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OutCare: Supporting Dementia Patients in Outdoor Scenarios

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Abstract. Ambient Intelligence (AmI) is a profound vision of computing power that is invisibly embedded into the fabric of everyday life. It is accessible through intelligent interfaces which are so natural that they can be used unconsciously. The increasing maturity, performance and miniaturization of processors, networking technologies and wireless sensor networks enable a move towards pervasive computing, ubiquitous connectivity and adaptive software. The Intelligent Agent paradigm has proven itself to be a promising branch of Artificial Intelligence (AI), complementing the pervasive trend of network engineering. One of the possible usages of AmI is Ambient Assisted Living (AAL) which attempts to utilize appropriate technologies to support citizens in living in their preferred environment independently, for a longer period of time than may otherwise be the case. This paper proposes an AAL solution for Alzheimer's patients based on the intelligent agent platform, exploring the practical delivery of intelligent environments that are sensitive and responsive to the patients, supporting them in performing daily activities and tasks in a natural, unobtrusive way.

Keywords: Ubiquitous Computing, Ambient Assisted Living, Intelligent agents, pervasive health.

1 Introduction

Demographics are changing at an alarming rate in both Europe and worldwide. Life expectancy is increasing; the percentage of older Irish male citizen aged 65 or over will rise from 9.7% in 2002 to 14.1 percent in 2021 [1]. The percentage of Irish female aged 65 or over will rise from 12.5% in 2002 to 16.4% in 2021. The absolute number of older citizens was 436,401 in 2002; the corresponding figure will increase to 730,000 by 2021 with the life expectancy rising to 84. The equivalent increase of people aged 75 or over will be approximately 52% by 2021. It is also projected that the number of older people living alone will increase substantially between 2002 and 2021, in line with the growth of the overall number of old people. By 2021 there will be over 30% of those aged 65, approximately 211,000 and over living alone.

Between 2002 and 2036, the approximate number of people with dementia in Ireland is expected to increase by 303% while the total population will increase by less than 40%; however dementia worldwide will witness a four folds increase by 2050 reaching 117 million.

The cost of healthcare is continuously increasing; for example, the fiscal cost of a hospital-bed has become punitive, running at a weekly cost of €778 on average [2]. There are nearly 50,000 people are currently involved in caring someone with one of the six symptoms of dementia [3]. In 2005 Ireland spent 8.2% of GDP on healthcare; in 2009 it rose to 16%, which is estimated to double again in 2035.

As the figures alluded to testify, the aging demography profile will give rise to significant problems, both financial and social. Thus a key issue for consideration concerns how technology might be prudently harnessed to such that these costs may be reduced.

1.1 Ambient Intelligence

Ambient intelligence [4] (AmI) is a multidisciplinary paradigm built upon ubiquitous computing. It fosters a novel anthropomorphic human-centric computer interaction design. AmI enables the basic criteria to build intelligent environments where devices can be so miniature as to disappear into the background, being seamlessly embedded into the environment. Fundamental to AmI is the recognition of objects and their situational context, and the delivery of services that are personalized, adaptive and anticipatory [5].

Intelligent agents [6] have become a mature technology for integrating ambient intelligence into smart applications. Intelligent agents are able to perceive their environment, apply deductive and practical reasoning mechanisms to respond in a timely fashion to changes in order to satisfy objectives. Secondly, they are able to exhibit goal-directed behaviours by taking the initiative, and capable of interacting with other agents. Their distributed nature makes agents are a particularly apt model for realising AmI.

1.2 Artificial Intelligence (AI) in Healthcare

Ambient Assisted Living [7] has been conceived as a paradigm for enabling people live on their own for longer periods than would otherwise be the case. In this way, costs would be reduced and quality of life maintained. Thought there are a multitude of technologies around which AAL systems may be constructed, AmI offers one particularly promising avenue. In this paper, a prototype mobile services for those afflicted with dementia is described.

