Orange Alerts: Lessons from an Outdoor Case Study

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Abstract— **Ambient Assisted Living (AAL) is of particular relevance to those who may suffer from Alzheimer's Disease or dementia, and, of course, their carers. The slow but progressive nature of the disease, together with its neurological nature, ultimately compromises the behavior and function of people who may be essentially healthy from a physical perspective. An illustration of this is the wandering behavior frequently found in people with dementia. In this paper, a novel AAL solution for caregivers, particularly tailored for Alzheimer's patients who are the early stage of the disease and exhibit unpredictable wandering behavior, is briefly described. Salient aspects of a user evaluation are presented, and some issues relevant to the practical design of AAL systems in dementia cases are identified.**

***Keywords:** Ambient Assisted Living, pervasive health, health informatics.*

I. INTRODUCTION

A major implication of demographic changes in Europe and elsewhere is that an ever-increasing number of elderly citizens make up a higher percentage of the population [1]. This is compounded by the fact that the incidence of dementia is also increasing, not only amongst the elderly, but by those who are middle aged [3]. This has significant implications for society, not least from a cost perspective. Meanwhile, people who are taking care of dementia patients are experiencing feelings of confinement and emotional adjustment due to caring responsibilities, as well as experiencing immense stress in managing the progressively degenerating behaviors [3][4]. These difficulties are compounded by a moral desire to respect the dignity of citizens with dementia by enabling them to live independently for as long as possible. This calls for a comprehensive healthcare solution for all stakeholders.

Information and Communication Technologies (ICT) form the basis of Ambient Assisted Living (AAL) systems [2][14]. Ambient Intelligence (AmI) [4] is a multidisciplinary paradigm built upon pervasive computing, and fosters an anthropomorphic approach to human-centric computer interaction design. AmI enables the basic criteria to build intelligent environments where devices can be embedded into the environment seamlessly, while enabling the recognition of objects and their situational context, and the delivery of services that are personalized, adaptive and anticipatory.

This paper is focused on addressing the issue of managing wandering behavior in patients with early stage Alzheimer's Disease. Studies [3] show that 67% of the Alzheimer's patients wander off, and may get lost. It presents the design and implementation of one such system, OutCare, for managing wandering behavior.

This paper is structured as follows: Section II discusses related research. A brief overview of the design and implementation is presented in Section III. Some pertinent results of a usability analysis are outlined in Section IV after which the paper is concluded.

II. RELATED RESEARCH

Significant research efforts have been made in AAL. Much of this has been in the research community but commercial products are beginning to appear.

The CareLab [10] project resembles a one-bedroom apartment for older adults. It is equipped with a rich sensor network in order to extract higher-order behavioral patterns. It does not address the specific needs of adults with dementia.

ALZ-MAS [9] presents an AmI-based multi-agent system aimed at enhancing assistance and health care for Alzheimer patients living in geriatric residences. It facilitates the integration of distributed services and applications to optimize the construction of Ambient Intelligence environments.

Comfort Zone [12] is one of the newly available commercial services unveiled by the Alzheimer's Association in the United States. It enables a web-based application includes location-based mapping services, providing information on the person's or object's location, and supporting the definition of zones and raising of alerts.

GPSshoes [11] is an geo-defence device designed for tracking individuals with Alzheimer's Disease or other dementia. It places a pair of devices into the shoes, one is GPS unit and another is the signal transmission module to transfer the position coordinates to a central monitoring station. If the patient wanders off more than the pre-set distance, their caregiver will immediately receive a geo-fence alert on their Smartphone or computer, with a direct link to a Google map that plots the wander's location.

OutCare [6], the focus of this paper, is similar in scope to Comfort Zone. However, it is designed around the construct of distributed intelligence [4], and employs the embedded agent paradigm as a means of enabling intelligent and adaptive behavior. By enabling a tracking capability using GPS, OutCare seeks to analyze patients' behaviors, and significant deviations from the daily behavior signature will

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give rise to alarms being raised for the associated stakeholders.

