Ambient Intelligence in Assisted Living for the Elderly

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ABSTRACT

The average life span is increasing, and as a result so is the average population age. The typical person aged 65 years or older lives in a single person home. To improve the quality of life experienced by these individuals, which are an ever increasing portion of the overall population, is the aim of the research into Ambient Intelligence for assisted home living. This field is rapidly expanding due to world wide coverage, and acknowledgement of the benefits it can over. Ambient Intelligence has endless possibilities to improve the lives of its intended users. This research paper looks at this field of research, which is now being extensively developed and tested. Looking first at the wider view of ambient intelligence, before looking in more depth at the specific and unique problems faced by researchers when dealing with systems for the older generation. This paper looks to indentify gaps in the current application base and identify areas that require improvement for the acceptance and use of ambient intelligence for elderly home care to become common place.

AUTHOR KEYWORDS

Ambient Intelligence, Home Care Systems, Elderly Care, Interaction, Acceptance, Ethics.

ACM CLASSIFICATION KEYWORDS

I.2.11; K.4.1; K.5.1

GENERAL TERMS

Design; Economic; Human Factors; Security; Standardization;

INTRODUCTION

Ambient intelligence (AmI) is technology blended into everyday life, the use of minuscule chips and devices to improve the lives of its users. Through the use of sensors and actuators, combined with the information and decision making performed by a centralised system, AmI can be used to perform mundane every day actions reducing the hassle of such tasks. The field of AmI is a rapidly progressing area of research. Particularly fast growth is seen in the area of AmI for the care and support of the elderly, those over the age 65. By providing in home support and medical care for the elderly not only is there an increase in the quality and length of life but also a decrease in demand on the medical sector as well as an overall reduction in medical costs. This paper will look at the use of Home Care Systems (HCS), a particular area of AmI designed for just that purpose. Starting with the motivation behind this area of research, this paper will then explore an over view of the wider field of AmI, before diving in more detail into the current state of applications in the area of elderly care. A particular interest of this paper is to look at the acceptance and ethical issues involved in the introduction of new technologies to the older generation.

Motivation

The population is increasing in age. With recent improvements to quality of life and advances in medical science and practice the average lifespan has been increasing for decades. It is expected that by 2050 15% of the world's population will be 65 or over, this is compared to just 5% in 2005 [1]. Not only is there this trend towards increasing life span there is also more and more desire from this age bracket to remain as independent as possible. This has resulted in a large proportion of the older generation living in single occupant homes. This is the main motivation for AmI in the Home Care System(HCS) sector. The cost to the tax payer as well certain sectors of the government is astronomical to provide the quality of life to these households that they deserve. With AmI the cost for callouts in medical emergencies can be reduced, the cost of home helpers can be reduced as well as the cost of state

funded housing or retirement villages can also be reduced [2].
While certain systems are already in place to assist the elderly in emergency systems [3], these are inadequate to manage the everyday situations that result from such things as memory loss and reduction of physical movement capabilities. The introduction of some of the following systems is the area where improvements to the quality of life for the elderly can be seen.

FIELD OVERVIEW

The field of AmI looks at the use of highly powerful, intelligent systems, seamlessly integrated into the everyday environment of its users [4]. So far there has been development and trials of AmI systems in HCS, Home Automation, Health Care systems, recommender systems, marketing and sales, security and travel and tourism [5].
The current model for an AmI is to have multiple sensors and actuators as well as a central server and database. Data is gathered by the sensors in the environment and data is transferred via wireless communication to the server where it is stored on the database. An application is constantly running on the server that data mines the database looking for statistical trends and patterns. If the incoming data meets the conditions of one of the patterns, then a wireless communication is sent out from the server to one, or many, of the actuators to perform a real world action. For example, a sensor may track the air temperature of a room, if the resident of the home closes the window when it is cold, on average below 14 degrees then after a given period of time the system can learn this pattern and automatically open or close the window depending on the temperature.
Currently this field has seen the use of silicon nano chips and radio frequency identification tags (RFID)[4] to embed into everyday devices so that they can be recognised and interacted with by the larger AmI system. This hardware is now reaching a level at which it can meet the needs of the currently perceived AmI systems.[4] This means that the highest proportion of limiting factors regarding the general public use of AmI is at the software level. From a purely implementation standpoint, despite the fact the some current systems have seen success as high as 90%,[6] there is need for further development of the artificial intelligence aspect of the system relating to the learning of patterns and user behaviours. From a higher level, the current development of AmI prototypes are individually developed systems by separate research parties. To have all of the devices and objects interact effectively with one another there is a need for a common architecture and interface [5] that is not yet standardized. From a higher level again, there is a certain stigma around the field. Many people view the information stored by such systems not only a breach of privacy but also a very real security threat [7]. As a result of this there is still a large amount of work to do in the area of acceptance testing and making sure that software and hardware systems produced meet a certain level of ethical standing.

