Longitudinal Health Interviewing by Embodied Conversational Agents: Directions for Future Research

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Abstract

Long-term health monitoring is becoming increasingly important with the rising prevalence of chronic disease in the U.S. While many researchers are investigating the use of remote biological monitoring and telemedicine technologies, the use of frequent self-report in long-term health monitoring remains a relatively unstudied area. We discuss some of the many cognitive, affective and contextual issues that must be addressed in maintaining a long-term stream of quality data from patients at home or in the field, and how many of these issues can be addressed through the use of conversational agents.

Introduction

Chronic medical conditions are affecting more and more Americans (Mokdad et. al. 2001), yet the time constraints of primary care physicians often prevent full chronic-care management within the office (Ostbye 2005). As a result, weekly or even monthly appointments between patients and their physicians are unlikely, and patients face an increased burden of self-managing their health (Bodenheimer et. al. 2002). Unfortunately, it is well known that patient adherence to medication regimens is generally poor, and worsens when the complexity of the regimen increases (Osterberg 2005).

Clearly, one area of research that continues to be important to the future of health care is telemedicine. Furthermore, with chronically ill patients increasingly responsible for the management of their own care, longitudinal health assessments will become increasingly important to provide trend and alert information to both patients and their physicians in the coming years.

We are interested in addressing the challenges associated with conducting automated health interviews with patients, repeatedly over long periods of time. For example, how do we conduct a daily conversation with a patient that provides interesting and useful data to both the patient and their physician? What techniques can we use to maximize the quantity and quality of self-reported health data, and minimize fatigue associated with longitudinal repeated assessments? How can we maintain patient engagement over time, and minimize social-desirability effects that can be associated with face-to-face interviews?

Despite the importance and fundamental nature of self-report in health assessment, little research has been done to address these questions to date, particularly in a longitudinal context.

Embodied Conversational Agents (ECAs) provide a particularly compelling interface modality for conducting longitudinal health interviewing. ECAs (Figure 1) are animated virtual humans that incorporate both verbal and non-verbal cues to simulate face-to-face conversation (Cassell et. al. 2000), and have several qualities that could positively impact longitudinal health interviews. First, they are easy to use, requiring no prior computer experience. Second, they are based on computational models of natural human behavior, allowing for rapport-building and empathy, which may be key to maintaining long-term engagement. Third, ECAs can provide health information that is adapted to the particular needs of a patient and to the immediate context of the conversation, and function in a low-pressure environment in which patients are free to take as much time as they need to thoroughly understand the information being discussed. Last, they have been successfully used in underserved populations such as older adults, and people with inadequate health literacy (Bickmore, Caruso, and Clough-Gorr 2005).

Longitudinal health interviews by ECAs could also provide a natural bridge between patients and their physicians. These interviews could serve several purposes,

maximizing the interests of both patients and their physicians. Long-term interviews would allow patients to self-report their health status along with any symptoms or side-effects that might be occurring. Furthermore, ECAs could educate patients about their medical condition, current health status, or prescribed medical regimen (medications, exercise, diet, etc.). The interviews could also be used by patients to log questions or comments for their physician, and provide patients with a detailed report of their progress, for discussion with their doctor.

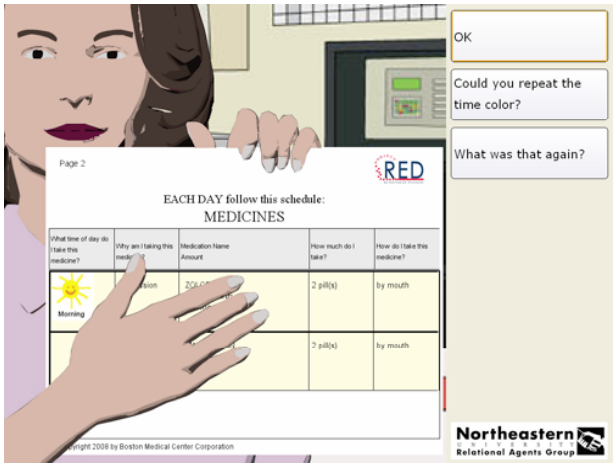

Figure 1. Embodied Conversational Agent

Related Work

Patient-computer interviews as a means of health assessment have been used for over forty years (for an overview, see Bachman 2003). Generally, these interviews are one-time assessments that occur prior to a patient's appointment with their physician and have generally high levels of satisfaction among both patients and their physicians. Computerized interviews also have positive aspects with regard to the quality of data collected, most notably a reduction in social desirability effects associated with face-to-face interviews, thus presumably collecting more accurate self-report data (Newman et. al. 2002).

