RECOGNITION OF STRESS LEVEL AMONG EMPLOYEES USING WEARABLE PHYSIOLOGICAL SENSORS

MAS YUNIZA BINTI ALI MUKHTAR

POLITEKNIK SULTAN SALAHUDDIN ABDUL AZIZ SHAH

DR. HJ. ZUNUWANAS BIN MOHAMAD
KETUA PROGRAM
IJAZAH SARJANA MUDA TEKNOLOGI KEJURUTERAAN ELEKTRONIK
(ELEKTRONIK PERUBATAN)
POLITEKNIK SULTAN SALAHUDDIN
ABDUL AZIZ SHAH

RECOGNITION OF STRESS LEVEL AMONG EMPLOYEES USING WEARABLE PHYSIOLOGICAL SENSORS

MAS YUNIZA BINTI ALI MUKHTAR

08BEU15F3007

THESIS SUBMITTED IN PARTIAL FULFILMENT FOR THE DEGREE OF BACHELOR OF ELECTRONIC ENGINEERING TECHNOLOGY (MEDICAL ELECTRONICS) WITH HONOURS

DEPARTMENT OF ELECTRICAL ENGINEERING
POLITEKNIK SULTAN SALAHUDDIN ABDUL AZIZ SHAH

2017

DECLARATION

I hereby declare that the work in the thesis is my own except for quotations and summaries which have been duty acknowledged.

Signature : ....

Name : MAS YUNIZA BT ALI MUKHTAR

Registration No. : 08BEU15F3007

Date : 29 May 2017

ACKNOWLEDGEMENTS

First of all, I would like to take this opportunity to express my gratefulness to Allah S.W.T. because giving me good health to finish and to complete my final year project. Apart from that, I would like to express my thankfulness to my supervisor Puan Fariza Binti Zahari and Madam Pushpa A/P Jegannathan who is giving me opportunity and chance to work with them and for their guidance during my final year project in completing degree course in Politeknik Sultan Salahuddin Abdul Aziz Shah.

In addition, my sincere appreciation goes to my partner under same supervisor, Jothi A/P Balakirushnan who helped and support throughout this project. I wish you all the best in future life and hope our friendship will last forever. Besides that, I also would like to my family who supported and gives suggestion to me in implementing this final year project especially during implementing data collection.

Lastly, I would like to thank all my housemates and classmates who helped and supported me in all aspects during the completion of the project.

ABSTRACT

When one in stress, the electrical conductivity of human skin subtly changes and this measured as Galvanic Skin Response (GSR). Besides, heart rate also increase variedly during stress condition. This situation applied to everybody including employees who are going through stress and pressure at workplace. This paper describes the employees' stress recognition using questionnaire as baseline and using physiological signals. This project is participated by 15 of respondents which are from office hour workers who has no critical disease background to acquire a real-time experimental approach in assessing employees' stress level. For baseline stress level, this project using Workplace Stress Survey published by The American Institute of Stress (AIS). This project use two physiological stress parameter which is heart rate and GSR that embedded in wearable sensors. The wearable sensor used has heart rate sensor with accuracy of 98.49% when compared to standard device. The wearable sensors read the physiological signal from sympathetic nervous system. The reading is taken throughout one working day during morning, afternoon and evening for each subjects. The decision-making of employees' stress level is implemented by building an interface using Microsoft Visual Studio software. Finally, this project compared the baseline stress level and wearable sensors-based stress level and thus analyzed the reliability and accuracy of heart rate and GSR as stress parameter which is 93.33% and 80.00% respectively.

ABSTRAK

Apabila seseorang tertekan, kekonduksian elektrik dalam kulit manusia berubah secara halus dan ini diukur sebagai Galvanic Skin Response (GSR). Selain itu, kadar jantung juga meningkat semasa tertekan. Keadaan ini dialami oleh semua orang termasuk para pekerja yang melalui tekanan di tempat kerja. Kertas kerja ini menerangkan pengenalpastian tahap stres pekerja menggunakan soal selidik sebagai garis dasar dan juga menggunakan isyarat fisiologi. Kajian ini disertai oleh 15 orang responden di mana mereka terdiri daripada pekerja yang bekerja mengikut waktu pejabat, 8.00 am sehingga 5.00 pm dan tidak menghidap penyakit kritikal. Ini adalah untuk mengambil pendekatan Eksperimental dalam masa nyata bagi menilai tahap stres pekerja. Untuk garis dasar tahap stres, projek ini menggunakan *Workplace Survey Stress* yang dikeluarkan oleh The American Institute of Stress (AIS). Projek ini menggunakan dua parameter fisiologi stres iaitu kadar jantung dan GSR yang terkandung dalam Wearable Sensors. Wearable Sensor yang digunakan mempunyai sensor nadi dengan ketepatan 98.49% apabila dibandingkan dengan peranti standard. Wearable Sensor membaca isyarat fisiologi daripada sistem saraf simpatetik. Bacaan diambil dalam masa satu hari bekerja pada waktu pagi, tengah hari dan petang untuk setiap subjek. Proses menentukan tahap tekanan pekerja dilaksanakan dengan membina antara muka menggunakan perisian Microsoft Visual Studio 2010. Seterusnya, projek ini membandingkan garis dasar tahap stres dan tahap stres berdasarkan Wearable Sensor dan kemudian menganalisis kebolehpercayaan dan ketepatan kadar jantung dan GSR sebagai parameter stress iaitu masing-masing 93.33% dan 80.00%.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