2 Related Research

The most significant step in AAL area is enabling the development of an environment based on the concept of ubiquitous sensing. It attempts to develop a distributed and

networked computing infrastructure to support users while remaining transparent to them. Combinations of processors and sensors are embedded into a distributed and elaborate network to provide user identification, face/speech recognition, tactile tracking, movement monitoring, pose tracking, facial expression and gesture recognition, audio processing and physical environment detecting functionalities, amongst others. Immense research efforts have been made in this direction and some commercial products are available.

CareLab [8] resembles a one-bedroom apartment which is equipped with a rich sensor network in conjunction with a health and wellness application, to support seniors' independent living. Higher-order behavioural patterns and the state of home infrastructures can be extracted by processing and combining the diverse sensor information.

BelAmI [9] aims at developing innovative technologies in the area of Ambient Intelligence. One of the contributions of this project is building a monitoring and remaindering solution that can address some characteristic requirements such as adaptively, dependability, interoperability, safety/security and resource efficiency. Objects' behaviours and Habit status will be observed and emergency assistance will be provided by enabling people to carry out daily tasks.

PAS [10] aims at maintaining the capability of independent living through a time-based daily activity reminder, non-intrusive monitoring of physical functions and mobility profiles, and more importantly maintaining a real-time communication with remote care providers and clinicians.

Since AAL has become a popular topic, many living labs for the study of ubiquitous technology in home settings have been established. Plenty of research efforts arise from either technological or medical fields, as it is extremely hard to develop any multidisciplinary access to this research realm. AAL requires not only technological or medical expertise but also attempts at including a social and cultural perspective to reach a high level of quality of life. One key observation concerns the predominance of indoor environments in many documented research efforts. In contrast, the work described here focuses on outdoor environments, focusing on the needs of both the patient and their carers.

3 Outdoor Healthcare System (OutCare) Overview

OutCare was designed as an AAL system specifically tailored for citizens with Dementia, for example, Alzheimer's Disease, and its design is based in County Carlow, Ireland. In line with the main symptoms of Alzheimer's disease, applying the intelligent agent platform, OutCare implements an intelligent outdoor assistance to provide remote and unobtrusive services to patient and efficient caring methods to the carers as well. The main functions implemented include:

1. Delivery and presentation of simple memory triggers for patients assisting in the repair of the activity sequence when performing simple routine tasks.
2. Adoption of an intelligent-agent based approach to facilitate distributed system intelligence and a modular system design.

3. Enabling a monitoring capability whereby patients' daily routines can be both learnt and deviations from such noted within a patient profile. Significant deviations from the normal daily signature could be sent as alerts to relevant parties (carers, relatives, medical-centres) via SMS, email, and voice.
4. Development of efficient and convenient caring mechanisms, as well as the collection of data that underpins longitudinal studies of the onset of such conditions and fosters a greater understanding of the condition itself.

