StayActive: An Application for Detecting Stress

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***Abstract*—In today's society, working environments are becoming more stressful and people working in these environments become prone to various illnesses. But, work should be a source of health, pride and happiness, in the sense of enhancing motivation and strengthening personal development. In this work, we present StayActive, a system which aims to detect stress and burn-out risks by analyzing the behaviour of the users via their smartphone. In particular, we collect data from people's daily phone usage gathering information about the sleeping pattern, the social interaction and the physical activity of the user. We assign a weight factor to each of these three dimensions of wellbeing according to the user's personal perception and build a stress detection system. We evaluate our system in a real world environment and in a daily-routine scenario. This paper highlights the architecture and model of this innovative stress detection system.**

Keywords*—*Stress Detection; Smartphone; Sleeping Pattern; Social Interaction; Physical Activity.

I. Introduction

Today stress is omnipresent as never before and it is one of the major problems in modern society. Detecting stress in natural environments is beneficial to avoid developing burn-out situations and illness.

The most common method to quantify stress is to simply ask people about their mood filling in questionnaires. There are standard methods for doing so like the Perceived Stress Scale questionnaire [1]. Questions in the perceived stress scale (PSS) assess to what degree a subject feels stressed in a given situation.

Nowadays wearable devices such as mobile phones and wearable sensors are ubiquitous in our lives. Several researchers have tried to understand personality from mobile phone usage [2][3]. Our stress detection system aims to use technology to recognize stress levels using data from the devices that users always carry and wear.

Sleeping patterns, social life and physical activity are connected with the presence of stress in people's lives [4]. We take into account these three dimensions for building our stress detection system.

The rest of this paper is organized as follows. In Section II, our designed stress detection system is described in detail. Experimental results using real data are reported and discussed in Section III. Future work to be done on StayActive is presented in Section IV. Finally, a brief conclusion is drawn in Section V.

II. System design

StayActive is an Android application running on a smartphone. We have chosen the Android based solution because it is an open source framework designed for mobile devices. The Android Software Development Kit (SDK) provides the Application Programming Interface (API) libraries and developer tools necessary to build, test and debug applications for Android. We implemented the prototype in Java using the Android SDK API 19.

A. System overview

Although there are still several open questions regarding the links between the behaviour of a person and their stress level, in StayActive we take a pragmatic approach and build an initial stress detection system which can be extended and refined.

The general architecture of our stress detection system is given in Figure 1.

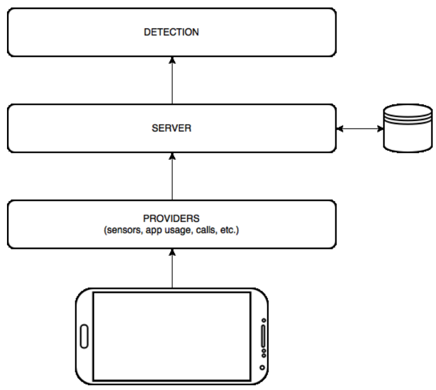

Figure 1. StayActive system architecture.

1) Providers: The first layer is the one that collects and provides the data to upper layers. The provider module contains all the implemented data providers, which are responsible for collecting a specific type of data from the device. They are free to implement the data monitoring behaviour as they wish. The currently implemented providers collect the following type of data: type of physical activity, calls and SMS, ambient light and temperature, location, battery level, screen on/off intervals, Wi-Fi, step counter, number of screen touches and finally type of applications launched. We give some examples of the results of these providers in Figures 2- 6.

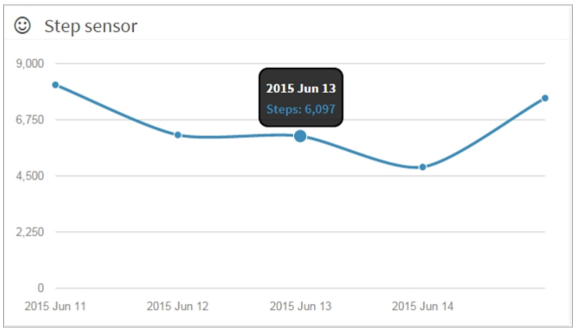

Figure 2. Step counter provider.

