

Ambient Information Systems to Support the Elderly in Carrying Out Their Activities of Daily Living

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Abstract. As they age, older adults present losses in their functional capabilities which cause them can't continue performing their activities of daily living (ADL) independently at home. We propose Ambient Information Systems (AIS) as appropriate pervasive devices to promote their independent living. Therefore our aim is to determine the utility and usability of AIS to support the independent life of older adults by helping them to perform their activities. In this paper we present preliminary results of a case study that we carried out for understanding the problems and needs that older adults face in doing some of their activities of daily living. In particular, we present results regarding the elderly problems to adhere to their medication prescription. Based on these results we propose AIS to support older adults to medicate. Finally, we present the design attributes incorporated into this AIS, which were identified from the design taxonomies of AIS reported in the literature.

Keywords: Ambient Information Systems, Elderly, Activities of Daily Living.

1 Introduction

During aging, older adults present losses in their functional capabilities. This may cause older adults to stop performing their activities of daily living (ADLs) at home independently. Consequently they need to be assisted in different ways: they may need help to complete an activity; they need to be reminded as they may forget some events or tasks that impede completing an activity appropriately; they may need to be warned when facing risks associated with performing an activity; and they may need to be motivated or persuaded in order to maintain a healthy lifestyle. Several technologies have been proposed to support elders' carry out their activities of daily living. One example is the use of assistive technologies like robots and software agents that deal with motor limitations and sensory and cognitive problems in older adults. Such is the case of Robot-O-Care II which helps older adults with their mobility and some household tasks [1]. Intelligent agents or systems that provide recommendations of suitable food recipes, taking into account their nutritional profile [2]. The aforementioned technologies may increase elders' quality of life and aims to eliminate the necessity of having a caregiver continually taking care of elders. However, there is

evidence that older adults may perceive these systems as obtrusive and restrictive of their privacy [3]. Most of the assistive technology we found in the literature has been designed for older adults that have a functional limitation [1][4]. These systems can cause functional dependence [5] if they are used for older adults that do not have a severe functional or cognitive limitation but only require some help to continue performing their activities with autonomy. Older adults that are still independent need technologies that encourage them to continue performing their activities by themselves.

We propose Ambient Information Systems (AIS) that enable older adults to complete their activities of daily living at home. Ambient Information Systems describe a large set of applications that publish information in a highly non-intrusive manner, adhering to Mark Weiser's concept of calm technology. The information sources may manifest as both novel devices and as devices embedded in common objects, such as toys, furniture, clothes, jewelry and even our own bodies. The behavioral characteristics of such systems are that they: display information that is important but not critical, can move from the periphery to the focus of attention and back again, focus on tangible representations in the environment, provide subtle changes to reflect updates in information, and finally, they are aesthetically pleasing and environmentally appropriate [6]. Therefore, AIS can be embedded in the tools and objects that elders currently use to carry out their activities by providing information that reminds elders to perform an activity, warns them of a risk associated with an activity or provides clues about how to accomplish a step in an activity or task. The aim of this research work is to determine the usefulness and ease of use of AIS to support the independent life of older adults by enabling them to perform their ADLs. In this paper, we present the design rationale of AIS for supporting one of the activities considered relevant for living independently, which is medicating. Before presenting this AIS, section 2 presents AIS proposed for improving different aspects of people's well being. Section 3 presents our approach, including the methodology followed for addressing the identified research questions. Section 4 describes the preliminary results. And finally, section 5 presents the conclusions and future work.

2 Related Work

Several AIS have been proposed for improving the quality of life and well being of people, but a few of them have been designed for addressing the needs of older adults. For instance, we identified AIS designed for motivating persons to adopt healthy life styles. Such as Ubifit Garden which is an AIS for mobile phones that presents a garden that blooms to make persons aware of their physical activities they perform daily [7]; and the Breakaway AIS, which is a sculpture in form of a chair that changes its position to encourage people to perform a physical activity, such as walking, after detecting the user has been sitting for a long period of time [8]. We also identified AIS designed for informing elders' caregivers and family members regarding the elders' activities and health status. For instance, Digital Family Portrait [9] and CareNet[10] are AIS that allow family members or caregivers to monitor elders' health status, activities and some of their events such as medicating, falls and relationships, using a digital portrait with a picture of the elder augmented with icons that are related to those activities.