CURRENT STATE OF RESEARCH

Currently there are a vast range of HCS that have been developed and are currently in testing. Some of these applications are simple, such as an sensor on a pill bottle that records when the bottle was opened and alerts the patient when it is time for the next dose, or contacts a doctor if the required dosage is not met [7]. With more complicated full home systems using a single or multiple sensors in every room to track the movement and behaviours of residents to notice trends, in an effort to be able to alert a health care provider should something drastically out of the ordinary happen. An example of such is the work done by Augusto et al. looking into the use of Event – Condition – Action rules (ECA). These are proposed to fulfil two criteria. Monitoring of patients for safety and long term monitoring of patients for profiling and learning behavioural patterns [8].
The first is covered in much more detail; with vast numbers of ECA rules implemented and tested in lab based mock living environments. For further understanding of ECA examples the following structure and example rules are given.

"On <event expression>
If <condition>
Do <action>.

On blood pressure higher than 200/175 for more than two successive samples within the same day
If medication regimen to control blood pressure has been altered recently
Do notify clinical staff.

On person having been in bed for a long period of time
If not expected to be in bed during this period
Do contact relevant carer."

These show some simple applications of the ECA rule technology. It is however, as mentioned previously, also intended to be used as a means of monitoring behavioural patterns. This is described as having two purposes with in its self. One is for the intelligent system to learn the habits and preferences of the subject and use this as a basis for the construction of additional, more personalised and specific ECA rules. The second use is the storing of these habits, patterns and behavioural notes over time to provide a user profile that can help health care professionals associated with the care of the patient to provide more relevant, accurate and specific advice and care.
This system has been further extended to include, in the event and conditional portions of the ECA rule, different methods of showing a state change. These are ingression and transition.

Ingression is the change form not state 1 to state 1 and transition is the change from state 1 to state 2. For example:

"On (occurs(ingr(cooker-in-use), T1][T2) and occurs(trans(at-kitchen, at-reception),T3][T4))

If (earlier(T2, T4) and ¬ holds(at-kitchen, [T2, Now]) and moreThanUnitsElapsed(T4, Now, 10 Mins))
Then (ApplyPossibleHazardProcedure and TryContact)" [9]

This has been used to show the change in state so as to remove the error that would occur of multiple events occurring simultaneously. Events that occur at the same time are expected to have all of the corresponding actions performed however if there is no link between events then the state stored will be overwritten by the event with the latest timestamp indicating the current event.

Another current application and area of testing is the smartHome developed by Barger T. S. Et al. for the Medical Automation Research Center. This system uses probabilistic methods to determine patterns in behaviour [10]. Based on a series of sensors, one in each room, the system monitors the duration of time that the user spends in each room. This is a simplified system but is an advancement on previous systems in the same area as it has been tested in an eight room house with a participating subject and as such is based on real recorded data as opposed to simulated data from a neural network based system that estimates the times spent in each room. It is also an improvement upon the systems that use cyclical behavioural monitoring as it does not require that the time recordings be broken down in to discrete periods but allow a continuous approach to the data recording that allows for the system to appropriately cope with fluctuations in time of similar events as well as the variation in behavioural patterns based on time of day, day of week and on a wider scale the time of the year.

Although these systems have shown improvements over other systems of its type, it is still lacking in one major area. Both of the above systems deal with the elderly living alone. This is due to the fact that there is no identifier on the person using the system. Although single person homes are the most common for the elderly[1], this assumes no partner, no visitors, no health care providers and no maintenance people entering the house. Any one else entering the house will cause the systems to gather false data.
One system that has got around this problem is the GerAmi system developed by Corchado, J. M. et al. The GerAmi system was developed in conjunction with the Alzheimer Santísima Trinidad Residence of Salamanca, an institute with multiple stories, multiple rooms and upwards of 40 residents [11]. As with all previously mentioned AmI systems, the GerAmi uses sensors to record patient and user data. However rather than sensors using motion or heat to track users, each resident and staff wears a bracelet containing a unique radio frequency identification chip (RFID). As each bracelet's RFID is unique it allows all of the residents and staff to be tracked individually without false data being recorded. This system is unique in that it also tracks the movements of the staff members, this is a major benefit in a system such as this when the medical care providers are on hand as it allows faster reactions to emergencies by alerting staff that are on duty and also located closer to the source of the problem.
The main functionality of the GerAmi is in planning in case of an emergency, the centralized database stores information on previous problems, emergencies and events that have occurred that required attention and also stores how these issues were dealt with. When something out of the ordinary occurs information is gathered by the sensors and processed by the centralised system. If intervention or assistance is required a message is sent to the staff members PDA. The message contains the name or identifier of the patient in question, the problem that has occurred as well as information from the database about the best way to deal with the situation based on previous events.