3.1 OutCare Architecture

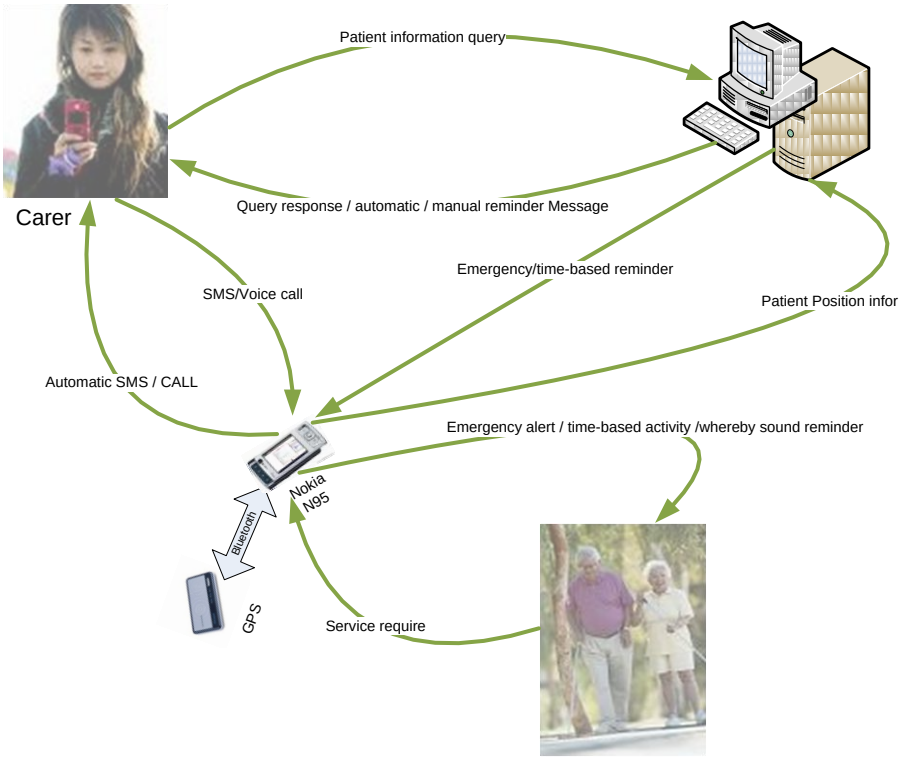

Fig. 1. OutCare System architecture

The general architecture of the OutCare system is shown in Fig. 1. There are three components involved in the system: the patient, the carer and a central web station.

– **Patients**: OutCare system is designed to support people with a cognitive impairment, particularly Alzheimer's. For this group of people, who are capable of maintaining basic independent living to some extent, may nonetheless suffer

from memory loss, disability of performing complex daily activities and tasks, such as getting lost when walking.

- **Carers**: people who are involved in taking care of the patients. The ever-increasing care demands result in the increasing requirement of a professional caring service.
- **Server station**: the central server which is responsible for patient profiling, data recording, processing, and visualization. The server station enables an efficient and trustworthy administrate tool, providing a convenient caring method.

3.2 OutCare System Intelligence

To facilitate system intelligence, the patient terminal within the OutCare system is implemented as a mobile multi-agent system [11], as the patient terminal is the start point which takes responsibility for collecting patient context information and boosts the system functions. It could be implemented on any type of mobile device as long as it supports 3G, Wi-Fi, Bluetooth and Java based applications. The Nokia N95 was identified as an archetypical mobile device although it incorporates a mobile device. In addition, it has considerable battery life and memory capacity. Usually the battery of Nokia N95 can last for a couple of days; the GPS unit allows 11 hours continuous use, which is adequate for daily tracking and allows charging occur overnight.

The intelligent agent platform is developed using Agent Factory Micro Edition (AFME) [12]. AFME is broadly based upon a pre-existing framework that support a structured approach to the development and deployment of agent-oriented application named Agent Factory [13]. AFME has been developed and widely used; it is actually supports the deployment of intelligent agents in AmI environment, especially for computationally restricted artefacts and environments. A collaboration of agents are deployed on the patient terminal, and the activities diagram is shown in Fig. 2.

- **GUI agent:** makes decisions about when and what information required to be displayed to the patient, and controls the graphical interface.
- **Device agent:** discovers the available Bluetooth devices, and manages the connection to the GPS device.
- **GPS agent:** collects the GPS position information of the relative patient.
- **Zone agent:** acquires GPS data from the GPS agent, analysis and calculates the patient context information, for example, what zone does the patient currently in, is she/he in a regular position, are they safe in the un-regular routine, etc.
- **Alert agent:** interprets the results from the zone agent, reasoning about what kind of alert is required, such as playing a sound or vibrating the mobile phone to get the patient's attention, and display relevant reminder message by the GUI agent to the patient.
- **Web agent:** updates patient profile information to the web server, such as patient's current position if the GPS device is active, alert records etc.
- **SMS agent:** communicates with the zone agent and alert agent; decides when and what message needs to be notified to the relevant carer or parties.
- **Map agent:** helps patient to find the correct direction on the map.