WSS	Workplace Stress Survey
AIS	American Institute of Stress
HR	Heart Rate
GSR	Galvanic Skin Response

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

This project details research on stress level during working among employees. It also details the application of wearable physiological sensors which consists of pulse rate and Galvanic Skin Response (GSR). The reason on why employee is chosen as project sample is based on recent study shows more Malaysians getting stress-related illness [1]. According to Dr Mohd Awang Idris, a Lecturer of Phsychology in University of Malaya, globally 2.5 million workers had suicide because of work and 60 percent of the suicide case occur in Asia. Hence, to prevent this statistic from increasing, it is better to monitor and identify the stress level among employee.

When one in stress, the electrical conductivity of human skin subtly changes and this is measured as Galvanic Skin Response (GSR). Besides, heart rate also increase variedly during stress condition. This situation applied to everybody including employees who going through stress and pressure at workplace.

This project is participated by 15 office hour workers who has no critical disease background to acquire a real-time experimental approach in assessing employees' stress level. For baseline stress level, this project using Workplace Stress Survey published by American Institute of Stress (AIS). This project use two physiological stress parameter which is heart rate and GSR that embedded in wearable sensors. The reading is taken throughout one working day during morning, afternoon and evening for each subjects

Finally, this project compared the baseline stress level and wearable sensors-based stress level and thus analyzed the reliability and accuracy of heart rate and GSR as stress parameter.

1.2 OBJECTIVES

The aim of this research is to study about stress level among employees. In order to achieve this project, below are steps must be followed:

1. To identify the stress level using questionnaire and wearable sensors
2. To build interface for stress level decision-making
3. To analyse the accuracy of physiological stress parameter

1.3 PROBLEM STATEMENT

Work pressure faced by employees can give a very big impact on organization or industry. Stress experienced by employees can lead to many negative effects such as lack of motivation to work, often skipping work, refused to cooperate, always sick and others resulting in decreased job performance and low quality of job may be produced. Stress can lead to the loss of performance, emotional stability and, in some cases, might lead to depression, burnout and, in severe cases, suicides [2]. According to global workplace provider Regus's latest online survey released early 2015, 70 percent of Malaysian workers are reporting more stress-related illness due to challenging global economic conditions. Apart from that, according to Dr. Arif Husaini, a Medical Officer (MO) at Sarawak General Hospital, working too much with little rest is all part job, and it should be something to be expected.

However, in cases of extreme exhaustion, other things can happen that can lead to death. Dehydration can cause kidney damage, leading to increase toxin levels in the blood. Severe constant stress can cause the rhythm of the heart to be affected and, in people who are at risk of heart disease, can precipitate a heart attack [1]. Stress can lead to the loss of performance, emotional stability and, in some cases, might lead to depression, burnout and, in severe cases, suicides.

Currently, published Questionnaire-based is a familiar method to identify stress which implemented by companies and organizations out there. Aside from using Questionnaire, simple scientific tool with bio-signal parameter is necessary to indicate their stress levels regardless of time and place. The reliability and accuracy of each of stress parameters remains a major challenge in the computational field [2]

1.4 SCOPE OF PROJECT

This project is implemented based on Malaysian employees. The experiment will focus on employees who is young adult office hour employees who has no background of critical disease to avoid any errors in data collection. Two parameters were used to measure the stress levels which are heart rate (HR) and galvanic skin resistance (GSR).

Stress can be defined as a "bad" and a "good" stress. Term of stress in this project means bad stress. This project only discussing the overall classification results rather than the individual signals and its feature performance.

