Towards a Platform for Persuading Older Adults to Adopt Healthy Behaviors

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Abstract. In ambient-assisted living scenarios there is the need of providing adequate support to elderly so that they can improve their quality of life. One of the most emergent needs is the capability of a system to be capable of adapting and reacting to user behavior changes. This is even more relevant when considering age related changes. In this paper, we introduce a platform supported by an End-User Development environment that allows older adults and their caregivers to tailor the context-dependent behavior of their Web applications and persuade older adults to adopt healthy behaviors. We present how this can be done by using a persuasion mechanism which collects information through sensors, identifies behavior changes and acts upon these adapting the user interface and application level. Additionally, we also show how these persuasion mechanisms can be personalized by modifying context-dependent trigger-action rules.

Keywords: persuasion; adaptation; personalization; elderly; behavior change

1 Introduction

Ageing is not only associated with improved living conditions, but also with the increased risk of developing health diseases and decreasing functionality in later life. The increased cost and sustainability issues, related to providing the support older adults need, is one of the most growing concerns today.

As most older people wishes to remain as independent as possible in their own home, informal care, mainly given by family members plays a key role. The provided support

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often consists in assisting the older adult in establishing goals and prepare routines that would lead them to their attainment. However, caretakers don't have the same availability to assess the progress towards the goals and to motivate the older adult in their daily routines [1].

Home-based sensor-based applications have a huge potential for providing this kind of support, especially if endowed with personalization and persuasion mechanisms based on the older adults' characteristics and goals. Applications like these not only need to adapt to continuous changes of contexts and evolving end-users needs, but also to anticipate all these requirements at design time. There is also the need for developing methods and tools which allow people who are not professional developers (like caregivers) to customize these applications [2].

As an answer to these problems, we introduce a solution which is composed by a sensing infrastructure and mechanisms for automatic adaptation of web-based applications targeting older adults. We give special attention to the persuasion process (Fig 1) which by creating and triggering a set of application-based rules can help disrupt unhealthy behaviors of elderly in care-at-home contexts. Additionally, we also evidence how by using a rule-editor, caregivers and elderly (if familiar with technology) can effectively personalize/configure those trigger-action persuasive mechanisms. Finally, we illustrate the entire process with an example usage of a remote assistant application.

2 The Architecture of the Solution

To be able to offer both persuasion and adaptation features, the platform is characterized by an architecture consisting of several models (Fig 1):

The **Context Manager** is the module that gathers and manages contextual data. It is composed of a server and several delegates installed in various devices (e.g., a smartphone can host software detecting environment noise through the device's microphone). These delegates collect data and pass them to the server. Data is gathered from sensors (physical activity, temperature, noise, light, etc.) or external services (e.g. weather forecast).

We plan to monitor the elderly's activities and aid when behavior deviates from the expected one. The **Behavior Analysis** module is expected to analyze the data collected in the context manager, model the elderly's behavior (activity levels, social interaction, etc.) and detect deviations from standard behavior showing that the individual behavior is deteriorating, or situations of no progress towards elderly's goals. The output of this analysis is then passed to: i) the Persuasion module, to identify what and how necessary persuasions are going to be applied, and ii) the Adaptation module, to adapt the outcome of user behavior analysis before being delivered to the elderly.

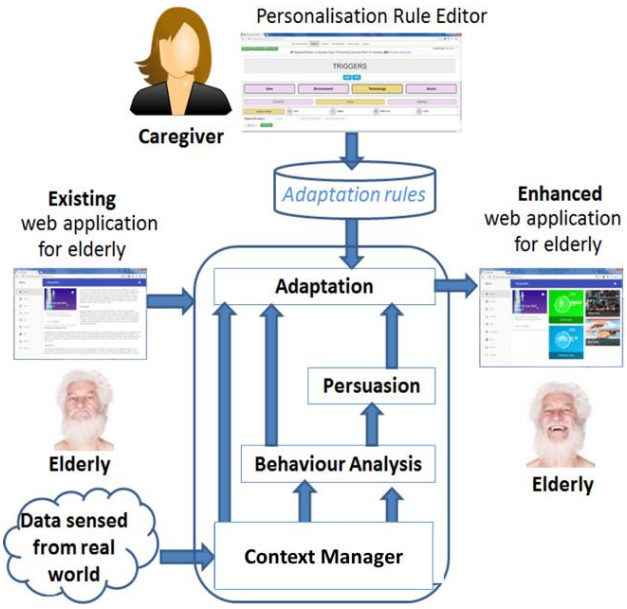

Fig 1. Architecture of the Solution

The **Persuasion** module is expected to identify situations in which persuasive mechanisms should be provided to change current behaviors. It needs to, based on the elderly's characteristics, goals, and motivation, identify the appropriate behavioral changing techniques and instantiate them for the current situation. The output of the persuasion module is a set of rules which establish relations between the system applications, modalities, messages and the user characteristics or contexts. This rules can be refined by caregivers, through a personalization rule editor (described ahead).

