NOCTURNAL Ambient Assisted Living

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Abstract. There is increasing interest in the development of ambient assisted living services to increase the quality of life of the increasing older population. Little consideration has been given to the specific problem of providing such services and systems at night. We report on the NOCTURNAL project which provides specialised night time support to people at early stages of dementia.

Keywords: Ambient Intelligence, Ambient Assisted Living, safety critical, Multi-Agent Systems.

1 Introduction

Assisted living systems for healthcare are being developed as part of the fundamental shift from hospital-centred to home-centred models of care within health services. Most of the contributions reported in the technical literature focus on the most active period of the day (daylight time). Our project NOCTURNAL (Night Optimised Care Technology for UseRs Needing Assisted Lifestyles) assumes that the night period and daylight periods of the day are different enough to require separate analysis [1]. It is estimated that 10 million people across Europe and 35.6 million people worldwide have dementia [2].

The environment at night is very different and disorientation is more likely for a person with dementia due to low light conditions. A person with dementia is also more likely to be confused and disorientated on awakening, either naturally as they awake from sleep, or if they are exhibiting 'sundowning', where the behaviour of people with dementia changes as the evening and night falls [3]. Older people generally experience changes in their sleeping behaviours. This includes going to sleep early but awaking earlier as well, having more fragmented sleep patterns, suffering from insomnia, and from sleep apnoea, which is "increasingly seen among older people and is significantly associated with cardio- and cerebrovascular disease as well as cognitive impairment" [4]. People with dementia may also be likely to move around their home and beyond causing distress to themselves and their carers [5]. Finally, a person with dementia is more likely to be alone, or not have as immediate access to carers as during the daytime. This can cause any stress and

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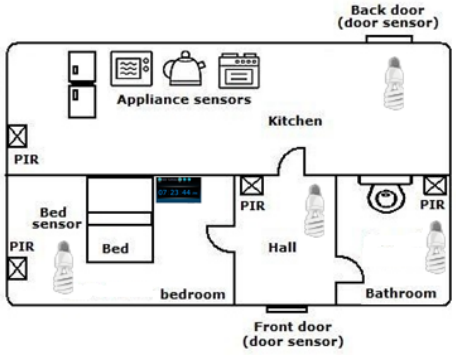
anxiety experienced, as they awake in the dark, to be significant and to increase unchecked and more rapidly than would otherwise be the case if a carer was with them. A literature study [6] shows that technology can play a pivotal role providing assistance to people with dementia during night time. However, these studies focused on monitoring only one specific aspect of the night time activity or on applying a single technology to aid people with dementia during the night. Our work builds upon the current setup commercial telecare offerings of our partner company[1] and provides additional features in what is a more holistic approach to night time care.

2 Technological Infrastructure of the NOCTURNAL System

The NOCTURNAL infrastructure has been designed so that the technology is transparent, user friendly, and cost effective. This has been achieved by focusing on the visualisation of the information in the interface for use by carers, and by using existing, common off-the shelf telecare and computing components. Our system (Figure 1) assumes only one house occupant is monitored at night time (i.e. around 11PM to 7AM) and it passes direct control to our telecare service provider partner when more than one person is inside the house.

(a) Typical dwelling with sensing



(b) Bedside unit interface. The default mode is to show the time. It also shows pictures and music previously selected by the client and video clips recorded by carers.

Fig. 1. Technological Infrastructure of NOCTURNAL system

The basic sensing set consists of Passive Infra-Red (PIR) sensors, and a bed movement sensor. The basic actuation set consists of a set of lights switches and dimmers and a tablet PC bedside unit, which can deliver time information and textual messages to assist the occupant with understanding of their context, as well as music and pictures for reminiscence and relaxation. Other technologies such as door sensors and appliance sensors can also be used but they are optional and the explanation of the system provided in this work will be focused on the behaviour of the system which is based on the basic configuration.

[1] Fold Housing Association(http://www.foldgroup.co.uk/), a not-for-profit organisation delivering telecare/telehealth services to UK/Ireland.

3 Design of the System

The multi-agent based platform was implemented in Jade and has three main roles: detect situations of interest with help of the sensing platform, decide whether the situation requires intervention, and delivering/follow up actuations to assess if the situation has improved.

Our system is organised around the monitoring of three main situations: restlessness, bed occupancy and movement around the home. Activities of the client trigger sensors which are recorded as events in a database. These events are fed to a group of three monitoring agents specialised on detecting those situations. When the number of episodes of interest detected by any single agent is above an acceptable threshold, which is dynamically adapted to the client and the context, the agent involved contacts a coordinating agent (CA) which has a holistic view of the context informed by all the single agent's reports. If appropriate, CA can order the Therapeutic Intervention Agent (TIA) to act helping the client. If subsequent reports from the monitoring agents show there is still reasons for concern the coordinating agent can issue a new intervention through the TIA or eventually, if the situation requires it, the call centre at the service provider can be contacted so that a human deals directly with the situation.