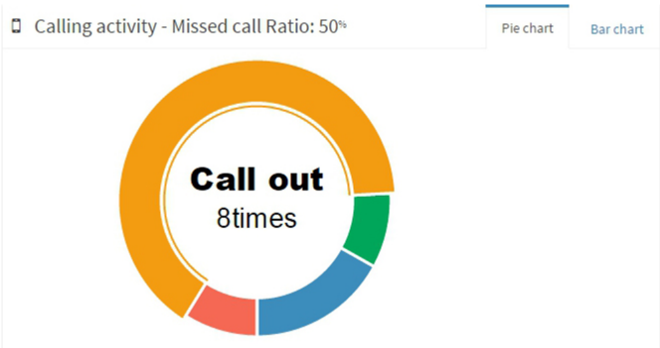

Figure 3. Call provider.

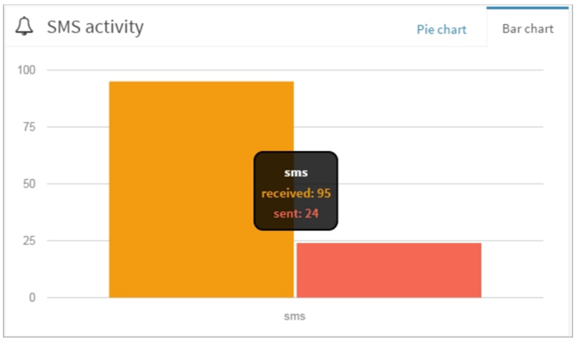

Figure 4. SMS provider.

2) Server: The server module is responsible for receiving data from the mobile devices and storing it in a database. We aggregate all the data and we process it in order to extract a relaxation score for each user as explained in the next section.

3) Detection: This module contains analyzers for each data provider, which extract useful information and patterns from the raw data to output a partial relaxation score. The core detector module will aggregate the results of these individual analyzers and compute a final stress level, as explained in the next section.

B. Stress detection

Simply collecting the patterns of people's behaviour is insufficient for helping them improve their personal wellbeing. It

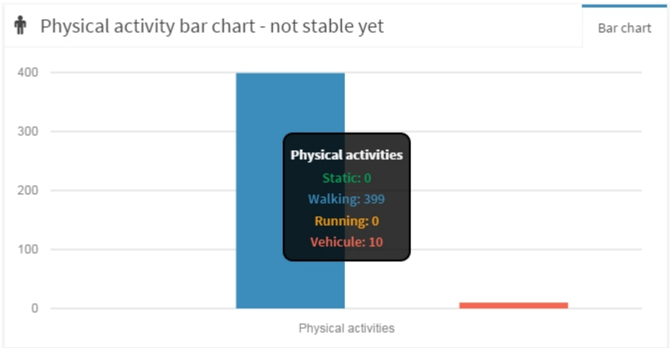

Figure 5. Physical activity provider.

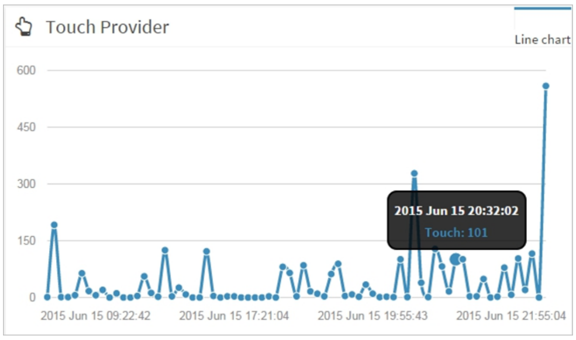

Figure 6. Screen touch provider.

is important to use different dimensions of people's wellbeing and compute their stress level. That way, we will be able to help them by giving advice for reducing their stress level and therefore improving their quality of life. Our stress detection module takes into account three main dimensions of wellbeing: the sleeping pattern of the users, their social interaction and their physical activity as reported in Table I.

TABLE I. Factors measuring stress.

