Ubiquitous Health Monitoring: Empirical Survey for the Delivery of Health Intercessions through Mobile Phone

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ABSTRACT

Mobile phones are playing a prominent role for the involvement of human health from past few years. Scientists and researchers have used mobile devices as the platform for promoting physical activities and healthy diet plans, calorie counters, sending timely reminders for upcoming appointments for the patients, encouraging smokers who are willing to quit smoking, monitoring symptoms of chronic diseases and wide spectrum of other health problems. This paper provides the state of art research survey and overview of rapidly growing work in this field. We also discuss the mobile technologies and various features that make them a promising platform though which the mobile phone and health intercessions can be acquired. Finally we summarize the area for future research that could help in understanding the requirements for the development of mobile phones health intercessions.

Keywords: automated sensing, health intercessions, health monitoring, ubiquitous

1. INTRODUCTION

From past few years, researches have progressively targeted to use mobile phones as podium for launching health intercessions. The main aim of this research is to target a wide spectrum of health conditions under the discipline of computer science in the field of ubiquitous computing. An experiment study among young adults in order to quit smoking through SMS[9], texting appointment reminders to patients those normally fail to attend the appointments[7], educating diabetic patients by providing various health tips through text messages[17], mobile phone based monitoring system for cardiac patients which predicted the health condition based on the collected data and also predicts the chances of occurrences of cardiac arrest in mere future[15] [14], users can themselves monitor their physical activities though various applications (quantified-self apps) and various sensing devices to keep track of their physical activities[3], to even remind the usage of sunscreen application through electronic monitoring[1].

The primary objective of this paper is to provide a classification of approaches and types of intercessions that have been implemented with mobile phones. With this approach it helps readers to understand the design space of mobile-phone health intercessions and building new intercessions by selecting elements suitable for their application field. The secondary objective of this paper is to recognize the opportunities for new intercessions for current developments in technologies for mobile devices.

Further, the paper describes the methodologies used in order to carry out this survey followed by brief discussion on how mobile phones acts as a launch pad for delivering health inter-cessions. We discuss few technologies that are used to create health intercessions. In the main part of the paper we provide examples of three health intercessions strategies and its types for which mobile phones have been used. Finally, we discuss the future enhancements in this domain of work based on the emerging technology and brief limitations of this review.

2. METHODOLOGY

In this paper the reviews provided are based on the literature survey that were found through a search on ACM Digital Library, IEEE Explore, PubMed and other main databases that provided the significant research literature on Ubiquitous Health Monitoring: Empirical survey for the delivery of health intercessions through mobile phone topic. Above mentioned search portals were searched based on the keywords "health," "mobile phone," "quantified-self," and "activity tracker". Resting on the abstracts obtained from these search keywords and related articles, we scrutinized and

analyzed the articles that described means of delivering health intercessions by using mobile phones. Through this process we could identify how mobile phones were used as a means of health intercessions, targeted audience and the achieved results. We then repeatedly congregate the inter-cessions demonstrated in the literature until we achieved at a convincing categorization described in this survey.

3. USAGE OF MOBILE PHONES FOR HEALTH INTERCESSIONS

Advancement of mobile phones availability and technologies has completely changed our life style. They are not just limited to communication purposes today; they are particularly a launching platform for delivering health intercessions due to the people's involvement with their phones. The ubiquitous acquisition of mobile phones with robust technical advancement, people aptness to carry their phone with them every-where, people's emotions and attachment towards the phone [16], the recent advancement of awareness features involving sensors and other personal information based on mobile phones. Below, we discuss few reviews that could do some justice to this topic.

Firstly, more often than not mobile phones are always in the persons hand or packet, unlike a desktop computer or a lap-top. Many of us are rarely more than a foot away from mobile phones. According to the study conducted based on the proximity of users to their mobile phones [14] which shows that around 60% of time users were just reach of the arm from their mobile phones.

Secondly, over a decade mobile phones have turned out to be quite ubiquitous. I.e. the accessibility has been easier towards the recent times. According to the information from International Data Conference, the Smartphone's running on third party applications like android devices has grown by 40% in the year 2012 [13] [5]. This statistics alone speaks about the adaptability of mobile phone universally and mobile phones that can access internet and run complex applications.

Finally, with the latest technologies and phones being really smart, the phones are aware of the owners current situation through location tracking and location prediction, accelerometer based detection and embedded sensing, and synchronizing with user's calendars and other personal information and with few applications that monitor the whereabouts of the users. This knowledge helps in creating immediate intercessions that provide immediate support for the needy users. These types of intercessions can be helpful in avoiding unhealthy behaviors resulting in assisting the users before getting involved into the behaviors that are unhealthy.

4.   MOBILE PHONE HEATH INTERCESSIONS TECHNOLOGY

In this section, we discuss a brief outline of the technical features of mobile phones and the ways in which these technical features have been utilized in involvement of the health. Each mobile phone health intercessions depend on the different type of technology being used. The potential of technology vary widely depending on the mobile phone the user is having. It varies from text messages on a basic phone to the compatibility of third party applications, internet access, sensing with other devices on smart phones like android, iPhones and phones which run on windows platform.

