Creating Salient Summaries of Home Activity Lifelog Data

Matthew L. Lee
HCI Institute
Carnegie Mellon University
5000 Forbes Ave
Pittsburgh, PA 15213 USA
Matthew.Lee@cs.cmu.edu

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Abstract
Keeping track of the fluctuations in functional abilities that elders experience is important for early detection of cognitive decline and maintaining independence. In this proposal, I describe my research in understanding how to design ubiquitous home sensor systems that can monitor how well individuals carry out everyday activities important for independence. These systems collect an overwhelmingly large amount of data and thus only the most salient details need to be presented. I will identify the information needs of stakeholders to inform the design of salient summaries of the data for elders, their family caregivers, their doctors, and their therapists to become more aware of changes functional abilities. I also describe the technical, HCI, and clinical contributions of this work.

Keywords
Embedded assessment, elder, salient summary, sensors, lifelog, functional abilities, caregiver

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Design, Human Factors

Introduction

Many elders experience cognitive decline as they get older. They may forget particular steps in a multi-step task or may have difficulty concentrating on a task. Occasional lapses in memory, attention, or decision-making are a normal part of aging, but consistent cognitive problems may be the first signs of progressive neurological conditions such as Alzheimer's disease or its precursor, Mild Cognitive Impairment.

Cognitive decline usually manifests itself first as changes in an individual's *functional* ability, that is, the ability to carry out everyday activities. In particular, Instrumental Activities of Daily Living (IADLs) such as preparing a meal, taking medication, using the telephone, and doing housework are important for maintaining independence and require a relatively high level of cognitive ability to be performed. Assessments of how well individuals perform IADLs can provide early indicators for decline and allow for earlier interventions to prevent accidents and delay institutionalization [[1]]. Maintaining awareness of changes in functional abilities and adapting to them is key for successful aging.

However, many elders [6] and even their family caregivers [4] often are not aware of the subtle changes in their functional abilities that may be early signs of progressive cognitive decline. Even performance-based psychometric testing is not always reliable due to their infrequency, lack of objectivity, and reliance on simulated, often contrived tasks.

Ubiquitous sensing technologies situated in people's homes can collect and provide information about *how often* an individual engages in various activities, *e.g.*, [8,9]. However, an even earlier indicator for decline is *how well* people perform IADLs [7]. This kind of embedded assessment [5] technology that can track the individual steps involved in performing a task and can detect the amount of time/effort spent or the number of errors committed prior to task completion can provide objective, timely, and ecologically-valid information. This information enables elders and their caregivers to maintain their awareness of early changes in abilities and for clinicians such as primary care physicians and occupational therapists to make earlier and more accurate diagnoses of decline.

Yet, embedded assessment sensing systems can produce an overwhelmingly large amount of lifelog data. The challenge is thus to identify the most meaningful aspects of these data and create salient summaries that are usable and useful for elders, caregivers, and clinicians to support their health goals.

For my dissertation, I plan to address the following research questions through formative field work, design of novel sensing systems, field deployment to collect real data, and evaluations with real users:

1. Is embedded assessment of how well people perform everyday activities useful for stakeholders (elders, their caregivers, and their doctors and therapists) for reaching their goals?
2. What are the information needs of each group of stakeholders, and how should meaningful salient summaries of lifelog data be produced?
3. How can embedded assessment data actually enable stakeholders to reach their goals and what information should future sensing systems collect?

Initial Field Work

To identify, at an early stage, the potential impact and usefulness of embedded assessment on elders, family caregivers, and clinicians, we conducted concept validation sessions in which we presented scenarios of sensing systems that were capable of monitoring how well an elder performs everyday activities such as taking medications, preparing a meal, and using the telephone. I also presented stakeholders with hypothetical data that these systems would have collected over the course of a year and asked how these data would be helpful to the various stakeholders to achieve their respective goals, for example, gaining awareness of changing abilities, diagnosing medical conditions, or applying solutions to fix problems. Addressing research question #1, the results of the concept validation were positive with stakeholders expressing that the data from an embedded assessment system was helpful. Elders expressed that the data would help them keep track of changes and make the changes necessary to maintain independence. Family caregivers said monitoring these "mundane" tasks gave them a new window into the daily functioning of their loved one. Doctors said that the sensor data provided them with more detailed information they can normally obtain from short interviews with patients during an office visit. Occupational therapists found the low-level details helpful for identifying the particular deficit and applying the right adaptation to maintain task adequacy. Clinicians also found it helpful for tracking the effect of a change in medication or new functional adaptation.

