CONTEXT-AWARE SUPPORT FOR ASSISTIVE SYSTEMS AND SERVICES

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Abstract

An assistive living system that gives our elderly population the comfort and confidence necessary to remain independently in their own homes is essential for enhanced longevity. Ambient Assistive Living technology that provides intuitive and context-sensitive support presents researchers with additional challenges. This paper details the creation and development of an "Ambient Assistant" application augmenting and extending the open source framework OpenAAL with enhanced reasoning, intelligent monitoring of the person and decision-making capabilities. The aim is a complete framework with fully interoperable components such as multi-parameter sensors.

1 Introduction

There is a very strong need to support ambient assistive living technologies in the home [15]. Nearly a fifth of people living in the UK today are expected to celebrate their 100th birthday and more than 10 million of the UK's current residents, the equivalent of 17% of the population, are expected to live until they are at least 100 [1]. As the population ages, elderly people are more likely to suffer from reduced mobility, disability and mental health problems such as memory impairments. There are currently over 750,000 in the UK with an age-related cognitive illness and this figure is estimated to reach one million by 2025 [3]. The financial cost to the government of illnesses such as Alzheimer's disease and Dementia is 20 billion pounds each year whilst family carers save the economy an additional 6 billion pounds plus per year looking after their loved ones at home. With figures and costs predicted to rise in the future it is important to develop successful Ambient Assistive Living (AAL) solutions which can help people stay independent in their own homes for as long as possible thus reducing avoidable entry into hospitals or care homes. Assistive Technology (AT) refers to 'any device or system that allows an individual to perform a task that they would otherwise be unable to do, or increases the ease and safety with which the task can be performed' [5]. It ranges from the simplest calendar, clock and pill-boxes to high tech solutions such as satellite navigation tracking systems which can locate someone who has wandered. Developing and applying AT within the home that can adapt and intelligently react to the users contextual needs is an extensively researched area. In spite of the significant research most AT on the market today requires the end user to adapt their behaviour to suit the limited intelligence or capabilities of the assisted living device or system. This is inadequate if we are to successfully support the social care of today's elderly population. This paper highlights the main challenges associated with assisted living technologies and describes the unique approach taken in this research to overcome these challenges. This research aims to address the challenges of existing frameworks by augmenting and extending the open source framework OpenAAL[10] with enhanced reasoning, intelligent monitoring of the person and advanced decision-making capabilities. The extended framework namely AMiCA (Ambient Middleware for Context-Awareness) will interface with sensor technology such as the Vicon Revue SenseCam [16] to model the user's behaviour and their environment. It also details the creation and development of an "Ambient Assistant" application for assisting older adults with activities of daily living. This work provides an attractive characteristic in that it offers a supportive environment for both inside and outside the home without relying on a large supporting sensor infrastructure, which means it can be easily deployed in a range of contexts and locations without any structural modifications or additions. New classes of ubiquitous AAL applications and devices can be developed with the framework thus enhancing the range of useful assistive technologies for older adults in the future.

2 Assistive living technology

Enhancing the social care of our elderly population can be achieved through the preferred strategy of aging in place. To date fulfilling the requirements of this approach has been difficult due to the diverse needs of this social group. Enabling an elderly person to remain in their own home has been shown to enhance their quality of life [9,13]. Designing dynamic AAL systems for an actively aging population requires highly adaptable and intelligent context-awareness of users and their behaviours. A greater number of challenges appear due to the complexity involved in designing dynamic AAL context-aware systems and services. Challenges include the integration of a wide range of software and hardware components whilst at the same time maintaining the need for user privacy and personalised interaction with the right levels of context-sensitivity [7]. The complexity involved in designing and developing context-aware systems and services makes context-aware middleware an essential requirement.

Context-aware middleware is recognised as the enabler and simplifier of technology and services for dynamic systems such as those necessary in AAL. The need for an efficient middleware framework to seamlessly join the required sensor, network protocols, hardware, and software components together is well accepted [8]. To date various context-aware middleware platforms and frameworks have been designed however none have become an accepted standard in this area [2,11,14]. The intention of our framework is to enable the seamless provision of context-aware services to highly dynamic environments such as AAL environments. AMiCA aims to simplify the design process and address the challenges by integrating sensor technology, intelligent algorithms and ontologies in its multi-layered architectural design approach.

