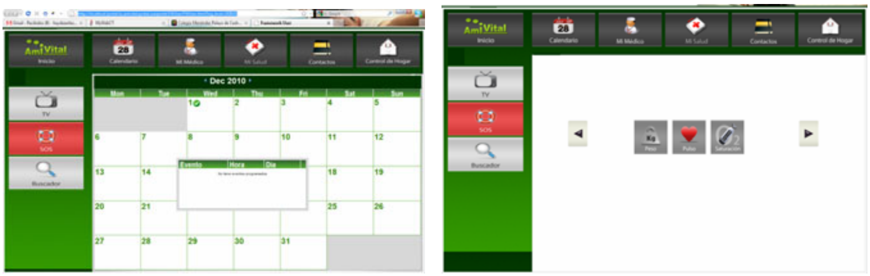

Fig. 5. This figure illustrates two examples of the third prototype of AmIVital user interface, showing colors, visual elements and position of the interaction elements

The validation tests of this final version have been especially focused on the multimodal and multi-device interaction aspects. The tests have taken place in the Ciami Living Lab [8] in UPM dependencies, involving six elderly users, living independently in their own houses (Table 3). Participants were free to use the graphical, voice recognition or text-to speech interactions, as well as different devices, in order to validate the diverse offered options.

Although the evaluation of the final interfaces has not finalized yet, preliminary results show high levels of acceptance of the multimodality functions among elderly, especially with the voice interaction. In the upcoming months, additional tests with end users have been planed, in order to assess all aspects of the developed user interfaces and AAL services.

Table 3. Validation of 3rd prototype. Distribution per participants and age.

Participant	Participant's age
1	65
2	78
3	69
4	72
5	71
6	73

4 Conclusions

AmIVital project final user interfaces have proved to be completely adaptable to the user needs and context, personalized in terms of desired services, and device independent. The design methodology utilized, the iterative development and intermediate validation procedure, and the involvement of end users in the different steps of the implementation, constitute an effective and efficient technique for developing AmI services' intelligent interaction. The validation of the resulting system with end users has shown high levels of acceptance, promising a quick and easy adoption the proposed AAL services once they are introduced into the market.

The final validation results are really promising. Participants who took place in the validation of the final prototype show high levels of acceptance and interest of the system. Their comments during the whole validation process were very useful to improve the interaction framework and a challenge for user interface designers.

As results of the process, the final interaction framework implementation has achieved high and accurate levels of adaptation and personalization that is expected to contribute to a better acceptance of the AAL services in the future and, therefore, to improve citizen's quality of life.

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