Longitudinal Health Monitoring

Telephone systems for home health monitoring have been used to interview patients about their health (Friedman et. al. 1997). These dialogue systems utilize Interactive Voice Response (IVR) to allow patients to respond to the system in natural language. A downside of these systems is that they require a large amount of cognitive load from users. At each turn of the conversation, users must remember the list of acceptable responses given by the system, which can often lead to confusion and frustration. Long-term engagement and use of home health IVR systems have not been examined.

Ecological momentary assessment (or EMA) has also been used for health interventions (Stone and Shiffman 1994). This approach involves prompting patients at several points throughout the day to report on a specified health behavior, with a goal of acquiring repeated assessments over time, and minimizing burdens of retrospective recall. While EMA approaches are excellent at gathering large amounts of data in-situ, like most long-term approaches it has the potential to produce fatigue in users over time and elicit data where users give the same response at each assessment.

Home-based devices and sensors have also been used by patients to self-report their health status. These devices can range from scales and blood-pressure monitors where patients self-report their results over the phone (for example, Scherr et. al. 2006), to web-enabled devices, such as the Health Buddy® in which patients answer a series of daily health questions that are automatically reported to a case manager for review (Cherry 2002). More advanced devices such as the LifeShirt™ incorporate sensors into clothing to create a wearable device that monitors the vital signs of patients during their day-to-day activities (Grossman 2004). Unfortunately, many of these these systems can be prohibitively expensive, and lack long-term empirical evaluations on their effectiveness.

ECAs in Health Interventions

ECAs have been used in several health interventions, including exercise and medication adherence. In an exercise system designed for older, low-health literacy adults, participants who had daily conversations with the ECA on a touch-screen computer found the system easy to use, reported high levels of trust in and liking of the ECA, and walked significantly more than those randomized to a control condition (Bickmore, Caruso, and Clough-Gorr 2005). Within the hospital setting, ECAs have been used for education at the time of hospital discharge and patients expressed high levels of trust in the agent, and indicated that they were comfortable receiving medical information from a computer (Bickmore, Pfeifer, and Jack 2009). ECAs have also been able to incorporate communication strategies that establish trust and report with patients in order to increase satisfaction and adherence to medical regimens (Bickmore and Picard 2005).

Current Challenges and Future Directions

Acquiring small amounts of self-report information from patients at a single point in time is straightforward. However, acquiring this information reliably for long periods of time introduces many challenges. People's lives are complex, and time is often of the essence. Having an ECA conduct a daily or weekly conversation that will be beneficial to the patient, and at the same time be dynamic, engaging and succinct, is challenging.

One area of importance will be to examine ways of reducing frustration and fatigue when prompting users for

self-reported data repeatedly over time. We plan to explore several directions to address this challenge, including research regarding empathy. Previous work has shown that a system for repeated assessments that incorporated empathy, was perceived to be less stressful and frustrating than an equivalent system with non-empathic interactions (Liu and Picard 2005).

Social desirability is another construct that can affect the accuracy of self-report data. In face-to-face interviews, it is not uncommon for interviewees to give fewer reports of socially undesirable behavior or give fewer answers to threatening topics. For example, it is not uncommon for patients to report high levels of medication adherence to their physicians, while in reality adherence to their prescribed regimen is poor (Rand 2000). Generally, reducing errors on self-reported data is done by increasing the privacy of the respondent, but improved theories of what causes respondents to answer incorrectly are needed (Schaeffer 2000).

We believe that solutions to these problems must take into account a diverse set of factors, including the importance of the information to be acquired, the framing of the inquiry (what the patient thinks it is for), the wording of the inquiry, the patient's cognitive, affective and physical state, the past history with the ECA, and the immediate discourse context.

ECAs provide an ideal research platform for exploring the fine balance between the advantages of face-to-face conversation (empathy, rapport, etc.) and the benefits computerized assessments can have on improving the accuracy of self-reported data. This platform will also provide an ideal mechanism for examining the effects of these phenomena on repeated health interviews over long periods of time.

Conclusion

The acquisition of frequent self-report data for long-term health monitoring is an understudied area of research and one that will become increasing important to the future directions of health care. We have examined several challenges to acquiring accurate, repeated self-reported health data, and have discussed the use of conversational agents as a platform for future research in finding solutions to these challenges.

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