Enabling Personalisation of Remote Elderly Assistant Applications

Cristina Chesta
Reply SpA
Italy
c.chesta@reply.it

Luca Corcella
CNR-ISTI HIIS Laboratory
Italy
luca.corcella@isti.cnr.it

Stefan Kroll
Terzstiftung
Swiss
stefan.kroll@terzstiftung.ch

Marco Manca
CNR-ISTI HIIS Laboratory
Italy
marco.manca@isti.cnr.it

Julia Nuss
Terzstiftung
Swiss
julia.nuss@terzstiftung.ch

Fabio Paternò
CNR-ISTI HIIS Laboratory
Italy
fabio.paterno@isti.cnr.it

Carmen Santoro
CNR-ISTI HIIS Laboratory
Italy
carmen.santoro@isti.cnr.it

ABSTRACT

One of the goals of Ambient Assisted Living (AAL) solutions is to extend the time that elderly people can live independently in their preferred environments by using ICT technologies for personal healthcare. However, in order to be optimal, remote monitoring services and health-related interventions should be strongly personalised to specific individuals' requirements, preferences, abilities and motivations, which can vary among the elderly and even dynamically evolve over time for the same person, depending on changing user needs and conditions associated with the current context of use.

In this paper we present how a platform for the development of context-dependent applications by non-technical users has been customized for remotely monitoring and assisting elderly people at home. The platform has been integrated with an application for remotely assisting elderly people at home. The user editable personalisation features are specified by using trigger-action rules. The way to personalise applications through the platform has been tested with some elderly people and informal caregivers, and the feedback they reported in the test was encouraging.

CCS CONCEPTS

• **Human computer interaction (HCI) → HCI design and evaluation methods**; • **Interactive systems and tools** → User interface management systems

KEYWORDS

End-user development, Ambient Assisted Living, Personalisation Rules.

INTRODUCTION

Nowadays, context-dependent behaviour is acquiring increasing importance in many applications and services covering a plethora of different domains. With the advent of the Internet of Things (IoT) its relevance is even more prominent given the increasing number of user environments characterised by the dynamic presence of sensors, objects and devices, according to which applications need to dynamically tailor their behaviour. In addition, applications that are targeted for a highly assorted population also need to be dynamically customized according to the needs of specific end users. All these aspects are especially relevant in the AAL domain, particularly for solutions targeting the elderly population, since they not only present a varied set of characteristics in terms of needs, abilities, knowledge (including technical know-how) and preferences, but also have specific, aging-related requirements that also evolve individually over time. In such environments it could be very difficult for developers to foresee all the possible context-dependent scenarios (and associated customizations to support in the software), because there could be some unanticipated (at design time) need that should be incorporated at runtime, when the application is actually used. Fortunately, the increasing affordability and availability of technology has also promoted new types of participation by end users in the creation process of software, such as EUD approaches [6], to improve the flexibility and acceptability of technological solutions by final users who at some point might want to incorporate new behaviour in their applications. This can be obtained through tools that do not assume specific technical background from their users.

In this paper we present an environment enabling end users to customize the behaviour and appearance of web applications in a context-dependent manner, by using an intuitive trigger-action paradigm. The approach has been applied to a remote assistance application, since in-house monitoring of elderly using intelligent ubiquitous sensors has emerged as a useful AAL service due to its potential of increasing the independence, safety and quality of life of the elderly while minimizing the risks of living alone and avoiding the costs of more expensive hospitalization solutions.

Using this tool both elderly (having some familiarity with technology) and people providing informal and formal care to them (e.g. family members or medical staff) can be empowered to, for example, set up reminders, alarms, and messages for promoting a healthy lifestyle, check medication adherence, and support monitoring functionalities, so adding new personalization possibilities not foreseen at design time, specified in a context-dependent manner. The personalizable actions supported by the platform range from User Interface modifications, to sending messages, to the possibility of changing the state of appliances and devices available in the surrounding context. The proposed solution has also been tested by a set of elderly people and caregivers.

RELATED WORK

In the AAL domain, the emergence of tools for older adults based on ambient intelligence paradigm has been identified and reported [8], together with the need to provide them with personalised services [12]. One further relevant aspect concerns tools helping elders reach their goals with IT products by working with their caregivers. One example of the latter is the work of Zhao et al. [13] who present the CoFaçade approach helping elderly people to reach their goals using digital artefacts by working collaboratively with helpers. In this approach, the elder uses a simple interface having a small number of customizable triggers, which are mapped to procedures that accomplish high-level goals with any IT product. The caregiver uses a customization interface to link triggers to procedures that accomplish frequently-recurring high-level goals with IT products. To demonstrate the effectiveness of their approach, the authors implemented a prototype using a handheld physical trigger interface and a desktop customization interface for defining procedures for both computer applications and consumer electronics. Then, they performed an evaluation in which they compared the CoFaçade approach with a baseline approach where 18 helpers either taught elders to perform a computer task or customized the trigger interface to perform that task. Their results indicate that the CoFaçade approach reduces helpers' workload and elders' frustration, and improves elders' task completion rates. While this approach goes in the direction of supporting the elderly in their everyday tasks, differently from our solution they do not consider context-dependent aspects that can modify the execution of procedures.