Current and Proposed Research

After this initial validation of the value of our proposed sensing system, I am currently designing and building an embedded assessment sensing system that will be deployed to collect real long-term IADL performance data from independently-living elders. With this personalized data we can further identify the information needs that each stakeholder finds useful for support their goals. Based on these information needs, I will create salient summaries of this personalized data to highlight the most important features, events, or trends for each stakeholder.

I am currently integrating various existing sensor technologies with a wireless infrastructure to wirelessly sense the individual steps of particular IADLs. I am developing sensing systems for three particular IADLs (medication taking, breakfast preparation, and telephone use) because these are important tasks for independence, common among elders, reasonably easy to sense, and most importantly, are already used in existing scales [2,3,7] of functional abilities.

In the near future, I will continue to refine the design of the sensors through a combination of field and laboratory pilot testing to ensure accuracy and robustness for detecting the individual steps of the task. I will then deploy the sensors into the homes of ten elders who live on their own who may be already experiencing some declines in functional abilities. Throughout the deployment, the sensors will be validated by comparing their data with expert assessors and standard psychometric tests for cognitive and physical decline. After a baseline period of 1-3 months, a subset of the participants will receive feedback about their functional abilities in the form of an interactive display in their home. Their interactions with these displays will be logged as well as their comments about whether it provides insight into their own abilities. After

six months of data, we will present these data to family caregivers and clinicians and ask them whether the data is useful or interesting to them. I will begin by showing them visualizations of the data very close to the sensor data and apply different summarization techniques to highlight trends. To address research question #2, I will use iterative design to develop visualizations that highlight the most salient information from the sensor data that each stakeholder wants. In contrast to the initial concept validation field work, engaging stakeholders with real data will enable us to address research question #3 by observing how the data actually impacts the practices of stakeholders, rather than having stakeholders only imagine what they would do.

Contributions

This research provides technical, HCI, and clinical contributions. From a technical standpoint, I will develop new sensing technology that can sense the adequacy—instead of merely frequency—of task performance. From a HCI standpoint, I will investigate the information needs of stakeholders of embedded assessment technology through evaluations before, during, and after a long-term deployment. From these data, I will generate and evaluate design guidelines for making salient summaries and visualizations for long-term performance data of functional abilities. This research will also have practical clinical contributions in the form of novel, objective, ecologically-valid, timely, and salient measures of functional abilities that can help clinicians make more accurate diagnoses of physical, cognitive, or functional decline. This research can also help elders and their caregivers become more aware of changes in their abilities as they age. These sensors and summarization techniques can influence the design of future commercial home monitoring for elders, children, and smart home residents.

Citations

[1] Barberger-Gateau, P., Fabrigoule, C., Helmer, C., Rouch, I. and Dartigues, J. Functional impairment in IADLs: an early clinical sign of dementia? *J Am Geriatr Soc.* 47, 4 (1999): 456-462.

[2] Diehl, M., Marsiske, M., Horgas, A., Rosenberg, A., Saczynski, J. and Willis, S. The revised observed tasks of daily living: A performance-based assessment of everyday problem solving in older adults. *Journal of Applied Gerontology* 24, 3 (2005): 211-211.

[3] Holm, M. and Rogers, J. (1999). Performance Assessment of Self-Care Skills. *Assessment in occupational therapy mental health.* B. Hemphill-Pearson. Thorofare, NJ, Slack Inc: 117–24.

[4] Kemp, N., Brodaty, H., Pond, D. and Luscombe, G. Diagnosing Dementia in Primary Care: The Accuracy of Informant Reports. *Alzheimer Disease & Associated Disorders*. 16, 3 (2002): 171-176.

[5] Morris, M., Intille, S. and Beaudin, J. Embedded Assessment: Overcoming Barriers to Early Detection with Pervasive Computing. *Pervasive* (2005): 333-346.

[6] Okonkwo, O., Griffith, R., Vance, D., Marson, D., Ball, K. and Wadley, V. Awareness of Functional Difficulties in Mild Cognitive Impairment. *J Am Geriatr Soc.* 57, 6 (2009): 978-978.

[7] Owsley, C., Sloane, M., McGwin Jr, G. and Ball, K. TIADL: Relationship to cognitive function and everyday performance assessments in older adults. *Gerontology* 48, (2002): 254-265.

[8] Philipose, M., Fishkin, K., Perkowitz, M., Patterson, D., Fox, D., Kautz, H. and Hahnel, D. Inferring Activities from Interactions with Objects. *IEEE Pervasive Computing* 3, 4 (2004): 50-57.

[9] Tapia, E., Intille, S. and Larson, K. Activity recognition in the home using simple and ubiquitous sensors. *Lecture Notes in Computer Science* (2004): 158-175.