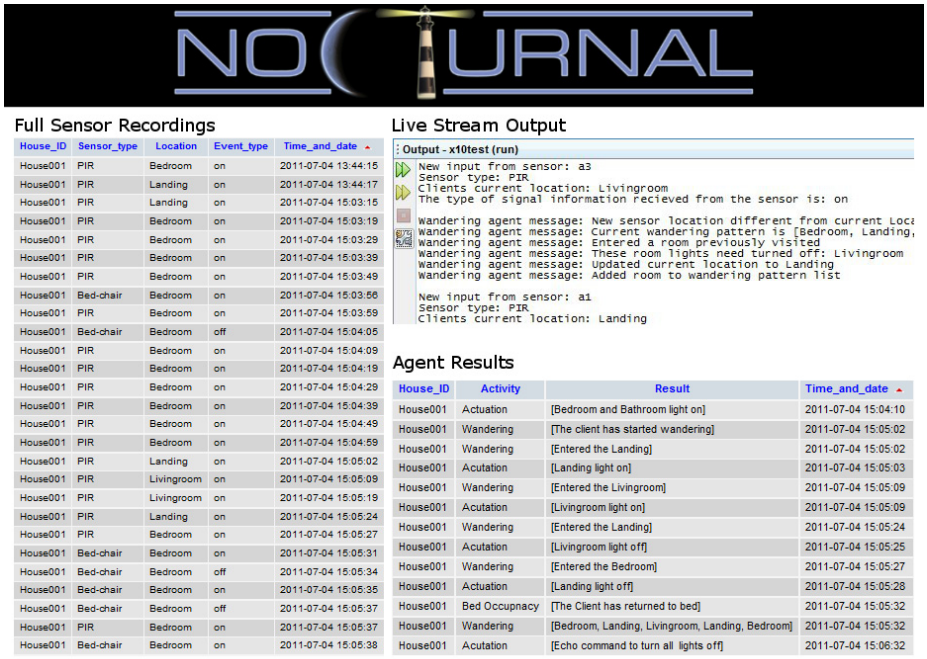


Fig. 2. Example of the system at work, clockwise from left to right: gathering information from sensors, a log of events and recording actuations

The strategy of the system to deal with situations can be described as a stack of situations upon which the system has to act. When there are no noticeable problems the stack is empty. If restlessness is detected, the system puts that in the stack and starts dealing with it. If this is dealt with effectively the system then empties the stack. If, instead, the person gets out of bed then this situation is put on top of the stack and becomes the focus of actuation. Should this be successfully addressed then this concern is removed and the focus return to the remaining one (restlessness), but if the person continues to move through many rooms this problem becomes the top priority. If at any stage a situation persists despite several attempts from the system, then the company is alerted and the contextual information is passed to the operators. Figure 2 shows the Multi-Agent System (MAS) at work whilst detecting movement after the occupant left the bed and visited a number of rooms. The system delivered actuations turning on/off relevant lights and using the bedside unit. The aim was to encourage the person back to bedroom, to return to bed to sleep. All the main components of the system including the four agents described above have been modelled using Promela and simulated and model checked with SPIN to verify the correctness of our strategy and algorithms. We recently reported in detail our models and findings [7].

4 System Services

The system provides several services, while safety assessment in real time is the main focus. If the system believes the actuation is not being successful on dealing with one of the three specific situations of interest (restlessness, bed occupancy or movement) then it will contact the company which delivers the service.

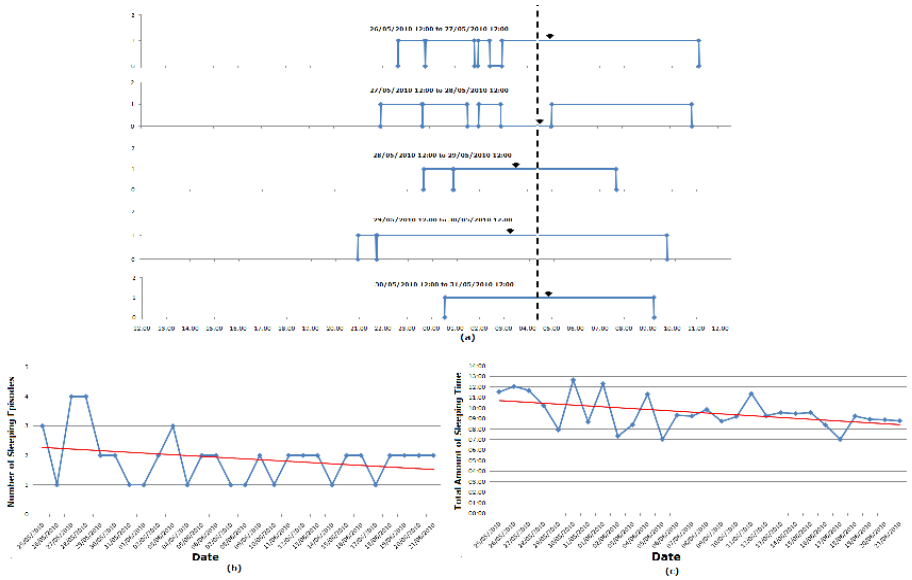


Fig. 3. Patterns of sleep for individual days, week and month

The procedures are the typical ones with an alert being raised at the call centre where human operators will decide on the best course of action (e.g., calling the client or a formal/informal carer). Also important is the information the system can provide on the lifestyle of the house occupant and the variations of some relevant parameters through time [8]. For example, the system can produce profiles of the sleeping and movement patterns of a specific person in a specific period of time (Fig. 3).

5 Conclusions

At night, a person with dementia is often likely to be confused and disorientated as they awake from sleep. It can be argued that for them a need for assistive technology may be as important as those that lead to the development of assistive technology to support independent living during daylight time. The opportunities for research for nocturnal care of people with dementia using holistic assistive technologies are for more specialised algorithms; specially designed interventions that provide therapeutic support to people to reduce anxiety through a multimedia device; and sophisticated guidance, through the use of lightning. Our system differs fundamentally from previous, narrower, approaches to the problem. We provide a more holistic and state-of-the-art extensible framework with a combination of cost-effective infrastructure supported by intelligent agents which can detect and act upon meaningful situations.

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