3 Our Approach

We propose Ambient Information Systems (AIS) that enable older adults to carry out their ADLs at home [11]. To reach this end, we consider that AIS should be used by older adults when they are still independent in order for the systems to make “aging at home” feasible. We believe that technology should promote their independent living by encouraging them to continue performing their activities by themselves. For instance, to correct a vision problem people use eyeglasses and are therefore able to continue reading without assistance from others. Therefore, during the design of AIS the elderly’s needs and problems regarding their natural functional limitations such as cognitive, visual and auditory decline should be considered. For addressing the above aspects, the following research questions have been identified:

1. What are the design attributes that should be considered for designing AIS that support the activities of daily living of older adults? To address this question, we analyzed the taxonomies and design guidelines for AIS that have been proposed in [6][12][13][14].
2. How useful are AIS for supporting the autonomy of older adults in their activities of daily living? We plan to develop AIS to evaluate the strategies used for helping older adults to perform their activities. Some of these strategies are persuasion, reminding, coaching or preventing risks associated with an activity of daily living.

3.1 Research Methodology

For addressing the above research questions, we are following a methodology that includes the following phases:

- *Analysis of the design attributes of AIS.* We analyze the taxonomies and heuristics that have been proposed for designing and evaluating ambient information systems [6][12][13][14]. This allows us to identify attributes of design that should be used in the development of AIS that will support older adults to live independently at home.
- *Case study.* To identify the desirable features of AIS, we first need to understand the problems that older adults face when performing their activities of daily living. To reach this end, we selected to study the medicating activity by using ethnographic techniques such as observation, interviews and questionnaires. To analyze the data obtained from these techniques, we used Activity Theory which enables us to focus on the interaction of human activity and consciousness within its relevant environmental context [16].
- *Design and implementation.* We apply the results from previous phases to propose and develop AIS. For instance we may consider the tools commonly used by older adults for carrying out their activities such as potential devices to be computationally enhanced to present relevant information for completing their activities as we present in [15].
- *Evaluation.* We plan to evaluate the ease of use and usefulness of the strategies incorporated into the ambient information system for helping older adults to perform their ADLs.

4 Preliminary Results

It has been determined that successful independent living requires that older adults be capable of performing the Basic Activities of Daily Living (BADL) as well as the Instrumental Activities of Daily Living (IADL) [17]. For this reason, our work will focus on analyzing activities that belong to the categories of BADL and IADL, such as medicating which is an IADL. Medication adherence has been identified as a problem that contributes to increasing health-care services utilization. Some studies have evaluated strategies in which health personnel, such as nurses or pharmacists, provide support to elders and educate them to improve their medication adherence [18]. The interventions strategies vary from providing face-to-face instruction, telephone consultations and written information. However, there is a lack of consensus as to how adherence should be effectively promoted, assessed and evaluated [18]. The aforementioned studies provide evidence that medication assistance is becoming a very important aspect of elderly care giving, and furthermore, motivate our work. We present preliminary results regarding a case study carried out to understand the problems faced by the elderly as they medicate. We have also identified some of the design attributes that should be incorporated into AIS that help the elderly take their medication appropriately.

4.1 Case Study

The aim of the case study we carried out was to:

- Identify needs and problems that older adults face in adhering to their medication prescription.
- Identify *tools or objects* that older adults use to medicate.
- Identify the *factors* that help or hinder their medication adherence.

Protocol. For this study, we selected older adults (OA) with no cognitive or functional disease to impede them from carrying out their daily activities. All OA self-managed their medications and were taking similar medications. We carried out contextual semi-structured interviews based on the Medication Management Instrument for Deficiencies in the Elderly (MedMaIDE), which is an assessment instrument for potential issues surrounding medication compliance and management in the home setting [18]. The interviews covered three aspects considered important for proper medication management according to the MedMaIDE instrument: i) What a person knows about the medication she is taking; ii) whether a person knows how to take her medication; and iii) whether a person knows how to get her medication from a doctor or pharmacy [18]. We also added questions to find out the place in the home where a person takes her medication; and the supporting resources a person uses to remember how to adhere to her medication. Contextual semi structured interviews were conducted with six OA between 62 and 73 years old.

Problems with Medicating. From the interviews, we identified that OA have the following problems adhering to their medication routine:

- Older adults forget to take their medicines on time. Two (2) OA commented that they have forgotten to take their medicines, due to the fact that they take several medicines and on different schedules.
- Older adults are not able to read the text of their medicines. Four (4) of them stated that they have problems reading the small text of their medicines.
- Older adults take expired medicines. Two (2) of the four (4) OA that have problems reading the small text of their medications commented that this was an impediment to realizing that a medication has expired before taking it.

Strategies to Adhere to Medication Prescriptions. We observed that older adults have their own strategies to adhere to their medication prescriptions:

- Participants have their own techniques to avoid taking incorrect doses and medicines; i.e. an older adult (OA4) stated: *“I place my medicines in order so I do not take them twice”* and (OA2) said: *“I put the medicine I take daily in this bowl”*.
- Older adults use resources to remind themselves of their doctors’ appointments in order to refill their medicines. In this sense, an older adult stated (OA2): *“I have an appointment card and in my work I have a calendar in which I mark my appointments with the doctor”*. and AO1 said: *“my daughter and I have our appointments with the doctor the same date”*.