RESEARCH ACCEPTANCE

It has been recognised that one of the key issues with the use of AmI for assistance in elderly care is that there is a high rate of rejection of new technology by the older generation [7]. This simple fact has lead to a lot of resources being put into the research of system acceptance. One attempt at this was to try and create completely autonomous systems that require no interaction from the user. This was seen as a way forward as it required no learning curve and provided no additional complexity to the user's lifestyle. Many participants found that this was just as unwanted as it gave the user no sense of control, and many felt that there was an invasion of privacy with a system that monitored there every move and gave no interactive options [4].
Instead, there has been a shift towards aiding the elderly to learn to use these systems in an easy to understand, and ongoing manner. One example of such a system is 'The Technology Coach' this system is designed to aid in the learning of using medical devices at home for tests that do not require the presence or assistance of a medical professional [5]. The Technology Coach tracks the use of such medical devices using sensors and offers assistance, advice and guidance to the user in a natural way to aid in the learning and understanding process related to the use of complex medical devices.
One example of the rejection of new technology is shown in a contrast between the works done by Niemela et al.[7] who used mobile phones as a means of tracking and sending data and Ballegaard et al.[12] who used tablet PCs.

There was a much higher acceptance for the study that used mobile phones as many elderly found the tablets difficult to use even after being trained.

There are many other issues with the acceptance of AmI than just the question of technological ease of use and preference. Looking at more detail at the work done by Niemela et al. this research looked at an expert focus groups of elderly individuals and medical professionals and their evaluation of three different AmI applications.

a) Medication monitoring
b) Sleep monitoring
c) Home security

A high proportion of the elderly focus groups felt that the medication monitoring using a smart pill bottle cap was an invasion of privacy as there was no control from their end whether the information gathered was sent to their health care provider. There were also concerns about security risks, such as pharmaceutical and drug companies getting hold of the information and no longer offering subsidies to individuals deemed unreliable when it came to taking their medication. There was a very positive feed back for the sleep monitoring however as it meant that there was a higher degree of comfort as simple EEG testing could be done from home without the need for hospital visits. The third scenario offered another acceptance issue again. Many of the elderly participants felt that they would be unable to afford the installation and maintenance costs of a full home monitoring AmI security system.

The collective research into the acceptance of AmI systems for the elderly seems to be centered on the concepts of:

a) Technological ease of use
b) Privacy
c) Security
d) Cost

CONCLUSION AND FUTURE WORK

The development of home care systems has clear benefits for not only the elderly users but also the medical professionals, health care providers and the average tax payer. Rapid advancements have been made in the hardware area of these systems, which is now at the level where perceived applications can be realized [4]. What is missing is the advancement in artificial intelligence and software development to meet the ever growing and ever changing needs of the elderly users without over complicating the systems. The incorporation of natural language recognition is a major leap forward in this area.

The development of AmI systems for use in assisted home living of the elderly has seen a rapid explosion in recent years. However due to this fact, there has been a segregation of techniques and concepts for the development. This segregation has lead to many unique and beneficial applications but has gone against the one of the core aspects of the field, which is the ease of use and acceptance by the elderly. If AmI is to become common place, all of the aspects within one home will need to be linked. The cognitive strain of becoming familiar with the operation of several systems is too high. This coupled with the cost of installation and maintenance of multiple systems puts the applications and devices out of reach of the vast majority of its intended audience.

I believe that for these systems to become common place, readily used and accepted by the older generation for which they are designed, there will need to be collaboration in design and architecture of the centralised systems as well as a standardised interface for all agents, sensors and actuators to allow easy "plug-in" use.

Furthermore there is need for a way to overcome the feelings of breached security and invasion of privacy. Until this is achieved there will always remain a feeling of doubt regarding the safety of using these systems, particularly in the elderly where there is already a large amount of distrust and rejection towards new technologies.

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