Smart Assistive Technologies to Enhance Well-Being of Elderly People and Promote Inclusive Communities

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Abstract. Within the framework of the H2020 IN LIFE project we have designed and developed two ICT services related to independent living and travel that support home activities, communication, mobility and socialization. A brief overview of the Spanish pilot, in which these solutions will be tested, is presented describing the inclusion and exclusion criteria, use cases, actors, as well as the services that will be tested. The manuscript also presents the description of functionalities and characteristics of the developed ICT services.

Keywords: AAL · Mild cognitive impairment · Elderly people · Assistive technologies · Well-being · ICT services · Inclusive communities

1 Introduction

Rising population longevity calls for increasing the quality and efficacy of health care and social support services demanded by the growing elderly population sector [1]. In particular, elderly people affected by mild cognitive impairment (MCI) might benefit from assistive technologies [2]. As MCI and early dementia entails memory decline and impairments in daily functioning ability that gradually worsen, ICT solutions that help them to improve their well-being, as well as promote communities more inclusive and adapted to their specific needs are needed. This manuscript is organized as follow. Section 1 presents the introduction describing the context in which the designed solutions are based, and a brief overview of the Spanish pilot approach in which they will be tested. Sections 2 and 3 describe the two ICT services designed and developed to address the needs of people with cognitive disabilities and/or reduced mobility in two areas: independent living and travel support. Finally, Sect. 4 presents the conclusion and the future work that is planned to be accomplished.

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1.1 IN LIFE Project Context

Following the challenges proposed by the H2020 call on "Advancing active and healthy ageing with ICT: ICT solutions for independent living with cognitive impairment" (PHC-20-2014) the IN LIFE project aims to "*prolong and support the independent living of seniors with cognitive impairments, through interoperable, open, personalized and seamless ICT services that support home activities, communication, health maintenance, travel, mobility and socialization tasks, with novel, scalable and viable business models, based on feedback from large-scale and multi-country pilot applications*" [3]. The specific objectives of the IN LIFE project are:

- To connect a wide range of adaptable ICT solutions for elderly with various cognitive impairments, into a common open reference architecture, to allow their interconnection and enhance their interoperability.
- To instantiate applications, services and business models to different geographical and sociocultural backgrounds, user group types (i.e. early dementia, moderate dementia, etc.), as well as lifestyles (i.e. living at home alone or with spouse, living at elderly home, traveling, etc.).
- To provide tools and systems for services adaptation and personalization, to meet the different needs and wants of each individual in a dynamic way, allowing services to evolve together with the users' health and condition.
- To provide tools and instructions to carers of people with cognitive impairments and/or dementia in order to support communication and functioning in daily life.
- To estimate the return of investment of the different business models and connected services through pilots in 6 sites Europe wide and highlight best practices for relevant viable business and financial models for their uptake and instantiation per region and market.
- To issue key guidelines on the proper and ethical application of the proposed business models, to guarantee the respect of users' wants, lifestyle, personal data and personal beliefs.
- To study the scalability and sensitivity of the tested business models and cases and provide guidelines on their optimal application in different financial, sociocultural and healthcare contexts.

The IN LIFE project is starting to conduct six pilots in six different sites: UK, Sweden, The Netherlands, Spain, Greece, and Slovenia. All sites cover holistically multiple services for elderly citizens with cognitive impairments, but each has different focus areas and diversity in ICT solutions offered for Ambient Assisted Living (AAL). IN LIFE will be able to ensure a good spread of test participants in terms of age, family status, socioeconomic status, location and ethnicity, by conduct long-terms tests with over 2100 users, in total; 1.200 with cognitive impairment and over 600 carers. Table 1 shows the main user groups targeted. This stratification of users allows to easily identify the needs and requirements using an extended evaluation framework that will address separately each user group and will be flexible to accommodate the potential transition of users from one group to the next.

In addition, other type of users will be stakeholders with an interest in IN LIFE solutions, but not with a direct involvement in day-to-day care provision. Some main

Table 1. IN LIFE main user groups.

User group	Description
Mild Cognitive Impairment (MCI)	Elderly who have lost cognitive functioning on at least one aspect with no sign of dementia and still functioning in daily activities
Early and later stages of Dementia	People that have been diagnosed with dementia but they are still maintaining some aspects of their daily functions (early signs of dementia are apparent) and people have been diagnosed by specialists and might be under medication
Cognitive impairment as a co-morbid condition	People with other conditions and diseases with cognitive impairment and other conditions as co-condition
Caregivers	Either formal (i.e. healthcare, social), or informal (i.e. family members and friends) that need to be empowered with knowledge and tools to support the elderly at their everyday life activities

