UpAlarm: Reducing a Sedentary Lifestyle by Encouraging Standing Up and Exercising

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ABSTRACT
This paper explores the design and implementation of an Android mobile phone application that aims to address the issue of overly sedentary lifestyle amongst students and working adults nowadays. The application uses Google Play Service's activity recognition and location detection. Given the difficulty in persuading people to change their behavior, we devised a three-pronged approach: individualized alerts to raise awareness of the user's sedentary lifestyle in a timely manner, a community-level heatmap that informs the user of the activity level in his/her local community, and an Actkarma board that rewards the user consistently when target behavior is detected.

Author Keywords
Mobile applications; intervention; college; white collar; health; Silicon Valley syndrome; activity recognition; location detection.

ACM Classification Keywords
H.1.2 User/Machine Systems; H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous; J.4 Social and Behavioral Sciences.

General Terms
Human Factors; Design; Measurement.

INTRODUCTION
When walking around campus buildings, one of the most common sights is that of students sitting in couches or chairs and typing away on their computers. This is not only common on college campuses, but also at workplaces around the country. According to a study done by a wearable and actionable feedback startup company, LUMO, the average American spends more than three-quarters of their workday sitting [1]. They even gave a name to this phenomenon: The Silicon Valley Syndrome (SVS) [4]. SVS is characterized by adverse health symptoms as a result of people's excessive time spent sitting, due to use of technology or working at a desk job. A sedentary lifestyle has become more prevalent nowadays because many jobs have moved indoors and improvements in technology provide entertainment and utility within easy reach.

However, a sedentary lifestyle can be very harmful to our health. We sit, we slouch, we type, we strain our eyes and necks, and while we may be writing prolific articles, building powerful software, coordinating marketing campaigns, chatting on Facebook, responding to email, and generally living life in the always-on Internet era, we are also hurting our bodies [3]. Human beings are not meant to sit all day long, yet the average computer worker could easily spend 48,360 hours sitting at work over a 30-year career [7]. Research has shown that simply standing up in sedentary time is beneficially associated with health factors. It is advised that people should get up at least every hour [11].

UpAlarm, an Android mobile phone application, is an inexpensive solution to SVS. It provides users with individualized alerts on their sedentary behavior and rewards users with better behavior. It also informs them of the level of activity in their local community. UpAlarm aims to help people increase awareness of their sedentary lifestyle and motivate them to move around more by incorporating theses two aspects.

RELATED WORK
Attempts to remedy SVS have been made, but many devices designed for the purpose are either too expensive or cumbersome. LumoBack, a startup company designing and marketing wearables that can encourage more exercise and improve posture, sells LumoBack and LumoLift peripherals at prices between $100 and $1000 [5]. The high price inevitably hampers users from wanting to try out this new product, thus preventing them from using wearable technology to potentially improve habits. In addition, there's also a significant learning curve associated with the product. Users not only have to spend a decent amount of money buying the device, but they also have to learn how to use it.

Another sensor designed by a startup company, The Rise, aimed to track sitting behavior and encourage users to be more active. However, it failed to achieve full funding on IndieGoGo and went unheard from since then [6]. UpAlarm is an inexpensive alternative that can track sitting behavior and use that information to persuade people to sit less and move more.

According to literature review done on the subject of persuading people to change their existing habit towards a target behavior, we discovered that what prevents the target

behavior mostly falls into some combination of the following three categories [8]:

- Lack of motivation
- Lack of ability
- Lack of a well-timed trigger to perform the behavior

Therefore, three elements must converge at the same moment for a behavior to occur: Motivation, Ability and Trigger [8]. Dr. Ran Cheng of University of Saskatchewan also pointed out in his paper Persuasion Strategies for Computers as Persuasive Technologies that personalized information receives more attention than general information and may potential influence the person more effectively [10]. Based on these findings, we decided to design UpAlarm in a way that alerts people and provide them with prompt individualized feedback depending on their behaviors so as to motivate them to change their behavior in a timely manner.