Also less recent work considered the need of enabling the elderly to customise their applications and environments. In [3] the authors present a tangible interaction technique using magnetic cards to empower the elderly in augmenting their ambient environment with software driven personalized behaviour. In particular, NFC-enabled magnetic cards allow elderly users to create personalized behaviour for their ambient environment and a digital memo board acts as a place holder for active behaviour ensuring the metaphoric resemblance of a memo board and post cards. However, this work is deeply centred on tangible interaction, while we consider Web applications which support interaction through a plethora of different devices.

In [2] the authors provide means to let end users create rule-based smart behaviour through the notion of object augmentation. However, in that work the developers still play a central role since they have to define, implement and install an augmentation module, while end users are expected just to configure the augmentation once it is installed by developers.

IFTTT (https://ifttt.com/) is a common tool that allows people without programming experience to create simple applications according to the pattern IF <something happens> THEN <do some action>. One of the most interesting features of IFTTT is the fact that it allows for connecting widely used Web services. However, with respect to our approach, which allows for combining multiple triggers, it has lower expressiveness, since it does not allow users to create more structured rules, i.e., those combining multiple events and actions. In addition, previous work [11] found that inexperienced users can quickly learn to create programs containing multiple triggers or actions. This shows that the trigger-action approach seems suitable to support EUD of context-dependent applications, but needs to be improved in order to allow users to express various desired combinations of events and corresponding actions. For this purpose, some authors have considered the 5W model [4] as well. In this work, we consider the TARE platform [5], which is mature for deployment in real contexts. For example, in [1] it has been shown the feasibility and convenience of using this strategy for tailoring applications, however that work considered young people (students) for validating their system, which is a different population from the one considered in this work.

THE PLATFORM

Requirements

On a methodological level, we first analysed the world of seniors to gain a thorough understanding of their needs and requirements. In order to do this, we identified three classes of stakeholders: elderly users (primary end-users), and informal and formal caregivers (secondary users). For each type of stakeholder separate requirements elicitation processes were conducted to understand current practices and possible meaningful customizations in the AAL domain. We involved them from the earliest stages of the design phase, so that their views, knowledge and feedback could be fed into the design and development of the platform.

With older adults we mainly used questionnaires, which were sent out to the contacts of a project partner, a Swiss foundation operating as a representative body for mature people and as a service provider in the market for elderly people, with the objective to promote the interests of mature people through a number of services ranging from information, consulting, education, societal and media dialogue, representation of interests, transparency and consumer protection, to project and product development.

In the end, we were able to collect 71 completed questionnaires. The large majority of respondents was in the age group of 65-74 years (64%), followed by 21% in the group between 75-85 years, and 11% between 55 and 64 years. A minority was over 85 years old; none of the respondents was younger than 55 years old.

As the living environment is an important factor for the analysis, we also collected some data on this aspect. Only minorities (5%) of the respondents from the end-user survey reported to live together with more than one other person, which might suggest a lower need for assistance by external caregivers for monitoring activities. 63% live with one other person (supposedly partners from similar age groups), whereas about one third (31%) live alone. Only 4% indicate to care for other people themselves. Continuous monitoring as a result of health issues is even less required by the considered sample, with only 2% reporting respective needs. Moreover, health problems experienced in the past were surveyed in order to learn more about the areas people might be sensible for. Vision turned out as the most important category with 44% reporting problems in the past, followed by hearing (38%) and motoric abilities (23%). Cognitive issues (14%) and fine motor skills (7%) were checked in the survey by minorities. However, none of the impairments reported are linked to medical problems currently faced, even if they could. A majority of the users would be willing to store health records (58%) and current physical conditions (56%), whilst 44% and 35% are still willing to store respectively their status of rehabilitation measures and private data. From analysing the gathered data, the need for not only having features tailored to specific individual impairments, but also to specific lifestyles and living environments came out. In addition, transparency, data control, and social aspects were identified as other relevant user needs.

In order to further gather requirements for elderly we also organized two interactive workshops with informal caregivers, in order to also have their feedback (Figure 1).