III. OUTCARE

A. Overview

OutCare is intended to realize an AAL system which will be tailored for citizens who suffer from cognitive decline specifically Alzheimer's Disease. Designed as an Multi-Agent System (MAS) [7], OutCare implements an outdoor tracking mechanism to provide remote and unobtrusive services to patients and efficient caring methods to caregivers as well. The main functions that are implemented include:

1. Enabling a monitoring capability whereby patients' daily routines can be learnt, and deviations from such routines noted within a patient profile. Significant deviations from the normal daily signature may be alerted to relevant parties (caregivers, relatives, medical-centers) via SMS, Email, and Voice.

2. Development of efficient and convenient caring mechanisms, and collection of data that underpins longitudinal studies concerning the onset of dementia thus fostering a greater understanding of the condition itself.

3. Delivery and presentation of simple memory triggers for patients, assisting in the repair of the activity sequence when performing simple routine tasks.

4. Adopting an intelligent agent-based approach to facilitate distributed system intelligence and modular system design.

The emphasis of this initial implementation has been on the first objective. Thus the focus is on bringing carers' attention to situations where the patient may be approaching a dangerous zone. An *orange alert* is raised indicating potential danger. Depending on criticality of the situation, the carer may raise this to a *red alert* by notifying civic authorities.

B. Design

The overall architecture of OutCare is shown in Fig. 1. It consists of three components, which are the patients, the caregivers and a central server.

Patient Component: This component of OutCare concerns the support of individual patients with Alzheimer's Disease. However, this group of citizens may be capable of maintaining basic independent living, though they may suffer from memory loss or experience difficulty when performing everyday tasks.

Caregiver Component: Citizens who are involved in taking care of patients with dementia need a mechanism of ensuring that the patient remains safe, while respecting the privacy of the patient.

Server Component: A central server maintaines the web services essential to OutCare. These include authorised access, patient and caregiver profiling, data recording and data processing as well as maintaining communications with multiple mobile clients including patients and carers.

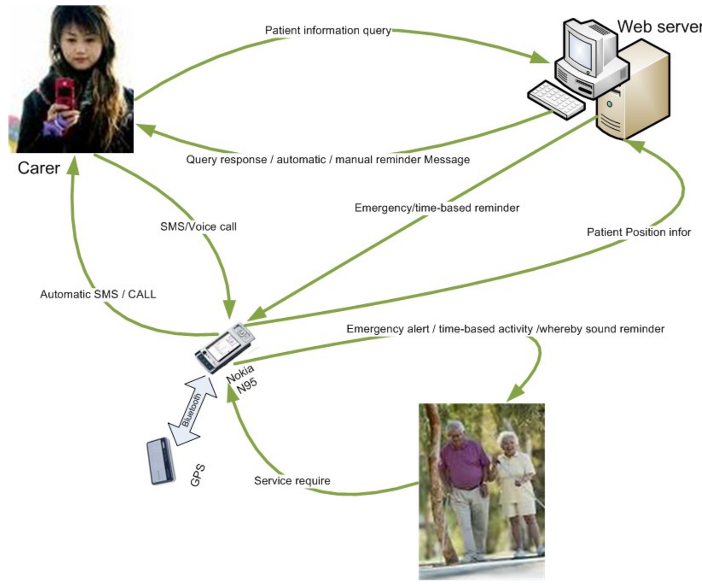


Figure 1. High-level Architecture of OutCare.

C. Implementation

Based upon the design, OutCare implement three categories of applications that are hosted on the patient's device, the caregiver's device, and the server respectively. All are interconnected and cooperate in the realization of all services.

Patient Application: The host device for the patient's application is a Nokia N95, as it supports Java for supporting intelligent agents, Wi-Fi, 3G, and Bluetooth for communications, and contains an embedded GPS unit for person tracking. The main screen of the patient application is illustrated in Fig. 3. It does not require much effort from the patient to interact with it, having been designed using simple icons for ease of use.

Caregiver application: This can be deployed on any type of mobile phone with Internet access and support for Java. With this application, caregivers are able to check information about associated patients and their status. Most importantly, it enables the tracking of patients via the phone, and, on irregular activities, receives alerts from the OutCare Server or the Patient Application. Fig. 2 presents an example of the alert message.

