Towards an Architecture Supporting Social, Adaptive and Persuasive Services for Active Elderly

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ABSTRACT
In this paper we present the architecture of a platform with the goal to support social, context-aware and adaptive/persuasive services aimed at stimulating the elderly to stay active/occupied in life. The platform is Web-based and consists of several modules whose main features are presented and discussed in the paper.

Author Keywords
Adaptation; Social aspects; Web-based architecture; Elderly.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Human Factors; Design; Languages.

INTRODUCTION
Nowadays, population ageing is a common phenomenon in various countries, which has important implications on the labour market, as the ratio between the number of inactive individuals and the ones still active in the workforce will continue to rise [1]. This leads to the consideration that for the economy and public health older workers should be encouraged to participate in or continue doing occupational activities, as there are several advantages. Indeed, raising the retirement age would increase the labour supply, so producing increased revenues from work and tax, and lead to lower pension costs. At the same time, there would be greater equity and intangible benefits for older workers e.g. improved sense of purpose/usefulness, respect, autonomy and higher self-esteem. Moreover, providing each person with a job could give them a sense of worth and responsibility, which adds more value to how they see themselves, while they feel less excluded from society.

In order to address this trend, the approach described in this paper consists in providing the elderly with a novel, technological Web-based context-aware platform offering social features (e.g. sharing knowledge, crowdsourcing services, etc.) aimed to support, motivate and persuade seniors to continue to be active in the workforce so promoting their lifelong workability.

The use of persuasive strategies for encouraging elderly people to adopt healthy lifestyle habits has been considered in some previous work. In [6] the authors report some guidelines to motivate elders to do (physical) exercise by following a user-centred approach so as to design appropriate persuasive technology prone to be adopted by elders. In particular, in that paper the authors report on the design and evaluation of an ambient information system for mobile phones, which supports a number of strategies for persuasion: abstraction, historical information and reflection, triggers for exercising, and positive and playful reinforcement. While doing physical exercise by the elderly has already been considered in the past, in our approach we focus on a quite novel and to some extent more difficult/demanding goal, which is encouraging the elderly to stay active in the labour workforce, which implies a more demanding commitment from them. This will be achieved by providing effective motivational strategies to stimulate seniors' behaviour change, by using just-in-time, context-dependent information, and present at the appropriate time/place, intuitive, timely and persuasive interactive services/suggestions stimulating them to change -or maintain- their attitude towards continuing being active. This will also be obtained by using natural and adaptive multimodal User Interfaces (UIs) that well fit specific elderly's needs, abilities, skills and characteristics.

In addition, the platform described in this paper is expected to monitor elderly's physiological parameters through suitable sensor-based technologies to check elderly's health status so that e.g. any possible signal of declining health (from sensorial, motor, and cognitive viewpoints) is detected and adequately managed. The technological solution presented in the paper will provide support for monitoring elderly's everyday routines, tasks and (social) experiences in order to assess their current level of occupational/social activity/wellbeing, to understand whether unusual activity/deviation appeared in seniors' everyday routines and act appropriately. Modelling routine tasks for improving users quality of life has also been used for various purposes in other works addressing ubiquitous environments. For instance, in [5] the authors have exploited models in which users' routine tasks are specified with the goal of automating (tedious) routine tasks, so improving users' quality of life by making users' lives more comfortable, efficient, and productive, and helping them to stop wasting time in performing tasks that they do not enjoy. In order to do this, they propose a context-aware model driven approach and a software architecture in which the task model and the context model are used at runtime, by means of being interpreted by an automation engine which executes the tasks required to automate the routines specified in the models. To achieve the automation of user tasks in the opportune context, a context monitor is continuously updating the context model according to context changes. When a context change is detected, the context monitor updates the context model according to the detected change, and informs the automation engine about this change. The engine checks if some behaviour routine has to be executed in the current context: if so, it executes the tasks required to automate the routines as specified in the models. Differently from this work, in our approach the routine tasks are just meant as the "expected" tasks and therefore they are analysed (namely: compared with the logged user's tasks) in order to check whether they are correctly carried out by users or deviations are occurring in their execution.

