Technological Assistance Tool for Elderly´s Autonomy Enhancing and care-givers support based on the use of portable devices and the Web

Cristina Rodríguez-de-Pablo, Miguel Loichate, Noelia Oses, M. Feli González, Cristina Buiza, Javier Yanguas

***Abstract*— This paper presents the development of a personal assistance tool based on the use of a PDA (personal digital assistant) to support elderly people with activities of daily living (ADL). Most ADL's require the use of cognitive capabilities such as memory, attention and orientation which are often in decline in old age [1]. Thus, this tool firstly aims to compensate for these impairments and promote the autonomy and independency of elders with the aid of an adapted and easy to use mobile device. And secondly, it also aims to support their care-givers by means of a web portal. Periodical, automatic data synchronisations allow keeping the mobile device and web portal up-to-date with each other via wireless communications.**

I. Introduction

Elderly people present a series of needs and limitations to carry out some activities of daily living on their own due to a kind of cognitive impairment caused just by age (Age Related Cognitive Impairment) [1]. The increase of life expectancy in developed countries and the ensuing change in the population pyramid [2] has given rise to, first, an alarming decrement of the number of potential care-givers per elder; and second, a considerable rise in the public expenditure for the assistance of this growing collective. And this problem has only just begun.

For this reason, this project aims to take advantage of the new technologies to give support to this group in their daily activities, enlarging their autonomy as much as possible and delaying a situation of partial or complete dependence, thus increasing their quality of life.

Previous to defining a technical solution, the State of the Art was analysed extensively and, as a result, three main conclusions were drawn. First, most of the applications and devices found are focused on a particular problem covering a specific need; there is a lack of modular and expandable solutions to cater for a wide range of needs. Second, most of the applications and devices found are not adapted to the user's cognitive level or capacities. And third, most of them only deal with the patient's role.

Also, a triple analysis of needs, interaction with NTIC's and an optimum interface for elderly people was carried out in collaboration with expert gerontologists and neuropsychologists.

It is of crucial importance to this project the fact that the research has been carried out by an interdisciplinary consortium composed by Fatronik (a technological research centre) and Ingema (a scientific research centre from the field of attention to the elderly). So, the characteristics of the designed solution (modularity, adaptability, etc), the decisions of the use cases (memory help, vital signs control, etc), requirements, targets, etc have been arrived to in rich discussions between the two partners and with the involvement of end users from the beginning of the project.

II. TECHNICAL SOLUTION

This project tries to stand out from the rest by being as complete and adaptable as possible.

First, it consists of a base platform and modules, which can be added or removed depending on the needs of the patient. Second, the tool takes into account not only the elders, with the personal device but also the people in their environment (relatives, clinicians, caregivers…), by means of the web portal. Third, it also provides different profiles to cater for the different disabilities of the users, i.e. for an advanced patient all the features will be available while some of them will be omitted for the less advanced ones. This also allows the tool to be adapted according to the progression of the cognitive decline of the patient. Finally, it provides a really easy to use interface designed in close collaboration with experts and end users.

Specific software application modules have been developed both for the mobile device and the web portal. Being modular, the possibilities for the tool are endless. At the moment, as well as the base platform, four modules have been developed: Memory assistance, Vital Signs control, Localization and orientation, and Communications.

Memory Help:

One of the major and more prevalent cognitive deficits shown by elderly people is memory related problems [3]. This memory loss gives rise to the need for help to carry out activities like taking medicine, remembering events (going to the doctor, birthdays, ..), doing the shopping list, etc.

Manuscript received April 30, 2008.

C. R., M. L. and N. O. Authors are with the Health Unit in Fatronik Foundation, San Sebastian, Spain ({crodriguez / mloichate / noses}@fatronik.com).

M. F., C. B. and J. Y. Authors are with the Matia Gerontological Institute Foundation, Ingema, in San Sebastian, Spain ({fgonzalez /cbuiza/ jyanguas} @fmatia.net).