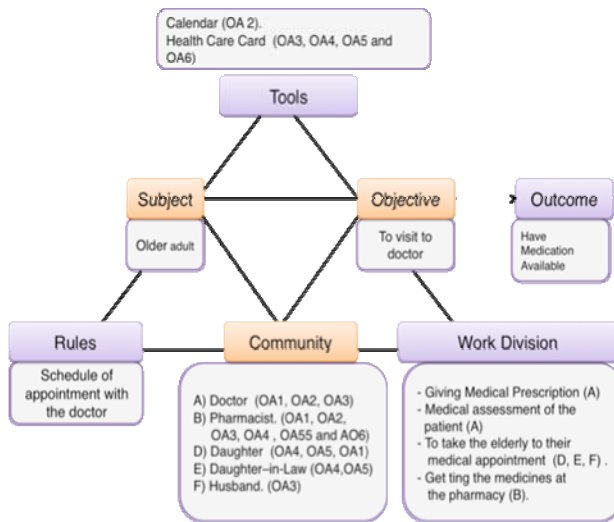


Fig. 1. Structure of the medicating activity by following the Engeström activity model

Activity Modeling. We used Activity Theory to identify the objects and/or tools that older adults use to adhere to their medication prescription, the community members that participate in the activity and the factors that benefit and limit the activity [16]. Fig. 1 presents the model of the medication activity for older adults that have the objective of visiting their doctors in order to have their medication available (expected outcome). For achieving this objective older adults use physical tools such as a

health care cards and calendars, which they use for scheduling their appointments. However, to achieve the objective, older adults need the participation of their community members. For instance, an older adult (AO3), need the participation not only of her doctor and pharmacists, but also of her husband to take her to the medical appointment. The interactions among the elderly and their community are limited by rules. In this case, the elder meeting with the doctor is limited by the schedule of the appointment. We also identified one of the factors that may affect the way the activity is performed. This factor is related with the place in which older adults take their medicines: the kitchen. Older adults provided arguments that indicated that this is the place in which they spent more time. Additionally, two (2) older adults indicated that the kitchen is the place in which they find the instruments they use for medicated. One (1) older adult indicated that since he spends more time in the kitchen, this also facilitates not forgetting to medicate.

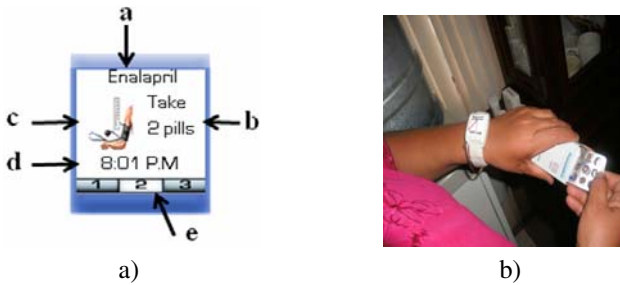


Fig. 2. a) WENOMA interface for coaching elderly how to take a medicine; b) Elderly wearing a WENOMA Prototype

4.2 Design of AIS for Supporting Medication Adherence

We designed a prototype Wearable Notification Display for Medication Adherence (WENOMA) for enhancing a help button in the context of a project that will study the impact of using help buttons to provide permanent socio-medical assistance to the elderly (Figure 2b)[19]. The WENOMA is an ambient information system to assist older adults in taking their medicines by *Reminding* older adults they need to (a) take their medicines and (b) refill them on time. To do this, the system *coaches* the user by presenting critical information that enables them to carry out these two specific tasks, such as (a) doses to take and (b) doses left in the medicine container. If an older adult persists in not performing any of these two important tasks, the notification display will periodically remind and coach the user in order to *persuade* him to achieve their medicating routine. The proposed user interface for the WENOMA system is shown in Figure 2. The figure 2a presents the user interface for coaching elderly of the medications and doses to take. It consists of the following elements: a) medicine name, b) doses, c) icon representing the disease or health problem treated with the medication, d) current time, e) number of pills to take at current time. The figure 2b presents an older adult wearing a WENOMA prototype.

Design Attributes. WENOMA addresses the following design attributes from taxonomies and design guidelines for AIS that have been proposed in [6][12][13][14]:

Notification Level. This is defined by Matthews such as degree to which AIS alert the person [12]. Matthews *et al* [12] defined the following levels listed in ranges from lower to higher notification: ignore, change blind, make aware, interrupt and demand action, considering the models: inattention, divided attention and focused attention propose by psychology of human attention science. In inattention the objects are not directly available for conscious awareness but may still affect behavior; Divided attention and focused attention, represent the two ways that humans consciously perceive stimuli, by distributing attention over several objects or using all attentional resources to focus on one stimulus[12]. WENOMA prototype uses higher notification levels that consider divided and focused attention because it provides older adults critical information about their medication when it requires their attention. Thus WENOMA prototype is not currently using lower levels such as ignore and change blind, because convey information in a way that consumes no conscious awareness. WENOMA uses the notification levels make aware, interrupt and demand action. The make aware level is used by WENOMA to represent information of some importance for the activity [12]. For instance, WENOMA provides information to older adults to remind them that it is time to take their medicines or that their medicines are running out. The interrupt and demand action is used by WENOMA to represent information that should grab focused attention temporarily distracting the user from their activity. But demand action also requires that the user perform action to stop the alerting [12]. For instance, an older adult is performing an activity such as reading a book, and then WENOMA use an interrupt notification level using an audio modality through strident sound to notify them that it is important to take their medicines and this demands action of older adults to go to their medicine dispenser to stop the notification.

Modality of Notification. This attribute describes how the data from the world is encoded in visual, tactile, olfactory, auditory and movement elements to convey information to the persons [6][14]. The WENOMA use different modalities of notification that make an older adult aware of the importance of performing relevant tasks regarding his medication. For instance, a slight *audible* alarm is used as a cue to attract his attention. Then, the older adult may focus on reviewing the critical information presented on the display, such as the name of the medicine and doses to take. To present this critical information, we are using *visual* elements, such as text and icons that easily coach the older adult regarding his medication. Our intention is to use visual notification modalities that do not demand the user's attention for long periods and that can be easily read and be interpreted.

Representation of ambient information system. This attribute describes the computationally enhanced objects required to become an Ambient Information System. In [6][14] it is stated that an AIS can be represented as a physical object developed for a specific purpose, for instance the Breakaway [8]. The AIS can also be integrated in objects that currently exist in our physical environment, such as the CareNet Display [10] which is a portrait. Finally, it has been identified that AIS can be a 2D representation that displays information by means of traditional screen technology, such as the Ubifit Garden for mobile phones [7]. Considering these definitions, we identified two

ways to digitally enhance home objects to create AIS for helping older adults to carry out their activities. Thus, we defined that AIS can be an *aesthetic object or an enhanced tool in the elderly home*. An aesthetic object while is embedded in are objects used to decorate homes or objects that older adult can wear, i.e., portraits, lamps and jewelry. An enhanced tool is an AIS embedded into the tools and/or instruments those older adults already use to perform their ADLs. The representation of WENOMA is considered an aesthetic object representation because it is embedded in a bracelet that the elderly wear as any other jewelry they normally wear.

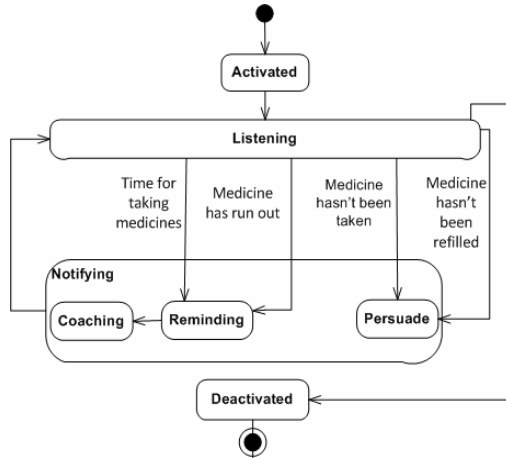


Fig. 3. WENOMA states for supporting elderly’ medication adherence

4.3 Strategies of WENOMA for Support Older Adults with Their Medication Adherence

Our wearable notification display (WENOMA) presents critical information that enables older adults to complete their medicating activity appropriately. To reach this end, we propose that the WENOMA system uses the following three strategies which are illustrated as states diagram of the system in figure 3: Reminding older adults they need to (a) take their medicines and (b) refill them on time. To do this, the display coaches the user by presenting critical information that enables them to carry out these two specific tasks, such as (a) doses to take and (b) doses left in the medicine container that is running out. If an older adult persists in not performing any of these two important tasks, the notification display will periodically remind and coach the user in order to persuade him to achieve their medicating routine.

5 Conclusions and Future Work

The application of MedMaIDE in the case study allowed us to identify the common problems that older adults face to adhere to their medication prescription. Using Activity Theory was a valuable tool for analyzing the study data and identifying the objects and tools that older adults use to perform their activities and the members of

the elderly community that help them to carry out their activities. This enables us to propose AIS integrated in the objects and tools that elderly currently use for carrying out their activity or proposed new ones, as the Wearable Notification Display for Medication Adherence. We plan to consider the object and tools that elderly use to perform their medication adherence to propose new prototypes of AIS that support medication adherence, and identify other attributes of design. We will extend the case study by including other group of older adults to strengthen our results and validate the models of activity we have already obtained. We plan to carry out a usability evaluation of the WENOMA to support the medication adherence and evaluate the utility of the strategies incorporating into the system for reminding, coaches and persuading to older adults in their activities.

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