stakeholders related to the IN LIFE approach are: (1) regulatory authorities on local, national or international level; (2) user interest organizations; (3) standardization organizations; and (4) public bodies, insurance companies and care organizations. The evaluation method will follow a longitudinal evaluation framework for a long-term evaluation characterized by a dynamic user-centered approach, in which the idea is to compare everyday living experiences of people with cognitive impairment with and without the IN LIFE system. It will focus on three main dimensions: (D1) QoL & Health Status; (D2) Sustainability of Health and Care systems; and (D3) Innovation & Growth. Each dimension will be addressed measuring different primary and secondary indicators. D1 will measure the Health related Quality of Life (HRQOL) including: physical activity, cognitive decline, functional status, fall, nutrition, and mental health. D2 will address change in resources or unit for resources, including: comparison of hospital care vs. home care, potential for care process improvement and cost gains, and the positive and viable Rol and SRol. Finally, D3 will measure innovation indicators such as: number of implemented technologies, and number of deployed technologies to users.

1.2 Spanish Pilot Description

Each pilot site tests a number of IN LIFE services that are different for each site but all represent important daily activities. In the case of the Spanish pilot we (Universidad Politécnica de Madrid), together with the Regional Transport Consortium of Madrid (CRTM) and the Matia Gerontological Institute (INGEMA), will test the following services: (1) daily functions assistant; (2) activity monitoring and coaching; (3) virtual gaming; public transport support; (4) care giving monitoring and supervision; and (5) caregiver scheduling and reminding.

The Spanish pilot will test two application modules, one for independent living support called “Daily Function Assistant module” and other for travel support called “Public Transport Support module,” that is described in the following sections. These

solutions will be tested with 220 elderly users with cognitive impairments, 60 health care professionals, 120 informal carers and 11 stakeholders. In total 431 users will test the proposed solutions. Also different use cases will be evaluated combining different functionalities of the applications. Table 2 shows the defined use cases for the Spanish pilot.

Table 2. Defined use cases for the Spanish pilot.

	Use case	Description	Primary and Secondary actor (s)
Independent living support	Home environment control with NFC pictograms	Control of domotic house appliances (lights, doors, blinds and media player) using pictograms	Healthy Elderly; Elderly with MCI; Early Dementia; Elderly at home
	Make a call with NFC pictograms	Making a call choosing the image of the person	Healthy Elderly; Elderly with MCI; Early Dementia; Elderly hospitalized and at home; Family members & Informal caregivers
	Send SMS messages with NFC pictograms	Composition of a SMS message using the desired pictograms. Send the message choosing the image of the person	Healthy Elderly; Elderly with MCI; Early Dementia; Elderly hospitalized and at home; Family members & Informal caregivers
	Smartphone functionalities control with NFC pictograms	Control a subset of elementary smartphone functionalities (battery status, date) and management of settings (silent mode de/activation, toggle Wi-Fi, etc.) using pictograms	Healthy Elderly; Elderly with MCI; Early Dementia; Elderly hospitalized and at home
Travel support	Favorite Journeys Database Arrangement	User and carer registration into the Server by means of a username and password. Both of them have to be able to create, consult and update the data User manages his/her own database of favorite routes, analyzes the routes and the possible critical points in its itinerary, and assigns them one or more checking points	Healthy Elderly; Elderly with MCI; Elderly at home; Family members & Formal and Informal caregivers; User interest organizations; Public bodies, insurance companies and care organizations

(*continued*)

Table 2. (*continued*)

	Use case	Description	Primary and Secondary actor (s)
	Personalized Journeys Database Arrangement	The final user and the caregiver make out the list of preferred routes giving them some symbols for easier and quick recognition	Healthy Elderly; Elderly with MCI; Elderly at home; Family members & Formal and Informal caregivers; User interest organizations; Public bodies, insurance companies and care organizations
	Personal journey navigation and tracking	Increase or create confidence in the Public Transport Network. Increase of his/her journeys/week ratio to expand his/her personal autonomy and experience in social relationships	Healthy Elderly; Elderly with MCI; Elderly at home; Family members & Formal and Informal caregivers; User interest organizations; Public bodies, insurance companies and care organizations

The inclusion and exclusion criteria defined are the same for all pilot sites, but each site will use their own diagnostic tools for categorizing and allocating users in different groups. The inclusion criterion is defined as follows:

- Mini Mental State Examination (MMSE) score or equivalent: 18–26.
- Cognitive impairment diagnosis after complaints, with not physiological measurements indicating Alzheimer's Disease (AD) (just Mild Cognitive impairment; MCI), unless stated otherwise [4].
- Good functional level.
- Still independent in most daily activities (Index of Activities of Daily Living - IADL)
- Diagnosis from specialists.

For the exclusion criteria we have defined the following rules:

- Participants with psychiatric or substance abuse.
- Only comorbid conditions stated in the recruitment will be included.
- Participants who cannot consent will not be included in the study unless stated otherwise in their pilots' objectives and covered by their ethics approval.