Figure 1: Interactive Workshops with Informal Caregivers

Overall, eight people between 55 and 80 years spread over two workshops participated. Four of them were women and four were men. The aim of the workshops was to scan the types of daily routines and health related activities which informal caregivers and their relatives are confronted with. During such workshops, two different methods were used. First, a timeline with five time slots was used to reconstruct a typical day of elderly persons with dependency needs. The timeline was intended to help the target group to return to mind typical activities and processes that take place in different phases of a typical day. Second, a table with five main activities of a typical older adults' day was used to complete the results from the first workshop part. Both exercises resorted to a mixture of card techniques and group discussions. Card techniques were considered especially suitable for situations in which participants should not be influenced by the ideas of their peers or even be intimidated by lead ideas generated by the group. Discovering daily routines and behaviour from our primary target group is the basis for this domain, as it is important to understand how elderly people interact with their caregivers and where the personalisation platform can fit and assist them.

The findings show that most elderly people with dependency needs require help with their *hygiene*. In addition, physical limitations on body movements are typical symptoms of old age, and they can have impact on a lot of other body-related issues. Moreover, *healthy nutrition* seems to be very important for elderly people. Elderly people might have difficulties to cook in a healthy manner, because they are not used to "modern" nutrition or do not have sufficient knowledge about it. Furthermore, sometimes they do not have enough energy to cook by themselves. This leads to the conclusion that older people would appreciate consultancy regarding their nutrition.

Another problem shared by many seniors is *to drink enough*, which is very important for their brain and overall health. Thus, they need to be remembered to drink more. A drinking diary reminds them to drink and give an overview about the amount of liquid required by their body. In other cases, it happened that older people forget to *switch off appliances*. Thus, it is especially important to remind them to switch off those which can cause serious damages, like stoves or irons. Moreover, many older people take several medications during the day. Some of them are very important and should not be forgotten. One help system, older people often mentioned, is a "medication plan". People use this to have an overview about their medications and the time when they need to take any medicine. Using this tool both the older person and the informal caregivers can control drug intake. Older persons can control themselves without feeling patronized, and informal caregivers still have awareness about it. One of the most important support older people appreciate very much is a *personal contact person*. Nearly all of the caregivers reported that it is important for the health and well-being of their relatives to have someone to talk with. This personal relationship greatly influences the aging process in a positive manner. In addition, some older people are used to do some physical exercises (to stay fit and work against impairments), as well as cognitive ones (e.g. they solve Sudoku and crossword puzzles regularly).

In order to gather requirements from informal caregivers, we used three different personas and an online survey. The three personas illustrated different seniors, and were used in scenario narratives illustrating how informal caretakers would interact with the person being cared for, and the professional caretakers. These scenarios also provide an illustration of different motivations that are pervasive in the formal caretaker user group, and how our platform can support them. The online survey was completed by 13 relatives of elderly people contacted

by the same Swiss organisation, with the aim to analyse daily routines and health-related activities which both informal caregivers and their cared relatives are confronted with on a daily basis. In particular, the sharing of personal data (according to e.g. privacy legislations, ethical considerations and individual preferences) was identified as an important factor when designing digital solutions for this type of users.
To sum up, the need of having solutions able to take into account the wide spectrum of seniors' characteristics and routines was acknowledged as a relevant need for smart AAL solutions.