In addition, as Dr. BJ Fogg, the founder of the Stanford Persuasive Technology Lab, mentioned in his paper Persuasive Computers: Perspectives and Research Directions [9], there are different levels and intents in persuasion using technology. Persuasion on an individual level differs from persuasion on a community level. However, the two may interact and enhance each other. As Dr. Fogg rightfully points out, Facebook is perhaps the most successful example of persuasive technology to date [8]. Facebook has created a system using the power of community to persuade people to upload pictures and share personal information. People invite friends, accept friend invitations, and check out their friends' news feed regularly. From this finding, we decided to incorporate the community-level heatmap so that users can engage with the community in a tangible way and stimulate a competitive environment.

As Dr. Cheng corroborated in his research, competition and recognition can be used to motivate people's behaviors since most people desire to win in contests and hope to obtain the glory as a kind of validation from others [10]. This could still hold when the recognition is only visible to people themselves. Based on this, we decided to devise a platform, Actkarma, so that users compete with themselves to be more active.

Driven by these ideas we developed UpAlarm, which is described in the next section.

UPALARM

UpAlarm is an Android mobile phone application that keeps track sedentary behaviors. The individualized alerts and in situ feedback regarding the user's activity level prompt and encourage him/her to move around more regularly. The history board helps the user keep track of his/her sedentary level. The community-level heatmap and the Actkarma board aim to stimulate a competitive environment with externally and internally so as to motivate the user to avoid sitting down for too long. Figures 1 to 4 show the interface of UpAlarm. The application was developed with the goal of helping people reduce their sedentary behavior gradually.

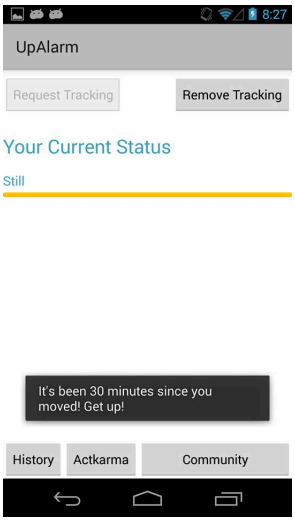

Figure 1 Home

Figure 2 History Board

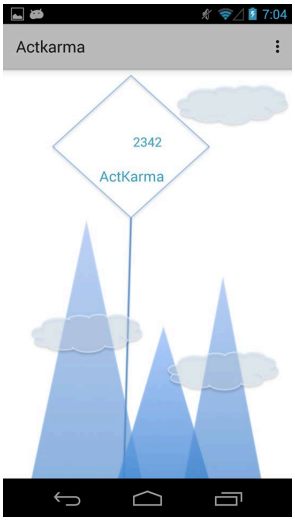

Figure 3 Actkarma Board

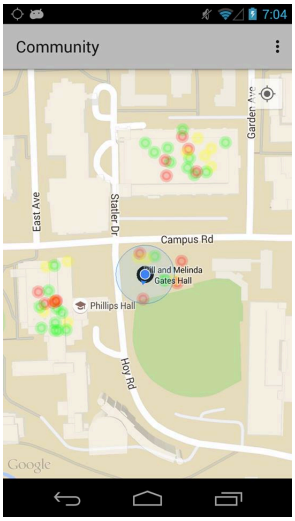

Figure 4 Commnity Heatmap

The application can be easily downloaded and installed onto the user's Android phone. The user needs to keep the phone in the pocket for best tracking results. Once the user turns the tracking system on, the application runs in the background and keeps track of the user's sedentary behavior throughout the day. After one hour of being sedentary, UpAlarm gives the user an alert and feedback to remind the user of the sedentary behavior. The user can navigate to the history tab to see how sedentary he/she has been in a day, a week, and a month. The user can also navigate to the community tab to see how sedentary he/she is compared to the local community. The Actkarma board rewards the user with less sedentary behavior. The less sedentary and the more active the user, the more Actkarma points he/she can score.

System Design Frame

UpAlarm aims to be cost effective and user specific. The hardware used is an Android phone that is widely used. Figure 5 presents a general idea of how the application process flow works.