1.3 SIGNIFICANT OF PROJECT

This project is significant in the aspect of preventing bad things happen. Based on this project's findings and results, we will able to identify the stress level among employees. They able to figure out on which time does stress parameter peaks whether in the morning, afternoon or evening. Only after knowing the real stress condition on what time does workers' stress level peaks then can proceed to take action and implementing solutions on them. This project also will be implemented to justify the hypothesis about stress level parameter based on the reliability and accuracy.

1.4 PROJECT COSTING

Before implementing the research experiment using wearable physiological sensors ensures that the device is available. Table 1.1 shows the items needed to succeed this project. The estimated cost for this project is RM580.00

Table 1.1: Project Costing

ITEM	COSTING
Wearable Physiological Sensors (Microsoft Band 2)	RM500.00
Thesis	RM80.00

CHAPTER 2

LITERATURE REVIEW

2.1 EMPLOYEES

In present day industrial societies, employment can be divided into two broad categories. The dominant type is the organizationally-employed worker whose salaried job is part of the organizational hierarchy. These jobs are generally characterized by a high degree of formalization and standardization and the job holders' personality, skills and job commitment can only make a modest difference on duties and rewards [4]. In contrast, the self-employed jobs generally exist outside corporate and bureaucratic structures, and the scope of the job and its pay-offs are largely determined by the skills, motivation and entrepreneurship of the incumbent [5].

2.2 STRESS AT WORKPLACE

Health professionals have identified stress as the underlying cause of 46% of all medical problems faced by the workers [7].There are three types of stress: acute stress, episodic acute stress and chronic stress [8]. Each of these types has its own characteristic, symptoms, duration and treatment approaches. Normal level of stress or acute stress is a small dose of stress in human body such as running fast on a challenging ski slope while episodic acute stress occurs is when someone who suffers from acute stress regularly such as waiting too long in the traffic jam everyday [9]. As for chronic stress, it is a very dangerous level of stress and should be prevented. It is defined as a neverending mode of stress and in long term can lead to high blood pressure [9]. Human beings are faced with situations that make the body react to stress with physical and emotional reactions such as fatigue, headaches, insomnia, unable to focus etc [10]. Stress is a highly individualistic experience and does not depend on external factors such as lack of time but depends on specific physiological determinants that trigger a stress response. Therefore, human stress can be detected by measurement of human signals such as heart rate, voice tone, salivary alpha-amylase, blood pressure, muscle-rigidity, pupil diameter, skin conductance, body temperature and electromyogram [7, 10-13]

Job strain is only one stressor workers may face at the workplace. Physical exertion and job insecurity can also cause stress. Even in an era of increasing high-tech information industries, the physical demands of work are still relevant and important to many. Being seriously concerned about physical exertion of work can become a stressor. This is related to concerns about physical hazards and work injuries. Undoubtedly, uncertain job security and the fear of layoff is also an important source of psychological stress for some, especially during times of economic contraction [5].

Proportionately more employed women reported greater work stress than men—28% had high-strain and 17% had low-strain jobs, compared with 20% and 24%, respectively, for men (Chart A). Men were more likely to have active jobs than women. Small, but significant, differences were also found for self-perceived work stress (Chart B). One-third of women felt quite a bit or extremely stressed most days at work, compared with 29% of men. According to a multivariate analysis, employed women were 1.2 times more likely to report high self-perceived work stress, even after controlling for other socio-demographic and employment- related factors [6].

2.3 PHYSIOLOGICAL PARAMETER OF STRESS

This sub-chapter provides the discussion on the indicators of measuring stress level based on physiological signals in human body. For example, Jorn Bakker et al [11] said that 62% of Americans say work has a significant impact on stress levels. 54% of employees are concerned about health problems caused by stress. One in four employees has taken a mental health day off from work to cope with stress (APA Survey 2004) [11]. Therefore, measuring stress related physiological signal from the sensor data like Galvanic Skin Resistance (GSR) and facial expression can make the stressors visible and detectable. The researchers [11] used GSR data and measured it at the wrist of the user. However, the GSR data is difficult to analyse due to the signal instability and other factors such as weather or room temperature having an effect on the user's GSR value. In fact, the researchers in [11] use only GSR signal to measure the stress level of the user so it is might be inaccurate or biased.

The researchers [2] measure the skin temperature variability as a primary measure for identifying changes in stress levels and they use The Stroop colour word as a test among subjects. They found that the skin temperature is a reliable measure for identifying stress level changes. In contrast with that, the researchers [3] is using heart rate variability (HRV) as stress biomarkers and they mapping correlations between ECG features and salivary measurements. They found that the system able to classify cortisol given ECG features with 80% accuracy, compared with 75% accuracy for salivary alpha-amylase. This shows that heart rate variability can be assumed as primary parameters of stress level.