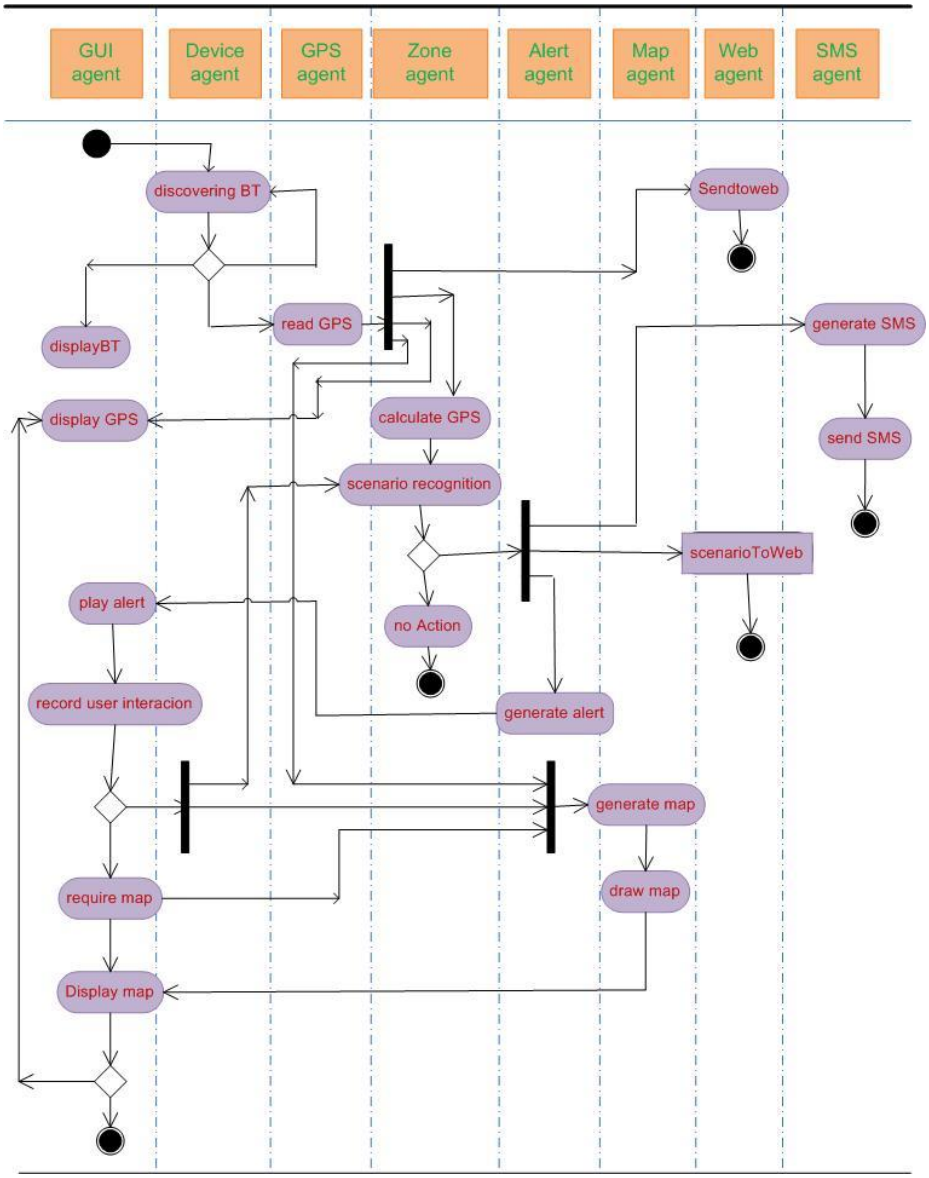

Fig. 2. Intelligent agent activity diagram

4 OutCare Design and Implementation

4.1 Patient Module

Fig. 3. Main interface (a), Alert example (b), and Location selection (c)

The patient module is designed to be embedded with the patient, two components are required - a mobile phone and a GPS receiver. This module harnesses intelligent agents running on top of the J2ME platform. Due to the fact that patients are often afraid of using technology, and their cognitive impairment may varies according to the stage of Alzheimer's disease, OutCare adopts a user friendly and unobtrusive interface with no interactions required unless any irregular activity is detected. Fig.3 (a) is the service screen; Fig. 3 (b) is an alert example, and Fig. 3 (c) destination selection interface.

