Alert Me: Enhancing Active Lifestyle Via Observing Sedentary Behavior Using Mobile Sensing Systems

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***Abstract*—The use of mobile sensing systems (MSS), via smartphone, in various application domains such as (medical and healthcare) are growing rapidly. However, there is a very limited research and development effort put toward exploiting these smartphone sensing technologies to promote human beings wellness and active lifestyle. This paper introduces "Alert Me", a smartphone application that quantifies the sedentary behavior (e.g., prolonged sitting) and aims at reducing it. It generates the timely personalized messages by suggesting short breaks to promote active lifestyle. We utilize the accelerometer sensor of smartphone to observe the sedentary behavior of the user under free-living conditions. Alert Me computes the features over accelerometer data and performs the classification to generate the alerts by using computation power of smartphone. It facilitates the users to create a personal profile and manage alerts according to their own choice. We develop an initial working prototype to evaluate the applicability of our approach in a real-world scenario to avoid prolonged uninterrupted periods of sedentary time.**

***Index Terms*—Active Lifestyle, Sedentary Behavior, Smartphone**

I. Introduction

Sedentary behavior is associated with an activity where energy expenditure is very low while sitting or lying down (i.e., energy expenditure 1.5 metabolic) [1]. In modern societies, prolonged sitting is ubiquitous at home, office and during leisure time. For instance, a research study conducted in England over office-based workers by using thigh-worn accelerometer and reveal a high levels of sitting every day (i.e., 10.6 hours/day) [2]. The prolonged sedentary time may lead to high risk of obesity [3], metabolic syndrome [4], and chronic diseases [1] [5]. Researchers also show that short breaks in sedentary time is beneficial for a healthier metabolism and independent of total active time [4]. To be active, there should be some efficient mechanisms to track the prolonged duration in sedentary activities.

The numerous mobile applications and wearable technologies are already assisting many people to be healthier, fit and lose weight. Examples of these applications are Lose It [6] Jawbone fitness trackers [7], Nike workout and fitness plans [8], Google Fit [9], iPhone as a physical activity measurement platform [10] and smartwatch activity apps [11]. Users can visualize their daily life activities pattern over the Internet or smart devices. However, these trackers generate a time-series of user activities, but do not track the consecutive time spent in sedentary activities. In such scenarios, users are unaware of unhealthy behavior they are conducting. Therefore, a self-management approach is required to support self-awareness and healthy behavior to reduce the health risks caused by sedentary behavior.

A smartphone is one of the personal ubiquitous devices that people carry most of the time with them. It can be best platform for monitoring human behavior due to its unobtrusive characteristics, rich of sensors and wireless interfaces. First, in our pilot study, we develop a cloud-based smartphone application supported by a web-based interface to visualize the sedentary behavior [12]. In this paper, we address the personalization part to generate the timely alerts while monitoring sedentary behavior. Based on the observed sedentary behavior, users will be able to get personalized messages for short breaks to avoid prolonged uninterrupted periods of sitting. In our proposed solution, users do not need to wear/carry extra gear to monitor and track the sedentary behavior. We believe that our application can assist people to reduce sitting time in a proactive manner.

The rest of the paper is organized as follows: we discuss the previous related work in Section II. In Section III, we describe our application architecture and its modules. In Section IV, we explain the implementation details and experimental setup along discussion. Finally, the paper concludes our findings and proposes future work in Section V.

II. Related Work

Recently, a significant amount of research has been conducted to physical activity promotion through dedicated systems, wearables and mobile devices. Ahtinen *et al.* [13] from Nokia research center developed a mobile wellness application to increase physical activity level. The idea was based on the virtual trip, accomplished by recording the users steps with the help of built-in accelerometer of mobile phone.

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Marrios *et al.* [14] developed SuperBreak, to facilitate a number of individuals frequently use computers for long periods of time. Their goal is to encourage people to take breaks while working on computers. Their application is Microsoft Windows based and they conclude that such application response contribute to increase the individual health. Similarly, Barwais *et al.* [1] used a wearable device Gruve for monitoring the sedentary behavior. This device contained a tri-axial accelerometer and requirement was to mount the device near the waist. It monitors the participants daily routines and stores the every minute data. An interactive online software is also developed to visualize the patterns and device is connected with universal serial bus (USB) port.

Dantzig *et al.* [15] developed an iPhone application Sit-Coach to monitor the sedentary behavior. This application sends alerts to the user for a 5-minutes break after one hour of uninterrupted sitting. They also consider the personalization factor and, users are free to change the setting of the notifications. They conclude that effective mobile applications can motivate people to take regular breaks from sitting. Our Alert Me application sends personalized messages to the user based upon his/her preferences. Furthermore, we are automatically identifying either users took short break or not after receiving the message. The next message context is based on the previous followed pattern. We are providing easy-to-understand visualization that may help the user to raise the awareness against the unhealthy sedentary behavior. In such a way, our application distinguish us from existing developed applications.