An Example Scenario

In this section we describe a scenario in which we envisage the use of the considered platform and highlight how seniors can benefit from it, taking into account the gathered requirements. Luisa is a 75 years old woman, who lives alone in her own flat: she does not suffer from any particular severe disease but recently she has started to present initial unhealthy life style patterns and some illness frequently associated with age. Indeed, recently her life is becoming more sedentary and, as a consequence, her weight needs to be regularly monitored. Luisa is very concerned by this aspect because she knows that getting extra weight can expose her to further problems such as cardio-vascular issues. Nevertheless, she has increasing difficulties to do enough physical activity and feels less motivated to do it especially after the death of her husband. In addition, she has to check regularly her blood pressure, because the doctor told her that it started to be slightly higher than it should be. As a side-effect of her less active life, Luisa's network of social contacts is slightly reducing, and she often is in a bad mood due to her feeling of social isolation.
Her daughter Elena, who lives nearby, takes care of her but, due to her work and family commitments, she is not able to provide the assistance and support she would like to give to her mother. Elena would like to have a remote assistance application to better monitor her mother's health situation (including emotional state), and alerting her if there are health-related risks or any situations which deviate from usual routine and would need immediate actions from her side. In addition, she would like to better motivate her mother to have regularly some physical exercises, so preventing potential onset of future diseases. Indeed, as being a doctor herself, Elena knows well that maintaining a healthy lifestyle by doing regular and sustained physical exercise has numerous short and long-term positive effects not only on physical wellbeing but also on mood and cognition. In order to motivate Luisa in doing physical activity more frequently, Elena uses some motivational arguments derived by her knowledge of Luisa (e.g. she would be very attracted by the possibility of walking with a friend).
A rule example created by Elena would be: IF <a friend of Luisa is available> AND <the level of social activity of Luisa was low in the last week> DO <suggest Luisa having a walk with that friend>. In other cases, Elena can set up a rule which better emphasizes wellness goals and stimulate Luisa to have good routines when her behaviour deviates from the expected one, e.g. IF <Luisa has not achieved a daily goal of 5000 steps OR was not very active in the last week> AND <there is sunny weather outside> DO <send Luisa a message of encouragement to have a walk outside>. In order to be more persuasive, the message can highlight that e.g. with only a 30-minute walk she might have the chance to both reach her current daily goals, burn a good amount of calories, enjoy the sunny weather, and also have the chance to meet some friends.
In addition, Elena, still using the application, would like to improve her mother's awareness about healthy behaviour and progress towards her goals. To this aim, Elena sets up another rule showing Luisa relevant health-related trends, e.g. showing her the percentage of daily and weekly step goals reached, also compared to the ones achieved by some friends of her, to be stimulated to compete with others' performances. When Luisa receives the suggestion about the possibility of having a walk with a friend in a sunny day, she accepts the suggestion with enthusiasm. When Luisa comes back at home the system shows her the burned calories and the progress towards her expected goals of physical exercise: Luisa is very excited about the results obtained, and she calls her daughter to comment on them.

The Personalisation Platform

In this section we explain the architecture of the platform used in the study (TARE, Trigger-Action Rule Environment) by referring to the scenario just described in the previous section. The Personalization Platform [5] was applied to a home automation domain, while in this case the platform has been customized in order to be used in the AAL domain.
Our starting point was a generic definition of the context model (the set of entities which compose the context of use). This definition includes common attributes that can be shared between all application domains (e.g. personal information such as age, gender, education, environment attributes such as temperature, humidity, light level, etc.), thus it is domain-independent. Then, it has been customised with the support of domain experts (caregivers), with the aim to identify the domain-specific triggers. Below are listed some of the triggers we identified as relevant for the AAL domain:

- Physical information: walking ability, heart rate, daily steps, body temperature, respiration rate, posture)
- Cognitive information: attention, reasoning, memory, language;
- Medication: planned and occurred (medicine name, dosage, notification time);
- Motivation (wellness, fitness, health, social)

All the context attributes compose the domain-specific context model and are available in the Personalization Rule Editor in order to define the personalization rules.
The software modules which compose the platform are:

- a Personalization Rule Editor, which allows users to define adaptation rules following the trigger-actions paradigm;
- an Adaptation Engine that stores and manages the rules, associating them to the available applications and users;
- a Context Manager, a middleware module that monitors the context and informs the Adaptation Engine when a change in the context triggers the execution of a rule.

When Elena wants to set up a rule for her mother, the Personalization Rule Editor (Figure 2) first loads the relevant context model, which provides Elena with a representation of relevant contextual elements (e.g. events and conditions) that can be associated with the triggers that she wants to consider in her rules. For instance, for the personalization rule encouraging Luisa to have more exercise when a low activity level is detected recently (see rule examples described before), the relevant *triggers* would include the fact that the weather is sunny outside, and Luisa in the last week had not reached the minimal thresholds in terms of walking steps. The relevant *action* would be sending a message to Luisa through her preferred device encouraging her to be more active. In particular, *triggers* refer to elements identified in the contextual model, and at the highest levels consider the following aspects: user, environment, technology, social aspects. In general, *actions* can be associated with: Appliances (to change the state of some actuator); UI Modifications (to change the presentation, content or navigation of the application UI); UI Distribution (how the application UI should be distributed across multiple devices); Functionalities (to access externals services e.g. weather forecast service); Alarms (to highlight some potentially dangerous situations); and Reminders (to indicate tasks that should be accomplished).

