Smart Interactions for Health Self Management

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Abstract

Chronic conditions often plague people, and many require frequent care and medications throughout their lifetimes. Mobile computer applications and sensors can be used to monitor and detect unusual chronic health conditions, to assist in self management of diseases, and to notify patients and their providers of trends and events in their health measures. This paper describes several applications of mobile systems that use the evolving role of Smart electronic Personal Health Record systems (SePHRs) to support these interactions. Some research challenges in this field will also be presented.

1 Introduction

Chronic conditions such as non-communicable diseases (eg., diabetes, cardiovascular disease and chronic obstructive pulmonary disease), long term mental disorders and certain communicable diseases such as HIV/AIDS are the leading causes of death and disability in the world. The World Health Organization reports that currently chronic diseases are responsible for 60% of the global disease burden. In Canada, the current cost of illness, disability and death due to chronic disease is over $80 billion annually. In response to this growing burden many countries around the world are taking a great interest in improving the management of chronic conditions [1]. Across Canada, every province and territory has programs for managing chronic disease and for training the chronically ill in self management. With this well-deserved attention to disease self management that will help reduce the overall societal burden of chronic disease, there are many ways in which technology could assist with the management process. In almost all such applications, it is important for the patient to have an associated repository where monitoring and self-entered event data can be stored, reviewed, and analyzed to detect trends and outliers. Electronic personal health record systems (ePHRs) can be used to meet this need. Patients have already begun to adopt them to keep track of health-related information and events such as prescriptions, doctor appointments, illnesses, etc. Some physicians also allow patient downloads of certain clinical records such as lab test results, etc., stored on physician electronic medical records systems (EMRs).

Consumers are generally enthusiastic about having access to their own electronic medical records. In a US online survey in 2007, 91% of respondents agreed that "patients should have access to their own electronic medical record," and 60% agreed that "the benefits of electronic medical records outweigh the privacy risks" [13]. Physicians are also in favour of their patients having access to their own records, but with some reservations [3]. Many patients use the Internet to e-mail their physicians, receive test results, schedule appointments, etc. But due to insufficient technical knowledge, most physicians and patients have an incomplete understanding of the capabilities of electronic health systems and the system interoperability needed to deliver needed information. A major drawback to existing ePHRs was found in an environmental scan of the ePHR field by Archer et al [4]. One of their major conclusions was that most of the ePHR systems that have been developed and studied are physician-oriented. Thus, many have not included additional patient-oriented functionalities that are needed for maximum effectiveness. Until such ePHR systems are provided for patients, it is unlikely that tangible and/or intangible improvements in health outcomes from patient health self-management will be demonstrated.

The purpose of this brief paper is to describe innovative extensions of ePHRs to develop Smart ePHRs (SePHRs), patient centric smart systems and repositories for managing data from patient and physician inputs, combined with monitored data from mobile devices from indicators such as heart rate, blood pressure, blood glucose, weight, and other measures relevant to patient health. Such systems, to be effective, must operate from mobile wireless platforms such as smart phones.

2 Smart Mobile Applications for Managing Health of Individuals

The Smart Internet [10] was recently introduced as the next Internet generation, to reflect the move of the Internet toward a more user centric network. Among other benefits, this concept will allow clients to select services that work best, based on client contexts and needs. To meet these goals, the underlying conceptual model and infrastructure of the Service Oriented Architecture (SOA) needs to be extended and modified. Emerging technologies such as Software as Services (SaS) and cloud computing propose to support applications as services which can then be distributed across the network and reused in other applications. This will result in an increase in the number of web services that offer similar functionalities. Discovering relevant services (service discovery) and choosing the best ones to meet client needs (service selection) will be more challenging. The following discusses a few related eHealth applications.

2.1 Virtual Remote Nursing

Traditional approaches to service selection comparison of web services are based on their descriptions published in service registries, including QoS and price/performance ratios, as well as adaptability. This information is generated by the service developer and may not be fully trusted by the client. Moreover, alternative services may exhibit different performance in different client contexts that cannot be determined accurately by service descriptors. In a recent paper Najafi et al [9], propose a novel service selection approach that compares alternative services based on their performance in a specific client context. For this purpose, the SOA reference model is extended with the addition of a "competition desk" component that manages competition among alternative services available to the service client. This assists clients in choosing services that best suits their needs. A generalized prototype system was developed for the proposed extended SOA model which supports two types of web services: traditional data services (where the service processes client data and resources completely at the server site) and the task services that are proposed in the paper (web services with the capability of processing client data and resources partially or completely at the client site).

A recent paper by Najafi et al [8] applies the novel service representative approach described above to a virtual remote nursing (VRN) system, with a virtual nurse agent installed on a patient's personal computer or smart phone to help manage the patient's health condition continuously. A variety of tasks can be assigned to the virtual nurse using a generic task definition mechanism. Here, a task is defined as a combination of medical workflow and operational guidelines such as those derived from evidence based medicine to guide physicians in the diagnosis of patients and the development of treatment plans [2]. Practitioners select the tasks that will help the patient follow particular treatment plans, and to indicate the patient's health status or to give the patient appropriate warnings, recommendations, and reminders in pre-defined situations. Combined with an ePHR that records monitoring and other data from the patient's electronic personal health record, this supports the use of the VRN by the patient and the health provider.