III. The Proposed Model

We develop our application, Alert Me, using an open source Google Android platform. The architecture of the proposed model is presented in Fig. 1. The details of sub-components are as follow:

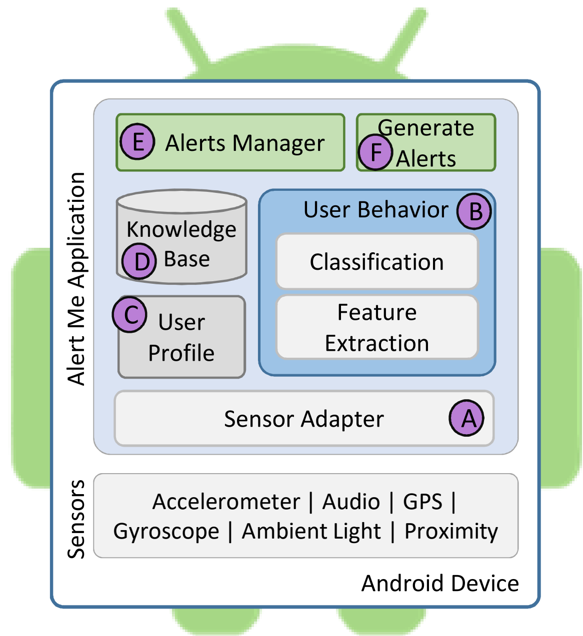


Fig. 1. The architecture of proposed model.

A. Sensor Adaptor

Sensor adapter works like a mediator between the embedded sensors of the Android device and our application. We utilized the Google provided sensor manager Application Programing Interface (API) to ping the built-in accelerometer sensor of smartphone. In our application, we read the tri-axial accelerometer data at normal delay. Further, this data will be forwarded to user behavior module to extract the features and classify the user state (i.e., sedentary or active).

B. User Behavior

We assume that if smartphone is stationary, then there is a high probability that the user is sedentary. In order to know the actual/current situation of the user, we first solve the orientation issue of accelerometer data suggested by Mizell [16]. It enables the user to carry smartphone under the free-living conditions. Secondly, we extract the useful information by calculating mean, standard deviation and energy feature from accelerometer data along (x, y and z-axis) over the defined fifteen seconds window. The extracted features help the classification algorithm to distinguish the behavior either sedentary or active. We implement k-nearest neighbor algorithm for the classification task. We set the distance parameter to Euclidean and consider four neighbors (i.e., $k = 4$) for classifying the user state.

C. User Profile

To provide personalized alert messages, personal profile information plays an important role. Our application creates the user profile the first time when a user log into the application. A new user can sign in by providing the name, surname, email, password, date of birth, and gender information. This profile helps the user to sign in our application into another device with its preferred configuration and settings. We also provide the guest account that will work with the generalize version of our Alert Me application.

D. Knowledge Base

We construct the knowledge base to store the alert messages as well as user profile inside the smartphone environment. At the present moment, we store simple alert messages to demonstrate the working prototype of the proposed concept. In the future, we have a plan to update the repository with more contextual messages that will be aligned to users' profiles and alerts manager setting.

E. Alerts Manager

Our application allows the user to change the default setting of the application through alerts manager. S/he can turn off the reminders, customize selection to receive the messages while being at home/office, and do not disturb mode selection during the nights. Users can also specify the times and application will behave accordingly without annoying its user.

F. Generating Alerts

When our application observers the user's state is sedentary for a prolonged time, it generates the alert message. These alert messages pop-up on the smartphone device after confirming the users setting from alert manager. The generated alert messages does not require any communication cost nor network. When an alert message triggers, it vibrates the device as well as notification audio tone depending on the user selected theme. We also facilitate the user with the LED light response based on the follow up of short breaks. We discuss this feature in implementation and discussion section.

IV. Implementation and Discussion

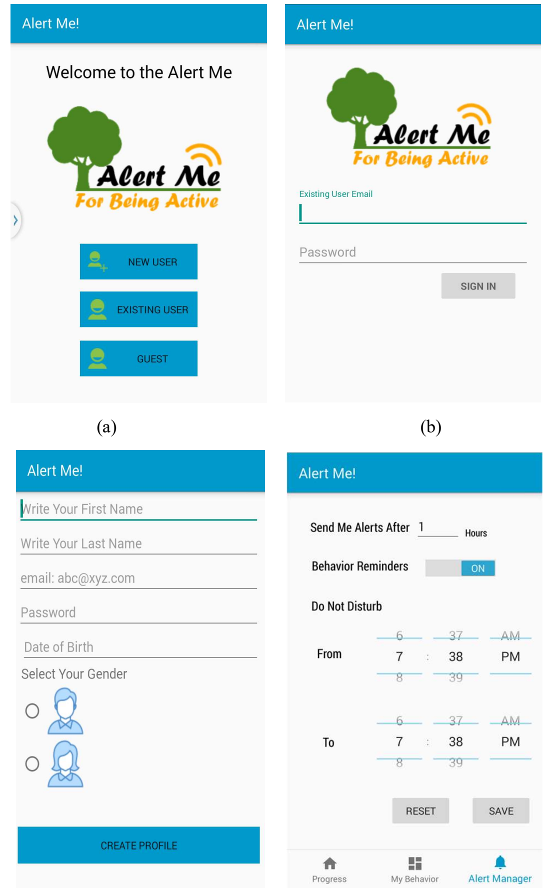
We develop Alert Me application in a native open source Integrated Development Environment (IDE) "Google android studio" [17]. The application is evaluated with the same testbed as we explained in our pilot study [12]. User can create a new profile, used existing one or log in as a guest to interact with the application. The proposed architecture (depicted in Fig. 1) adopts the design principle of human computer interaction to design user-friendly interfaces. Fig. 2(a) presents the three mode of interaction with the application. Existing users can interact by providing an email and password as shown in Fig. 2(b). We also provide an interface to create new user profile as presented in Fig. 2(c). User can also change the default alert time that is after one hour observing a continuous sedentary behavior shown in Fig. 2(d). User can also turn-off the reminder as well as make selection for do not disturb mode.

