Personalization of Mobile Health Applications for Remote Health Monitoring

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Abstract. Mobile technologies have significantly developed in the last two decades. These technologies are now commonly utilized in many mobile applications, especially on health. Remote health monitoring including wearable sensors and various health applications has attracted the attention of communication and health sectors reducing the cost of patient monitoring and improving the quality of treatment in hospitals or at home during the period of convalescence, thus increasing patients' quality of life. In addition, behavior change support features and persuasion strategies are integrated into mobile health applications to provide more efficient healthcare for patients. In this paper, remote health monitoring is explored together with behavior change support features and persuasion strategies used in mobile health applications.

Keywords. Mobile applications · Personalization · Mobile health · Remote health monitoring ·

1 Introduction

Recently, there has been an increase in the aging population and the number of disabled people, for this reason there are many patients who need long term health monitoring and the provision of healthcare solutions especially at home and in hospitals anywhere and at any time. It has been reported that approximately 14 percent of the older population in the United States suffer from different types of physical or cognitive disabilities. To provide long-term health monitoring and healthcare solutions, particularly for the disabled and elderly, mobile and wireless technologies are utilized. These technologies allow the easy monitoring of patients' vital signals. Missed doses of prescribed medicines can be given within a specific time period. Furthermore, sweating and breathing intensity can be measured during several activities, such as walking and running as well as sitting and resting including environmental data on temperature, wind speed and humidity [1].

Sensor networks, telehealth and internet-based electronic health records are used to reduce the workload of health professionals. In addition, health context-aware algorithms for predictive health assessment and chronic disease management can be im-

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proved with the integration of health data such as the vital sign measurements of patients. The data gathered via telehealth can be used in the nursing of patients with chronic diseases such as depression, diabetes, post-traumatic stress disorder, heart and respiration problems by monitoring patients' blood pressure, blood oxygen, blood sugar and weight [2,3]. One of the most popular health monitor systems are wearable medical sensors collecting several types of physiologic data such as body temperature, blood pressure, pulse and heart rate [4,5,6].

With the improvements in communication and informatics, remote health monitoring systems offer easy-to-use cost-effective portable and wireless solutions for the health sector. These systems allow monitoring patients in their daily life, and inform doctors, patient relatives and health institutions in case of emergencies. In addition, since these remote systems keep long-term records of patients, they make it possible to reach an accurate and early diagnosis of several diseases, thus improving patients' quality of life [7].

Today, many basic health checks can be performed using the wireless technologies on a mobile device. Thus, medical and mental data from patients with chronic diseases such as asthma, cardiovascular or cognitive disorders can be easily collected via wireless sensors and transported to a remote server. This is remarkable in terms of allowing the integration of information technologies into medical systems. Furthermore, every year, incorrect treatment and patient carelessness concerning the use of medication result in many deaths. Remote health monitoring is presented as a solution to these health problems.

2 Discussion

Basically, a healthcare system is concerned with illness, injury, physical and psychological disorders together with the diagnosis and treatment coordinated by health workers, dentists, nurses, pharmacist and doctors. Accessing health services depends on the social and economic status of the population and the level of care provided in the country. Traditionally, in order to monitor the health status of a patient, the medical staff, doctor and the nurses should be near to the patient whether in hospital or at homes. However, in some situations certain patients may face difficulties in travelling to hospital due to the distance or disability and home medical care for these patients may be expensive. Thus, real-time and remote health monitoring systems integrated with wireless sensor networks present an effective solution by automating several medical procedures [4], [8,9,10,11].

In previous work [12], we developed a patient health monitoring system to detect the patients' vital signs at regular intervals during the day. We worked with patients who required monitoring after their treatment in hospital. Using wearable sensors and smartphone applications, we gathered, monitored, processed and stored heart rate data from disabled and elderly patients. This data was then sent to patients' doctors via wireless communication to be kept in their permanent records. Furthermore, the gathered data on vitals can be compared with patients' threshold values determined by their doctor and in cases where a significantly higher or lower value is detected, both the patient and the doctor can be informed through messages [12].

The main structure of the designed health monitoring system [12] worked efficiently, thus we consider it to be useful for patients and doctors. However, we noticed that the patients using wearable and mobile systems would, after a while, lose interest and the motivation to monitor themselves over time. Technology that is intentionally designed to change a person's attitude or behavior is called persuasive technology [13]. Fogg [13] describes persuasive technology as computers being able to change human attitudes and behaviors. Following Fogg, Oinas-Kukkonen went one step further and defined the concept of behavior change support systems [14]. Behavior change support systems (BCSS) benefit from persuasive technology on behalf of individual's needs and goals and they are designed to assist users in pursuing their goals [14]. BCSS are widely used in health domain as well as welfare, commerce, education, energy saving and others [15].

The applications in the mobile health category employ a wide range of persuasive user interactions to encourage healthy behavior. Persuasive applications are an effective approach to motivate healthy behavior in an individual, with the use of ubiquitous technology for tracking and monitoring human behavior and addressing personal needs and progress.

Many systems have been developed for various purposes such as; assisting individuals in stopping smoking [16,17], following a healthy diet [18,19,20], reducing depression [21], managing chronic diseases [22,23,24] or engaging in regular physical activity [25,26]. The majority of these applications utilize features provided by the BCSS to encourage physical activity.

Consolvo McDonald and Landy [27] stated that systems that are abstract and reflective, unobtrusive and positive are effective in achieving behavior change ends. They also showed that goal-setting could be an effective way to encourage behavior change. The application they designed, Ubifit Garden uses virtual gardens in the background screen of mobile phones, which are enriched by flowers and creatures that are rewards to the healthy activity of the users. Lin et al [28] developed an application named Fish'n'Steps that used fish avatars to reflect the number of steps taken by users. It used gamification features such as virtual rewards and animated fishes that grow and change their expressions. Shakra was another mobile application [29] that used avatars on mobile phones and used social networks to share user's progress. Houston [30] presented a mobile application that used a pedometer that provided the user with options for self-monitoring and personal awareness. Users share their scores with a group of friends and reflect their activity, and obtain social support from text messages. Chick Clique [31] also used a pedometer and a mobile phone application together with text messages to increase the daily steps taken by the user. In recent studies on mobile health applications, the persuasive effects of mobile features are further explored. Using reminders and goals is presented as a more effective way of encouraging certain user activities than rewards [32]. Sharing progress is also considered beneficial albeit not as effective.

To identify the most effective persuasive features for the development of a promising system design, we plan to improve our work by integrating persuasive technologies. In our ongoing project, we are going to explore the use of features such as reminders, rewards, self-monitoring, goals and sharing progress with other users, visualization of results, self tracking, commitment, competition, social support, social facilitation, social learning and comparison, expert opinions, tunneling and personalized recommendations in terms of their effect on users' activities.

Mobile health systems should avoid one-size-fits-all approach to meet different needs of individuals. Understanding the patterns of mobile device and application use is significant to reveal user preferences to improve the features of mobile health applications and personalized mobile services. It can also help tailor for specific needs and specific populations such as elderly people. When designing and developing mobile and remote health monitoring applications, designers can focus on certain persuasive features relevant to the specific group of patients. Personal historical health data, demographics and user profiles will be considered for a personalized system design. The theoretical ground in persuasive technologies can be incorporated into health applications with the help of clinicians and experts to develop better context-aware, personalized and persuasive healthcare systems.

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