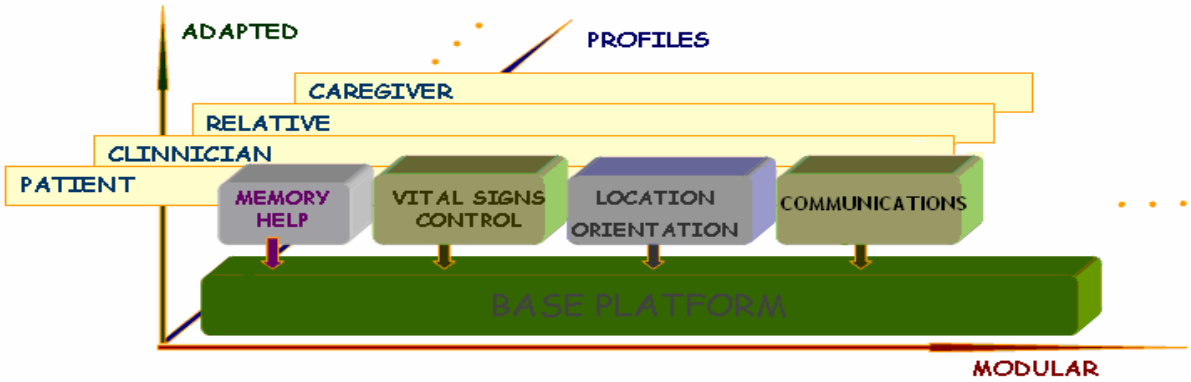

Fig. 1. Conceptual architecture of the entire system: an expandable modular solution, adapted and catering for the different profiles involved.

The memory help module is basically an activity planner. The patient can manage his own easy-to-use agenda or just receive, in his portable device, the warnings about the activities and instructions given by his caregiver or appointments arranged by his doctor from the Web.

In this way, for example, a doctor will login to the application using his username and password and will see a list of all the patients he treats. Then, he can select a specific patient to see the evolution of his illnesses and, if necessary, enter a medical appointment for the patient. This appointment will be stored in the server's database. Next time the patient synchronizes the data with the server, the patient will be able to see the appointment the doctor has entered for him. This will bring an enormous saving in time for both the patient and the Administration, and therefore a saving in money. Relatives and care givers will be able to introduce other kinds of activities to remind the patient to take his pills, to do his tasks at home, etc.

This module is also very useful for the caregivers to track the patient's activities and tasks, to be able to detect a hypothetical worsening of certain cognitive capacities or anomalous behaviours.

Vital Signs Control:

This module consists of an application developed to acquire data from sensors the user is wearing, like a pacemaker, or from devices the patient uses to measure any parameter, like glucose level in blood or blood pressure.

This module helps the patient monitor his illnesses and it also allows the clinicians to have important patient data available on the web portal without needing the patient to be present at the surgery, allowing an improved and more continuous illness monitoring.

A practical application of this module has been developed focused on Diabetes Mellitus due to the high incidence of this illness in elders and the intensive care that it needs [4]. This module consists of different sub-modules, each of them focused on the control of a different aspect related to the illness. Firstly, the glucose control, with the help of a glucometer which acquires the glucose level in blood, automatically downloads the measured value to the PDA. Secondly, the weight control has an easy-to-use interface that allows advanced users to record their weight daily. And finally the nutrition control, which includes two applications that help the patients configure their shopping lists and their daily menus based on a list of recommended, limited and prohibited foodstuffs personalized by the doctor through the Web.

Location/Orientation:

Another important problem that elderly people suffering from early stages of dementia suffer very often is the orientation problem [5]. It is very usual for them to get lost and to find it difficult to find the way back home.

In order to avoid this, this module includes a GPS [6] (either integrated in the PDA or external via Bluetooth communication [7]) which provides the current position of the user. The user himself can know where he is, and the relative or caregiver will have access to the patient's exact location at the web portal.

Communications:

This module intends to offer the functionality of a mobile phone, which is truly useful for the elders. By means of a sensorial and cognitive adapted interface, it tries to make their interaction with this new way of communication as easy as possible. This application caters for a reiterated demand of the patients involved in the discussion groups and testing.

The module offers the patient the possibility to make phone calls and to send predefined SMS to a reduced group of contacts defined by his relative/caregiver from the Web portal. For advanced users, there is also the possibility to dial a number.

To be able to subscribe to this module the user will need to have a PDA with phone functionality, that is to say, any PDA with an operating system subsequent to Windows Mobile 5.0 Phone or Windows Mobile 6.0 [8].

All the modules described above were developed taking into account the user requirements. Exhaustive analysis and testing of these issues was carried out in order to

achieve friendly and easy to use interfaces. An intuitive way of navigation, instruction screens and an emergency button are available everywhere in the application. Besides, all user interface related parameters (colours, icons, sounds…) and other aspects can be easily configured for each patient/user by the administrator from the Web portal.