As target group we consider healthy retirees as well as people who are coming closer to their retirement, both having basic familiarity with ICT technologies e.g. Internet, Web browsing, use of smartphones. It is worth pointing out that such target group is not homogeneous. Indeed, some of them may have limitations in using technology depending on e.g. cognitive issues (memory, language comprehension, visual attention, ..), perception problems (vision, audition) and motion problems, not mentioning that such abilities can also decline over time. In addition, target seniors span an array of different age, background and knowledge, and may be even considered differently depending on the sector in which they work/have worked. For example, in the information technology sector, a main concern for a potential employer is not represented by user motor impairments, but rather by his/her cognitive abilities and knowledge skills. Therefore, suitable adaptation /personalisation techniques should be put in place to address such highly varied yet specific users' characteristics.

From a technological point of view we have designed a platform including a number of modules described in the continuation of the paper. In the following section, an example scenario of use is provided for the expected system.

An Example Scenario

Giovanni is a 70 years old man, former employee of an ICT company. He retired two years ago. Three months ago his wife died: since then, he is facing an increase in his monthly expenditure (e.g. he pays someone to fulfil the home needs previously done by his wife). He was told by one friend about the existence of a platform through which companies can indicate consultancy/knowledge transfer needs they might have and which could be filled by an older candidate. Giovanni decides registering to the platform and fills in some information about himself. After some days, the platform informs him of an opportunity posted by a small company, which cannot afford the high costs of a specialized assistance. Giovanni logs in the system from his PC and receives further details on the offer through an adapted, multimodal UI. Giovanni is a bit sceptical about his capability to cope with that challenge: the system detects a lack of reaction and adapts its behaviour accordingly, by providing him with further info about the advantages of accepting the offer, e.g. possibility to work from home, with flexible time arrangements and, if selected, he will be paid 2000 euros, a good complement to his pension. Giovanni finally accepts the offer and starts drafting a solution. The platform, according to the information associated with him (e.g. knowledge, preferences, skills and abilities) adapts its UI so that he can easily submit his proposal in the system. Three weeks later, Giovanni is informed that his idea was selected. Apart from being satisfied by his personal achievement and regaining self-confidence, he also thinks that the monetary reward are very welcome. Finally, the monitoring system of the platform, which tracks Giovanni's work/social activity and health status, records his improvements in the last period and appropriately informs him about them. It also rewards and further encourages him to stay active, by highlighting the overall benefits of this good behaviour.

THE PLATFORM ARCHITECTURE

The platform aims to support a variety of services for active elderly, e.g. sharing experiences and content across their communities, connecting job seekers that offer jobs for elderly, as well as persuading users to stay active through adequately adapted Web interfaces supporting anytime-anywhere access to the platform services.

The architecture of the platform is mainly based on Web-based technologies to allow the elderly to access and use anytime and anywhere the platform from various devices (PCs, tablets, smartphones, TVs, ...). It consists of a number of modules providing the needed functionalities, which are split into *User-oriented services* and *Core Services* in Figure 1. The latter is the set of logical modules providing basic functionalities mostly exploited by other modules of the platform. The *User-oriented* services have instead a more user-related dimension, i.e. being either platform services directly exploited by users, or services exploited by the system applications.

The *Core Services* mainly include *Adaptation*, *Behaviour Analysis* and *Context Manager*. Context information is gathered by the Context Manager which has a client-server architecture. The context manager server receives the contextual information from the *Context Delegates* associated with each user/device, and which are able to supply the context data detected by the sensors connected to the devices. A Context Delegate can be implemented in different ways according to e.g. device capabilities. For instance, the Context Delegate for monitoring user position could be a lightweight stand-alone application that reads the GPS serial stream, extracts the terrestrial coordinates and forwards them to the Context Manager, while the Context Delegate for tracking user's Web activity can directly be included in the navigated Web page as JavaScript code. The connection between a Context Delegate and the Context Manager can occur e.g. over HTTP (i.e. in case of a JavaScript Context Delegate, an Ajax call can be used).

The Context Manager server uses an associated repository (Context data) for e.g. storing and updating four types of context information: *user* (preferences, tasks, physical and emotional state, …), *devices* (interaction resources, connectivity, …), *environment* (light, noise, ..), and information concerning *social relations* (groups of users, privacy rules, …).

