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Stress Detection using Galvanic Skin Response: An Android Application

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Stress Detection using Galvanic Skin Response: An Android Application

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Abstract. Stress is one of the factors that affect human health in many aspects. It is considered as one of the culprits in increasing the risk of getting sick that could probably lead to critical physical or mental illnesses. Stress can be experienced everywhere and in different circumstances. Hence, stress should be controlled and managed by monitoring its progress or regress. Physiological information can be used to determine stress levels. One of these is the Galvanic Skin Response (GSR) that utilizes skin conductance which is known to be directly involved in the emotional behavioural regulation in humans. In this study, a method on how to determine stress when a person is engaged in mobile communication is proposed. An Android application was developed that is capable of determining the stress level of a person while doing SMS composition. GSR data were utilized and the performance of the proposed method was found of no significant difference with a commercially available device. Factors like phone size and period of texting was investigated and were found out that these only contribute an extremely low level of stress. The developed App could be used to determine stress levels especially if emotional conversations are considered.

1. Introduction

Modern communication systems transformed the way people talk and perceive information. This is brought about by the advanced telecommunication devices which are easily accessible by hand, the smartphones. A recent survey shows that 66.72% of the world owns a cell phone with mobile connections close to 9 billion consisting of unique mobile users approaching 5.2 billion out of the approximate 7.7 billion population of the world. People ages between 18-29 are all found to have mobile phones while 94% own a smartphone only [1]. The demand for more voice and data services is ever increasing parallel to the increasing contents that the Internet can provide.

The most common method of communication is via text messaging or technically known as SMS (short message service) which is available on-line or off-line. This is viewed by many people as a key part of daily social life. Receiving a text message somehow provides an instant urge to read and send a reply to the sender regardless of whatever the recipient is doing [2]. Nonetheless, it is anticipated to experience stress during this instance in communication. A direct link exists between stress levels and texting using mobile phones [3]. Texting induces stress to a person that probably varies with the period of texting time and the size of the phone aside from the thoughts of the message received. Long term exposure to mental stress could lead to some health problems as well as disruptions of the different systems of the human body [4]. Aside from mental issues, the physical and social well-being of a person can also be affected.

Physiological information can be used to identify if a person is stressed or not. They are used to possibly predict increasing or decreasing levels of stress once a person is engaged in a certain activity. In a more practical and economical way, the electrical conductance of the skin can be utilized through what is known as galvanic skin response (GSR) or electro dermal activation (EDA) [4]–[6]. GSR or EDA is the measure of the continuous variations in the electrical characteristics (conductance) of the skin caused by the variation of the sweating activity of the human body. This concept is based on the assumption that skin resistance varies with the state of the sweat glands in the skin. The resistance was just reciprocated to determine the conductance. This concept is based on the activity of the Autonomic Nervous System (ANS) with which if its sympathetic branch is highly aroused, the activity of the sweat gland follows. This results to decrease in skin resistance thus, increasing skin conductance. This instance is used to measure human sympathetic nervous system (SNS) responses which are directly involved in the emotional behavioural regulation in humans. Hence, GSR data were used in relation to mental state, such as stress, drowsiness and engagement [7].

This study would like to look at the effect of the ergonomic design of the mobile phone in terms of its length, height and width as well as the length of time that a person is engaged in a texting task. Two types of mobile phones were used; conventional phones and smartphones. Phone size matters and has been a constantly changing design parameter since mobile phones were made available in the market. Mobile phones in the 1990's are big and bulky. Their size was reduced around the year 2000's. But when the smartphones were invented with touchscreens, phone sizes varied proportional to the area of its screen [8]. Keypads are now made available on screens and other characters are available for additional means of conveying information. The physical appearance of mobile phones has evolved to further improve user-experience and ergonomics.

The utilization of conventional phones that uses T9 keypads versus the modern touchscreen smartphones with "qwerty" keypads poses an issue of which among the two induces lesser or greater stress levels to the users especially when they are engaged in emotional conversations. Factors like the size or dimensions of the phone, and the time of composing messages were investigated in relation to the possible stress level induced. GSR was used as the physiological information which was then processed to assess stress levels. Moreover, a stress level detection application was developed in the Android platform which was benchmarked from the performance of a commercial grade eSense GSR skin response application [9].

