THE APPLICATION OF INTELLIGENT BUILDING TECHNIQUES TO CARE SERVICE PROVISION

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New Technology and Care Provision

With the development of digital services, the explosive growth of the Internet, and the increasingly widespread use of embedded processors in everyday products, the application of technology will bring about a revolution in the way we live our daily lives over the next ten years. We, at Essex, believe that new technology could bring about a similar revolution in the way care services are delivered.

Figures from the European Commission show that in Europe there are at least 100 million older people (i.e. people over 65 years old). Estimates indicate that around 9% of these are over 85 years old, and, with life expectancy gradually rising, this figure is likely to increase over the coming years. Many have developed illnesses or disabilities as they have become older, or have become frail, and may have difficulty performing simple tasks such as getting out of bed or cooking food. In addition there are 50 million people who have physical disabilities and as many as 60 million with some form of learning difficulty. Although one solution is to group those needing care in an institution, at present approximately 80% of all persons who are dependent on others for assistance with day-to-day tasks still remain living at home [Uhlemberg 97]. Less than a quarter of these receive any kind of formal care service (either local authority or private) [Baldock 97] yet annual expenditures for home care services have been growing at a rate of 20% each year. Governments have recognised this problem, and initiatives such as the EU 5th Framework [TIDE 98] and the UK Foresight [Dearlove 95] programmes have proposed the development of novel, technology-based care services. We are investigating one such solution: the use of technology in the form of Intelligent Building systems, which combine AI, embedded computing and networking to provide a supplementary means of care, either in an institution or in a domestic setting. The latter of these could be thought of as an extension to the sheltered housing model, enabling those who so choose to remain living at home.

Intelligent Buildings

Intelligent Building systems take inputs from sensing devices located around a building (e.g. temperature sensors, passive infra-red detectors, etc) and then use this information to control devices connected to a network (e.g. heating, lighting, etc). Building automation systems are already commercially available for the provision of services such as heating, ventilation and security. In a care environment this type of system could gather information from sensing devices around the residence, and use it in a variety of supportive ways such as maintaining a comfortable environment, increasing personal safety, minimising energy costs and providing information to assist the carers. For example, such a system could automatically switch on lights, open or close curtains, or control heating and switch off any unattended appliances. It could also summon help should the person have an accident (e.g. fall out of bed or down stairs. Within the care industry there is an increasing range of stand-alone and manually operated devices on the market. Current research into more sophisticated systems is still at an early stage, though, with much of the work funded by the EU TIDE programme. These projects mostly concern either remote or pre-programmed control of household devices via a PC. An example of a project that attempts to incorporate a degree of intelligence is the BT Plc Telecare project [Barnes 98]

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which is able to recognise individuals' patterns of living. Currently, however, this information is only used in a passive sense, to report deviations from the occupier's normal habits to remote carers.

Decentralised Architecture

Our proposed solution is based upon the fact that the physical and logical unit of an intelligent building is a single room. Each room may contain many sensors and output devices, which will be controlled and monitored locally by a node (a small embedded processor). All the nodes are connected together via a network, thus forming a decentralised architecture that enables building-wide collaboration.

In contrast to the care systems described earlier, we utilise AI techniques to produce a system that is capable of learning how to modify its environment in a manner that is consistent with the occupant's preferences, with only a minimum amount of explicit input from the user or carer (although it does allow for the possibility of some centralised control by the carer where appropriate). This also differs from existing building automation systems, which tend to be pre-programmed by an "expert" and impose a rigid set of conditions on all of the building's occupants.

A Behaviour-based Approach

A ***behaviour-based*** approach is used for the internal architecture of the nodes. This is a relatively new approach, used with great success in robotics by researchers such as Brooks, Mataric & Steels [Steels 95]. It has been found to be more suitable than traditional AI techniques for dealing with embodied systems, in which the information is likely to be partial, unpredictable, and environment-driven, thus preventing an exact or complete solution from being predicted in advance. In this paradigm, control systems are often referred to as "agents" (although this term is also associated with many other types of intelligent entities, e.g. Internet Agents). In this context an agent consists of a *set of behaviours* operating in parallel, each of which decides when to become active, based on the current internal and / or environmental conditions. In our system each node could be thought of as an agent, with its own set of both ***fixed*** and ***dynamic*** behaviours.

Fixed Behaviours

In the control of lighting within a room, the fixed behaviours might minimally consist of a ***safety*** behaviour - responsible for ensuring the light level in the room is always at a safe level; an ***efficiency*** behaviour - ensuring that energy is not wasted (e.g. that the light is not left on when the room is empty, or when there is sufficient natural light in the room already); and a ***comfort*** behaviour - that ensures the light level is always comfortable for the current room occupant (e.g. a resident who is only partially sighted may prefer or require a higher level of light than another resident whose sight is good).

These fixed behaviours, on which the agent infrastructure is built, are sufficient to ensure a minimum guaranteed safe level of performance at all times. (However, the occupant always remains in full control through the usual means e.g. light switches, thermostats, panic buttons, etc, should they choose to over-ride any system-generated behaviour).

Dynamic Behaviours

In addition to this basic set of behaviours, the system creates new behaviours dynamically, during operation, whenever a new situation is encountered, thus allowing the system to tailor itself specifically to suit the current users and their environment. This is done through the use of a technique similar to fuzzy instance-based learning, whereby the system gradually learns to associate particular combinations of input conditions to particular actions. We are also developing mechanisms which cater for the removal of dormant behaviours and merging of similar behaviours, to ensure the size of the behaviour set within each room-node remains manageable (as the agents will need to be, by design, small inexpensive processors).

This combination of fixed and dynamic behaviours operating in parallel ensures that even if the more sophisticated behaviours aren't activated, the basic, fixed set will always operate, so that ***a reasonable, safe response is always guaranteed***, even though it might not always be the ideal, optimal output.

Future Work

The longer-term aim of this work is to deploy the system in a real care environment. To this end we are collaborating with a number of local end-user organisations including Hamilton Lodge, which houses people with learning difficulties, and the Balkerne Gardens Trust, which operates several establishments ranging from residential and nursing homes through to sheltered housing. However, in order to conduct the necessary preliminary research and development we have built a bench-based demonstrator consisting of a mock building with real sensors and actuators. The initial results obtained from this test rig have been most encouraging. We are currently developing the system to include temporal information, and are investigating further the complex mechanisms needed to generate and maintain the dynamic behaviours essential to the system. Later we are planning to deploy a prototype system in the author's flat as an intermediate step before moving the system into a residential home for final development.

This work is at an early stage, but our hope for the future is that it will make a cost-effective contribution to the task of improving the quality of care delivered to those in need.

References

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