DEPLOYING WIDE-SCALE IN-HOME ASSESSMENT TECHNOLOGY

Jeffrey Kaye¹, Tamara Hayes¹, Tracy Zitzelberger¹, Jon Yeargers¹, Misha Pavel¹, Holly Jimison¹, Nichole Larimer¹, Jessica Payne-Murphy¹, Eric Earl¹, Kathy Wild¹, Linda Boise¹, Devin Williams², Jay Lundell² and Eric Dishman³

¹Oregon Center for Aging & Technology, Oregon Health & Science University, ²Spry Learning, ³Intel Corporation

ABSTRACT

Cognitive or motor function decline are major causes of loss of independent living among the aged. Several methods employing ubiquitous or unobtrusive technologies have been proposed for application toward in-home assessment to identify clinically meaningful change. Most attempts at multi-dimensional home monitoring have been on a limited scale. This has been the result of both technical and clinical research challenges in applying and more importantly testing the efficacy of such methods on a community-wide scale. We designed and implemented a system for application to a community based clinical trial of the efficacy of a basic sensor net (motion and contact sensors, RF location systems, and personal home computer interaction) to be studied in 300 homes of independent seniors. In this manuscript we describe a protocol to ensure several key outcomes: facilitation of recruitment and enrollment, customized training of elders for in-home computer use, optimized sensor net installation, tracking of subject status and linkage to study management software to enable on-line, real-time testing and trouble-shooting with seniors. The methodology suggests that large-scale unobtrusive in-home assessment is feasible for research needed to establish the efficacy of such systems for detection of cognitive decline and related conditions of aging.

1. INTRODUCTION

Over 34 million world-wide are projected to be directly affected by dementia or age-related cognitive decline in the coming decades [1]. Improving the outlook for these individuals and their families will require the realization of several research milestones. These include both improving the care and management of people with dementia as well as identifying disease modifying therapies and ultimately preventing cognitive decline. In order to improve the ability to reach these goals methodologies for detecting cognitive change at its earliest time-point and tracking change over time is a critical objective. Conventional approaches for assessment of cognitive decline rely on clinic or office-based assessments that are inherently time-limited and episodically conducted between relatively long periods of time. An alternative to this approach is to bring the evaluation into the home setting using several monitoring technologies thus providing opportunities for frequent or continuous assessment. Several models and technologies have been proposed and employed to monitor or assess a number of health related functions in the home environment [2]. Currently commercially available systems are being deployed. However, few have been formally tested in a community setting on a large scale over a long period of time. Their sensitivity to change is not known. In order to begin to study this model of cognitive and behavioral assessment we have developed a protocol for organizing and deploying the technology and research team necessary to conduct this research. The goal is to scale this research up to conducting a 36-month longitudinal study of incident cognitive decline in up to 300 seniors living independently in their own homes. Described in this manuscript are the procedures to achieve this aim and the results of a pilot study conducted to confirm the applicability of the protocol.

2. METHODS

2.1 Outline and overview of study

The protocol was approved by the Institutional Review Board of Oregon Health & Science University (OHSU). Participants all provided informed written consent. In summary, subjects were recruited from the Portland, Oregon metropolitan area. Entry criteria included being a man or woman age 80 or older, living independently (living with a companion or spouse was allowed, but not as caregiver) in a larger than one-room (“studio”) apartment, not demented (Mini-Mental State Examination score > 24; Clinical Dementia rating < 0.5) and in average health for age (medical illnesses that would limit physical participation (e.g. wheelchair bound) or lead to untimely death over 36 months (such as certain cancers) were exclusions). After signing informed consent subjects were screened for inclusion into the study. A physical and neurological examination was completed along with a gold standard neurocognitive assessment employing the battery of the National Alzheimer Coordinating Center. Home layouts were drawn and broadband Internet access
was obtained. A wireless sensor net along with study computers were placed in the home. Subjects not living alone were asked to wear an identifying RFID device. Once subjects met criteria for computer literacy (sending and receiving e-mail) they were queried weekly using a standard set of questions with regard to their health and activity status. Those not using a computer were mailed the same forms. The overall configuration of the research platform is summarized in figure 1.

**Figure 1.** Diagram of the relationship of the home based system (user PC, wireless sensors, sensor system PC and router) to the remote distributed research operation (research staff, activity servers and data servers).

### 2.2 Facilitation of recruitment and enrollment

In order to facilitate recruitment, subject enrollment focused on seniors living in congregate housing (e.g. continuing care retirement communities, senior housing apartment complexes). Initial contact was made with facility directors or managers, a formal presentation was made to the seniors living in the facility and a potential participant pool was created at the end of presentations. Follow-up calls to interested parties were made within 2 weeks of contact. Additional subjects were identified through word of mouth at these facilities. For the pilot phase subjects were selected from a list of current OHSU Layton Aging & Alzheimer’s Disease subjects who met the pilot study criteria for age, address and past computer use and have been followed longitudinally.

### 2.3 Training of elders

Subjects were instructed in use of the system and trained according level of computer familiarity as determined with an initial standardized assessment. Training entailed 6 sessions over 3 weeks. Ability to send and receive email was the criterion for computer proficiency.