The **Adaptation** module enables Web applications (and the system) to have adaptive behavior (changing in accordance to relevant events occurring in the elderly's context, needs, requirements, (dis)abilities, etc.). It is responsible for deciding the best combination of modalities to render messages to the user. It receives rules specified by both previous modules and the caregivers' (through the personalization rule editor) and communicates with the applications and the context manager.

3 The Persuasion Steps

The described modules are all involved in the persuasion process that is triggered by contextual delegates collecting data. For a better understanding of the entire process' flow, we next present a processual description of the persuasion steps (Fig 2) instead of an architecture based one.

3.1 Collecting User Data

The first step is related with monitoring and collecting data from both the elderly and caregivers. This data will allow the detection of unexpected user behaviors happening in short periods, as well as making assessments on relevant deviations from an expected pattern over long periods (such as changes in the level of physical activity).

The system exploits context-related data from a variety of sources: (1) data assessed prior to using any application, and collected using standardized measures; (2) features that monitor a user's interaction performance (speed, wrong clicks, etc.); (3) user self-reported data; (4) software deployed in any device acquiring data from an external or wearable device (like biosensors and smart-watches); and (5) standalone apps deployed on the user's smartphone with embedded sensing devices (e.g., accelerometer, light sensor, GPS). Biosensor data such as muscle activity, heart activity, lungs activity, arousal state, motion, light intensity and temperature, can be captured with a BITalino [3]. While pre-assessed data (1) is needed to create a baseline (section 3.2), all the data collected from the other sources (2, 3, 4 and 5) is used to establish user patterns and calculate behavior deviations in an assessment loop (section 3.3).

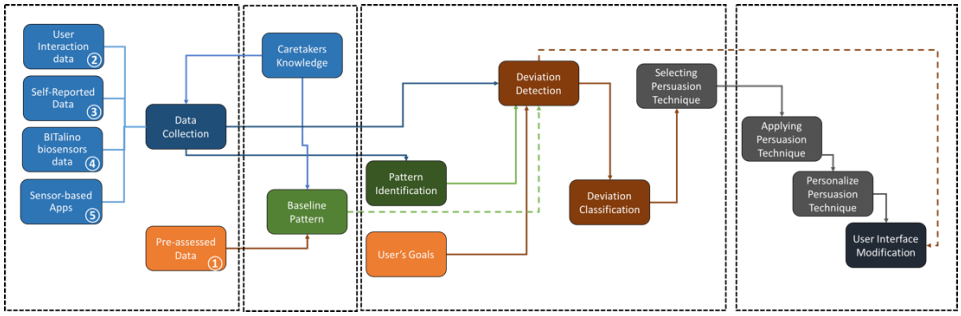

Fig 2. The Persuasion Steps

3.2 Setting the Baseline

The first thing to do before an older user starts to use the system, is build a primordial behavioral pattern from the information collected through the pre-assessment measurements. Additionally, information is also presented to authorized stakeholders through appropriately generated user interfaces that follow established usability and accessibility standards (e.g., ISO9241, WCAG2.0) as well as design-for-all approaches. This care is paramount, since many caretakers might be older adults themselves. This allows family members and caretakers to make judgments about the current situation of the older user, reflecting their knowledge on the baseline profile.

Following this, a set of accessibility and adaptation mechanisms is activated to adapt the intelligent system presentation, its variety of devices (TV, desktop, mobile device, etc.), interaction modalities (remote control, gestures, voice, tactile feedback) and environment conditions (e.g., noise, light) to each user's baseline profile.

3.3 The Assessment Loop

After the baseline profile has been set, and as the user begins using the system, more data is collected initiating a continuous assessment loop. During this, behavior analysis is used to identify possible deviations in the older adult's behavior or routines (which may indicate initial signs of decline).