All the data collected is gathered by the Context Manager server and stored in the Context Data repository, which is a collection of context entity instances modelled according to a specific XML-based language. The Context Manager provides an interface for performing typical operations on such repository (e.g. insert/query, update/remove a context entity, (un)subscribe to receive updates on changes of context entities' state).

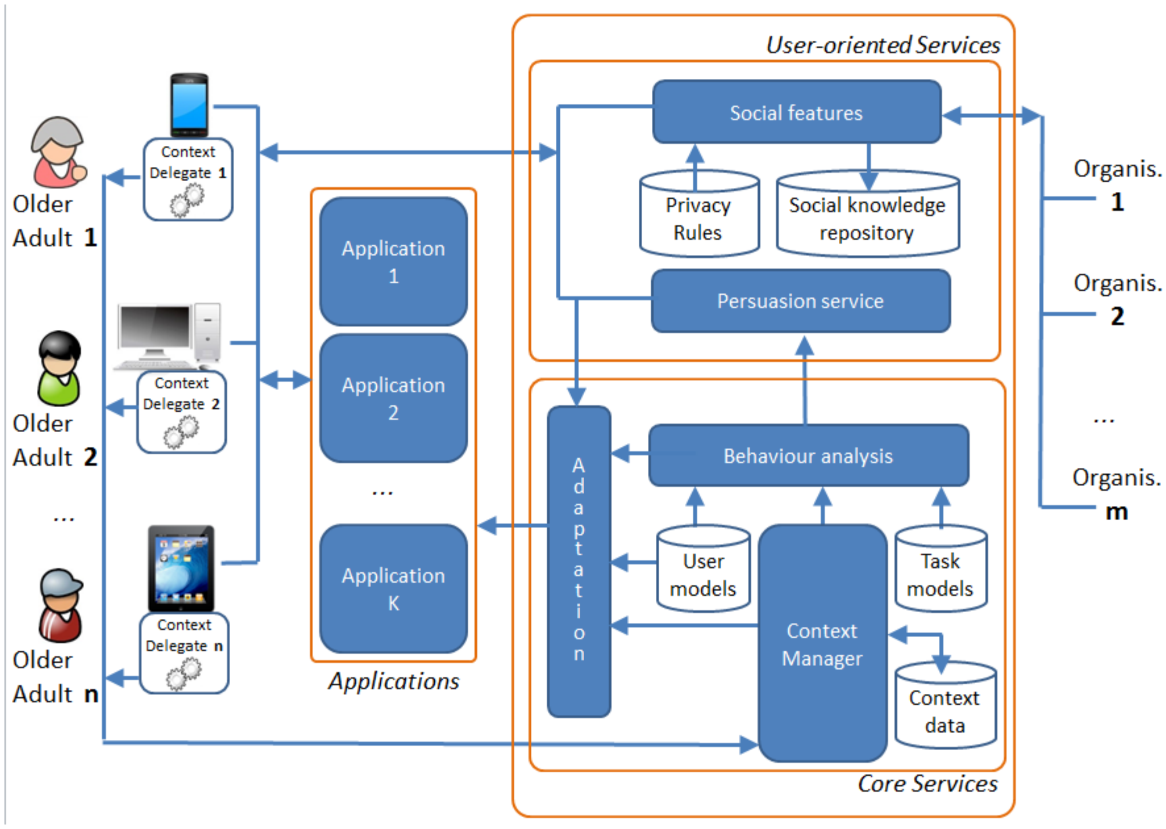

Figure 1: The architecture of the platform for active elderly.

The Context Manager also provides the *Behaviour Analysis* module with relevant context information, so that the latter module can assess whether any abnormal situation has occurred in users' behaviour. The *Behaviour Analysis* module gets information about users (User models repository), their planned activities (Task models repository, represented using the ConcurTaskTrees notation [3]), their current activities and e.g. the current environment (Context data repository). Depending on this input, the *Behaviour Analysis* module is able to assess whether the user is behaving properly or not, possibly providing relevant input to the *Persuasion* service when further actions are needed. For instance, the *Persuasion* service is expected to identify situations in which suitable messages should be provided to users to stimulate them to change their current behaviour [2]. Such messages will pass through the *Adaptation* service in order to be appropriately tailored to the current context of use before being actually exploited by the applications built on top of the platform. Indeed, the *Adaptation* module provides the platform applications with adaptation functionalities. It will use relevant information (i.e. context data and information about users contained in User models) to decide which adaptations should be applied in order to provide users with effective and intuitive applications.