OutCare Server: This enables web services, with which authorized users, usually caregivers, can log into the service, track the patients on a map, and also access patients' profile information such as routines, movement history etc. It also enable users to register new patients, and caregivers, create zones for given patients and so on. Fig. 4 shows an example of web screen.

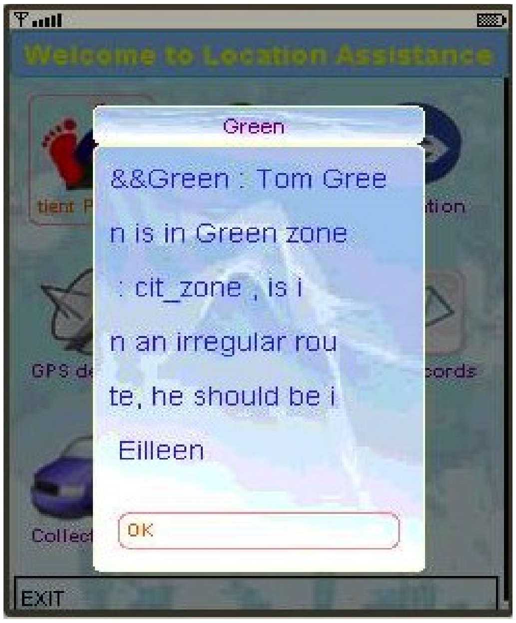


Figure 2. Example of an Outcare Alert.

