Requirements Engineering of Ambient Assisted Living Technologies for People with Alzheimer's

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Abstract. A rapid growth in the ambient assisted living technologies (AALTs) is being witnessed due to the aging society. Evidence suggests that AALTs empower the elderly's involvement with their surroundings, and hence; improves the quality of their living. Therefore, public service organizations (e.g. The Saudi Alzheimer's Disease Association (ALZ)) have been established with the aim to raise awareness about AD, in order to reach a comfortable lifestyle for all elders with AD. Moreover, this fact is the motivation behind addressing our problem in the paper. Each AALT has its own special requirements in usage, care, extensibility, reusability, scalability and adaptability. More importantly, there are many other factors that have great influence on those requirements. In this paper we will investigate some of these factors, such as: the environment, the caregiver's experience, and the elder's age, culture, and social structure. Furthermore, adaptability and cultural factors are the pivots of our study, to show their influence on designing AALT and specifying their requirements.

Keywords: AAL · Alzheimer · Requirement engineering · Design consideration

1 Introduction

Due to the aging society, a population of 35 billion people worldwide are developing Alzheimer's Disease (AD) [1], and the number has exceeded 50 thousands of elders in Saudi Arabia [2]. Alzheimer's Disease is known as a degenerative brain disease [3]. AD is a progressive deterioration in memory and cognitive skills (i.e. thinking and reasoning). Furthermore, AD can be identified and diagnosed at an early stage in order to help individual's administering treatment. Alzheimer's Association has formed a list of warning signs for Alzheimer's. As an example of such signs that disrupt daily life: memory loss (i.e. Dementia), challenges in solving problems and planning, confusion with time or place, difficulty in conversations and completing tasks [4]. To help assess those elderly's, monitor and diagnose AD early and support aging in place, assistive and intelligence technologies have been introduced. Those technologies are referred to as "ambient assistive living technologies" (AALTs). AALTs are aware of the elderly's presence, sensitive to their movements and gestures, and responds to them

C. Stephanidis (Ed.): HCII 2015 Posters, Part II, CCIS 529, pp. 381–387, 2015.
DOI: 10.1007/978-3-319-21383-5_64

adaptively [8, 9]. AALTs improve the quality of the elderly's living [5]. Subsequently, there is an emergence towards the use of AALTs in healthcare and homecare domains [6, 7].

More importantly, there are many other factors that have influence on those requirements. In this paper we investigate some of these factors, such as: the environment, the caregiver's experience, and the elder's age culture, and social structure. Furthermore, adaptability and cultural factors are the pivots of our study, to show their influence on designing AALT and specifying their requirements.

2 Background

The evolution of AALTs has started by addressing heterogeneous users to facilitate many services and monitor the user interactions with the environment for various reasons, such as data prediction of future activities. EasyLiving [10] and Carelab [11] are one of the initial AAL projects that began under the category of smart environments that provides a cohesive user experience by detecting activities and behaviour patterns [10, 11]. AwareHome [12], I-Living [13] and BelAmI [14] are as well other smart environment but with the focus on the assistive living perspective such as addressing security and safety concerns [14].

Many of existing AALTs have the capability to address more than what they were designed and built for, as slight adjustments and modifications broaden their target users. Some of them have even high potential in serving more specific users with their current highly suitable technology, such as MavLab [15]. One of the most AALTs that wasn't designed for elders with AD specifically, but for elderly and disabled in general is MavLab (i.e. MavHome lab) [15]. MavHome is a smart environment utilized to monitor the health of elders and people with disabilities, and assist them in carrying out daily activities at home by themselves. It provides a novel data mining and prediction algorithm that learns how to detect patterns from the collected data. Moreover, it detects anomalies in their regular activities, which thereby might be of great help in the case of AD, where the detected outliers is useful to monitor the progress and level of AD the elderly is reaching. The SmartHouse system [16] as well carries out the same mechanism as the MavHome, and can be adapted for AD patients too. Moreover, below are three AALTs developed for elders with AD and their state of art.

ALZ-MAS is a multi-agent system aimed to enhance the assistance and healthcare for Alzheimer's patients [17]. The system integrates different technologies for context awareness agents to collaborate with, such as radio frequency identification, wireless networks and automation devices. All information gathered by these tools are processed by agents as the writers have justified the employment of agent in their system because "as they possess the capability of adapting themselves to the users and environmental characteristics".

3 Problem

Recent research in healthcare and informatics had shed light on the inadequate support available for people with AD, and the increasing need for a sustainable model of assistive technology provision for people with AD and their caregivers.

It can be argued that AALTs -which were developed in other countries- might not necessarily be embraced by target user populations in Saudi Arabia due to variations in socio-cultural context. And as each AALT developed for Alzheimer's patients is based on one certain culture, and this is for the variations that are in the daily life activities between cultures. This is affecting the adaptation of those technologies to different environments due to the socio-cultural factors and how they translate to functional and non-functional requirements. Consequently, these design considerations affect the usability of these technologies when integrated with the targeted environment. Adapting existing AALTs to our culture requirements is what we will be investigating.