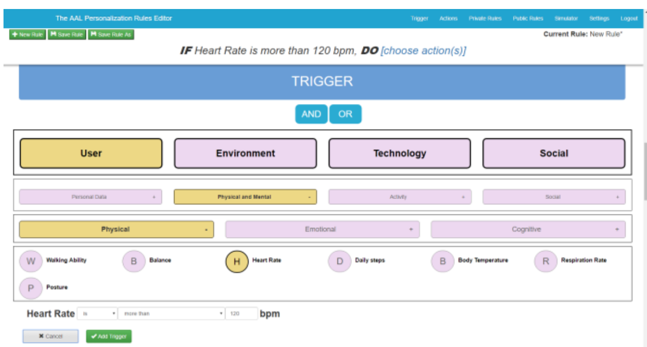

Figure 2: The Personalisation Rule Editor

After Elena finishes specifying the rule through the editor, the rule is sent to the Adaptation Engine, a software service that subscribes to another module of the platform, the Context Manager, for being notified about the occurrence of events associated with the rules received in the current context. Afterwards, when the application of remote assistance is activated, it subscribes to the Adaptation Engine. The Context Manager is composed of a *Context Server* and several *Context Delegates* installed in various devices (e.g. a weather service can detect the weather outside, a pedometer worn by Luisa counts her steps all the day). Delegates collect data and pass them to the Context Server, which stores and analyses them. Thus, in the architecture, the Context Server is the module that detects when the subscribed triggers occur: when it happens, the Context Server notifies the Adaptation Engine, which extracts the list of actions from the concerned personalization rules, and sends them to the application for interpreting and executing them. For this purpose, the application contains some JavaScript scripts able to understand the requests that correspond to the actions to be done on the application in order to realise the meant personalisation changes. In the example considered, the action would be sending a message through the TV (Luisa's preferred device).

Remote Assistance Application

The application developed in this work addresses mainly elderly people with a good degree of independence with the goal of preventing decline rather than safety purposes, and therefore includes functionalities related to fitness and well-being as well as support for monitoring vital parameters such as heart rate and body position.

The benefits of a physically active lifestyle are well known and demonstrated, however older adults often conduct sedentary behaviour. Motivation is a critical factor in supporting sustained exercise, which in turn is associated with important health outcomes. Several studies have addressed the different sources of motivation and barriers to exercise and proposed classifications in broad categories [10].

Knowledge about personal factors influencing motivation and exercise involvement can be used to tailor interventions to the individual and to improve long-term adherence to regular physical activity.

In our work, we combine the main individual motivation factors, assessed using the EMI-2 questionnaire [7], with context information detected through Plux BITalino[1] biosignal sensors. The goal is to dynamically adapt the application accordingly in order to reinforce the motivation of the specific users and to encourage them in the most effective way to exercise.

Initial Application

The initial version of the application (see the home page in Figure 3) supports the following main functionalities:

- Wellbeing goals settings and status update
- Personalized news
- Planning of the activities
- Health information overview
- Contacts and personal profile
- Possibility to receive motivational messages

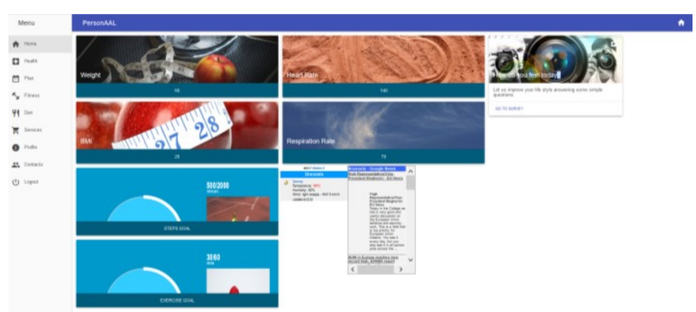

Figure 3: Remote Assistant Application – Initial Version

[1] BITalino toolkit documentation: http://www.bitalino.com

Real time values of steps performed, heart and respiration rate, user body position and temperature are detected through BITalino sensors embedded in a chestband. These values are also sent to the context server by the BITalino context delegate. Weather and news contents are incorporated as RSS feed from external providers based on location information.

Strategies to increase Exercise Motivation

In order to understand the individual motivation for the physical activity and then persuade the user to have more movement, we derive a measure of the participation motives or reasons for exercising based on EMI (Exercise Motivation Inventory) self-report assessment. The current version of the instrument (EMI-2) is valid for males and females and applicable to both exercisers and non-exercisers. It comprises fifty-one questions grouped in fourteen subscales.

The fourteen measures have been mapped to four main motivation factors:

- **Wellness**: enjoy the activity itself, relax, satisfaction in reaching personal objectives.
- **Health**: desire to keep good health conditions or to improve them.
- **Social**: enjoy spending time with others, do something with friends, compare with others.
- **Fitness**: desire to lose weight, look better, feel stronger.

The knowledge of personal source of motivation can be used in order to highlight the information most relevant for the specific user. For example, a user mainly motivated by Wellness aspects would appreciate to see in the home page her daily goals compared to current status, while a Social user would prefer to see her performance compared with other users. A user motivated by Fitness would like to see her weight trend and calories burnt with the exercise, while a user motivated by Health would prefer to see details about her average heart rate and respiration rate.