4.2 Carer Module

The aim of the carer module is to provide carers with an efficient and convenient caring method. The carer module is loaded onto the mobile device and its main functions include:

5. Receive emergency alerts from both the patient module and the web server (see Fig.4 (b)).
6. Patient tracking and profile inquiry. Fig. 4 (a) shows the screen where OutCare can request patient's current location, patient tracking, query device information, view patient profile such as the alert history, collection records and so on. Fig. 4 (c) represents an example of a server response when the carer requests the patient routines for a given day.

Fig. 4. Main screen (a), Alert example (b), and Routine query (c)

4.3 Web server module

The web server is responsible for patient profiling, data recording, processing and analysing, information visualization and providing a convenient interface. Fig. 5 is the consolidated interface of the server browser. To implement patient monitoring functionality, we deploy patient profile information onto a map (Google maps, in this case), centred on Carlow.

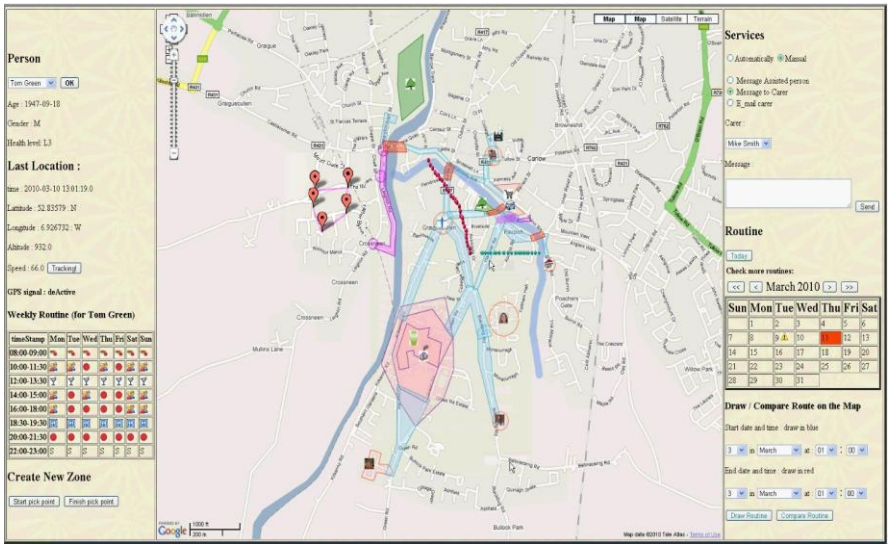

Fig. 5. Web server browser

Web server module plays an important role in the backstage of the OutCare system, with which the patient's daily movements can be recorded; real-time movement tracking, movement replay for a given person and time can be deployed on the map; analysis for the comparison of movement across several days according to individual patient's profile using overlays on the map; generate patient's regular routine; allow specification of alert activation conditions and recipient and contact modalities by SMS/Email.

5 Conclusion and Future Work

Given careful investigation and consideration of how to maintain the full capability of independent living for the elderly and particularly Alzheimer's sufferers, how their lives can be influenced by technologies, how to satisfy their needs not only physical but also social and personal, this paper presents an intelligent outdoor routine monitoring and assisting care system. Based on the AmI construct, the OutCare solution can maximise the utilisation of resources and deliver efficient monitoring and assisting services.

One of the novelties of OutCare comes from the location zone awareness and deliberate reasoning mechanism which maintains a patient's capability of independent living, respect of for their independence and dignity, as well as effective resource utilization. As OutCare has been implemented, user trials and evaluations is expected to commence in the near future. One important issue for future investigation is balancing patients' privacy with an efficient monitoring and assistance service. Another interesting issue concerns the integration of more sophisticated outdoor environmental models. .

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