The *User-oriented* services include two main functionalities and two main data repositories. The data repositories are the repository for handling privacy rules and the repository containing structured information on social knowledge. Both of them will be used by the *Social Features* module, which includes social-oriented services, such as features supporting users to share/annotate relevant content based on their experiences, crowdsourcing services providing relevant functionalities for handling task/job offers from organisations/job providers and then connect such offers with skills, knowledge and abilities of elderly through an adequate match-making strategy. It is worth noting that users will be able to exploit not only the applications (built on top of platform functionalities), but also directly some services of the platform (namely: crowdsourcing service, social knowledge sharing and persuasion service). A number of applications can be identified (e.g. sharing personal knowledge on multimedia TV content, supporting workers having initial health diseases). They will be developed on top of the services provided by the platform.

Monitoring and Behaviour Analysis

The literature reports that electrophysiological body signals (e.g. galvanic skin response or skin conductivity, heart rate, facial electromyography, electroencephalography, blood pressure and respiration) are related to personal emotional state. Thus, one of the goals of this module will be to monitor the elderly's status so as to be able to develop algorithms for analysing/handling their emotional state.

Moreover, this module will perform an analysis of users' behaviour in order to detect whether abnormal deviations occur. The analysis is carried out by comparing elderly routine/planned/expected user tasks, with the behaviour that they actually show. Routine tasks are specified in task description repositories (namely: CTT task models, which are specified in XML, a format which supports high flexibility/interoperability), while the actual behaviour of the elderly will be captured through various types of ubiquitous/body sensors. The analysis will be mainly carried out by comparing the expected actions (specified according to the hierarchical CTT task model) and the sequence of logged actions corresponding to the actual user behaviour, which are gathered in the current context and provided by the Context Manager. The outcome of such a comparison will be able to highlight a range of possibilities about where the main problem is, for instance performing actions in a wrong order, not performing at all an action, performing an action too many times, performing the action using incorrect resources, and so on. The various outcomes will then be classified in terms of importance/seriousness and adequate actions will be undertook accordingly by the platform (e.g. sending some messages to the user).

Identifying elderly's decline in cognitive/physical/social activity

Functional decline and chronic illness become increasingly prevalent/likely with advancing age. Our idea is that, by comparing the usual elderly's routines with tasks they actually do, or more in general, by analysing their health status, it is possible to spot in advance early symptoms of a mild/progressive decline in their physical, mental/cognitive and social status. This, in the long term, could compromise their willingness/ability to remain active, then it is important to identify such deviations early so as to be able to act promptly.

Mental/cognitive/emotional changes. A typical example of initial mental/cognitive decline can be represented by a non-adherence with medication, e.g. elderly start to mismanage their daily medicines (alter the doses, swap medicines), or they even forget to take them. If this occurs frequently it could be a sign of a mental decline. Another example considers the fact that older people often link the administration of such medication to specific lifestyle events, time and patterns of daily activities: involuntarily –and frequently– altering these patterns can be a symptom that the elderly is mildly/progressively experiencing a mental decline. Other deviations can occur when the elderly e.g. place objects in the wrong place, or when they are unable anymore to carry out common/essential daily activities autonomously, as they used to do before. Other changes could involve emotions: feelings of sadness over an extended period of time could indicate depression. However, it is worth pointing out that depression could also be connected with e.g. elderly not eating regularly anymore and/or staying in bed longer than usual.

Physical changes. An abnormal behaviour could be identified in a progressive reduction (or even a lack) of physical activity, or a deterioration of elderly physical/muscular strength (e.g. the elderly is less able to grasp common objects with a hand, or his/her moving is becoming slower than before). Another example of a physical decline can occur e.g. when the elderly experiences more frequent awakenings during the night (e.g. to go to bathroom). This could lead to have a poor sleep, which in turn could conduct to memory declining and brain deterioration.