2. Methods

Stress level detection using GSR is guided by the block diagram shown in Figure 1. An initial skin conductance is required to establish baseline readings when the person is in a relaxed state. A specialized sensor attached to the fingers of the participant and connected to the headphone socket of the mobile phone was used to gather the GSR. Readings should be obtained when the person is idle or basically at rest. GSR is taken again when the person is engaged in a texting task or when composing a pre-defined text message. These readings are then pre-processed to determine the upper and lower thresholds or cut-off values.

Figure 1. Stress level detection block diagram

A total of 25 tests were conducted from five different participants doing a texting task five times. The baseline data was recorded when the participants are in a relaxed position for a minute and the actual test data follows with a variable period of time. Two apps were used: the eSense App and the GSR App. Initial data acquisition was performed in a quiet and controlled environment. This was performed to calibrate the conductance readings of the GSR App as compared to the commercial grade eSense App. Six mobile phones were used. Three mobile phones are of the conventional type while the other three are of the smartphone type.

2.1 GSR data processing

The next part is to convert the obtained readings into a set of values that can be graphed similar to what the eSense App does. This process took several iterations before coming close to the commercial grade output of the eSense App. The results were repeatedly analyzed and the processing was recalibrated in order to arrive at values similar to how the eSense outputs were obtained.

Five participants were invited to test the system by texting the predefined message 5 times. After all the GSR data were gathered, the values were converted into its corresponding stress levels. This was done by calculating the mean maximum and mean minimum GSR's of the participants which were obtained from both apps. Given the minimum and maximum bounds, the interval was equally divided into seven to provide stress level points. The average GSR values of the participants during text composition were then marked against their corresponding stress levels in the scale. All stress levels data for each app were then statistically compared.

2.2 GSR application program logic

The GSR sensor sends data to the mobile phone through the audio jack and socket terminals. The recording can be started and can be stopped by the user at any given time. The readings are saved in a *csv* file format which can be accessed using the smartphone itself or a computer for further processing and analysis. They also serve as inputs of the real-time graph displayed on screen. The graph shows a skin conductance vs. time plot with a 0.2-second interval.

The program logic flowchart of the application is in Figure 2. The start / stop button is used to trigger the start and stop of the data recording task of the application. The GSR App will continue to read skin conductance and calculate the stress levels until the start / stop button is pressed. Results are saved in a csv file and the user can have the option to view or share this data. Initial sharing feature is via electronic mail only. In addition, a new session can be started for new set of data or for another user. The threshold values can be altered for new users. This was made possible because of the understanding that people have difference skin conductance thresholds. This feature allows the application to be customized according to who is using it. Results may also vary depending on the person's skin conductance. The stress level of one person may or will be really different from the other. Hence, the recorded files can be stored for future reference mapping the history of stress level tests done using the application.

2.3 Hardware overview

There are six phones used in this study. Three phones (Phones 1-3) are conventional and the other three are smartphones (Phones 4-6). Conventional phones use T9 keypads while smartphones uses "QWERTY" touchscreen keypads. These phones were used to gather data using the eSense App and the GSR App. Figure 3 shows the mobile phones used in the study. Among the conventional phones, Phone 1 is the biggest and Phone 3 being the smallest. Among the smartphones, Phone 6 is the biggest while Phone 4 is the smallest. The brand and models are different in consideration of design variability.

2.4 Experimental procedures

Thirty participants were randomly selected to test the developed application. The participants were asked to compose a text message using conventional and smart phones. The GSR App and the eSense App were both used to gather skin conductance data and later be processed to determine the stress level. The stress levels of the 30 participants during the texting task were averaged per phone and were compared to the average baseline of the participant to determine if there is a significant difference between the reading obtained between the GSR App and the eSense App.

