A Sensor Enabled Smart Space for Health Research

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Abstract and Objective

The Smart Space research facility described here provides a laboratory environment for investigating technology-oriented aspects of new models of health care for out-of-hospital settings. It provides an instrumented, configurable space for simulating, modelling, observing and measuring health care activities using various new information and communications technologies (ICT). This environment allows a wide range of subjective and observational studies to be performed in tandem with gathering quantitative experimental results, using wearable ambulatory devices and embedded sensors. This is intended to help develop and improve new health care processes, allow benchmarking and evaluation of alternatives, facilitate collaboration between technology and health experts, and assure ongoing continuity of related research via e-Science mechanisms.

Keywords:

Ambulatory monitoring, Data collection, Data mining

Introduction

New models of care based on more patient-centric processes are currently emerging in health care, with the consequent adoption of new methodologies and technologies including ICT. With widespread rapid growth in demand and shrinkage of resources in acute care based health systems globally, new models of care offer many benefits to nations and communities in terms of economy, efficiency, access, quality and safety of care. These innovations can impact directly and positively on many high cost and high volume health care needs, such as aged care, assisted living, chronic disease management, occupational therapy and rehabilitation.

The successful development and use of new methodologies and technologies require appropriate health care location configurations, supported by appropriate health care team dynamics and behaviour. Often health care delivery must occur in highly varied working or living spaces which are not ideally designed for that purpose, such as clinics or homes. The health professionals and other carers involved in the care delivery must function effectively through sharing and communicating of information, including obtaining accurate data about the patient, and for decisions about variations to the care plan. All of these tasks can be well supported by ICT, but need more knowledge about design and integration decisions to be gathered, as well as evidence of their efficacy through trials and evaluations. The facility described here is designed to meet these requirements.

Method

The fundamental underlying design concept of the research facility is that of a "smart space", i.e. a sensor-rich, user-aware, adaptive, reconfigurable environment. It consists of two physical components: Experimental and Computational rooms.

The Experimental room provides the physical environment in which measurement and observational studies occur, involving human subjects using equipment or undertaking activities. Different forms of equipment are necessary to ensure that the most appropriate type is available for a given experiment, and to allow duplicate collecting of results during some experiments by using two different equipment types simultaneously. The initial equipment types provided consist of a network of wearable human movement and physiological signals sensors, fixed motion and interaction sensors, and mobile wireless communication equipment (including mobile phones). These will soon be expanded to include multiple camera video capture, 3D space tracking, and remote site "eWindow" for human communication and interaction (e.g. for investigations involving telehealth). Basic furniture and moveable partitions incorporated in the space allow a range of different living and working scenarios to be simulated (e.g. home, office, bedroom).

The Computational room consists of a dedicated server system for data collecting and storage (including archiving), and for running specialised software associated with the equipment in the Experimental room to enable communications for control and data collecting. This server provides the core eScience platform for the facility, and also drives a viewing/demonstration area for researchers to use in collaboration activities. Satellite nodes will in the future be located at collaborating institutions. A node may contain a reduced scale sensor network system, to support research on tuning and augmentation of the hardware and software components, or may also contain another "eWindow" installation, to provide a remote site for human communication and interaction experiments.

Results

Initial projects making use of the facility include developing evaluation methodology for home telecare stations; estimating exercise energy expenditure through multiple sensor data streams; adapting web based data collection resources to support cohort-specific targeted wellness programs. Future work will allow creation of virtual spaces, or augmented reality spaces for

virtual interactivity with real spaces, to simulate actions unable to be made in real spaces, and use of mobile health and web based technologies to support carer and patient needs.