The wearable physiological sensors will measures changes occurring in the body of a subject such as pulse rate, skin temperature and skin conductance (GSR). These measurements are then compared to the normal levels of the subject. The wearable do not detect stress level accurately; however, they are designed to look for substantial involuntary changes in bodily rates, which occur in a person's body when that person is subjected to stress, such as the stress associated with works.

One of paper review are using three physiological stress parameter including Skin Temperature, Heart Rate and GSR [3]. The researcher are using Rules of Stress Detection to combine the stress parameter as below:

Table 2.1: Rules of Stress Detection

TEMP \ HR	L	M	H
L	NS	MS	S
M	NS	NS	MS
H	NS	NS	MS

2.3.1 GALVANIC SKIN RESPONSE

The Galvanic Skin Response (GSR) is defined as a change in the electrical properties of the skin. The signal can be used for capturing the autonomic nerve responses as a parameter of the seat gland function. The measurement is relatively simple, and has a good repeatability. Therefore the GSR measurement can be considered to be a simple and useful tool for examination of the autonomous nervous system function, and especially the peripheral sympathetic system.

Several terms are used for this phenomena such as EDA (Electrodermal Activity), EDR (Electrodermal Response), EDL (Electrodermal Level), SCA (Skin Conductance Activity), SCR (Skin Conductance Response) and many more.

Out of the number of terms used for this phenomenon, it is clear that GSR has more than one property. It can be described in terms of conductance, resistance and electrophysiological potential. The electro-physiological signal is generated by the sweat glands and then the sweat is probably the origin of the variation in resistance and conductivity, although the vaso-dilatation and constriction may also play an important role in electro-physiological signal.

GSR originates from the autonomic activation of sweat glands in the skin. The sweating on hands and feet is triggered by emotional stimulation: Whenever we are emotionally aroused, the GSR data shows distinctive patterns that are visible with bare eyes and that can be quantified statistically.

Sweat glands, also known as sudoriferous or sudoriparous glands, from Latin sudor, meaning 'sweat',[6][7] are small tubular structures of the skin that produce sweat. Sweat glands are a type of exocrine gland, which are glands that produce and secrete substances onto an epithelial surface by way of a duct. One of them is Eccerine. Eccrine sweat glands are distributed almost all over the human body, in varying densities. Its water-based secretion represents a primary form of cooling in humans [17]. The densities of sweat gland is vary according to human body parts. Based on figure 2.1 below:

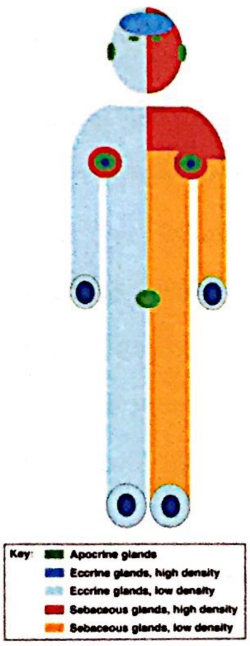


Figure 2.1: Density of Glands on Human Body

The GSR can be measured using several measurement methods which are :-

- Electro-physiological measurement such as ECG or MRI
- Variation in resistance or conductivity
- A combination of these two

In most cases, the GSR is measured using a part of the skin having a lot of sweat glands. A part of the skin with less or no sweat glands is used as a reference. Another way to measure GSR is in the same area as the active electrode. When finger electrodes are used, the index finger and the middle finger are used as shown in figure 1.

Figure 2.2: Sensor placement when measuring GSR on finger

Our body has about three million sweat glands. The density of sweat glands varies markedly across the body, being highest on the forehead and cheeks, the palms and fingers as well as on the sole of the feet. Whenever sweat glands are triggered and become more active, they secrete moisture through pores towards the skin surface. By changing the balance of positive and negative ions in the secreted fluid, electrical current flows more readily, resulting in measurable changes in skin conductance (increased skin conductance = decreased skin resistance). This change in skin conductance is generally termed Galvanic Skin Response (GSR). Galvanic Skin Response reflects the variation in the electrical characteristics of the skin.

GSR is also known as Skin Conductance (SC), Electrodermal Activity (EDA), Electrodermal Response (EDR), and Psychogalvanic Reflex (PGR). GSR activity is typically measured in “micro-Siemens (uS)” or “micro-Mho (uM)”, mirroring the conductance of a certain material.