2.1 Challenges

The following computer science challenges arise in the field of assisted living:

Sensing the users' environment: as regards gathering data about the users' daily living activities in the home and outdoors. Current sensors often gather imprecise data.

Data: acquisition, integration, modelling, presentation and distribution of data from multiple sources can often be difficult and lead to uncertainty.

Interaction: supporting effective communication between the user, family/carer and social care provider.

Personalised interaction: recognising the users social care needs and how they change over time. Interaction which is unique to the user needs to be context sensitive, adaptable and flexible in order to accommodate the changing needs.

Analysis: consider all context data, current environment conditions, surrounding objects which are used to exploit and derive the users' activity. This data is often 'noisy' and difficult to apply intelligence and inference mechanisms.

Confidentiality: appropriate measures to support individual privacy and dignity, confidentiality, information and network security, and appropriate use of sensors and data collection.

Integration: interoperability issues between all the heterogeneous hardware and software components in AAL systems and devices. No acceptable standards to date.

In view of the diverse challenges in assisted living, this research aims to benefit many people through improved home care and support by providing a complete framework which will support dynamic context-aware services and systems for use in an assistive living environment.

2.2 Addressing the challenges

Developing an efficient framework from scratch is a significant task, mostly due to the length of time involved and level of expertise required to design and develop an efficiently generic system. A practical alternative is the adoption and improvement of an existing middleware platform. Based on the timeframe and scope of this research, the OpenAAL [10] framework with additions such as an enhanced intelligent reasoning module, a dynamic inference module and an activity prediction module will add the missing functionality required to build context sensitive applications for all AAL domains. The AMiCA framework is a multi-layered design with intelligent reasoning and decision-making support. This approach aims to seamlessly and opportunistically provide the connectivity required by services of highly dynamic environments such as AAL clients. By delivering appropriate context-aware services at the appropriate times, new classes of ubiquitous AAL applications and devices can be developed thus increasing the quality of life of an increasing elder population. The key components within the AMiCA framework are the environmental sensing layer, the sensor integration layer or sensor fusion layer, context management layer, the application logic layer and the service layer. Figure 1 outlines the intelligent context reasoning-based approach, within the architectural framework. The lowest level of the architecture consists of new and existing sensors in a person's home environment and other relevant context sources. To enable the dynamic integration of context sources, it is essential to keep all the sensing separate from the other layers. Hence details related to data acquisition of the various types of sensors are hidden and can be dynamically discovered as and when required.

At the lowest level of the system direct and indirect context is sensed using the Vicon Revue SenseCam and if required other desirable sensors such as Java Sun SPOT's and Parallax ultrasonic sensors. The users existing assistive technology systems such as telecare systems etc can also be incorporated into the framework. This will address integration issues found in existing frameworks. Systems which are interoperable and can co-exist with other plug and play devices offers another unique aspect to this work as yet there are no acceptable standards in this area. The sensor integration layer combines the data that has been acquired by the sensors and other relevant context sources and intelligently groups the data together. This approach simplifies application development by promoting reuse of software properties. Additionally this higher-level context data can be more easily inferred as a result of intelligently managing the data at this lower level. Data which can be easily inferred, will also address a key challenge within context-aware computing. The context data is transformed into an application understandable format in this layer also. This intelligence supporting data is further enriched with context facts about the user or service and passed to the context management layer for intelligent reasoning, inference and activity prediction. A combination of ontological reasoning and rule-based reasoning is used to efficiently group and reason over the context data in the reasoning module. Domain modelling and a combination of Bayesian networking and a HMM algorithm approach is used to optimise inference over uncertain data as part of the analysis of users' behaviour. This will enable prediction of profiles to assist with intelligent monitoring. The contextual manager stores details on all the

context sources that are available or become available during discovery. The contextual data store records the context data received from the various context sources and also records Spatio-temporal changes in the data. Each sub-level of the context management layer will have access to this data store over time. The application logic layer implements the logic of the actual context-aware 'Ambient Assistant' application and will make calls for additional resources such as web-based services on hosted servers in the cloud. Based on the results of context reasoning and decision making mechanisms in the lower layers, the higher-level applications can adjust their behaviours and adapt their services for users. Service discovery and registry is also delivered at this level in the AMiCA architecture.