The context data, combined with user characteristics, can be used to reinforce the motivation through persuasive messages in case the activity measured is less than expected. Moreover, it can be used to lower barriers, such as the fear of safety issues, providing alerts in case some problem is detected. Finally, depending on the presence of additional ambient sensors and actuators (vocal assistant, smart lights, etc.) in the elderly's home, the application can be extended with actions involving not only the web user interface, but also the surrounding environment.

Adaptation through personalization rules

In this section we report some examples of the personalization rules defined with stakeholders and created using the Personalization Rule Editor.

Personalized presentation of information

In this case the main user motivation factor is used to present the most relevant information in the home page, hiding or showing some user interface elements. This is realized through rules like:

(a) IF Motivation is wellness, DO Show Goal Element, Hide Health Element, Hide Fitness Element, Show News Element, Hide questionnaire

(b) IF Motivation is health, DO Show Health Element

In particular, Figure 4 shows the result of applying rule (a) to the initial UI of the Remote Assistance application shown in Figure 3.

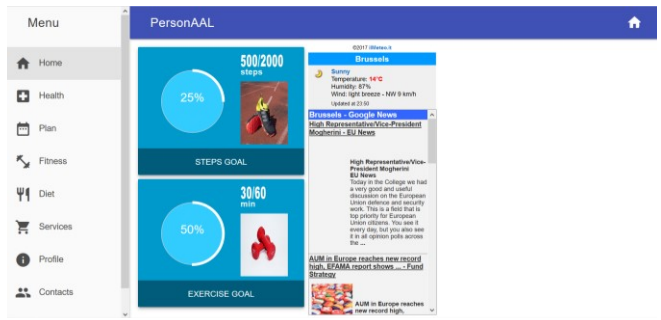

Figure 4: The UI of the Remote Assistance Application after applying a personalization rule based on a wellness motivation

Motivation reinforcement through persuasive messages

In this example the idea is to suggest that the user go for a walk if the steps recently performed are less than the ones associated with the planned goal. The message content can be further personalized on the basis of user characteristics, for example suggesting to go with a friend in case of a social motivation. The rule to apply in this case will be:

IF Motivation is social AND Daily steps is less than 1000, DO send a reminder to me.

Barriers lowering through safety alerts

In this example an alert message is sent through SMS to the caregiver if the monitored heart rate or breath rate are too low, and the user is laying down and still, suggesting he may be fallen down or fainted. The message could propose the caregiver to call the elderly user and check he's doing well. The corresponding rule will be:

IF (Respiration Rate is less than 10 breaths per minute OR Heart Rate is less than 50 bpm) AND (User position is laying down OR User position is still), DO provide an alarm by sending a SMS to the caregiver.

Ambient adaptation to increase well being

In this case, the system identifies a possible dangerous situation for the user, who has the body temperature too high and shows an alarm on the remote assistance application and it also sends a SMS to the doctor. The rule is as follows: IF Body Temperature is more than 38oC, DO show an alarm AND DO send a SMS to <phone_number> with the following text: 'Patient <patient_name> has high fever'.

USER TEST

The test on the personalisation rule editor was carried out with a sample of 7 participants that included 3 older persons (aged 74-

80) and 4 informal caregivers (aged 45-67). Three out of the four caregivers care for their mother/mother-in-law and they are not living together, but nearby. Two females participated to the test (1 female elderly and 1 female informal caregiver). As for their education, 2 had a University degree, all the other test persons had a medium educational level. Nearly none of them has experience in programming: in a 1(low)-5(high) scale, only one person declared to have good experience in programming, while the others declared no or minimal experience. In addition, all the participants declared that, before the test, they had never used any tool supporting personalisation based on dynamic events.

For the user tests, a laptop PC (Lenovo Z570) with a 15.6-inch display was exploited, since it was judged more appropriate for supporting folding and unfolding of the hierarchy of triggers and actions. This test took place in the offices of the end user organization involved in the research and the participants were questioned alone. A paper questionnaire was used, organised in such a way that it could filled in by the users themselves or by the test leader who was questioning the test person. After the test session, the results were filled in an excel sheet to be used for further analysis.

To test the full usability of the rule editor application the test session was divided into two main parts. First the users had to judge about the exhaustiveness of the way to model the users' context of use and the possible actions. Therefore, in order to help the participants to keep track of the content a mind map with the tree structure of the possible triggers and actions was used for assistance by the test leader. This mind map covers the whole application and turned out to be a helpful method.

During the first part of the test users were asked (1-7; 1=very bad; 7=very good) about the exhaustiveness of the set of triggers that can be specified with the tool and the results were: min:3, max:6, median:5. In addition, they were asked about the exhaustiveness of the set of actions that can be specified with the tool and the results were: min:4, max:5, median:5.