Figure 5 Process Flow of UpAlarm

The phone acts as a sensor that collects activity and location data from the user. The activity and location data are then uploaded to a remote server for processing. The server then process and store the data into the SQL database, which then sents out stored location and activity data periodically in order to generate alerts, display history, and compute Actkarma score. Details on the system prototype are explained in the section below.

System Prototype

Detection and Recognition of Activity and Location

The first and the most crucial aspect in developing UpAlarm was to automatically, continuously, and accurately identify the user's sedentary behavior and location. In order to do that, we chose to implement Google Play Services' ActivityRecognitionAPI and LocationAPI for its robustness and accuracy. The implementation allows us to continuously detect the user's behaviors and location. Since we're only interested in sedentary behavior, we collected and uploaded sitting activity with a confidence level of above 40% from the array of detected activities. The reason why we chose 40% was from trial and error with volunteers. We asked 4 college students, 2 male and 2 female, to leave the phone in the pocket and perform different behaviors including sitting, standing up and stretching slightly, walking, and running for 5 times. The results showed that activities were detected with high confidence level each time. But when volunteers were sitting, the sitting behavior, especially at the beginning, only had a low confidence level of around 30%. It was almost true every single time. In order to include as much detected sitting behavior as possible and not miss out any sitting behavior, we decided to accept detected sitting behavior as long as it had a confidence level of above 40%.

To gather location data, the app uses Google Play Services' LocationAPI. The LocationAPI has been optimized to reduce battery usage and pull location data from multiple sources, so it is both reliable and low-cost. The API returns a Location object with many features in addition to latitude and longitude, but we are only concerned with those and send those as strings to be added to the database.

Upload and Storage of Activity and Location Data

In order to ensure that we capture accurate and consistent activity and location data, we upload the collected data to the PHP script we stored on a web server powered by Amazon Web Services (AWS) every 30 seconds. We send and upload the data by making a HTTP POST request to a PHP file on the server.

The PHP files on the server act as an intermediary between the app and the database. They add or select entries from the database, depending on context. Each adds a request containing a userID (dependent on the device), a timestamp, latitude, longitude, the activity label (0 for sedentary, 1 for active), and a color. If it has been more than 60 minutes since the user was last active, the color field is red. If it has been 30 minutes, it is yellow, and if the user has remained active, the color is green. These colors are used in conjunction with the coordinates, to generate a single point on the community heatmap.

Retrieval and Display of Activity and Location Data

Since UpAlarm is dynamically updated according to the user's sedentary behavior and location, an HTTP request is made from the phone to the web server every 2 minutes to retrieve and display data. The data retrieved is then used in four ways:

- To recommend moving around when too much inactive time has passed.
- To compute Actkarma score to be displayed in the Actkarma tab. The current implementation is very naïve and rudimentary, awarding 100 points for continuing activity, 40 points for intermittent activity, and 0 points for no activity.
- To plot diagrams detailing a user's behavior on different timescales (throughout the day, week, month, and year). These are displayed as total accrued Actkarma in a given timespan.
- To update and display the heatmap. The heatmap returns the position and color of all entries from the database on the server. Using Google Maps API v2 for Android, these are then each overlaid onto a Google Map, centered on the user's current location.

The entire workflow of the system is displayed in figure 6 below.

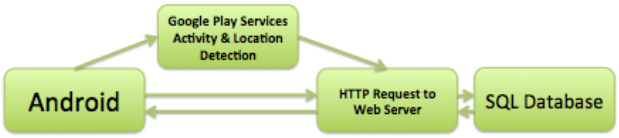

Figure 6 System Prototype Workflow

EXPERIMENT

The development of UpAlarm aims to persuade the user to sit less and move around more. Its implementation is grounded on three main assumptions that the user would change his/her behavior when there are:

- Timely and individualized alerts
- Competition with the community
- Competition with him/herself

In order to test out if we can successfully motivate users to gradually change their behaviors, we identified three most important areas to evaluate UpAlarm after extensive discussion:

- **Accuracy**: How accurately can the application identify sedentary behavior and location and provide feedback on that?
- **Potency**: How potent are the persuasion approaches including the individualized alerts, Actkarma, and community heatmap?
- **Area of Improvement**: How can UpAlarm improve to cater to your needs better?