The sympathetic nervous system represents a rapid response mobilizing system, facilitating immediate motor action (“fight or flight”). Increased sympathetic activity is associated with bodily indicators of “autonomic arousal” such as increased heart rate, blood pressure, and sweating. Exposure to fear-inducing stimuli (an angry face, the sight of a creepy spider etc.) induce emotional arousal, causing an increase in sweat secretion and, ultimately, measurable electrodermal activity.

In emotional situations, bodily processes are triggered automatically: The heart beats faster, the pulse rises, hands become sweaty. To put it bluntly: While we are physiologically or psychologically aroused (in fear, extreme joy or under stress), we start to sweat. Sweat glands are present on almost all body parts and certain areas respond more strongly to emotional stimulation.

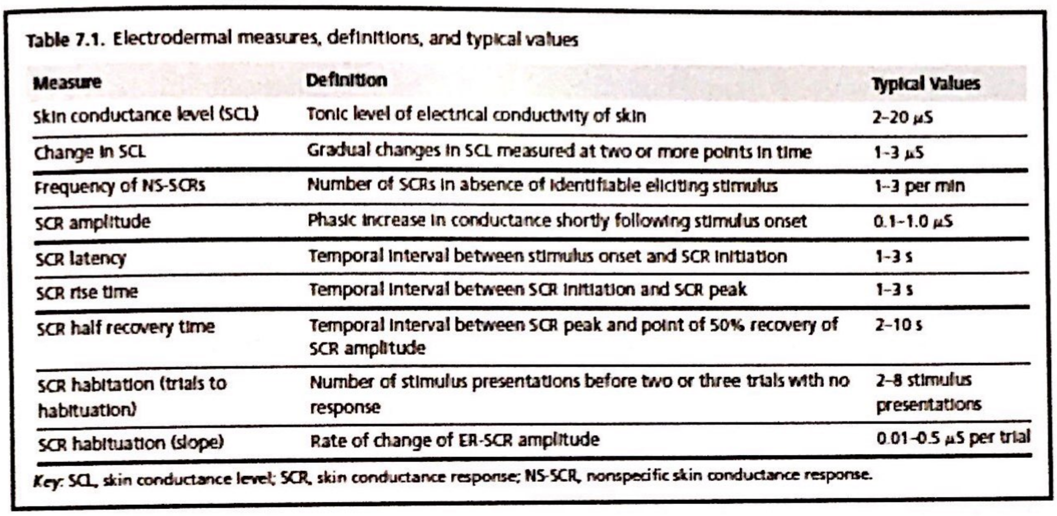


Table 7.1. Electrodermal measures, definitions, and typical values

Measure	Definition	Typical Values
Skin conductance level (SCL)	Tonic level of electrical conductivity of skin	2–20 µS
Change in SCL	Gradual changes in SCL measured at two or more points in time	1–3 µS
Frequency of NS-SCRs	Number of SCRs in absence of identifiable eliciting stimulus	1–3 per min
SCR amplitude	Phasic increase in conductance shortly following stimulus onset	0.1–1.0 µS
SCR latency	Temporal interval between stimulus onset and SCR initiation	1–3 s
SCR rise time	Temporal interval between SCR initiation and SCR peak	1–3 s
SCR half recovery time	Temporal interval between SCR peak and point of 50% recovery of SCR amplitude	2–10 s
SCR habitation (trials to habituation)	Number of stimulus presentations before two or three trials with no response	2–8 stimulus presentations
SCR habituation (slope)	Rate of change of ER-SCR amplitude	0.01–0.5 µS per trial

Key: SCL, skin conductance level; SCR, skin conductance response; NS-SCR, nonspecific skin conductance response.

Figure 2.3: Typical Values of GSR

According to Sean Montgomery, the range for resistance of skin is typically 50 kΩ to 10 MΩ (). Skin conductance is the reciprocal of the resistance. Thus 50 kΩ is 20 µS and 10 MΩ is 0.1 µS. To summarize, skin conductance is inversely proportional to skin resistance.

The typical normal range of GSR is from 2 micro Siemens to 20 micro Siemens. Note that Siemens is the parameter for conductance and is the reciprocal of resistance. According to Mayo Clinic, a normal resting heart rate for adults lies between 60 and 100 beats per minute, and a lower number at rest shows more efficient function and better cardio fitness.