A. Short Message Service (Text Message)

Short Message Service (SMS) or commonly referred to as text message. With SMS one can send a message up to 160 characters to another device. The message which exceeds more than the threshold characters are automatically split up into several parts. SMS is the most basic and primitive way of communication through text. It is widely used in all parts of the world. According to facts and figures provided by International Telecommunications Union provided in 2010, there is a mobile phone penetration rate of 68% in the developing countries [17]. This extensive use of technology makes text messaging the most widely accepted technology for delivering the health as a platform.

Text messaging has played a vital role in health technology. This technology allows delivering of messages without any effort from the receiver side (push technology). Text messages are most likely to be used in sending reminders and tips regarding the ailments [15], health related educational information [7] [17] and helps in achieving health related goals. For example, a text messaging app called "Sweet Talk", that is designed to enhance self-efficacy, facilitate uptake of intensive insulin therapy and improve glycaemic control in pediatric patients with Type 1 diabetes [8].

Text messages provide users to enter their health related activities and other health related parameters and receive tailor made feedbacks based on the provided data. For example, in a pilot study conducted by collecting the data from asthma patients through mobile phones and SMS and providing them with a customized feedback.

The above mentioned examples provide evidence of how text messages or SMS plays a prominent role for delivering health intercessions.

B. Automated Sensing

Today almost all mobile phones can connect to sensing de-vices over many forms of personal area networking. Thus, mobile phones can connect to digital scales, health monitors, blood pressure monitors, ECG, pedometers, and other sensors. Mobile phones when connected to these health devices acts as a receivers and stores the data through which the health status can be analyzed and monitored. The elevation of mo-bile phones from past couple of years have resulted in devices with built in GPS and accelerometers which helps in tracking user's routine without the aid of external device. For example, an application called RunKeeper which is used in iPhone which tracks the user's physical activity and creates maps for their exercise plan. It also calculates the amount of calories burned during the workout. The built in sensors in a mobile phone acts as a motivation for users in focusing on their health by freeing user from the wearing additional device [4].

But with the automated sensing applications there is a drawback with respect to the privacy being concerned. These applications usually gather a huge amount of data about the users and their behaviors. Hence to protect the users privacy is a huge concern. As privacy being the main concern of the users, they usually end up not participating in health oriented applications [2].

C. Native Application

Native applications are basically written for a specific plat-form, they can communicate with operating system features and other application software's that is available on that plat-form. All major Smartphone platforms such as iOS, Android, Blackberry, WebOS and Windows phone provide developers with programming interface that can be used to build different applications. The API's provide access to different phone features that helps in creating complex applications. Thus re-searchers with the help of these API's they can develop many different types of health applications.

An application named "Balance" - pervasive wellness application that provide accurate activity inference is the best ex-ample to demonstrate the use of application in maintaining the health [6]. The BALANCE system automatically detects the user's caloric expenditure via sensor data from a Mobile Sensing Platform unit worn on the body. Users manually enter information on foods eaten via an interface on an N95 mobile phone.

Figure 1: Wearable Mobile Sensing Platform [6]

Figure 1 depicts the images of the system hardware. (Left) wearable Mobile Sensing Platform. (middle) The Nokia N95 mobile phone. (right) Measuring oxygen consumption when on a treadmill with the help of wearable apparatus which is attached to a metabolic cart. Mobile sensing platform inference engine identifies when a user is performing activities like sitting, walking, bicycling and running [6].

The BALANCE system can also keep a track of the user's daily food intake. Based on the food consumed a custom exercise chart will be provided. It keeps track of the amount of calories consumed.

(a) BALANCE software's main screen: the "Personal Fuel Gauge."

(b) The summary screen of daily food intake.

(c) In the custom meal interface individual food components of a meal can be selected or deselected when viewing the meal.

(d) The tab showing the daily activities that have been automatically detected.

Figure 2: Screenshots from a BALANCE software depicting the users food-exercise balance [6]

Figure 2 is an image from the Balance software [6]. In the above figure (a) displays the home screen of the application which depicts the users "Personal Fuel Gauge" with respect to the amount of calories intake and its expenditure. The daily food consumption are shown in detail as shown in figure (b). In the figure (c) a customized list of food that can be consumed is displayed. The user can choose the food that has to be consumed by viewing the list. The software provides a customized exercise schedule and the particular days exercise as shown in the figure (d).

5. MOBILE PHONE HEALTH INTERCESSION STRATEGIES

Computer scientists and researchers have utilized the maxi-mum technical capabilities to develop a wide range of heath intercessions. The most basic one is to send SMS reminders to patients regarding upcoming appointments [10]. In this section, we aim to further elaborate more on specific applications and map out the design space by identifying the intercession strategies and specific form that the intercessions incorporating the strategies take. The three main strategies that will be discussed in this paper are (1) Inflating the accessibility of health information (2) monitoring health information (3) involvement of healthcare team.