Sleeping pattern	Social interaction	Physical activity
sleeping hours/day	touches of the screen/day	number of steps per/day

1) Sleeping pattern: There is a big body of research work which analyzes the link between sleep hygiene and the mood of people [5][6]. People usually exchange sleep for additional working hours as a coping mechanism for busy lifestyles. In our stress detection module we take into account the user's duration of sleep. We set the number of normal sleeping hours at 8 and penalize insufficient sleep and oversleeping. We set the lower threshold of normal sleeping hours at 7 and the upper threshold at 9 hours according to [7]. For any extra missing or more hours of sleep we penalize the behaviour of the user with a weight factor per hour. In order to compute the sleeping pattern of the user we take into account the Screen analyzer. Between 6 p.m. and 10 a.m. we compute the biggest time interval that the user did not touch his screen and we compute the duration of his sleep. An example of the sleeping pattern of a user for some days is depicted in Figure 7.

2) Social interaction: The daily social interaction of people has a serious impact on many dimensions of wellbeing [6].

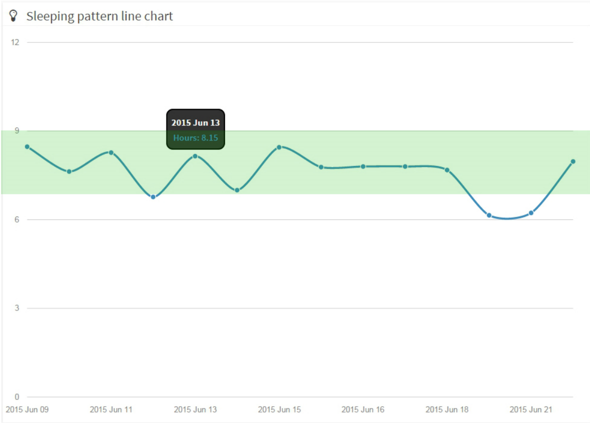

Figure 7. Sleeping pattern.

People who maintain dense social connections are more likely to have resilient mental health. They tend to be able to cope with stress and often are better able to manage chronic illness.

On the other hand regarding communication, researchers are hypothesizing that perhaps people become so used to and even dependent on receiving constant messages, emails, and tweets, that the moment they do not receive one, their anxiety increases. People feel compelled to check their phone constantly, which can then lead to disappointment when there are no new messages, and increased stress about why no one is messaging them, or when the next message might come.

Repetitive checking of mobile phones is considered a compulsive behaviour [8]. People who are highly dependent on the Internet for interaction act impulsively, avoid emotions, and fail to keep up a proper planning or time management [9]. We identify features which are relevant for detecting problematic phone usage and therefore increase the stress level of the user.

For the moment in our system we take into account the number of touches of the screen as a factor for the social interaction of the users using their smartphones. The accumulated result per day is multiplied with the corresponding weight factor and therefore it is accumulated in the total relaxation score. In the next StayActive version we plan to take into account per day, the number of calls and SMS's that the person received, the number of touches of the screen, the number of times the screen was turned on and off and the number of social applications the person used.

3) Physical activity: Several studies have linked exercise to improved depression, self-esteem and stress [10][11]. Our system monitors the physical activity of the user, making the distinction between the type of activity (e.g. walking, running, bicycling). We have also implemented a step counter which gives us the opportunity to find the number of steps that each user took per day. The American Heart Association uses the 10,000 steps metric as a guideline to follow for improving health and decreasing risk of heart disease, the leading cause of death in America. 10,000 steps a day is a rough equivalent to the Surgeon Generals recommendation to accumulate 30 minutes of activity most days of the week.

In our model we assign the maximum value of wellbeing, and therefore the lowest stress level, when reaching the goal of 10,000 steps per day. If someone reaches less than this number we penalize (decrease relaxation factor) with a weight factor per 1,000 steps.

III. Evaluation with real data

For the evaluation of our data, we followed an empirical model. We monitored the behaviour of the user in the above mentioned three dimensions (sleeping pattern, social interaction and physical activity) collecting data for a week.