Accuracy is important because we want to make sure that we correctly identified the user's sedentary behavior and location as well as provided relevant alerts and feedback according to their behaviors. Inaccurate alerts and feedback could instantly discourage the user from using the application in the future.

Potency is the most crucial aspect to evaluate since it allows us to find out if the three ground truths that we identified as the foundation of UpAlarm are indeed useful and effective in persuading the user to change his/her behavior. And we also want to find out which one of the three in particular is the most important.

Area of improvement is a valuable aspect for us to gain better understanding of the user experience. It will allow us to focus our attention on aspects that are the most pertinent and important to the users in later development. Good design with a user focus will ensure that the user is constantly catered to so that they keep using the application and would experience more significant behavioral change in the long run.

Participants

In order to evaluate UpAlarm, we conducted a pilot study with 6 volunteers who live on west campus. All participants were Cornell undergraduate students (3 females and 3 males). They were invited through social connections.

Task

We asked 6 volunteers to use UpAlarm for 3 days. After 3 days, we asked each participant to answer a survey containing 5 questions. In 4 of the questions (question 1 to 4 below), the participant was asked to select an option ranking from strongly disagree (1) to strongly agree (4). Apart from these 4 questions, there was also 1 open ended questions asking about the design and implementation of the application. The questions in the survey were:

Accuracy

1. Do you think the detection and alerts provided were accurate with respect to your behavior?

Behavioral change

2. Do you think the individualized alerts stimulated and encouraged you to sit less?
3. Do you think the Actkarma board stimulated and encouraged you to sit less?
4. Do you think the community heatmap stimulated and encouraged you to sit less?

Recommendations

5. How do you think UpAlarm can improve to cater to your needs? What other features do you want to see?

RESULTS AND DISCUSSION

Accuracy

The answers about the accuracy of UpAlarm ranged from 2 (disagree) to 3 (agree), with an average of 2.833 and a standard deviation of 0.408. Figure 7 shows the results from the participants.

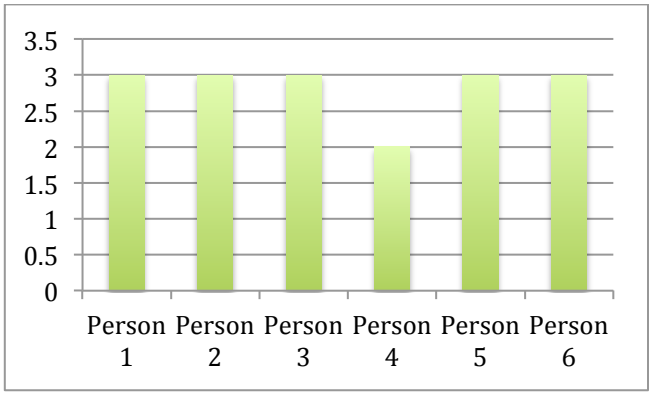

Figure 7 Answers on the accuracy of UpAlarm

As seen from above, 5 out of 6 participants agreed that the activity detection and alerts provided were accurate with respect to their behaviors. The participants answered that the detection and alerts were accurate because it correctly reflected their sedentary behavior during the 3-day study period. For example, UpAlarm was able to correctly keep track of the time the user was sedentary and when the user has been sitting for an hour, the user got "Hey, you've been

sitting for an hour. Get up and move a bit!" When the user has been getting up regularly before reaching the one-hour limit, the user got "Great job! Your efficiency has improved since you moved around!"

Participant 4 chose "Disagree" on the survey. She wrote that:

"The alerts are inaccurate since I've been moving but it says I haven't been for a while."

We think that the activity recognition should not have caused this problem since once the user is moving, especially standing up, the confidence level for sitting drops to 0 every time. We suspect that it could be an issue with the Internet connection on the user's phone, which resulted in data not being exhaustively uploaded to the server to get processed. It could be that some of the user's activities were missing in the database, which resulted in alternative alerts being sent out to the user.