2.3.2 HEART RATE

The crucial pump of the cardiovascular system, the heart, consists of special cardiac muscle with properties different from that of skeletal muscle found elsewhere in the body According to Mayo Clinic, a normal resting heart rate for adults lies between 60 and 100 beats per minute, and a lower number at rest shows more efficient function and better cardio fitness.

A stressful situation sets off chain of events. Human body releases adrenaline, which is a hormone that temporarily causes breathing and heart rate to speed up and blood pressure to rise. These reactions prepare human to deal with the situation which is often called the "fight or flight" response.

More research is needed to determine how stress contributes to heart disease which is the leading killer of people in Malaysia. But stress may affect behaviours and factors that increase heart disease risk: high blood pressure and cholesterol levels, smoking, physical inactivity and overeating. Some people may choose to drink too much alcohol or smoke cigarettes to "manage" their chronic stress, however these habits can increase blood pressure and may damage artery walls.

In stress parameter research field, heart rate remains one of the dominant indicators of human stress compared to other physiological signals. Previously, several studies have considered the HRV signals for the identification and analysis of stress [1], [2], [6], [7]. More often these studies have been laboratory-based, rather than in real time. One of previous study concludes the dominant stimuli, physiological signals and lack of signal processing methods are the major impediments in this work [8]. The High Frequency [HF] and Low Frequency (LF) range of HRV is frequently investigated and is one of the reliable measures. How long the heart rate was elevated due to stress is measured, which leads to computational problems.

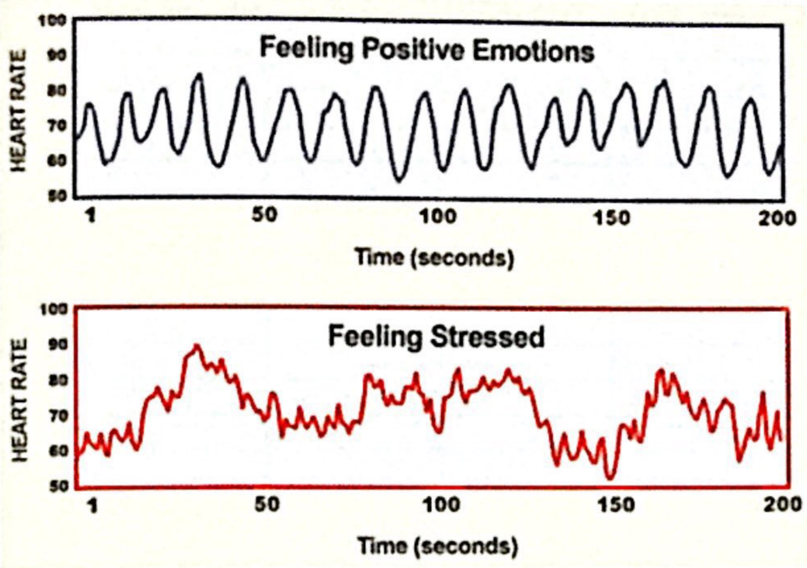


Figure 2.4: Waveform of Heart Rate Related to Stress Situation

Because the HRV is unevenly sampled signal, this leads to the unknown sampling frequency. Usually, the duration of heart rate signals is important to the efficacy of the frequency band analysis. Therefore, the determination of the duration of the sample as well as sampling frequency or suitable methods required to process the data.

2.4 WEARABLE SENSORS

A recent trend is the inclusion of such sensors in wearables, which, unlike other technologies, are designed to be in contact with users all day. Commercial devices such as the Samsung Gear S and the Apple Watch measure users' HR and EDA in real time; although their sensors are currently limited to fitness activity tracking, future and more sophisticated versions of these devices will likely be more accurate, supporting the detection of stress and other emotions.

There are many types of wearables sensors that invented to measure one's stress level based on their physiological signals. The types of wearable sensors are including chest sensor, wristband sensor, and more. Commonly, the wearable will comes along with the application on smartphone in order for user to monitor the readings of stress parameter. The most updated wearable sensors designed for measuring stress are

Empatica and Affectiva wristband which is founded by Rosalind Picard, a Professor and director of Affectiva Computing Resesarch Group at MIT Media Lab.

Figure 2.5: Affectiva GSR

Figure 2.6: Comunication System of Empatica Wristband

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

In this chapter, we will discuss about the methodology and items used in implementing this project. Experimental setup was divided by two main principal which include psychological method and physiological method.

3.2 PARTICIPANTS

The participants were 15 young adult employees age from 18 to 35 years old who works during office hours which is from 8 a.m. to 5.30 p.m. The employees is a healthy one which has no background history of critical disease. Although, all participants has normal as usual and none had any kind of disorder. Informant written consent form was provided as in Appendix A to all participants before completing questionnaires as well as undergoing Wearable experiment.