Also other exclusion criteria relate to: (1) other medication intake; (2) history of alcohol, drug abuse; and (3) history of psychiatric illnesses; will be followed.

2 Daily Function Assistant

The Daily Function Assistant is a tool that enables users to be assisted in their daily living activities by means of the NFC technology. It is composed by two components: (1) scanning a tag to perform an action; and (2) recording a tag to configure a desired functionality. In the first case, the users can trigger a pre-defined action only by scanning the smart tag related to the action. For example, Fig. 1 shows a user scanning a smart tag already configured to "call Alison". The user scans the smart card and the smartphone automatically calls Alison. There are many possibilities depending on the actions and functionalities previously recorded in the smart tag.

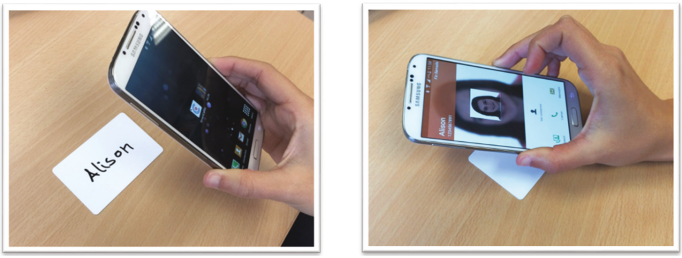

Fig. 1. Make a call example.

The recording application, designed for Android smartphones, allows to create physical smart tags that automatizes a wide set of functions addressing different options such as: identifying objects, controlling the phone, making a call or communicate and express needs or emotions. Those actions can be configured so the user just needs to naturally scan one of these tags in order to automatically trigger an action. Figure 2 shows the main menu of the recording application.

Within the recording application, users have eight types of functionalities in order to create a smart tag:

1. *Mobile settings*: users can put the device in Normal, Silent or Vibration mode, know the date and time, the device battery level, switch on and off the Wi-Fi and Bluetooth, and increase/decrease the volume;
2. *Contacts*: users can record a number into a tag, or record any number by typing or choosing it from the contact list;
3. *Pictograms*: there is a set of pre-defined Alternative and Augmentative Communication (AAC) tags with pictograms that represent an action, a need or a feeling [5]. Users could also create personalized pictograms by choosing an image from the device gallery or by taking a photo. With these pictograms users can compose a text in natural language by scanning them (limited to two pictograms);
4. *Music*: users can control the open VLC media player once it has been configured;
5. *Reminders*: users can create and define reminders. They are able to store a text or configure a voice alarm;

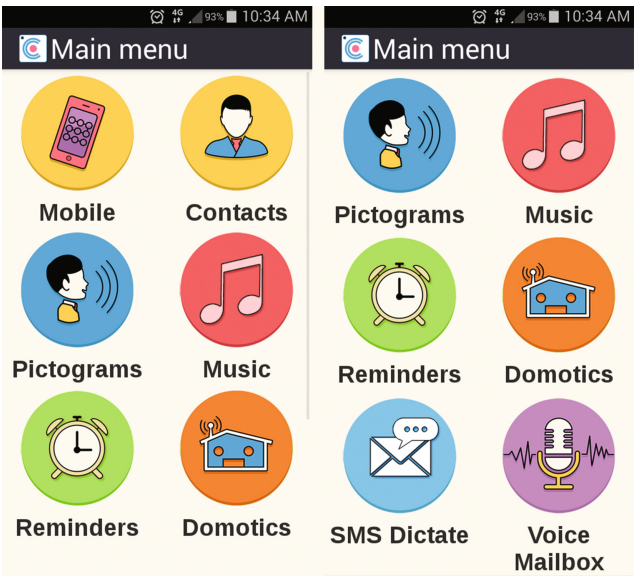

Fig. 2. Recording smart tags - main menu.

6. *Domotic controls*: pictograms that can automate a domotic action targeting the UPM's Living Lab domotic system;
7. *SMS Dictate*: after composing a text, the user can scan a contact tag and an SMS with the composed message will be sent;
8. *Voice mailbox*: allows to create a private communication channel from one to many users, where they cloud store voice messages that are saved on the cloud;

3 Public Transport Support

Regarding the travel support approach, we have developed an application to provide public transport support, called MY ROUTES. MY ROUTES is an on-route assistant composed by a Web-based portal and an Android mobile application for guiding persons with reduced mobility (due to cognitive impairments related to age, illnesses, foreign language, and/or other issues related to accessibility) while travelling by public transport, specifically inside the Madrid bus network.

3.1 The Web-Based Portal

The Web-based Application allows the carer and/or the end user to configure usual routes they use on daily basis and register them using a map interface similar to Google maps (see Fig. 3). The configured routes will be kept in the server protected and recovered by means of registry and password through the IN LIFE portal.