A prototype VRN is being developed, with plans to extend it to an SePHR operating on a smart phone platform. The smart version would gather data through both patient and environment monitors, along with patient-entered data, for either healthy patients or patients with a variety of diseases or conditions. Data gathered in this manner would be mined in the sense that correlations would be evaluated between context measures (such as activity and location) and patient measures (in the case of people with heart disease, heart rate and blood pressure) to determine the patient's functional response to specific contexts. Knowledge derived from this type of analysis would be helpful in determining limits [2] to patient exposure, as these would show up in continuing monitoring activities. Warning messages could be generated as the monitored results reach or exceed preset bounds. Data gathered in this manner would be very helpful to physicians in devising treatments for their patients, and it may be useful in other applications such as sports medicine for people wishing to keep fit [11]. Note that active monitoring of patients through devices such as "Holter monitors" to record heart electrical activities is well known. Linking these measures to context characteristics (e.g. the activity in which the patient is engaged) opens up new areas of investigation, such as the work by Mouttham et al [7] and Shahriyar et al [12] on personal health monitoring. Our work proposes to monitor environment (as context) and patient measures and then correlate them analytically to develop knowledge that will help both patients and physicians to recognize unusual activity and events and to take the necessary steps to remedy problems that may materialize as more information is recorded and analyzed. The system could be individualized to each patient through the knowledge gained from measures of patient response to day to day activities, thus responding to symptoms or measures that are unique to the patient.

2.2 Automated Message Triage

Tavasoli [14] developed an automated message triage (AMT) technique for supervised text mining to classify messages or short documents according to the semantic significance of their content. This technique uses a combination of several algorithms that are known to work well for classifying documents that may have a significant overlap in their content. Environments that display this type of overlap include e-mails, text messages, user opinions, requests for user support, etc. There are many possible applications of AMT in healthcare, and this high performance classifier has been demonstrated with messages exchanged between patients and physicians in a trial of a system that used an ePHR to gather data from patients with hypertension. The intent in cases like this is to provide 24/7 monitoring of patient messages and to redirect them according to their level of priority. The highest priority messages can be directed to the attending physician or emergency service, medium priority messages can be handled by nurses or other staff, and lowest priority messages may result in automated responses with educational or other online materials. The system, once trained on known priority messages, can improve its classification ability over time as new messages that arrive are reviewed by an expert to define an accurate classification for the AMT system.

One potential application of AMT is as an augmentation of a recently introduced system called *FrontlineSMS: Medic*, designed specifically with open source software that runs on a laptop [5]. It basically turns a laptop and a mobile phone into a central communications hub. Once installed, the program enables users to send and receive text messages to individuals or groups of people through mobile phones. This system was designed for, and is used in, developing countries to more efficiently help healthcare providers provide services to people within range of cell towers. When combined with ePHR capability and the AMT classifier, this system could become an SePHR that would reduce the load on physicians by distributing messages to others who can handle the specific requests or by automatically responding with information relevant to low priority requests. The associated ePHR database could also provide a source of continuity for online patient records, for patients and physicians alike.

The preceding advances in smart self managed healthcare with SePHRs represent some of the research we are involved in. With these working prototypes, more effort will follow in testing and validating real applications, making adjustments as needed to suit clients and their physicians, and ensuring reliability of the systems and validity of the results. Future research will also address issues related to homecare nursing applications.

3 Research Challenges

We have identified the following research challenges to the further development of SePHR applications such as those discussed above.

3.1 Establishing Effectiveness

It is a challenge for home healthcare workers to support chronically ill and frail people cost effectively at home, while government agencies are promoting homecare as a way to help reduce healthcare costs. Technological advances have generated new devices that may provide some of that support. Homes equipped with mobile applications, including sensors that monitor activities and send information to healthcare providers are called smart homes. However, many of these new technologies are used without appropriate evaluation. A recent review of the smart home literature [66] found a large volume of literature on the use of smart technologies in home healthcare, many of which measure user satisfaction, but none that tested their effectiveness. The challenge in this research is similar to problems faced elsewhere in the mobile health field, which is to establish the effectiveness of these interventions.

3.2 Privacy and Security

Maintaining security in mobile self management systems is a major challenge, but advances continue to occur in smart phone technology, making encryption of data and messages feasible. This requires further attention to system design, with a level of security that will maintain the desired level of privacy for users. Specific types of techniques for secure access to databases (eg., role-based, team-based, attribute-based) may be suitable for mobile self management systems.

3.3 Usability and Adoption

Although usability is often an afterthought, with SePHRs it must be kept in mind from initial concept development, and built into the design with a testing regime that accommodates the eventual users of the system. This means that a simple user interface is the first and foremost design principle. Otherwise adoption will not succeed.

3.4 Change Management

Even with the most usable interfaces, the organization that interacts with systems such as those described, including physicians, nurses, administrators, and others, may need to change workflows and procedures to accommodate these innovations. Moreover, stakeholders have to be convinced that such systems will benefit them as well as their patients. Accommodating to such changes must be considered and planned in advance, with the main consideration being to involve all the stakeholders in the selection and adoption process from the beginning.

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