3.3 PSYCHOLOGICAL METHOD

The survey instrument for this study is a set of Workplace Stress Survey (WSS) questionnaire as in Appendix B. a total of 15 sets of WSS questionnaire were distributed to subjects for gain information about the problem of the stress at workplace. The questionnaire covers stress aspects such as job satisfaction, job requirement, conflict at work, job control and more. The table below shows details of the stress scope:

Table 3.1: Scope of Questions

SCOPE	NO. OF QUESTIONS
Control	2
Job satisfaction	1
Job requirement	1
Conflict at work	1
Internal conflict	2
Social support	1
Physical environment	1
Non-working activities	1

Apart from that, the demography form consists of employees' background information, namely the gender, occupation, race and age as in Appendix C.

3.3.1 WSS QUESTIONNAIRE

This project use Questionnaire of Workplace Stress Survey (WSS) published by The American Institute of Stress (AIS) which contains 10 questions. The AIS Workplace Stress Survey (WWS) was developed in 1998 to serve as a simple screening measure to determine the need for further investigation with more comprehensive assessment.

The WSS Questionnaire is a 10 item self-report questionnaire specifically designed to measure the severity of a range of symptoms common to Job Stress. In completing the WSS Questionnaire, the employee is required to indicate the presence of a symptom over the last 30 days. Each item is scored from 1 (strongly disagree to the statement) to 10 (strongly agree to the statement). The essential function of the WSS Questionnaire is to assess the severity of the core symptom of job conflict, job satisfaction and depression. Accordingly, the WSS Questionnaire allows not only a way to measure the severity of stress at work but a means by which a subject response to treatment can also be measured. Furthermore, the questionnaire distributed to employees before implementing real-time experiment using Wearable and must answer all the questions that is given. The WSS Questionnaire severity ratings or scores shown in Table 3.2 below.

Table 3.2: Score Range for WSS Questionnaire

STRESS LEVEL	SCORE RANGE
Not stress	10 – 35
Medium stress	36 - 65
Stress	66 - 100

3.4 PHYSIOLOGICAL METHOD

3.4.1 INTRODUCTION

Besides the questionnaire based method, features from stress parameter including Heart Rate and GSR was used for real-time experimental setup. When one stress, the physiological signal will vary and this include heart rate and sweat secretion.

Based on figure below, this project starts with Pre Survey as trying and experimenting the questionnaire on subjects. Then for the real experiment, this project implement Post Survey which divided into two method – Physiological method and Psychological method. The two method is then compared and analysed. During interpreting the results obtained, a decision-making interface is build.

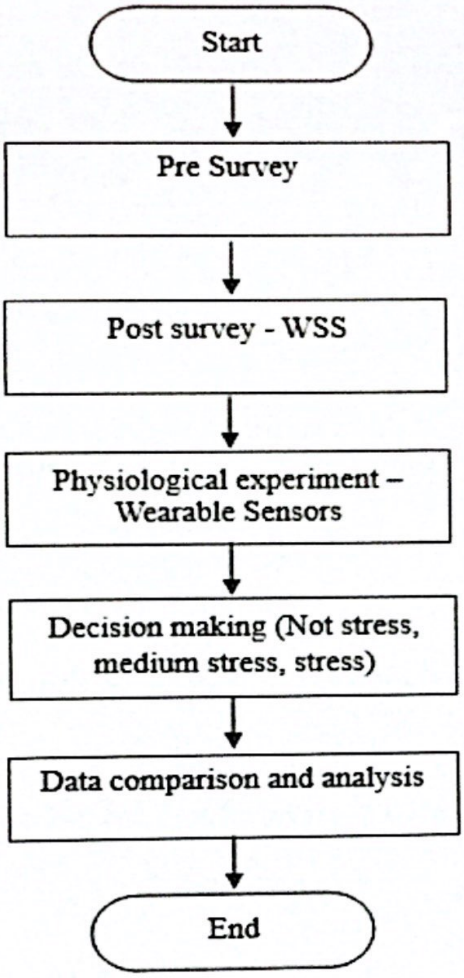


Figure 3.1: Project Flowchart

3.4.2 WEARABLE SENSORS

The main method used in this project is Wearable Sensors. It is a fitness band which wirelessly connect with smartphone using Bluetooth and display reading from all sensor including Heart rate and GSR. The Optical Heart rate sensor continuously monitor and reports current heart rate. For GSR, two GSR electrode is embedded in the Wearable and measure conductivity of skin between the GSR sensor diodes.

