MONITORING THE WELL-BEING OF OLDER PEOPLE

Andrew Sixsmith[*] , Nick Hine[**]
Steve Brown[***] and Paul Garner[***]

[*] *University of Liverpool*
Division of Primary Care, PO Box 147 Liverpool, L69 3BX, UK
sixsmith@liv.ac.uk
[**] *University of Dundee*
Division of Applied Computing, Dundee, DD1 4HN, UK
nhine@computing.dundee.ac.uk
[***] *BTexact Technologies*
Adastral Park, Martlesham, Ipswich IP5 3RE, UK
steve.j.brown@bt.com
paul.2.garner@bt.com

This paper looks at the use of pervasive computing for the provision of care in the community for older frail people living alone in their own homes. The concept of well-being is explored using a conceptual framework that incorporates person, context and experiential factors. The paper reviews how different aspects of well-being might be monitored within the home of an older person using non-intrusive pervasive sensors and computing devices. The data from sensors in the home can be used to detect long term trends in six key activities, that might be indicators of changes in the physical, psychological and social status of the person. The aim of the well-being monitoring system is to provide care workers and carers with an intuitive early warning system to allow appropriate care interventions, leading to a reduction in the cost of care to the state and enhanced quality of life for the individual

INTRODUCTION

Recent research points to the increasing use of telecare and other assistive technologies to support the independent living of older people. A "first generation" [1)] of telecare includes community alarms that currently provide elderly and vulnerable individuals with the means of raising an alert should assistance be required. More recent research and development have included 'smart sensors' which incorporate a degree of intelligence. These second generation systems automatically call a designated person even if the client is incapacitated and unable to raise an alert [2)].

Most recent trends involve "pervasive" technologies that will constitute the domestic, consumer and business computing and communications environment of the future. These embed intelligence in non-PC products, so that everyday appliances and electronic environments can communicate with each other and transform digital technology into an integral and intuitive part of daily life, accessible to those who do not regard themselves as "computer-literate".

As well as enhancing safety and security, this "third generation" of telecare could contribute to enhancing the quality of life for elderly people in other ways, such as facilitating social interaction and helping with everyday activities.

The BTexact Care in the Community Virtual Centre [3)] is developing and deploying third generation telecare systems to monitor long-term activity trends which may indicate changes in the 'well-being' of the client. The information provided could be useful to both formal and informal carers and the clients themselves in helping to enhance feelings of security and improving the client's quality of life. The Care in the Community Centre involves collaboration between BTexact and several UK universities and comprises four related projects to specify and develop a demonstrator system. This paper develops a concept for well-being monitoring and assesses its implications for the development of a demonstrator system.

THE CONCEPT OF WELL-BEING

While terms such as quality of life and well-being are commonly used, they are concepts that are not easily defined [4)]. Clearly, there is an underlying idea that well-being is in some way about the 'goodness' in someone's life and much of the academic literature points to both objective (circumstances, situations, resources, capabilities, etc.) and subjective (positive and negative feelings, life satisfaction and happiness, etc.) factors

contributing to quality of life. Beyond this there is no straightforward or agreed definition. This presented an immediate problem: if we were going to develop a system that monitored well-being among frail older people, then some kind of conceptual framework or model was necessary

A first task was to map out the various domains of well-being and this is provided in Fig 1. The model draws on various literature sources [5-6] and on the results of five focus groups with elderly people, carers and professionals. The sessions were semi-structured discussions based on an agenda of issues, including: definitions of well-being; problems people encounter; positive aspects of life; the potential role of monitoring technologies. This semi-structured approach allowed these issues to be explored in depth, emphasising the perspective of the participants. The interviews and focus groups were tape-recorded. The moderator took notes and a post-session summary was written-up. A thematic analysis was carried out through listening to the recordings in conjunction with field notes following principles of grounded theory [7].

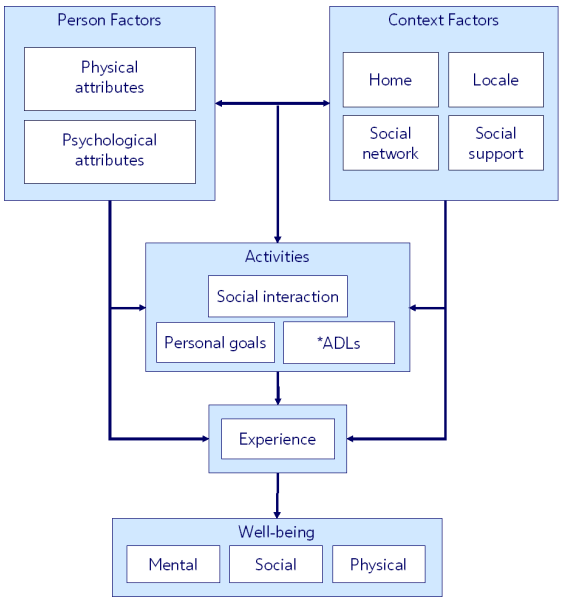

Figure 1. A conceptual model of well-being

While the model is simple, it represents a robust basis for development within the project, emphasing a holistic perspective, where the person's abilities, circumstances and experiences contribute to their sense of well-being. The model combines the objective and subjective factors mentioned earlier.