The results about the accuracy of UpAlarm suggest that the activity detection and alerts provided are largely accurate with respect to the user's behavior. It shows that we've correctly implemented Google Play Services and utilized its robust ActivityRecognitionApi. Nevertheless, it's important to note that HTTP requests and server connections may fail at times depending on the user's Internet connection capability. In the next iteration of UpAlarm, we could think of alternatives to external database and could instead store and extract data directly on the user's Android phone. However, we need to consider the tradeoffs with respect to battery life and memory capacity due to this kind of implementation.

Behavioral change

In order to investigate if UpAlarm led to or could potentially lead to behavioral change, we asked the participants to answer questions 2 to 4. We wanted to find out if any of these measures that we devised based on literature review was effective and if so, which one was the most effective. Question 2 asked the user if the individualized alerts were helpful; questions 3 asked the user if Actkarma board was helpful, and question 4 asked the user if the community heatmap was helpful.

The answers regarding individualized alerts ranged from 2 (disagree) to 4 (strongly agree), with an average of 3.167 and a standard deviation of 0.753. Figure 8 shows the results from the participants.

Clearly, participants had different experiences with the individualized alerts. 2 out of 6 participants strongly agreed that it was helpful in changing their sedentary behavior yet 1 participant disagreed that it was helpful at all. Participant 4, who chose "Disagree" wrote that:

"The alerts were annoying and it was interrupting my work all the time. I didn't want to stand up in the middle of my work so I ignored it."

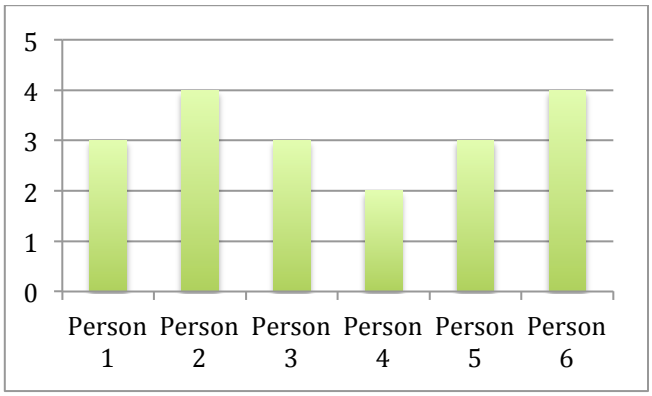

Figure 8 Answers about the question asking if individualized alerts motivated less sitting behavior

Participant 2, who chose "Strongly Agree", however, wrote that:

"The alerts accurately identified my sedentary behavior and reminded me to stand up and move around. Although I needed to turn it off sometimes, I found it very helpful."

From the results above, we saw that most participants were motivated by the alerts despite the fact that they may have liked it or may have been annoyed by it. However, we also saw that the functionality could be improved in the next iteration so that the user could have a "do not disturb" option. With this, individualized alerts will not become overwhelming. We could also integrate UpAlarm with the user's Google calendar so that UpAlarm knows when the user is in class or is busy and won't send out any alerts.

The answers regarding Actkarma ranged from 1 (strongly disagree) to 3 (agree), with an average of 2 and a standard deviation of 0.632. Figure 9 shows the results from the participants.

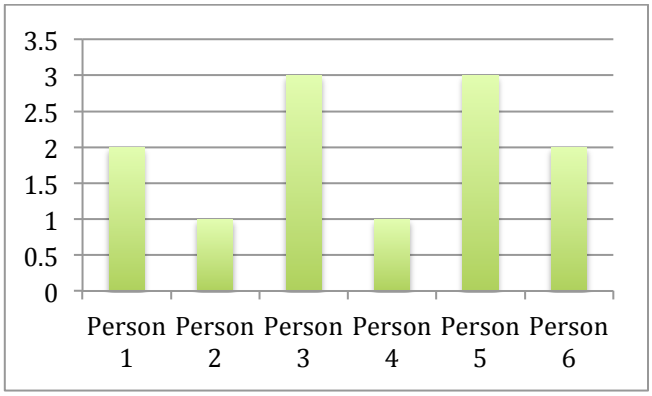

Figure 9 Answers about the question asking if Actkarma motivated less sitting behavior

The results show that the majority of participants did not find Actkarma helpful as a measure to motivate them to sit less and move around more. Some of the notable comments are:

"I thought it was fun but I didn't really see the point of it."