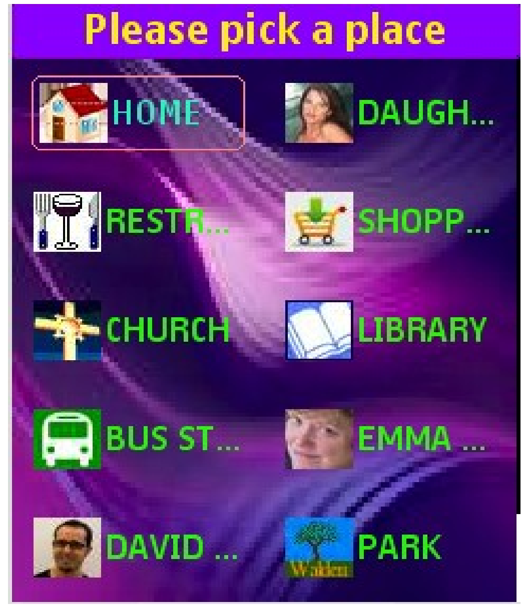


Figure 3. Outcare Introduction scree

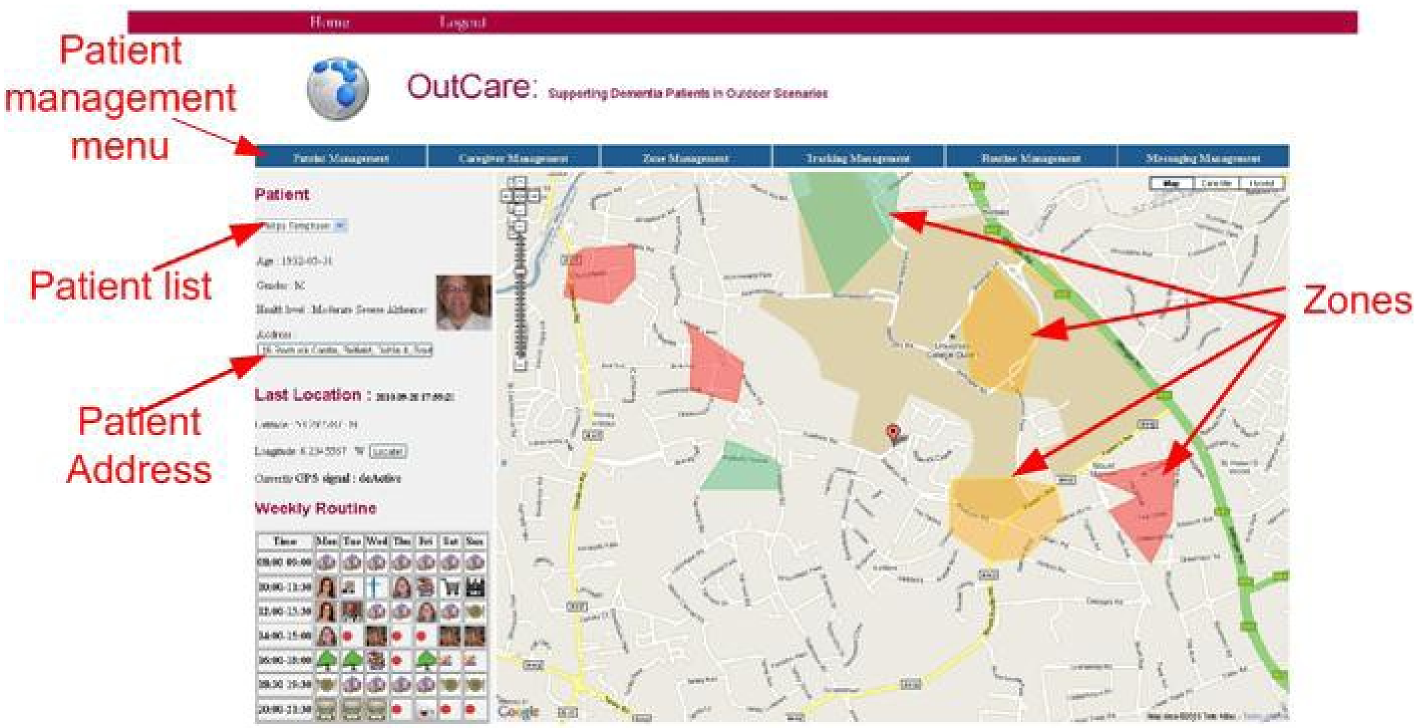


Figure 4. The OutCare portal where the web services are accessed and configured.

IV. EVALUATION

There are three conceptual dimensions of usability delineated according to the International Standards Organization (ISO) [13], which are effectiveness, efficiency and satisfaction. Regarding this initial OutCare evaluation, the focus is placed solely on the measurement of perceived satisfactions by the potential users. The term satisfaction refers to “the comfort and acceptability of the work system to its users”.

The evaluation process followed standard procedure, which includes three main steps:

- Each participant was given an instruction sheet about the OutCare project;
- Each participant was asked to completed a number of tasks with OutCare, such as register a new patient/caregiver, create zones, tracking the patient and so on;
- Finally, each participant was asked to fill a questionnaire form that contains factual data and usability questions

There were 52 participants including 27 males and 25 females between 17 and 60 years old attended this process. Fig. 5 presents the distribution of age group based on gender. The participant group was ethnically diverse, covering eight nations. While the majority of the participants had good English, a small number would encounter problems when communicating with English.