### 2.4 Sensor net and computer installation

To collect continuous activity data, an unobtrusive activity assessment system was installed in the home of each participant. Passive infrared pyroelectric motion sensors (MS16A, x10.com) were placed in every room at locations expected to pick up the participant’s movements restricted to that room. Magnetic contact sensors (DS10A, x10.com) were placed on each door of the home to track visitors and absences from the home. To estimate walking speed, MS16A sensors with a restricted field of view were installed along a hallway so they would fire only when someone passed directly in front of them (restricted to ± 4° field of view, or about ± 6.5 cm at a distance of 90cm from the sensor). To determine who was moving in the home, subjects wore RFID tags (Ekahau, Finland) that used 802.11 signal strengths to determine location. All sensors sent their data wirelessly to a laptop computer, where the data were time-stamped and uploaded daily to the project data center. All data were stored in an SQL database.

### 2.5 On-line subject assessment and project management

We developed a program to monitor the status of data transfer and quality on a daily basis. The program provides a secure web-based interface to the data, along with data summaries and plots of activity that can be used to detect equipment malfunction (e.g. dead batteries), acute changes in behavior patterns (e.g. vacations), non-compliance (e.g. failure to complete the health status report), or failure to upload. Each home monitoring system can also be remotely accessed if needed for trouble-shooting or software upgrade.

### 3. RESULTS

#### 3.1 Subject characteristics, enrollment profiles

In the pilot study 36 subjects were screened and 13 subjects were enrolled from one continuing care retirement community. Primary reasons for non-inclusion were: disinterest, self-described health complications that discouraged individuals from taking on more activities, or living in a studio apartment. The average age of subjects was 85.4 years old (age range, 79-92 years). The ratio of men to women was 4:9. All were Caucasian. There were nine residences monitored with four cohabitating couples and five living alone. Of the four couples, only one had a partner that also used the computer, two were not interested and the other was unable due to stroke. These three were considered ‘Motion Only’ subjects as only their motion sensor data was collected. Of the remaining 10, six were deemed intermediate to advanced users by the Computer Proficiency Test, two were labeled ‘semi-
naïve’, both having completed a computer training course within the last year, and two were ‘naïve’ to computers. These latter four attended the six session training course with good consistency. In addition, four additional intermediate users attended several classes, depending on that day’s curriculum. 2.5 months post-enrollment, one naïve user opted to drop out of the study due to undisclosed health conditions. The other naïve user, 92 years old, asked that we remove her computer due to vision complications that couldn’t be accommodated for with additional magnifying software or other more expensive vision aids. She continued to be followed in the motion-only portion of the study for several weeks, until she suffered a fall resulting in hip fracture and moving to another facility.

3.2 System performance and monitoring

Over a 12 week period, the project team installed 9 home study systems; 2 were removed during the course of the pilot period. In summary we deployed: 9 study laptop computers, 5 subject use computers (and supported 3 subject owned), 9 routers, 83 motion sensors, 10 door sensors, and 45 wireless access points. In the course of supporting these systems there was frequent need (21 times) to visit the homes for adjustments. In addition there was frequent telephone contact; research team initiated calls, 97 times; subject initiated calls, 47 times. Sensor falls were the most common technical problem: 7 access point sensors, 5 door sensors, 1 refrigerator sensor. Two motion sensors needed to be moved because they kept getting bumped off the walls (suboptimal original locations). The systems provided a total of 818 (19,632 hours) days of monitoring with 131,079 sensor firings. The console software used for monitoring the systems and subjects was used frequently by the study staff. Examples of the information obtained from this monitoring software is presented in Figures 2-3. The computer users in the homes all completed the weekly on-line questionnaire as to their general health and life events status.

4. DISCUSSION

We completed a 12-week pilot study of deployment of a scalable in-home cognitive and behavioral assessment system. Recruitment for the pilot phase described here was not difficult and was facilitated by prior positive relationships with the continuing care retirement community. Further deployments to new communities will clearly need to pay careful attention to building community relations and close ties to facility management and residents. Among those enrolled the major causes for drop out were health changes (hip
fracture, cognitive impairment). This is likely to be an ongoing source of disruption in studies within this demographic. Subjects without major life events were very compliant. This is similar to the experience in focused telehealth monitoring studies [3]. Subjects did not appear to find the weekly questionnaire too intrusive of their time. Despite the excellent response of the enrolled subjects, certain technical challenges remain. Many of these are predictable in the field setting. Simple technical issues such as sensors falling off of their placements or not initially being optimally positioned speak to the need to build into studies a period of test-monitoring before formal “baseline” data is collected. It also means that staffing of research personnel needs to be adequate to enable timely responses to needed change. The single most challenging barrier to rapid deployment is the personnel time needed in set-up, computer training and post installation adjustments. The Console software for monitoring the project was a major aid in facilitating these steps of the study and allowing the study team to coordinate their efforts. Because of the relatively high number of cohabiting couples (likely a result of the population being healthy adults), a system for identifying which individual’s activity data is being acquired is necessary for this research. This adds to the expense and effort of this research, but more importantly with current solutions requiring a worn sensor or device for this need, this means that subjects face a more obtrusive and involved research regimen. Nevertheless, among the target population it appears that the perceived benefit of ultimately understanding how such systems might extend or enable their independent living outweighed any concerns about disruptions to their daily activities. This suggests that applying the lessons learned from this study will result in successful deployment of this research platform for larger longitudinal studies.

5. CITATIONS


ACKNOWLEDGEMENTS: Supported by National Institute of Health PHS grants P30-AG008017, P30-AG024978, R01-AG024059 and Intel Corporation.

CORRESPONDENCE: Jeffrey Kaye, MD
ORCATECH: Oregon Center for Aging and Technology
Email: kaye@ohsu.edu Website: www.orcatech.org