Social activity changes. Elderly decline in social standing include e.g. having a smaller social network, less frequent participation in social activities, less interaction with friends, etc. Social disengagement/isolation/exclusion could have consequences also on elderly's mental decline.

Above, we just provided examples of abnormal situations that could be signs of a starting elderly's decline. They could be identified by comparing suitable descriptions of *expected* elderly activities (e.g. contained in CTT task models) and/or status, with *actual* elderly activities/conditions. Of course, the situations actually detected will depend on the specific type of sensors used.

The Context Manager

The sensed context data will be made available to other architectural components by the Context Manager, which consists of a set of (REST) Web Services providing access to various operations (e.g.: subscribe, update, notify) for handling context data. Thus, it will act as a centralised mediator between entities providing context information (e.g. sensors), and entities consuming context information (e.g. services). The Context Manager will also store and access in a consistent and flexible manner rough context data acquired from heterogeneous and arbitrary sensors/devices/applications in the user's environment, and then aggregate/abstract these data into relevant context information, so as to make it available to other context-sensitive components of the platform architecture.

The Adaptation Module

This module supports relevant context-aware techniques able to support runtime adaptation depending on the characteristics of e.g. users (characteristics, limitations, knowledge, skills, emotional state), available devices, surrounding environment. In order to be able to express various types of adaptations, a specific language for adaptation has been developed [4] within the SERENOA Project. It is structured in terms of *events* (related to something that happens in the application or the context of use), *conditions* (related to the current state or previous user interaction) and *actions* (indicating the effects that the adaptation should provide. The Adaptation Modules module will receive from the Context Manager information about updates of the status of contextual entities. Such updates will trigger the selection of suitable adaptation rules, which in turn will trigger the application of the needed (in the current context of use) adaptation actions. Such actions can be very simple (e.g. changing a background colour or font) or more complex (changing completely the user interface since a different interaction modality is more suitable for the current context of use). The Adaptation module will also consider the issue that information presentation may need to adapt to the same user even over time (as e.g. user abilities themselves can change/deteriorate over time). Finally, this module also addresses more specific user-related aspects by exploiting information contained in user models.

Social Features

This module provides intuitive social/knowledge sharing mechanisms empowering seniors to e.g. share their experience/expertise with others, facilitate information transfer/communication, and get in contact with other people. This will have the benefit of e.g. helping the elderly in creating and maintaining social relationships and contacts, while limiting the risks of their social exclusion and isolation. In addition, the social/knowledge sharing features will support a process in which the elderly will be engaged in informal learning activities where people will be able to learn from life experiences of seniors, even in inter-generational interaction. Moreover, this module will provide some Web-based crowdsourcing services supporting elderly in having an easier and more effective access to job/activity opportunities specifically targeted to them will be developed. Through this crowdsourcing services potential job providers (e.g. public/private organisations, industrial companies, etc.) can specify tasks and/or particular expertise/knowledge/skills they need. According to requested skills, users of the virtual elderly crowd will be able to respond, by offering their availability for filling that gap through their contribution/work. The crowdsourcing services will be built in such a way to support match-making between skills required and competences offered, as well as facilitate even non-technologically skilled senior people to access, be part and actively engage in the virtual elderly crowd.

Persuasion Services

This module supports effective motivational strategies to stimulate seniors' behaviour change, by using just-in-time, context-dependent information, and present at the appropriate time/place simple and tailored triggering messages, to persuade elderly to have a target behaviour. Persuasive techniques will also be realised through positive reinforcement/rewarding strategies delivered to seniors when they perform the desired behaviour. They can be realised by using e.g. virtual points/scores or monetary incentives and/or by reminding users how good it is to them a certain behaviour and/or by providing them with suitable visualisation techniques for supporting self-awareness/monitoring of their current behaviour progress.

CONCLUSIONS

In this paper we have presented the architecture of a Web-based platform for stimulating the elderly to stay active in their life. The platform consists of a set of logical modules supporting core and user-oriented services.

Future work will be dedicated to developing some applications for active elderly able to exploit the features of such platform and to provide opportunities for end user validation.

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