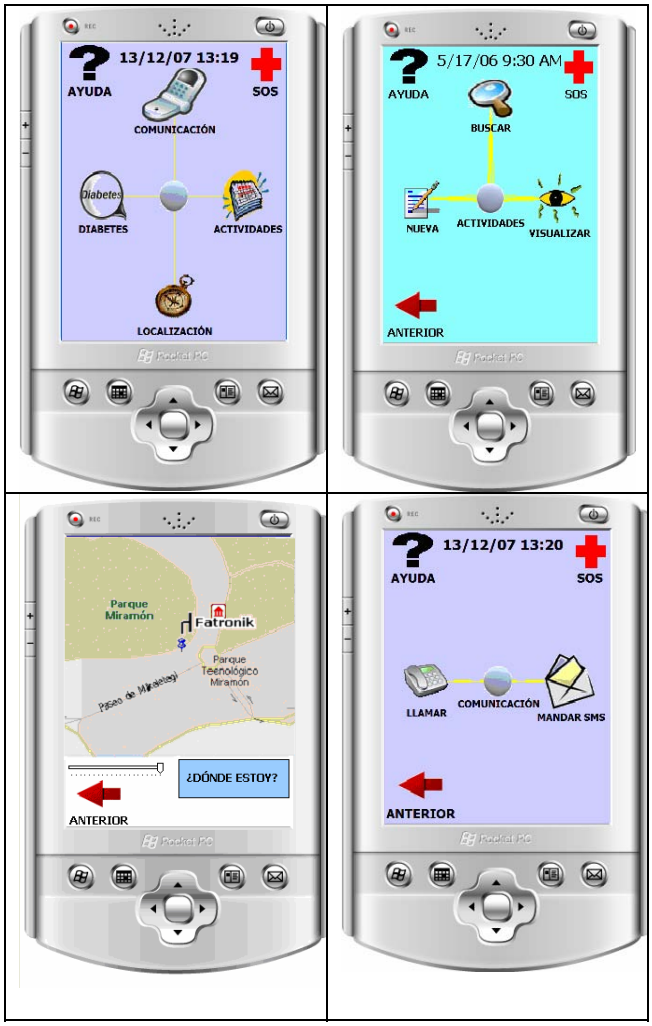

Fig. 2. Different screens of the mobile application

III. TECHNICAL SPECIFICATIONS

As mentioned before, the system is composed of two main different scenarios: a software application that runs on a commercial mobile device the user/patient carries with him; and a kind of web portal where doctors, relatives and caregivers can track and support the patient.

In addition, periodical, automatic data synchronisations allow keeping the mobile device and web portal up-to-date with each other via wireless communications. On the one hand, this bidirectional synchronization lets the user download changes entered by the doctor or the relatives from the Web application, such as configuration aspects, new appointments or changes in the personalized diet. And on the other hand, it lets upload to the server the local changes, for example the current coordinates of the user, glucose data, programmed activities, etc.

Fig. 3 shows a schema of the whole system.

A. Mobile user

A PDA was chosen as the optimal portable device due to its characteristics: big processing capability, big touch screen, the possibility of integration of a local database, big storage capacity and communication capabilities (Wifi [9], Bluetooth, RS-232 [10], etc).

The software application running on the PDA relies on Microsoft‘s Compact Framework 2.0 [11], which is a subset of Microsoft’s .NET Framework 2.0 that targets mobile devices. This set of libraries offers rich functionality to make the most of current mobile device capabilities and allows the application to run on most of the mobile devices that are currently in the market, with any Windows operating system newer than Pocket PC 2003 (Windows Mobile 2003). Third party controls and the Smart Device Framework [12] have also been used to enrich and extend the functionality of the Compact Framework.

B. Web portal

Following with the Microsoft technologies, ASP.NET 2.0 [13] has been selected as the base technology for the development of the Web application. This is nowadays a mature framework that includes many improvements; for example role-based security and personalization, which allows our application to be personalized depending on the profile of the web user (administrator, doctor or relative/care-giver) and on the patient assigned to it.

This Web application works against a SQL Server 2005 database [14]. This powerful backend database from Microsoft was chosen due to the optimal integration provided between this technology and the .NET framework.