The assessment comprises different comparisons. An objective comparison with the user's goals (collected together with the baseline, or with the help of caregivers/family) is regularly performed. Two other comparisons are made. One with the user's regular behavioral pattern, and another with the average behavioral pattern for the user's age group. During the initial usage of the system, the low amount of existing data precludes the usage of data mining and machine learning techniques to identify the user's regular behavioral pattern. During this period, and for the comparison with the user's goals, a set of activity related metrics (e.g., number of steps per day, number of social contacts per week) is computed and grouped per a mean and standard deviation rational into three groups: green ("Ok"), yellow ("beware"), and red ("concern"). When a yellow or red state are detected a deviation is identified which can result in an intervention.

After enough usage of the system, data will be sufficient to support automatic detection of behavioral patterns. Initially, data mining techniques will be used to identify patterns in the data. When these have been identified, machine learning techniques will classify current user behaviors as a deviation from the patterns or not.

After a deviation is identified, either from objective comparisons or through intelligent mechanisms, the process classifies it in accordance with the COM-B model [4]. Deviations will result from a combination of factors associated to the user's capabilities (C) (which tend to be stable), the user's opportunities (O) (which tend to vary because of external factors), or the user's motivation (M) (which tends to fluctuate). Modifications in any of these, will result as a trigger for maintaining, removing or applying different types of persuasion. Moreover, the system also adjusts the level of adaptation and accessibility mechanisms to be applied to the user interface variables. The amount and type of deviation dictates the modifications to be applied (if any).

As an assessment process ends (with or without a deviation and a consequent set of responses), a new one is initiated incorporating the new data collected. The period between each assessment can be defined both automatically or by the caregivers, family or other factors such as the amount, or the type of previous behavior deviations.

3.4 Applying Persuasion

When a deviation in a user's behavior is recognized, along with the need for an intervention, the persuasion module is activated. Thus, according to the behavioral deviation occurred, the target behavior, and the user's history of success, the appropriate persuasion (behavior changing) techniques [5] are picked, along with the target system devices or interfaces where they can be applied. These choices are then reflected into the appropriate set of rules.

4 The Personalization Rule Editor

To enable the personalization of both applications and persuasion mechanisms, we provide caregivers (and technological expert elderly) with an intuitive Web authoring environment where they can define and refine rules (which will be provided to the Adaptation module to manage the adaptations in the platform).

To create and refine rules, users can start either from triggers or actions. Regarding the former, selection is performed by navigating in the hierarchy of concepts associated with each contextual dimension until a basic element is reached. When this element is chosen, the tool shows the possible attributes and relevant values to build the trigger of the concerned rule. In a similar way, when selecting an action, the tool shows the corresponding supported options. Triggers refer to elements identified in the contextual domain-specific model and at the highest level consider: i) user characteristics, ii) environment aspects, iii) technology, and iv) social aspects. Actions involve appliances, UI modifications, UI distribution, functionalities, alarms and reminders.

5 An Example Application

To better illustrate the solution, we provide an example. Alan is a 79-year-old adult who, like many others of his age, likes to be in front of the TV all day. Because of his doctor's recommendation, Alan has the Remote Assistant Application installed at home. The application monitors health-related parameters (weight, biosensor data), as well as lets him set and track goals for various periods, receive guidance for doing fitness exercises and access external information services.

Because of a serious risk of muscle loss, he must do a 3km walk every couple of days. Alan doesn't like to walk, and frequently takes a book with him so he can enjoy some reading in the park instead of just walking. His son knows this, and knowing about the existence of a book fair near his father's house, makes use of the personalization rule-editor to suggest a walk to the book fair when the system detects that Alan needs to go for a walk.

It has been three days since he got out of the house and the system detects it (the pedometer incorporated in Alan's watch shows a very low step count record for that period). On the third day, the system captures Alan behavior as a deviation from his regular pattern and deciding he needs additional motivation, the system selects to apply as primary behavioral changing technique the "Encouraging Incompatible Behaviors" technique. Thus, after Alan has eaten his lunch and while he sits in front of the TV, the system sends a message through the Remote Assistant Application showing Alan he should go for a walk and suggesting there is a book fair close by. Alan answers "yes" out loud to the TV, puts on his snickers, and gets out of the house.

6 Conclusions

This paper presented a persuasive solution which focuses on understanding, monitoring and acting upon elderly behavior changes in a health-at-home context. Both the architecture and the persuasion steps capable of evaluating, intervening and disrupting unhealthy or unwanted behaviors, are described. We also describe how by using a Web-based tool caretakers can use their knowledge about elderly users and personalize the type of adaptation and persuasion applied to them by editing simple trigger action rules. This kind of technology has the potential to help increase quality of life for this segment of the population while reducing healthcare and caretaking costs.

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