Abstract

Tracking health related behaviors regularly helps in forming good health habits, which greatly improve our health status in the long run. Self-reporting is the most acceptable behavior tracking method, but it suffers from issues like recall bias and low consistency. We propose a novel platform to mitigate these issues: It can send smart reminders to the user’s smartphone soon after completion of an activity to be reported; the reminders are based on smart-phone context information such as location, time and historical information. Additionally, to test the effectiveness of the smart reminders in our self-reporting platform, we conducted experiments to quantitatively analyze the effectiveness of our platform.

1 Introduction

1.1 Problem Definition

Behavior is the most important predictor of a person’s health, contributing as much as 40% of all the factors [1]. According to study [2], people who track their health-related behaviors regularly are more likely to form good habits due to awareness of their health status. Therefore, it is crucial to regularly and accurately track personal health behaviors.

Self-reporting has long been utilized in studies as a method to track health related behaviors [3],[4],[5]. Self-reporting captures a wider range of health behaviors which may not be possible using automated objective monitors (which are specifically designed to track a small set of behaviors accurately). As smartphones and other portable devices become more prevalent, mobile applications (apps) on these devices provide a promising platform for convenient data entry, making it a powerful tool to enhance self-reporting.

Nevertheless, self-reporting suffers from two major limitations, recall bias and inconsistency. Recall bias is introduced due to incomplete memory when the users report their past behaviors. [6],[7] demonstrated that reporting data in real time can effectively reduce recall bias. The second limitation, inconsistency, is caused by users when they gradually forget to report their data over time[8]. To overcome this issue, prompting the users through reminders have been shown to improve self-reporting consistency in [9],[10]. However, the reminders used in these studies are sent out at preset, regular time intervals without consideration of whether the behavior of interest, such as physical exercise, has just been performed or not.

We propose a novel method to improve self-reporting by sending out smart reminders based on current context, e.g. location, time, and historical information. The smart reminders fundamentally exploit repeatability in human behavior, both in the type of activities people perform and where and when they perform them. The smart reminder has two main advantages: 1) reminders are sent out just-in-time so that recall bias and inconsistency in the data can be minimized; 2) reminders
are sent out only after an exercise has been performed to reduce unnecessary interruptions caused by the app.

For future work, we will conduct a trial in the context of physical exercise to test out the effectiveness of smart reminders. Furthermore, the results could be extended to the context of other health related behaviors. We are developing an app which utilizes smartphone ge-location and time information, and past recorded geo-temporal tagged activities (historical information) to generate smart reminders soon after the user finishes exercise. The reminder will prompt the user of the smartphone to report their data ensuring more complete data logging.

1.2 Related Work

Recent emerging objective physical activity trackers, such as Fitbit, Jawbone UP and Nike+, provide users with accurate daily activity data without direct self-reporting. However, these devices can only recognize limited activities, such as walking, running, swimming and cycling, because they are built upon accelerometers, and work in the similar way of conventional pedometers. For other health related behaviors that cannot be detected with a motion sensor, such as exercises without intense motion, or food and medication intake, there are few objective mobile applications to track them. Given these problems, it is imperative to complement automated trackers with self-reporting for generic behavior monitoring.

One experimental study [10], was conducted with similar intuitions about smarter self-reporting and their results and conclusions align with our motivations of leveraging smartphone context to improve self-reporting. In the study the authors designed and developed an app called Mobile Teen which utilized sensor data of the phone to detect transitions of physical activity, sedentary behavior, and phone non-wearing period. The timestamps of the transitions are stored. At the end of each day, the users were be reminded to complete a survey about the activities done in the phone non-wearing period based on the time cues. The study claimed a high rate of compliance, but the number of subjects involved is small and there is no systematical comparison with compliance rate when there is no reminder used. Besides, the reminders are not instant, so there is still possibility of recall bias existing in the data.

2 The OWLympics Platform

We built an mobile application, OWLympics, for Android and iOS platforms, to implement exercise data collection and smart reminder capability. We have also integrated our mobile application with a data collection server to store data for future analytics.

2.1 OWLympics App

There are three main design criteria that guide the development of the mobile app.

2.1.1 Cross-platform support

Since most users use a variety of smartphones with either iOS or Android operating systems, it is necessary to have cross-platform support for different users. The OWLympics app Figure [1] is built using Titanium Studio SDK, which allows us to develop Android and iOS device version of app in a single framework.
2.1.2 Usability

The OWLympics app has user-friendly interface to collect exercise-related information. We have built the app with a single-screen data entry UI, where the user can swipe up and down to navigate and enter all the information.

2.1.3 Fast Entry

Traditional paper and web-based self-reporting tools rely on questionnaires or forms for reporting of information, resulting in a time-consuming and inconvenient experience. We designed our app UI such that the data entry can be completed by clicking or selecting personalised options provided for all the fields. The placement of buttons and fields are also optimized for smooth usage. We aim for a less than 30-second entry time for a single-activity reporting.