The key components within the multi-layered AMiCA architecture are:

– Sensing mechanisms
– Sensing integration layer
– Context management layer
    – Intelligent reasoning module
    – Inference module
    – Activity prediction module
    – Contextual shared data store
– Application logic layer
– Service registry
    – Cloud data store

A cloud-based assistive living application, namely Ambient Assistant (AA) will be developed to validate the efficiency of the framework. The application will be cloud-based thus promoting true ambient intelligence. In addition, the creation of such a highly adaptive and context-aware cloud-based assistive living application will provide support for successful active aging in our society.

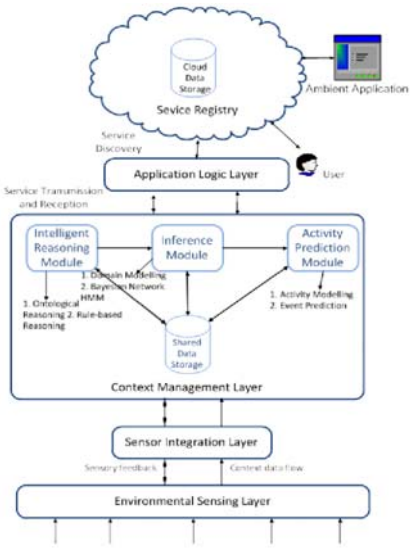

Figure 1: High-level overview of AMiCA framework

2.3 Sensing using the Vicon Revue SenseCam

The majority of the context data collected in this research will be sensed using the Vicon Revue SenseCam. The SenseCam is a small lightweight, wearable device that passively captures the persons' day-to-day activities as a series of images and sensor readings [4,6]. In our research the SenseCam image data is mapped against actual locations both inside and outside the home and is used to monitor the user's activities on a daily basis. The SenceCam image mapping data although created inside and outside the home by somewhat different means uses key reference points and their associated tagged images for intelligent monitoring of the person. This background mapping data can now be used in two main ways. The first way relates to real-time monitoring of the persons' behaviour from the incoming images and uses these images to determine if the person is coping sufficiently well or needs immediate prompting regarding their expected daily routine via an intelligent "Ambient Assistant" application when indoors. If they are outdoors and are not following their expected daily routine (e.g. they are half a mile from home, when their 'meals on wheels is arriving') then they can be proactively prompted via a voice based prompt from a mobile device. The second way of using the image data is to use the data gathered over a period, say a month/year to determine the lifestyle behaviour of the person and evaluate if they are carrying out their activities to an acceptable standard – e.g. less time spent outside the house or shorter distances travelled may indicate a deterioration in their mobility. This history profiling requires intelligent processing of the collected image data and sensor readings to enable meaningful results to be obtained. For example the persons' behaviour can be profiled with regard to expected daily/weekly/monthly behaviour changes and using rule-based reasoning and intelligent techniques to determine change in lifestyle or deterioriation in health related activities recognised. The data acquired to date is integrated into the AMiCA framework and an intelligent user interface application and voiceXML based mobile prompting system will be developed to test the context-sensitive user requirements of the system design. In addition a communication link to the family carer/helper via a text message will be incorportated in to the design and if major deviations from the persons' expected behavior have occurred during monitoring the carer will receive communiction. This work provides an attractive characteristic in that it offers a supportive environment for both inside and outside the home without relying on any supporting sensor infrastructure, which means it can be easily deployed in a range of contexts and locations without any structural modifications or additions.

2.3 'Ambient Assistant' application

The proposed 'Ambient Application' will be a unique contribution to the field of assistive technology in that it will offer the user a fully interactive touch-screen companion on a screen appropriately placed inside the home and also on a mobile device. The application will prompt, remind and

locate the person if they are lost and generally offer comfort and support.

3 Conclusion

Ambient frameworks for assistive living environments have particular requirements not present in other domains thus presenting many challenging problems for the researcher. It is widely accepted that a standard middleware platform is needed if proactive context-aware support is to be realised. As a result new classes of applications, technologies and services will be delivered and the current state of the art will move forward. This paper has presented AMiCA, an ambient middleware framework for supporting the development of context-aware applications. It is based on a multi-level intelligent reasoning approach where dynamically sensed context can be represented, reasoned, adapted and utilised. By providing this level of intelligent decision-making, innovative and intuitive assisted living solutions can be developed thus supporting and enhancing the quality of life of our aging population.

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