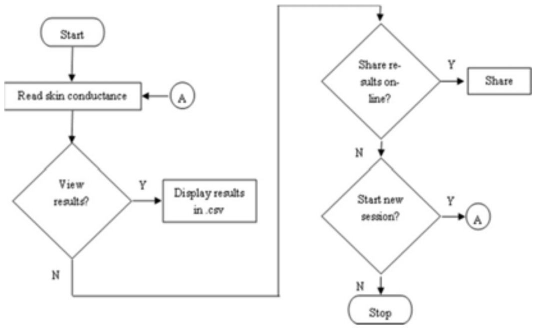


Figure 2. Stress level detection block diagram

Figure 3. Mobile Phones used

3. Results and discussion

The GSR App was developed in Android Studio. The graphical user interface (GUI) is shown in Figure 4. The parts of the App are labelled accordingly and their functions are literally understandable.

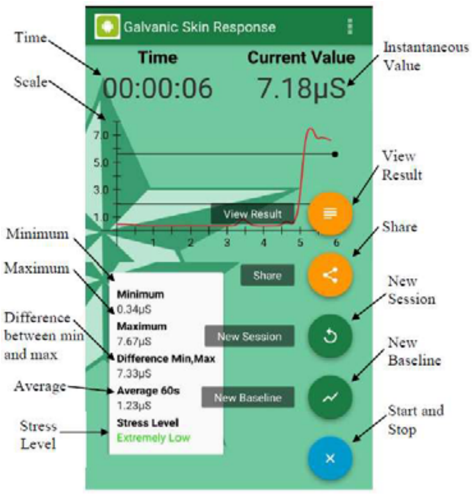


Figure 4. GSR App Graphical User Interface

3.1 eSense App and GSR App result validation

Figure 5 shows the graphical representation of some of the average skin conductance of the participants as recorded by the eSense and GSR Apps using Phones 1-6, respectively. The left bar of each pair is the result of the eSense App while the other of from the GSR App.

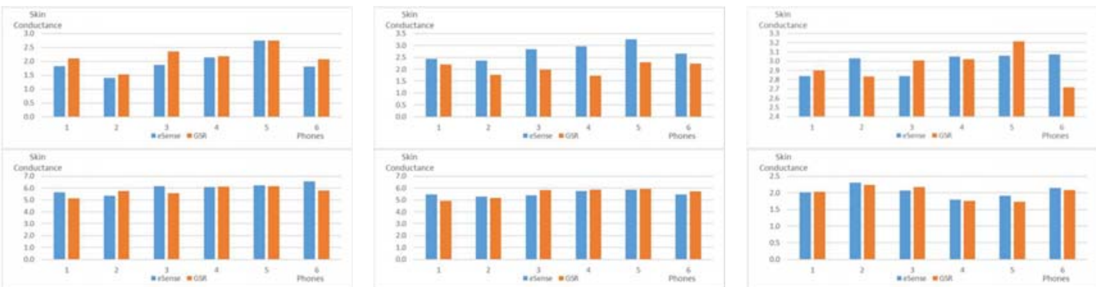
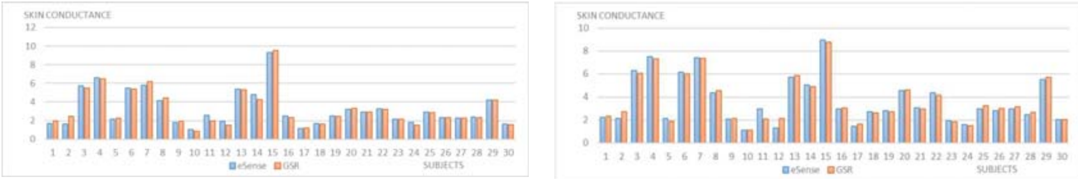