C. Synchronization

The mobile application works locally and it periodically synchronizes data with the server. It stores all the data in a local SQL Mobile database [15], the SQL Server version for Windows Mobile devices. This technology, together with Compact Framework 2.0, provides easy-to-configure synchronization methods between databases.

On the server side, as previously said, the application relies on SQL Server 2005. There, the data is stored and the synchronization with the user’s device is configured..

For the data synchronization, the mobile application tries to use a free network connection, such as LAN or WIFI, first. When these networks are not available, the application tries to open a GPRS connection [16], it synchronizes data with the server and it closes the connection. If it’s not even able to synchronize over GPRS, the user can still work locally; in the next synchronization interval or whenever a network connection is available, the synchronization will take place in a transparent way.

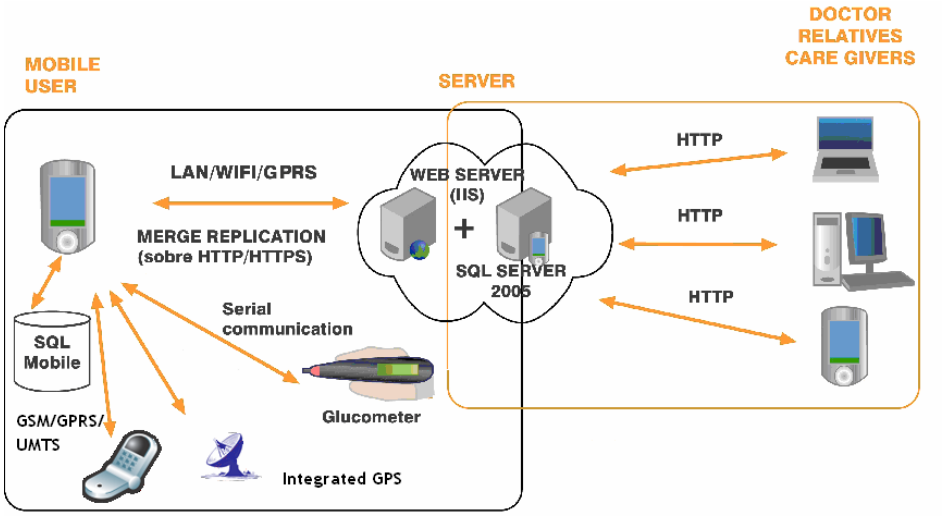

Fig. 3. Technical architecture of the entire system.

There are several data synchronization methods between mobile devices and a server. After diligent testing and feature comparison [17] between the three possible methods: Web Services, RDA and Merge Replication; the last one was chosen as the most appropriate one in this case due to its characteristics. Merge Replication provides automatic data compression and encryption, custom conflict resolvers, different kind of filters and less client-side configuration.

IV. TESTING

The first step taken in order to make a valid requirements definition was to organise discussion groups with potential real users of the system. In the discussion groups, the participants completed three kinds of questionnaires: (1) history of the participant (mainly socio-demographic data and history of his/her interaction with new technologies); (2) a technological questionnaire, about their needs/requirements regarding functionality, interfaces, etc; (3) a psychological questionnaire, about their feelings and their attitudes towards new technologies in general, and towards this system in particular. A total of 70 elderly people participated in these groups. Discussion groups with experienced professionals were also organised. In those groups several interviews were conducted with the aim of gathering the requirements for the system. Quantitative and qualitative data was taken into account. A first sketch of the tool was shown to them in order to get their impressions on how it would fit their needs, how usable it would be, etc. The data collected from these two kinds of groups was compiled into the first draft of the user requirements specification.

Then, the first real prototype was tested with real users (7 diabetes patients) to get feedback regarding usability issues. The methodology used was field testing. With this information, some modifications were developed taking into account the user opinions and several application testing groups were organized. As this shows, an iterative approach to design was adopted in this project. Each one of the modules was tested and improved after testing. A validation test was carried out after integrating all the modules. In these testing, real end users tested the PDA on their daily life for a week.

Finally, in order to validate the entire system, a final testing was carried out. 14 real end users (8 men and 6 women) participated in this testing; their ages ranged from 51 to 70 years. Participants had to carry out some proposed tasks with the system. This test had a triple objective:

1. To verify that the final system satisfies the needs of elderly people
2. To prove that the interface and the system are easy to use for elderly people
3. To verify that the system works suitably both on the PDA and the web platform.