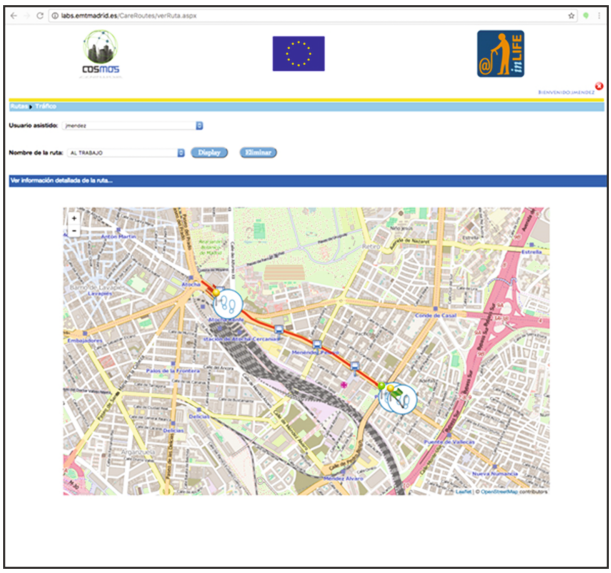

Fig. 3. Web-based portal.

The following are the options and functionalities endorsed within the application:

- Favorite routes (origin-destination) contain on-foot and on-board bus laps including bus changes.
- Favorite routes will be registered and associated to a particular user and features (time laps, days of week, duration, etc.).
- There is no restriction in the number of favorite routes.
- Favorite routes can be classified by an assorted number of personal utilities, for example: day of week, period of the day and number of invocations.
- The carer could use "Check-in" points to monitor the journey. These points can be defined by the user, the carer or both. Also, there are several "check points" already defined such as: route start and end point; and the stop where the user takes or leave the bus. The carer will be notified during the entire user's journey while on-route about their performance, and will be notified also by SMS if any contingency occurs.
- The selected routes could be visualized anytime on the Web Portal.

3.2 Mobile Application

The mobile application allows people with reduced mobility, to travel using the public transport with the confidence of not getting lost. The application will guide the users in their journey indicating which is the bus they need to take and the stop where they need to get off in order to reach the desired destination. Also, using the Wi-Fi access inside the bus, the application provides different resources to get essential information regarding the current state of the trip, such as the next stop or the remaining time to

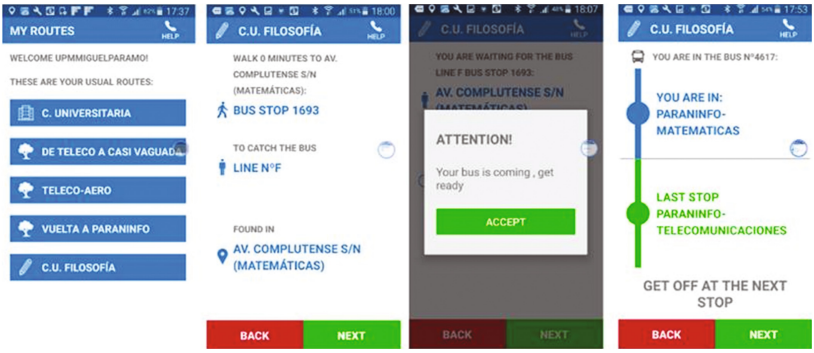

Fig. 4. MY ROUTES application screen shots.

reach the destination, etc. Using the smartphone GPS, the application sends the position of the user to the Web-based portal, so the carer obtains also information about the user's journey.

Figure 4 presents some screen shots of the functionalities of the mobile application listed below:

- The users can choose one route among their favorite routes.
- The chosen route is shown on users' mobile smartphone, showing all the stops in an accessible and easy to understand way.
- The tracking starts at the beginning of the initial point of the journey (first checking-point), including walking to the nearer stop.
- Every 30 s the mobile application checks the position of the user and verify if he/she is correctly located and follows the track of the chosen route.
- The carer will be informed about every deviation from user's destination. If any deviation occurs the user will also receive a SMS through the mobile smartphone notifying the deviation. This SMS message will include user's actual position.
- If the user is approaching the end of the route, he will be advised to get off the bus 200 m before the last stop.

4 Conclusions and Future Work

The Daily Function Assistant and the Public Transport Support modules have been technically tested and different versions have been released, in order to follow an iterative development cycle. The current final releases are widely compatible with different commercial Android devices and the different available versions of OS. Also different elements of the user interfaces were improved according to the recommendations from the end-users' organization in order to increase the usability of the overall solutions. The developed solutions are currently being tested within the IN LIFE project specifically in the Spanish pilot site, which will last at least 10 months. After the end of all IN LIFE pilots, different types of analysis (e.g. cost-effectiveness, cost-benefit, usability, effect on care provision and QoL, etc.) will be conducted and published accordingly.

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