The second part focused on the usability of the rule editor. Here the test leader gave to the users some rules written in natural language (in German). The rules covered all available areas of the Personalization Rule Editor to guarantee a complete coverage of the system:

- If it is 8 o'clock in the morning, then open the blind in the bedroom.
- If the user is very stressed, then turn on the radio in the living room.
- If the front door is open, then remind the user to close it. Send him a message on his phone.
- If the W-Lan connection is off, then send an e-mail to your daughter with the message "W-Lan does not work".
- If the light is very bright, then change background colour into black.
- If the person is older than 80, then increase the font size.

The exercise for the participants was to specify the rules by using the tool. Using this method, the test person gains a deeper insight into the system and can give a more detailed feedback.

A 1 to 7 Likert scale (1=very bad, 7=very good) was used to rate a number of aspects of the Personalisation tool:

- Usability of the trigger selection mechanism supported by the tool (min:4, max:6, median:4)
- Usability of the action selection mechanism supported by the tool (min:2, max:6, median:4)
- Usability, in general, of the rule-based approach (min:3, max:6, median:4)
- Exhaustiveness of the set of events that can be specified with the tool (min:3, max:6, median:5)
- Exhaustiveness of the set of actions that can be specified with the tool (min:4, max:5, median:5)
- Usability of the tool support for reusing previously saved rules (min:3, max:7, median:5)
- Usefulness of describing the rules in natural language (min:6, max:7, median:7)

The results of the usability test show that the structure of the application is clear and well-structured at a first glance. The structure of triggers and actions resulted clear to the users, as they said that it somewhat resembles other programs (e.g. 'if' conditions when programming rules with Microsoft Excel). The tree structure of the rule editor helps the user to get along with its various elements. However, once deep in the tree structure users might get lost. For instance, some of them reported to have difficulties to remember where they can find the next steps, because the whole structure is not visible anymore. To overcome this problem, we have developed a search function helping users to more easily find a specific hierarchy element without exploring the whole tree (of triggers and/or actions). Moreover, users can be helped by a virtual assistant that after each step can suggest the following one. In additions, users cannot easily remember where to find some functions of the tool. Other times users cannot use the system properly due to e.g. too small font sizes, or because the selection fields were too small.

Furthermore, in some fields of the trigger or the action tree empty fields needed to be filled in with free values provided by users. However, users rather prefer having UIs providing more control over data values and data types: for instance, instead of directly editing values, they would prefer selecting values through drop-down menus, or number keypads if numbers are needed. In addition, to guarantee a smoothly use of the rule editor a detailed written introduction and help function are seen as necessary.

Regarding the strategies participants adopted in performing the exercise, no specific strategy was used by most of them who found not immediate to get the whole overview and the full potentiality of the system by just doing a few exercises. For further development, a more consistent and clear structure of the UI was suggested: in particular, consistent use of buttons, symbols and colours is important for a smoothly handling by end users (e.g. consistently use green colour for "ok" or "done" and red colour for "not already done" or "does not work"). In addition, to guarantee a good user experience the UI should provide more support on data types and data values.

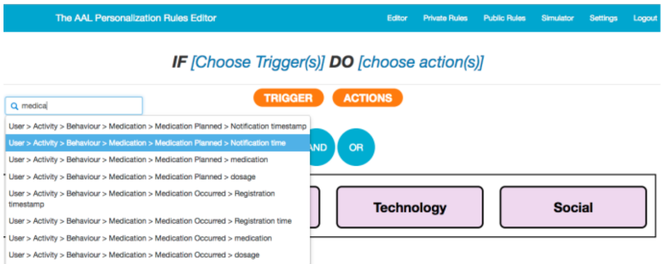

Figure 5: The new support for identifying context attributes

As a result of this study a new user interface for the rule editor has been designed and implemented. It supports users in finding the relevant aspects of the context to use in order to specify the triggers in the personalization rules (see Figure 5).

For this purpose, a specific search functionality has been added. Thus, it is sufficient to enter the desired concept and the tool shows the paths of the elements where it is considered within the context model. Then, the user can easily select the most relevant one amongst those listed. When the user selects the desired concept, the user interface shows it in the logical structure of trigger classification, and provides users with the possibility to edit the corresponding attributes (see Figure 6).