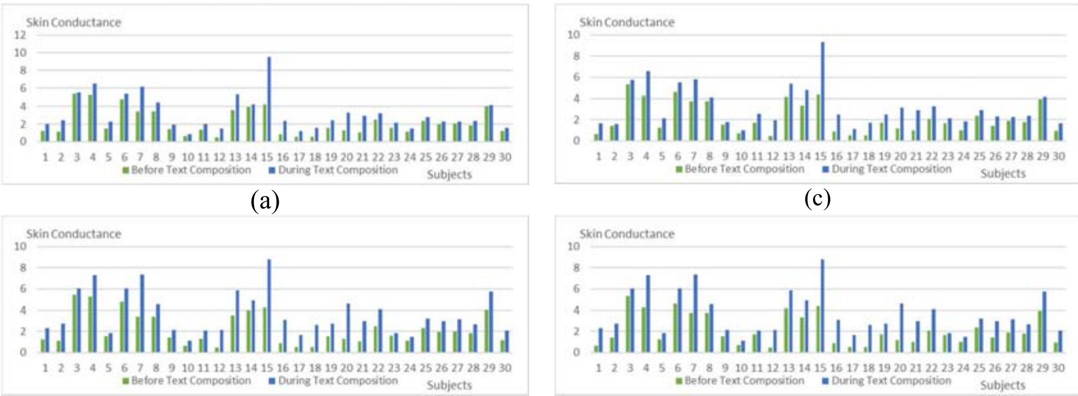
Figure 5. Average skin conductance of the participants



(a) (b)

Figure 6. Average skin conductance using (a) conventional phone, (b) smartphone

Figure 6 shows the average skin conductance of the participants when using conventional phones and smartphones, respectively. Results were obtained using the eSense and GSR apps. Again, the left bar of each pair is the result of the eSense App while the other of from the GSR App.



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

Figure 7. Skin conductance in the (a), (b) GSR App and (c),(d) eSense App before and during texting using conventional and smart phones, respectively

Figure 7 shows the increased level of skin conductance when the participants are engaged in a texting task using conventional phones and smart phones, respectively. Results were obtained using the GSR and eSense Apps. The increase in skin conductance is evident in the graphs.

3.2 Test for significant difference

To validate the results of the GSR App, the skin conductance measurements were compared to the skin conductance measurements of the eSense App. A total of 180 tests were conducted involving 30 participants who used 6 different mobile phones to perform a texting task.

The t-test was used in order to statistically determine and test the null hypothesis (Ho) that there is no significant difference between the skin conductance measured using the eSense App and GSR App before and during text composition. The t-values obtained ranges from -0.0036 to 0.1278. Results fall below the t-critical which is 1.6716. This is indicative that there is no significant difference between the skin conductance measured by eSense App and the GSR App during a texting task for all the phones considered. The developed GSR App can perform at par with the commercial grade eSense App.

3.3 Stress level analysis

Stress levels were determined using of a 7-point equally divided Likert scale. Each average skin conductance value was converted and gauged according to its corresponding stress levels as defined by the range of values in Table 1. Extremely low stress levels starts with 1.0 going up to 7.0 to indicate extremely high stress levels. In Table 2, the average stress levels of the participants were averaged per phone used. Results show an extremely low level of stress when the participants are using the phones doing a texting task using the mobile phones as presented.

Table 1. Stress level assessment scale

Description	Extremely Low	Very Low	Slightly low	Moderate	Slightly high	Very high	Extremely high
Range	1.0 – 1.8	1.9 – 2.7	2.8 – 3.6	3.7 – 4.5	4.6 – 5.4	5.5 – 6.3	6.4 - 7.0

Table 2. Average stress levels

	Phone 1	Phone 2	Phone 3	Phone 4	Phone 5	Phone 6
eSense App	1.0333	1.0333	1.0667	1.0667	1.1000	1.1333
GSR App	1.0333	1.0667	1.0333	1.0667	1.0667	1.1000

4. Conclusion

The developed Android application (GSR App) can simulate the performance of the commercial Galvanic Skin Response (eSense) application. The GSR App can record skin conductance and systematically determine the stress level of a person during a texting task. The GSR App was able to display the stress levels of an individual on the smartphone. The stress level was based on the value of skin conductance of the person while doing a texting task. The skin conductance recorded by the eSense and GSR App was compared and results show that there is no significant difference between the results given by the two apps. The texting task provides an extremely low level of stress though there are evidences that task increased some of the participants' skin conductance values. However, it is not enough to elevate the low stress levels to higher level.

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