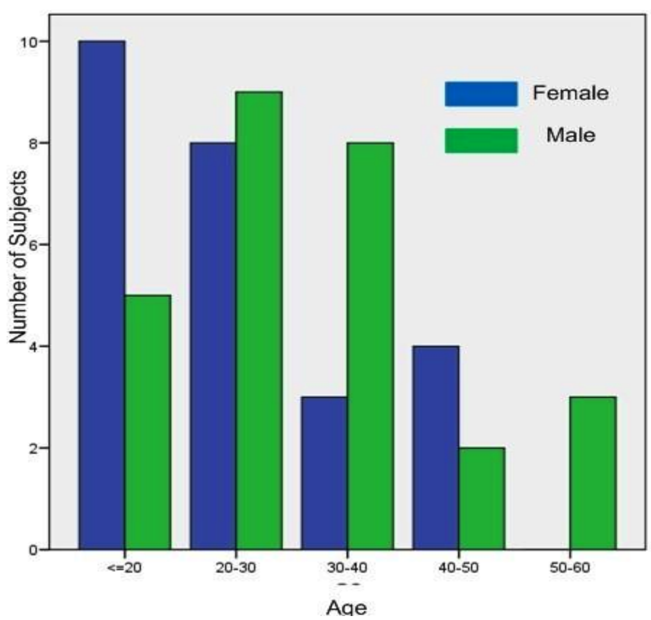
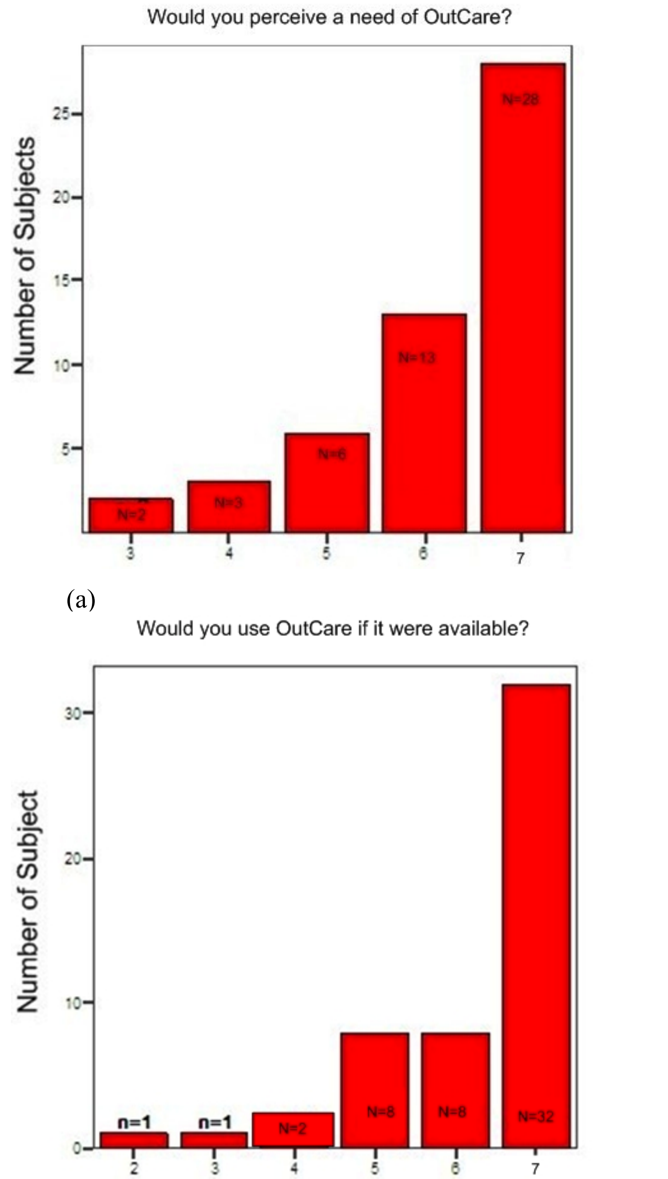


Figure 5. Age and gender of the participants.

To analysis the usability results, we first evaluate the questionnaire itself. The usability questionnaire is designed to measure a number of dimensions including satisfaction and market potential. For the former dimension, the Cronbach's alpha was 0.86; for the later dimension, the alpha was 0.87. Both values indicate good reliability. The questionnaire itself consisted of a series of questions organized within a 7 point Likert scale with 1 indicating complete disagreement, and 7 indicating complete agreement.

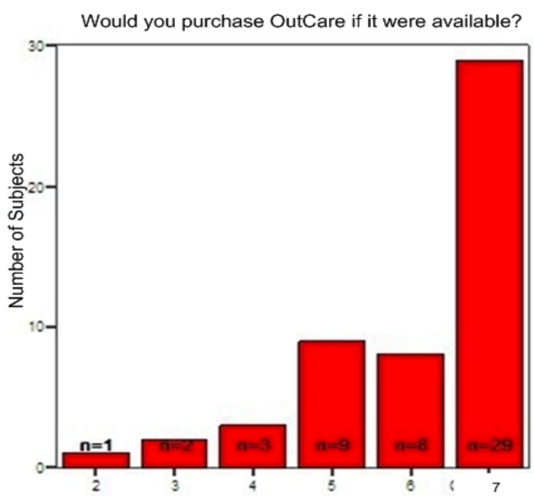


(b)