All the questionnaires used in this test were exclusively developed for this issue. All of them were based in a Likert scale.

The main results were the following:

- All the participants in the validation test found that their needs are addressed by the system.
- In the list of “things to do” with the device the instructor asked the participant to perform several tasks with the PDA (e.g. to create an appointment, to send a SMS to his/her wife/husband, to shape a menu, to control the glucose…), and with the web platform (to introduce a new activity…). Two measures were taken into account: the speed and the accuracy while carrying out these tasks. After a short explanation about how the system works, all the participants were able to perform these tasks quickly and without mistakes.
- The system (both the PDA and the web platform) has worked without any important technical problems during the test.

Regarding how users found the interaction with the system, their contributions could be summarized as follows:

- The device doesn’t cause bad feelings such as invasion of intimacy or embarrassment.

Only one of the participants mentioned the intimacy invasion.

- Five of the participants mentioned a dependency feeling; they defined this dependency like the dependency that they feel with their agenda.
- Elderly people think that the system will contribute to making them feel safer.

End users positively assessed the following points:

- The different functionalities of the implemented modules.
- The possibility of personalizing the interface to the user, taken into account their previous level of interaction with the technologies.
- The ease of use of the interface.

V. CONCLUSION

Other modules that are being considered for implementation in the future are: leisure and entertainment combined with cognitive decline monitoring and rehabilitation, sensory compensation, smart home, etc. Thanks to its modular architecture this system leaves the door open to the creation of a whole range of services provided by third parties, both for the mobile application and the Web portal.

In addition, other profiles could be added to the Web portal for other groups of people involved (chemists, other trades, transport systems, etc).

ACKNOWLEDGMENT

Special acknowledgment to the Association of Patients with Diabetes Mellitus in San Sebastian, and all the individuals and professionals who have taken part in the testing for their voluntary collaboration in the project.

REFERENCES

[1] Perneczky, R., Pohl, C., Sorg, C., Hartmann, J., Tosic, N., Grimmer, T., Heitele, S., Kurz, A. (2006). Impairment of activities of daily living requiring memory or complex reasoning as part of the MCI syndrome. Int J Geriatr Psychiatry. 21 (2): 158-62.

[2] Chande, H. (2001). Esperanza de vida y expectativas de salud en la edad avanzada. http://www.redadultosmayores.com

[3] Craik, F. I. M. (1990). “Changes in memory with normal aging: a functional view”. Adv Neurol., 51, 201-205.

[4] Wild, S., Roglic, G., Green, A., Sicree, R., King, H. (2004). Global prevalence of diabetes. Estimates for the year 2000 and projections for 2030. Diabetes Care, 27 (5): 1047-53.

[5] Kalova, E., Vlcek, K., Jarolimova, E., Bures, J. (2005). Allothetic orientation and sequential ordering of places is impaired in early stages of Alzheimer´s disease: corresponding results in real space test and computer test. Behav Brain Res, 159(2): 175-86.

[6] GPS http://www.gps.gov/

[7] Bluetooth specification https://www.bluetooth.org/spec/

[8] Windows Mobile http://www.microsoft.com/windowsmobile/default.mspx

[9] Wifi http://www.wi-fi.org/

[10] RS232 http://www.camiresearch.com/Data_Com_Basics/RS232_standard.html

[11] NET Compact Framework 2.0: http://msdn2.microsoft.com/en-us/netframework/aa497273.aspx

[12] Smart Device Framework from OpenNETCF: http://www.opennetcf.org/home.ocf

[13] ASP.NET 2.0: http://www.asp.net/

[14] SQL Server 2005: http://www.microsoft.com/sql/default.mspx

[15] SQL Mobile: http://www.microsoft.com/sql/editions/sqlmobile/default.mspx

[16] Synchronization methods (RDA & Merge Replication): http://209.200.119.101/Articulos/Articulo.aspx?ID=16 http://msdn.microsoft.com/library/?url=/library/en-us/dnppcgen/html/sql_serverce_replication_net.asp http://msdn2.microsoft.com/en-us/library/ms172916.aspx http://msdn2.microsoft.com/en-us/library/ms172367.aspx http://msdn2.microsoft.com/en-us/library/ms172917.asp

[17] GPRS http://www.gsmworld.com/technology/gprs/index.shtml