A. Relaxation score

At first we compute a relaxation score for each individual user for every day of the monitoring week. The relaxation score is in the scale of [0-10] where the more stressed you are, the lower your score will be (so the more relaxed you are the higher your relaxation score). The idea of the scoring procedure is the following. We assign a weight factor to each of the three dimensions of wellbeing that we have taken into account in our study. This factor is based on the response of the participants to the following question which was asked in the beginning of the experiment. Which of the three dimensions do they personally consider as the most important for their wellbeing? To the most important dimension we assign a weight of $w_1 = 0.4$ and to the rest we assign a weight of 0.3 respectively ($w_2 = w_3 = 0.3$), so that $w_1 + w_2 + w_3 = 1$. Based on these factors we are able to calculate the per day relaxation level of each person as depicted in Figure 8 according to the Equation 1. Therefore we compute a result per dimension and adding them we calculate the final daily relaxation factor of the user. For each of the three dimensions we normalize the results in the scale of [0-10] and then multiply each of them with the respective factor. Adding the three results per user, per day we extract the daily relaxation level of each user.

$$relaxation \quad score = w_1 * dm_1 + w_2 * dm_2 + w_3 * dm_3 \tag{1}$$

TABLE II. Dimensions of Equation 1.

Dimension 1 (dm_1)	Dimension 2 (dm_2)	Dimension 3 (dm_3)
sleeping hours/day	touches of the screen/day	number of steps/day

B. Preliminary results

The three participants of our first tests were young adult members from our research group. The evaluation of the results takes place by asking the people who participated in the experiment how they felt on each day corresponding to the monitoring week when data was collected, without knowing the outcome. Then, we compare their personal perception with the relaxation score that we have computed using the StayActive application for each individual day. The more score you have the less stressed you are. This is the first step of evaluating the accuracy of the relaxation score that we produced through our empirical model. Secondly, we extract

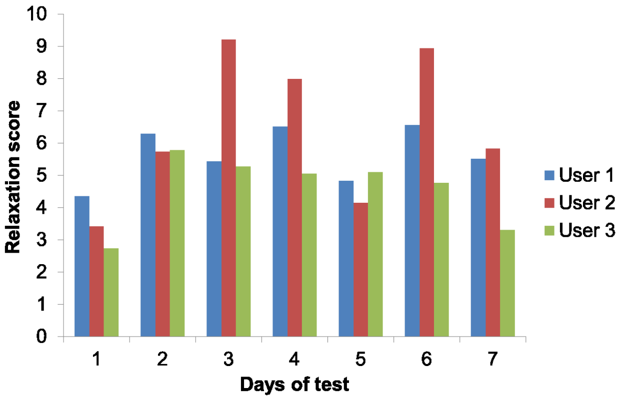

Figure 8. Relaxation scores.

a pattern for the behaviour of the user based on the data that we collected during the testing week and then we compare this pattern with the average daily activity of the user for this week. We calculate the deviation from the normal behaviour that we have extracted from the seven-day experiment and based on that we characterize the user as stressed or not. We also calculate the mean of the stress factor for each person during a week in order to have more robust and accurate data.

IV. Future work

This is a first model of our stress detection system. We are still enhancing and improving it. The immediate steps after the work that has been presented are the following. Further use of the application collecting data for a month and comparison of the different stress results of each individual day with the means that we have extracted from the initial testing period. In the long term, we are targeting a final machine learning approach which will take more features into account in order to improve the accuracy of stress detection. We will create a pattern per user based on his behaviour for a month and a possible deviation from this pattern because of the sleeping hours, the social interaction or the physical activity of the user should agree with the respective decrease in the relaxation score (more stressed). The long term idea of StayActive is to provide older adults with a personalized, adaptable tool which can also monitor some changes to biological signals like skin conductance and heart rate, using wearable sensors and link them to a low relaxation score (increased stress level). Then it will recommend and present various relaxation activities just-in-time in order to allow the users to carry out and solve everyday tasks and problems at work.

V. Conclusions

Stress detection is a research field that has a big impact on the improvement of people's daily life. In this paper we present a first prototype which takes into account three main dimensions of wellbeing. The sleeping pattern, the physical activity of the users and their social interaction are accumulated with different weight factors and give an estimation of the daily stress level of the user. To the best of our knowledge, this is the first system that computes a relaxation score based on different dimensions of human wellbeing.

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