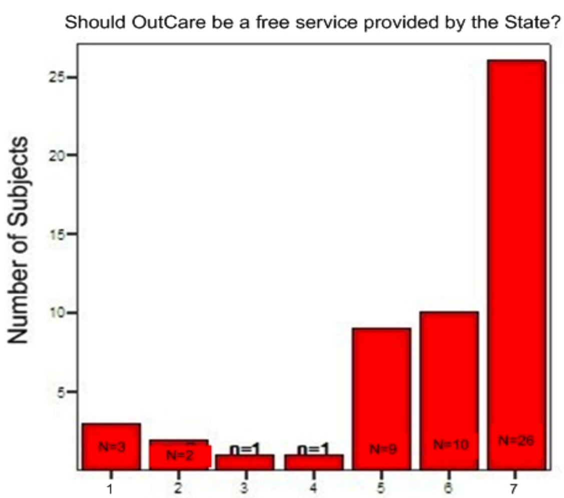
Figure 6 OutCare market potential. (a) Do users perceive a need for systems such as OutCare? (b) Would potential users use OutCare if it were available?

The results gained from the questionnaire were encouraging. The average score on the satisfaction with the overall performance is 5.62, the result of the One-Sample t-test with test value 5 indicate that users were very satisfied with the overall performance ($t(51) = 3.628$, $p < 0.001$). Furthermore, the results indicate that 75% of the subjects perceived OutCare as being very easy to interact with, with only 4% encountering some difficulties in completing the tasks. 92% of the subjects were able to successfully complete the required tasks.

A second measured was market potential (Fig. 6 and Fig. 7). As is shown in Fig. 6(a), 54% of the subjects believe OutCare is definitely needed, scoring this a 7 on the Likert scale, and another 36% ranked it between 5 and 6. 62% of the participants claimed that they would use OutCare if it were available, and if they were taking care of somebody who suffers from dementia (Fig. 6(b)). Fig. 7(a) demonstrates the results of whether subjects were willing to pay for OutCare or not. It was found that 56% of the subjects were prepared to pay for the service provided by OutCare if they were using it. A one-sample t-test with a mean value of 5 confirmed that users are not reluctant to pay for it ($t(51) = 6.062$, $p < 0.001$). However, half of the subjects believes OutCare should be a free service provided by the state (Fig. 7(a)), $t(51) = 5.637$, $p < 0.001$.



(a)



(b)

Figure 7. OutCare market potential. (a) Would a potential user buy OutCare? (b) Should OutCare as a free service provided by State or not?

V. DISCUSSION

As is discussed above, OutCare is tailored for patients with Alzheimer's Disease in the earlier stage, with the specific objectibe of managing wandering behaviors. It assumes that the patient will carry a mobile device. This is a limitation, and its effectiveness is questionable. For early stage patients, it may not be a problem if they are used to carrying mobile phones. Alternative approaches, such as that adopted by GPSShoes must also be considered.

Though the results are promising, a number of issues arose that must be factored into the redesign of OutCare. These include:

1. Privacy & Security - a majority of subjects expressed reservations about privacy though they acknowledged that safety should take priority.
2. Cost – the issue of cost, given the 24/7 nature of AAL and the limited financial means of many older adults was seen as a potential limitation.
3. Isolation – though OutCare and AAL have altruistic objectives, a side effect of such technologies could be that a reduction in human contact thereby leading to isolation and loneliness.
4. Indoor scenario – the emphasis on the outdoor scenario in this version of OutCare was noted and a number of subjects expressed the view that its functionality should be extended to the indoor realm also.

VI. CONCLUSION AND FUTURE WORK

OutCare demonstrates a novel and competent health care approach to AAL in the case of dementia scenarios. It is planned to extend the concept in a variety of dimensions thus enabling a more holistic approach to safety and behavior monitoring. A test-bed compromising a suite of movement sensors is being planned. This will be augmented with a system to track everyday electrical device usage. Such common yet unobtrusive technologies offer significant scope for detecting behavior patterns, establishing long-term behavior signatures and determining deviations from common behaviors.

Acknowledgment

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