4 Methodology

As reported in the literature [33], it is recommended to use semi-structured interviews to investigate requirements in the context of AD patients' needs. It is also suggested in [34] to involve experts from various fields to form a multidisciplinary perspective. Participants in our research are categorized into three categories:

Category (1): Specialists from the Saudi Alzheimer Disease Association in which they represent the caregivers' perspective.
Category (2): Industrial engineer, Dr. Eng. Shady Aly.
Category (3): Geriatric psychiatrist, Dr. Fahad Al-Wahhabi.

The adopted research design strategy is an exploratory design conducted in two phases as follows:

Phase 1 - Data Collection: Literature Review: Reviewed the state of art and studied related literature on Alzheimer's disease, AAL tools in general and AAL tools for Alzheimer's patients related studies are studied and analyzed in depth to derive a set of requirements in which these tools perform.

Semi Structured Interviews: Interviews are conducted in person. We interviewed specialists from the Saudi Alzheimer Disease Association. The objective of these interviews is to investigate and discuss the cultural factors and their effects on Alzheimer's patients in Saudi Arabia. We have also interviewed a geriatric psychiatrist. Our goal is to explore the psychological perspective of elderly with Alzheimer's diseases. All interviews are analyzed qualitatively.

Surveys: All questions in the questionnaires are educed after reviewing the literature. The targets of the survey are engineers, as we wanted to reflect on the deployment of AAL tools from engineering respective.

Phase 2 – Data Analysis: Tools review is shared with Category (1), the goal is to observe how they will reflect on existing technology, and they shared their concerns and reflection in terms of pros and cons. After receiving the output from Category (1) on tools review, we have summarized their reflection along with interviews and survey analysis to form design considerations as seen in Table 1.

Table 1. General requirements

Type	Tool name	Design consideration
Memory aid	Memory glasses [18]	1. DC4. Experts from all categories show concerns regarding wearable technologies, as they experienced that AD patients are not necessary cooperative when instructed to carry them, as they tend to remove them
	Memoclip [19–21]	2. DC1. Experts in categories one and three had touched on the social aspect of wearable technologies. As they add a distinguishable element that pins them out as AD patients, whereas caregivers prefers them to blend with the community
	Interactive symptom assessment and collection (ISAAC) [22]	3. DC7.1.2 Category one experts one have questioned AD patients' perception of using such technologies. As deriving a positive acknowledgement of the audio alert requires a level of familiarity of interaction with technology (i.e. to touch the screen in order to stop the audio) 4. DC7.2.3 The system shall add Arabic in the available languages
Navigation aid	Opportunity knocks [23]	5. DC1 Local AD patients don't use public transportation. Private transportation is available for Male patients if they are capable of driving, whereas Female patients require a male driver as local regulations prohibits female driving
	Activity compass [24]	Refer to point 3. DC7.1.2
Motion detection tool	Talking motion detective [25]	6. DC4 The audio customization feature offers adaptability
	Motion detector with remote alarm [26]	Interaction is only with caregivers; therefore, no design consideration for AD patients
Environmental aid	Possum primo [27]	Refers to point 4. DC7.2.3
	Alert-IT door activity monitor [28]	7. DC8 Category three experts have highlighted the usage of labels in requesting the caregiver (i.e. pressing the "HELP" button).

(*Continued*)

Table 1. (*Continued*)

Type	Tool name	Design consideration
		As 5 % of local population is illiterate; therefore adding an image that illustrates the meaning of HELP is recommended
Wandering and tracking aid	MindMe [29]	8. DC1.4 Carried devices might be disposed or forgotten by AD patients. Therefore, experts in all three categories have recommended the separation of the device's functionality from the patient's control, where they shall function without the patient's cooperation (i.e. carrying the device)
	GPS shoe [30]	9. DC1 Category one experts have suggested the shoes to be customized to local designs
Physiological/functional aid	Fall detector [31]	10. DC1 Experts in all categories have emphasized on the privacy aspect, where users tend to find having cameras in their living environment uncomfortable
	Bedwetting alarm [31, 32]	This technology addresses a matter which falls out of the cultural requirements scope, where it is concerned with physiological functions

4.1 General Requirements and Design Considerations

Table 1 illustrates the general requirements elicited and educed from the previously listed AAL tools, and design considerations that evolved from the experience and knowledge of subject matter experts (SMEs) in all three categories.

5 Conclusion

In this paper we have proposed a set of design constrains that needs to be taken into consideration while deploying those technologies in our culture for ambient assisted living technologies for AD patients. Three categories of different disciplines experts were involved in reviewing a pool of AAL tools. The resulted set of design constraints suggest that the variation in socio-cultural context presented in Saudi Arabia might demand an adoption mechanism in order to raise those tools effectiveness.

We believe and aim that the investigation of those design constraints could assist AD patients indirectly by designing tools that suit their culture best and therefore ease

their lives. Those design constrains could be seen as a primality requirements for manufactures as they could use them as guidelines to design AAL tools.

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