After log in to the application, user can visualize the last hour progress of behavior state as shown in Fig. 3. In Fig. 3, each point represents a one minute state of the user's behavior. After one hour, when user state is still, we generate the alert to remind the user for a short break as shown in Fig. 4.

We select different messages from knowledge base each time, to motivate the user for doing some short breaks and make interaction possible with Alert Me application. Fig. 5, presents another short break alert while application recognized the user is inactive in the last hour. If a user thinks an hour is too short to have a break then flexible alert generation interface will increase the time according to the user.

After sending messages, we also keep the track either user make short break or not. If application observe user did not have a short break then different message is selected from knowledge base according to the present situation. For instance, Alert Me, found the person sedentary activity from last three hours and could not follow the suggested short breaks. In this context, more personalized alert may motivate the user to being active as shown in Fig. 6.

Furthermore, we also control the front LED light with alert message to green, yellow and red. Green means that user needs to do short break during the sedentary activity. Yellow means last alert was not followed by short break and red means that it is very important to have a short break to being active. If our application find the user active as shown in Fig. 7, then no alert message will be generated.



(a) (b) (c) (d)

Fig. 2. User interface of Alert Me application.

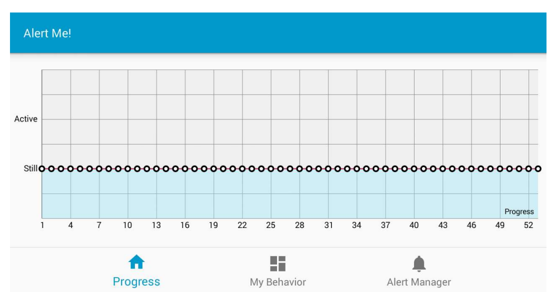


Fig. 3. User behavior visualization of last hour progress.

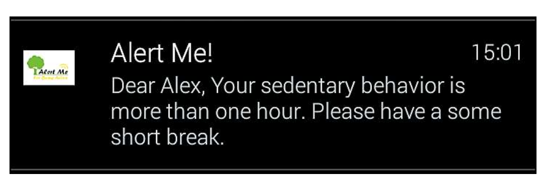


Fig. 4. Alert message for short break.

Fig. 5. Alert message for short break.

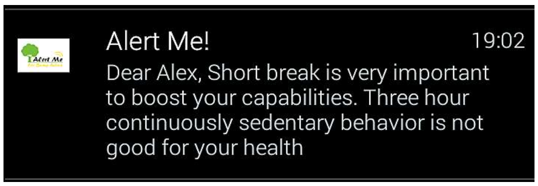


Fig. 6. Alert message for short break.

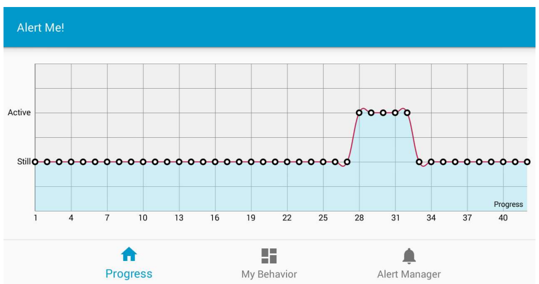


Fig. 7. User behavior with active state of the user.

We also presented the visualization of the each hour user behavior in the form of bubbles started from 8'o clock in the morning. The number inside the each buble present the total minutes either active or still as shown in Fig. 8.

Fig. 8. Hourly user behavior visualization.

The provided feedback from the participants are more positive to adopt and do small initiatives for short breaks during the sedentary activities. Our future plan is to detect the users environment either home or office and generate more personalized alert messages accordingly.

V. Conclusion

Sedentary lifestyles are ubiquitous in our daily routines. In order to track sedentary lifestyle, we proposed a tracking application based on the accelerometer sensor of smartphone. It can help ordinary people to monitor their lifestyle in a proactive way. Based on the tracked behavior, users will be able to monitor and manage their daily activities that may help to adopt active lifestyle. For self-management purposes, our application provide visualization of sedentary behavior patterns and personalized alert messages. With this approach, health care providers will be able to predict patients deleterious sedentary behaviors as evidence to drive computer generated preventive interventions based on behavior change theories. In future, we have a plan to update the repository with more contextual messages that will be aligned to the users' profiles and alerts manager setting.

Acknowledgment

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