Objective factors include the attributes of the person that have a direct bearing on the person's well-being, such as physical attributes, general level of health and fitness, psychological attributes that help them to adapt to life changes that may occur in later life. Objective factors also include the context within which a person lives, which has an important bearing on well-being by either facilitating or constraining the person's goals and actions. These include the person's home environment, the social network and social support, neighbourhood, services provided.

Subjective factors refer to the person's mental/psychological, social and physical well-being, e.g. positive or negative affect, life satisfaction. Psychological well-being involves internal processes that are not amenable to direct monitoring. However, we can assume that other factors within the model will have an impact on well-being. For example, the physical environment can have a major impact on health and well-being [8].

However, a major weakness in quality of life research is that it often fails to account for the processes that link the objective factors and the subjective outcomes. The assumption behind the conceptual model is that "well-being" is grounded in a person's everyday experiences that combine the person and contextual "input" factors. These everyday experiences comprise activities and experiences/meanings.

Activities refer to what the person actually does and within our model these relate to: social interaction, personal goals and activities of daily living. In the development phase of the project, it was important that all these activity areas were monitored to get a wide perspective on the person's well-being. The approach is to measure changes in the specified activities and to highlight those changes that vary significantly over time, for example, the frequency and duration of an activity. This could then prompt the care organiser (e.g. a social worker or occupational therapist) to reassess the person's needs and provide useful objective information for the assessment of needs.

Experience refers to the subjective interpretation of situations or activities by the person and it is through this process that a person's life activities become personally meaningful. For example, for one person, lack of social contact may mean "loneliness", while for another it may mean "peace and quiet". Clearly, it is not possible to monitor these meanings directly. However, they have important implications for well-being monitoring, in that we can only understand the significance of activity changes in the context of the

person's subjective perspective. Thus, information from the well-being monitoring system has to feed into some kind of client-centred decision-making process. For example, an individual client will have a care plan which specifies their individual needs and goals, providing criteria for judging the possible impact of activity change. Users of the well-being data (care organisers, family carers) would also be able to use their knowledge to assess the significance of activity change. Of course, consulting the elderly persons themselves can provide the best interpretation, but this may not be possible for people with cognitive impairments. The uniqueness of individuals means that well-being monitoring systems will need to be configured to their specific requirements and situations.

MONITORING ACTIVITIES

Two activities from each of three activity categories in Figure 1 were chosen for the initial well-being monitoring system. This initial set of six activities included:

- leaving and returning home (category: social interaction)
- visitors (category: social interaction)
- preparing food and eating (category: ADLs)
- sleeping patterns (category: ADLs)
- personal appearance (category: personal goals)
- leisure activities (category: personal goals)

The choice of these activities was based primarily on their general importance to independent living and well-being, although some consideration was given to technical feasibility. Moreover consideration of the kinds of information to be generated by the system was based on the kinds of "high level" questions that are likely to be asked by users of the the system. Thus the main criteria for technology development was user-driven rather than technology-led.

The development of the well-being "map" and the determination of key activities for monitoring represent the basic concept behind our approach and has set the agenda for the main phases of the project: development of a sensor network; data analysis and output. An initial system has now been integrated and a demonstration scheme has been set up in the United Kingdom. A brief outline of the system development and the potential practical benefits are outlined below.

SENSOR NETWORK

Sensors are installed in every room within the older person's home. Most of these are motion sensors similar to those used in security alarm systems. Other sensors include contact sensors on doors and cupboards, pressure sensors under rugs, etc. Household appliances such as TVs and fridges can also act as sensors, providing information on their usage. The sensors are triggered by daily activities which occur within the home such as walking into a room, opening doors etc. These triggers are then recorded and analysed by a computer linked to the sensors in a wireless network.

A wide variety of systems and equipment within the home may be possible sources for capturing data. Some of these sensors may be built into existing equipment which can give a better impression of 'what' the person is doing compared to the 'where they are' information that comes from conventional location activity sensors. As well as technical aspects, the key criteria for selection of sensors were:

- Low-cost, the well-being system should be a generally affordable solution within a very price-sensitive care market.
- Unobtrusive and unintrusive, the sensors should not impinge on the privacy of dwellers, e.g. the use of cameras was avoided
- User-passive, the system should not be dependent on the person, e.g. wearing devices or tags
- Reliable and robust, usable in the everyday home environment with minimal maintainence.