2.2 Context-based Reminding

In addition to the user friendly self-reporting interface of our OWLympics App, our platform also utilizes context information of the smartphone to generate smart reminders for the users to self-report in time and in place by performing geo-temporal fencing. The location context information is retrieved from the geo-locating feature of the app. The geo-fencing feature is made customizable on the app to satisfy the requirement of different users. Users are allowed to freely geo-fence places where they typically perform exercise, such as a gym or a volleyball court. In Figure 2 we show the setup of geo-fencing on our mobile app.

Once set up, the geo-temporal fencing works in such way that when a user enters a place, an trigger will be sent out to the server; another alert will be sent out to the server when the person leaves the place. The server then can determine whether the person has done exercise based on the duration he stayed in that place. If the server determines that the person has exercised, a
Figure 2: Geo-fencing setting on our app (a), (b), (c) and (d)

Figure 3: Smart reminder notification prompted on smartphone

notification (see Figure 3) will be sent out to the phone to remind the user to report data. We use this centralized approach so that the smart reminder can be turned on or off without the users’ knowledge, which satisfies the experiment requirement.

2.3 OWLympics Server

We built our server back-end using Python Flask framework. It runs on Apache HTTP servers, which handles the requests from our mobile clients, and stores the user-reported data in the SQLite database.

2.4 OWLympics Website

We also developed a website where users can log into their accounts and view detailed analysis of their past activities. Several charts regarding performance trend, group participation, social levels are displayed based on the data input by the users using Google Chart engine. The locations of past
activities can also be viewed. The website is located at: \texttt{http://owlympics.ecg.rice.edu:81} and Figure 4 is a screen-shot of the website.

\section{Experiments}

We use exercise tracking as the scenario for our self-reporting study. Therefore, we ask the participants to report the time, duration, type, intensity and group participation for every activity users have performed.
3.1 Alpha testing

In the alpha testing stage, we conducted three experiments to test whether the app meets its design requirement. In the first experiment, we asked three users to use the app and fixed the bugs complained by them. A subsequent experiment was conducted to quantify the amount of time consumed in one data entry. We recruited 5 different subjects in the experiment. For each subject, he/she was asked to perform complete data entry for ten times and the time consumption for each data entry was recorded accordingly. The result is displayed in Figure 5. We can easily tell from the chart that the time consumption for all data entries is below 30 seconds, which satisfies the design criteria. The average time consumption for each subject is 14.4 seconds.

In the third experiment, we evaluated the geo-fencing function reliability of the app. First, we chose a starting point as the center, then geo-fenced the area which is 20 meters radius from the center point. A subject is asked to leave the geo-fenced area with a smartphone where the OWLympics app is installed. The subject would stop when a notification is alarmed on the phone. Then the distance from the place where the notification is received to the center point is calculated and recorded. The process is repeated twelve times. Then the whole process is repeated again with a 30 meters radius geo-fenced area. The result of both trials are displayed in Figure 6. With a 20 meters radius, the notification can be received within 45 meters from the center point, while the notification can be received within 55 meters with a 30 meters radius. It demonstrates that the geo-fencing functionality of the app is reliable.

4 Future Plan

We plan to conduct our primary experiment (beta testing) in the coming summer. The experiment will test the quantitative effectiveness of smart reminder in increasing the self-reporting success rate of the users when compared to using preset reminders or no reminders.
4.1 Beta testing

During beta testing, we plan to work with collaborators from Baylor College of Medicine to ensure unbiased subjects for the experiment. The collaborators will recruit anonymous participants for the study. The recruited participants will then be divided into two groups - A and B. Group A will use the version of the app with the smart reminders while Group B will use the app without smart reminders.

In addition to OWLympics serving as a research platform for behavioral scientists, we expect our platform to be used by individuals for personal behavior tracking. We will, therefore, commercialize the OWLympics app for personal fitness and behavior tracking purposes.

5 Feedback from Potential Clients

For the first set of customer interviews, we focused on meeting with behavioral scientists. We contacted a number of researchers studying nutrition and physical activity behaviors of both children and adult population. We discussed our challenge of improvement in self-report by leveraging smartphone context information with three behavioral scientists, Dr. Kelley Gabriel from UT Health, Austin, Dr. Deborah Thompson and Dr. Thomas Baranowski at CNRC (Children’s Nutrition and Research Center), Houston.

We received very positive responses from all the scientists about our research goals and detailed feedback about methodologies for testing the effectiveness of smart reminders for improving self-reporting. Dr. Gabriel offered to collaborate with her research team for conducting the trial during July 2014. She is very interested in using OWLympics as a platform for recording data in many physical activity interventions. Dr. Thompson and Dr. Baranowski provided us with details on conducting feasibility studies as well as qualitative interviews to gauge the usability of the OWLympics app. They also advised us to integrate objective monitors like wearable sensors as additional validation of the activities performed.
6 Conclusion

To summarize, we developed a complete platform solution for self-reporting in the context of exercise tracking. It will smartly remind the user to report at ideal timing and location, provide an easy and nice way to report and eventually provide support for post-reporting analysis. Such platform can also be extended for other general self-reporting scenarios such as food or medication logging with modifications.
References