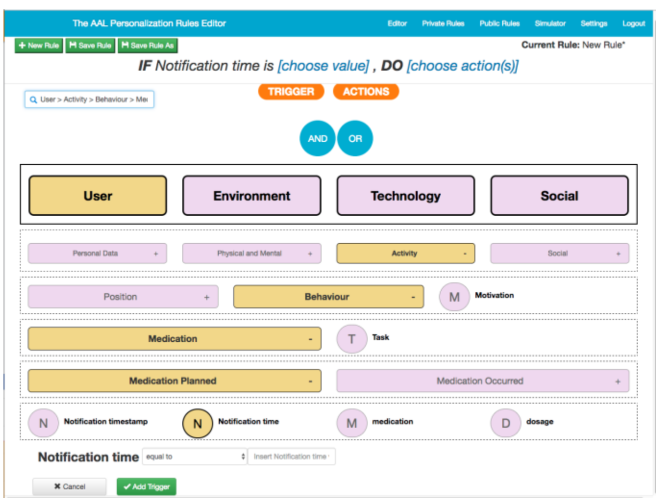

Figure 6: The selected element is presented in the context structure

CONCLUSIONS AND FUTURE WORK

In this paper we present a first study with elderly concerning the use of a platform for end user development of context-dependent applications, which has been customized for an application aiming at remotely monitoring and assisting them at home. We report on an initial test with some elderly people as well as caregivers.

From the reported evaluation the platform rule editor, after a first learning and familiarisation phase, was judged sufficiently easy to use by older persons and their informal caregivers who also provided suggestions for improvements, which have been addressed in a new version.

As future work we plan to validate the new version of the system in longitudinal studies in the elderly homes to investigate how the use and appropriation of the tool vary over time.

ACKNOWLEDGMENTS

This work was partially supported by the Ambient Assisted Living Project PersonAAL (http://www.personaal-project.eu).

REFERENCES

[1] Luca Corcella, Marco Manca and Fabio Paternò. 2017. Personalizing a Student Home. Proceedings of the 6th International Symposium on End User Development (IS-EUD'17). 18-33. http://dx.doi.org/10.1007/978-3-319-58735-6_2

[2] Johan Criel, Laurence Claeys, and Lieven Trappeniers. 2011. Deconstructing Casensa: The CAEMP context-aware empowering platform. Bell Lab. Tech. J., 16, 1 (June 2011), 35-53.

[3] Johan Criel, Marjan Geerts, Laurence Claeys, and Fahim Kawsar. 2011. Empowering Elderly End-Users for Ambient Programming: The Tangible Way. International Conference on Grid and Pervasive Computing (GPC'11). 94-104. http://dx.doi.org/10.1007/978-3-642-20754-9_11

[4] Giuseppe Desolda, Carmelo Ardito, Marsitella Matera, Empowering End Users to Customise their Smart Environments: Model, Composition Paradigms, and Domain-Specific Tools, ACM Trans. Comput.-Hum. Interact. 24(2): 14:1-14:33

[5] Giuseppe Ghiani, Marco Manca, Fabio Paternò, and Carmen Santoro. 2017. Personalization of Context-Dependent Applications Through Trigger-Action Rules. ACM Trans. Comput.-Hum. Interact. 24(2): 12:1-14:52

[6] Henry Lieberman, Fabio Paternò, Markus Klann, Volker Wulf. 2006. End-User Development: An Emerging Paradigm. In End User Development, Henry Lieberman,

[7] Fabio Paternò, and Volker Wulf (eds.). Springer, The Netherlands, 1-8. David Markland, and Lew Hardy. 1993. The Exercise Motivations Inventory: Preliminary Development and Validity of a Measure of Individuals' Reasons for Participation in Regular Physical Exercise: Personality & Individual Differences, 15, 289-296

[8] Parisa Rashidi and Alex Mihailidis. 2013. A Survey on Ambient-Assisted Living Tools for Older Adults: IEEE Journal of Biomedical and Health Informatics, 17, 3, 579-590

[9] Jeff Sauro, Joseph S. Dumas. 2009. Comparison of Three One-Question, Post-Task Usability Questionnaires. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '09). 1599-1608. http://dx.doi.org/10.1145/1518701.1518946

[10] Pedro J. Teixeira, Eliana V. Carraça, David Markland, Marlene N. Silva and Richard M. Ryan. 2012. Exercise, physical activity, and self-determination theory: a systematic review: Int J Behav Nutr Phys Act., 9, 78, 1-30

[11] Blase Ur, Elyse McManus, Melwyn P. Yong Ho, Michael L. Littman. 2014. Practical Trigger-Action Programming in the Smart Home. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '14). 803-812. http://dx.doi.org/10.1145/2556288.2557420

[12] Dimitrios D. Vergados. 2010. Service Personalization for Assistive Living in a Mobile Ambient Healthcare-Networked Environment. Personal and Ubiquitous Computing, 2010, 14, 6, 575-590.

[13] Jason C. Zhao, Richard C. Davis, Pin S. Foong, and Shengdong Zhao. 2015. CoFaçade: A Customizable Assistive Approach for Elders and Their Helpers. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '15), 1583-1592. http://dx.doi.org/10.1145/2702123.2702588