DATA ANALYSIS AND SYSTEM INTERFACE

Making sense of the sensor data is perhaps the major challenge facing all pervasive computer applications. The use of passive environmental sensors makes this task even more diffilcult, as data is often ambiguous (e.g. different persons and different activities can generate the same sesnor data). The triangulation of sensor data and the adoption of systematic approaches to intelligent data analysis are essential if interpretations are to be made with any level of confidence. The approach has been to try and answer the 'high-level' questions that might be asked by professional carers about the mental, social and physical aspects of a clients' well-being. For example, the user may be interested in the social interaction of the client. The well-being monitoring system would not be able to provide information on the quality and nature of social interaction, but would be able to

provide relevant lower-level information on social contact, such as trips outside the home and people visiting the home, which to some degree reflects the social interaction which may be occurring. The motion sensor data can be used to determine three types of activity:

1. The duration of high levels of activity indicating that the home is occupied
2. The time duration of low levels of activity, but the home is known to be occupied
3. The duration of time when there is no activity and it is known that the home is unoccupied.

Other sensors can be used to detect when the front door is opened and closed in order to improve the accuracy of the recorded occupancy state of the home. Using the recorded durations A and C, it is a simple calculation to determine the maximum amount of time that social activity might be occurring.

The aim of the system is to highlight significant changes in general well-being by displaying the data collected from the sensors on a some kind of simple graphical output showing activity patterns over time. A possible example of this is given in Figure 2., showing changes over time for the six activities, as well as an overall well-being index. This aspect of the system is likely to be crucial and it is important that any information generated is "usable" within the care planning process; ie. the information should be a useful basis for assessing client needs. The development of the system interface will require close liaison with potential users in order optimise presentation and ensure that the information content is appropriate.

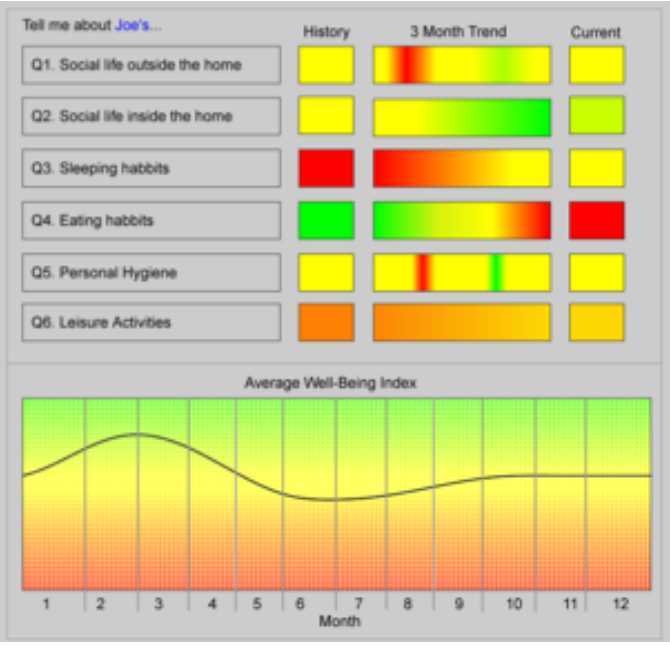

Figure 2. Example of graphical output for well-being monitoring System

SCENARIOS

In order to illustrate the way the well-being monitoring system might be used in practice, it is useful to provide some brief scenarios.

Scenario 1: Mrs Jones is an elderly widow who lives alone. Her daughter has recently moved away and can no longer see her on a daily basis. The well-being monitoring system detects that Mrs Jones now has fewer visitors and that she is steadily reducing the amount of time she spends outside of her home. The social worker detects this decrease in social interaction and informs the daughter. The daughter discusses this with her mother and her friends and relatives who decide to increase their visits and make more regular phone calls.

Scenario 2: Mr Collins lives alone and suffers from severe arthritis in his hands. The condition is becoming progressively worse and he is finding it increasingly difficult to prepare his meals. The well-being monitoring system detects that Mr Collins is spending more time in the kitchen and taking longer to perform specific activities. The system highlights this to the occupational therapy assessor who decides to reassess Mr Collins. A new care package is put in place to help Mr Collins with daily activities such as cooking and cleaning. Mr Collins' GP is also informed who decides to reassess the medication he is receiving for his condition.

CONCLUSIONS

The well-being monitoring system discussed in this paper is an example of emerging "third generation" telecare systems that exploit the potential of pervasive computing. These kinds of systems represent potentially important avenues for the development of new technology-based services in the context of ageing populations across the world. The need to service larger numbers of frail and care-dependent older people, while at the same time enhancing quality and extending consumer choice, are major drivers within this market. The well-being monitoirng system outlined in this paper has a number of specific benefits, most importantly, the provision of targetted information that can be used by professional carers, family carers and older people themselves to help them remain independent and enjoy a good quality of life.

Major IT and engineering challenges still exist and, in many ways, the concepts underlying pervasive computing applications are in advance of what is currently technologically feasible. In this sense, we are still creating "roadmaps" for development over the coming years. Challenges also exist in respect to the implementation of these kinds of systems. The introduction of new technology into an industry that has been based overwhelmingly on face-to-face human contact will require new business models and changes in organisational culture. The use of these technologies also raises ethical issues, such as loss of privacy and information usage and appropriate guidelines for practical deployment are required.

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