A. Inflating the accessibility of health information

The main benefit of using mobile phones for health intercessions is that content can be delivered without putting in any effort from an individual's side. The usage of text messages is the perfect example as it based on the "push" methodology i.e. delivering of messages without any effort from the receivers side. Thus with the help of text messages, intercessions can be pushed to individuals' mobile phone providing them with timely reminders, health information, diet plan and motivational messages to inspire them and many different approaches that helps in managing their health.

In recent times, the health related information are being delivered through informational messages- to send messages periodically regarding the health goals and management of their health conditions, through reminders- send timely messages as a reminder so that the user cannot forget the appointments and through glance able displays- displays the health information on the screen throughout the day.

For example, Figure 3 is a screenshot of an application named "UbiFit" [4] keeps track of the users activity and the feedback is displayed on the users mobile screen. It displays the image of a garden where different flowers represent different types of physical activity the user has participated. Upon performing each exercise a flower is automatically added in the garden at a specific amount of time and also as a motivation, a large butterfly appears when a user completes the weekly activity goal.

Figure 3: UbiFits glanceable display on the phones background screen. Different types of flowers represent different types of physical activities that the user performed this week

B. Monitoring health information

The most prominent strategy for any mobile phone health applications is to track health related behaviors, physical states, calorie intake and other factors relevant to an individual's health. Monitored health data has many advantages, often referred to as self-monitoring. These self monitoring apps pro-vides an elevation of desired behavior and demotion of un-desired behaviors. The typical self monitoring applications can be implemented through native journaling applications, through text messages and through automated sensing and recording.

Native journaling applications are tailor made to support entering one or more health related behaviors like physical activity, calorie intake and the respective measures of those behaviors (blood pressure, glucose level). They help in analyzing and keeping a track of daily routines and act accordingly. For example, as mentioned before Ubifit [4], an application for encouraging physical activity which tracks the cardio exercises, strength training and other different warm up exercises which are tracked and monitored on a daily or weekly basis.

Monitoring of health behaviors is also possible by using text messages. Text messaging can be useful medium for self monitoring because it is possible to automatically analyze the logged data and provide an immediate feedback. This quick response is possible due to text messages being processed on the servers. In addition to Monitoring of health behaviors, automated sensors are used for tracking. According to the paper in wellness diary [12] shows the usage of Pedometer which automates the recording of the user's physical activity (walking, jogging, running).

C. Involvement of healthcare team

Monitoring health information encourages tracking our health behavior change but effective management of many health conditions requires involvement of healthcare team. Keeping updated regarding the patient's activities and other factors can enhance the health care for the patient. In the presence of healthcare team the diagnosis can be more effective in nature. Basically the two health intercessions, remote coaching and remote symptom monitoring keeps the healthcare team updated regarding the patient's health condition and provides a closer understanding of their routine behaviors.

In remote coaching intercession the collected data on a patient's mobile phone is used and analyzed to find interesting results of their health behavior. The collected data from the phone are uploaded to the website where the healthcare team analyze the data and propose further actions based on those data. This method is usually carried out over a phone, through SMS or through a website. For example, a health monitoring application called MAHI that assists newly diagnosed individual's with diabetes in acquiring the required knowledge regarding the disease [11]. This application allows users to upload the glucose reading on a regular basis, the healthcare team examines the data in detail and they educate the patient regarding information on how to overcome the ailment, its remedies and cure.

Apart from remote coaching, mobile phones play a significant role in monitoring the patient's health and alert the healthcare team if any dangerous symptoms occur. In time detection and treatment is the key to prevent further deterioration in patient's health condition. Hence many intercessions rely on the collected information as medium for identifying defects in user's health.

6. LIMITATIONS

The review presented in this paper has two main limitations that are important to acknowledge. The first limitation is that the review is largely based on research literature from health sciences and human-computer interaction and does not survey the many commercial mobile-phone health intercessions that have been developed in recent years. One reason for this choice is that unlike for research literature there is no systematic way to get a comprehensive overview of commercial products. The other reason, however, is that our goal was to provide an overview of the design space of phone-based intercessions and that in the commercial products we found we did not identify any intervention strategies that were not also represented in the research literature.

CONCLUSION

This paper provides the state of art research survey and overview of rapidly growing work in the field of monitoring health. We also discuss the mobile technologies and various features that make them a promising platform though which the mobile phone and health intercessions can be acquired. Finally we summarize the area for future research that could help in understanding the requirements for the development of mobile-phone health intercessions. The objective of this research is to target a wide spectrum of health conditions under the discipline of computer science and portray the illustrative examples on how the mobile phone plays a prominent role in delivering health intercessions. These intercessions helps in avoiding unhealthy behavior among the users and also alerts the users by predicting the health behavior for future

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