"The score kept going up no matter what. I didn't understand what it was for."

Although we thought that Actkarma could potentially stimulate a "self-competition" environment, the survey results reflected otherwise.

The answers regarding community heatmap ranged from 2 (disagree) to 4 (strongly agree), with an average of 3.333 and a standard deviation of 0.817. Figure 10 shows the results from the participants.

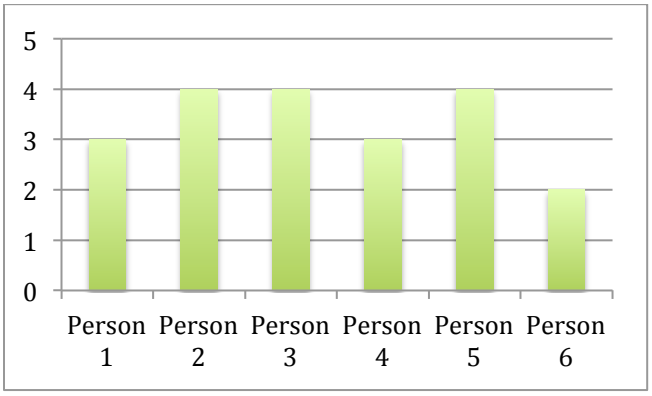

Figure 10 Answers about the question asking if the community heatmap motivated less sitting behavior

The results clearly show that the participants found the community heatmap helpful in motivating them to sit less. 3 out of 6 participants chose "Strongly Agree" and 1 participant chose "Disagree". One of the participants expressed that:

"I really like the colored bubbles and I hate it when I see other people have green bubbles and mine is red."

It seems like the participants became competitive during the study and wanted to maintain a green bubble on the community heatmap. Their reactions, in general, echoed with our findings from the literature review that competition and recognition could be used to motivate people's behaviors. The community aspect of UpAlarm seems to be motivating people to sit less and move around more in the more effective way. However, the study only lasted for 3 days due to time constraint and there's no way for us to find out if this behavioral change will last in the long run. As such, a future study should be conducted for a longer period of time to investigate if people indeed reduced their sedentary behavior over time.

Recommendations

Many participants agreed that the app needed more polishing. The most notable comments on improvements mentioned the arbitrary value of Actkarma and annoyance at the notifications during poor times.

Several participants made specific recommendations, by suggesting a leaderboard for Actkarma so that users could be driven to beat their former selves, but also their peers.

Several participants also lamented the annoyances of notifications at intentionally sedentary times, so they recommended that there should be a user setting portal or a connection to Google calendar so that users can preset when alerts should be sent and when they shouldn't.

FUTURE WORK

In light of feedback from user testing, there are several clear issues that need to be addressed to improve the usability and efficacy of this app in the future. As many participants suggested, UpAlarm could be more entertaining and engaging. An Actkarma leaderboard, for example, could be added to increase the usability and effectiveness of Actkarma. Users will be able to compare their scores to others' and this competition can stimulate more effective behavioral changes. Along these lines, the Actkarma reward algorithm could also be refined and improved in the next iteration to better correspond to user's activity level.

In addition, as suggested above, there could be a user portal that allows the user to preset "Do not Disturb" period so that UpAlarm doesn't appear to be intrusive at times. The fact that we leveraged Google Play Services in the activity detection and location recognition also suggests that it may be possible to integrate UpAlarm with the user's Google Calendar so that there will automatically be no interruptions during the user's classes, meetings and other scheduled events.

Although not addressed in the surveys, there are another potential aspects for improvement that we considered. The interface of UpAlarm, for instance, can be redesigned to be more aesthetic and appealing. Despite the fact that the participants did not mention anything negative about the appearance of UpAlarm, a production-level app should take into account more user experience factors.

CONCLUSION

In this paper, we described the prototype of a persuasive application, UpAlarm, aimed to encourage people to sit less and move around more. We discussed the evaluation of UpAlarm's current and potential functionalities. The initial user study suggests that it has certain positive impact on people's behaviors.

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