This method is implemented in order to monitor a real-time working condition based on GSR and Heart Rate reading. In this Wearable Sensors-based experiment, it is divided into two: at rest situation and at work situation. The situation at rest is required in order to gain neutral baseline reading since everyone have different resting heart rate and resting GSR. For at-work situation, the real-time stimuli are exist. All the procedures and experiment is implemented among samples employees. Experimental protocol is followed for each situation in order to avoid error in data collection and to synchronize the readings for each subjects.

AT-REST EXPERIMENTAL PROTOCOL

1. No stimuli are presented
2. Respondent sits in comfortable, relaxed position (when subject almost doing nothing)
3. The Wearable is worn on non-dominant hand
4. Application of Wearable sensors on smartphone display readings in bpm and kΩ
5. Three readings are taken and then the average is calculated

AT-WORK EXPERIMENTAL PROTOCOL

1. The Wearable is wore on non-dominant hand
2. Make sure the skin is dry when start wearing Wearable and no skin product is applied on the area of hand
3. Reminder is set on the Wearable at 9am, 12.pm and 3pm so it will vibrate and notice the respondent
4. At morning (9am) first reading is collected using the application on smartphone
5. Then next reading collected at 12pm and 3pm
6. Average value is calculated from the three readings

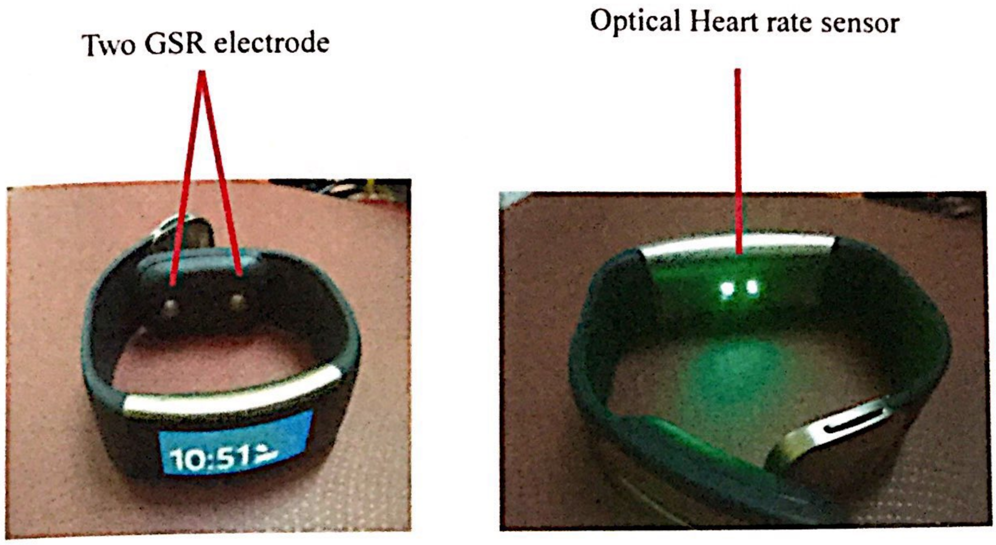


Figure 3.2: Sensor Placement on Wearable

3.5 DECISION MAKING

In order to classify the stress level, an interface is required to ease the flow of work. The interface is built using Microsoft Visual Basic 2010. For variable in the interface, this project using value of Difference, Δ between AT REST reading and AT WORK reading. Rules of Stress Detection which contains nine rules is applied in combining the two parameter in order to indicate stress level. The Rules of Stress Recognition is applied when more than one stress parameter to determine the employees' stress level. The system used nine rules to indicate the stress level as shown in table below.

Table 3.3: Rules of Stress Recognition System

ΔHR / ΔGSR	Low	Medium	High
Low	Not Stress	Not Stress	Medium Stress
Medium	Not Stress	Medium Stress	Stress
High	Medium Stress	Stress	Stress

Based on threshold value calculated, the Rules of Stress Recognition is upgraded considering the ΔHR and ΔGSR as table below:

Table 3.4: Rules of Stress Recognition System

ΔHR (bpm) / ΔGSR (kΩ)	ΔHR < 6.43	6.43 < ΔHR < 10.56	ΔHR > 10.56
ΔGSR < 1172.47	Not Stress	Not Stress	Medium Stress
1172.47 < ΔGSR < 1573.94	Not Stress	Medium Stress	Stress
ΔGSR > 1573.94	Medium Stress	Stress	Stress

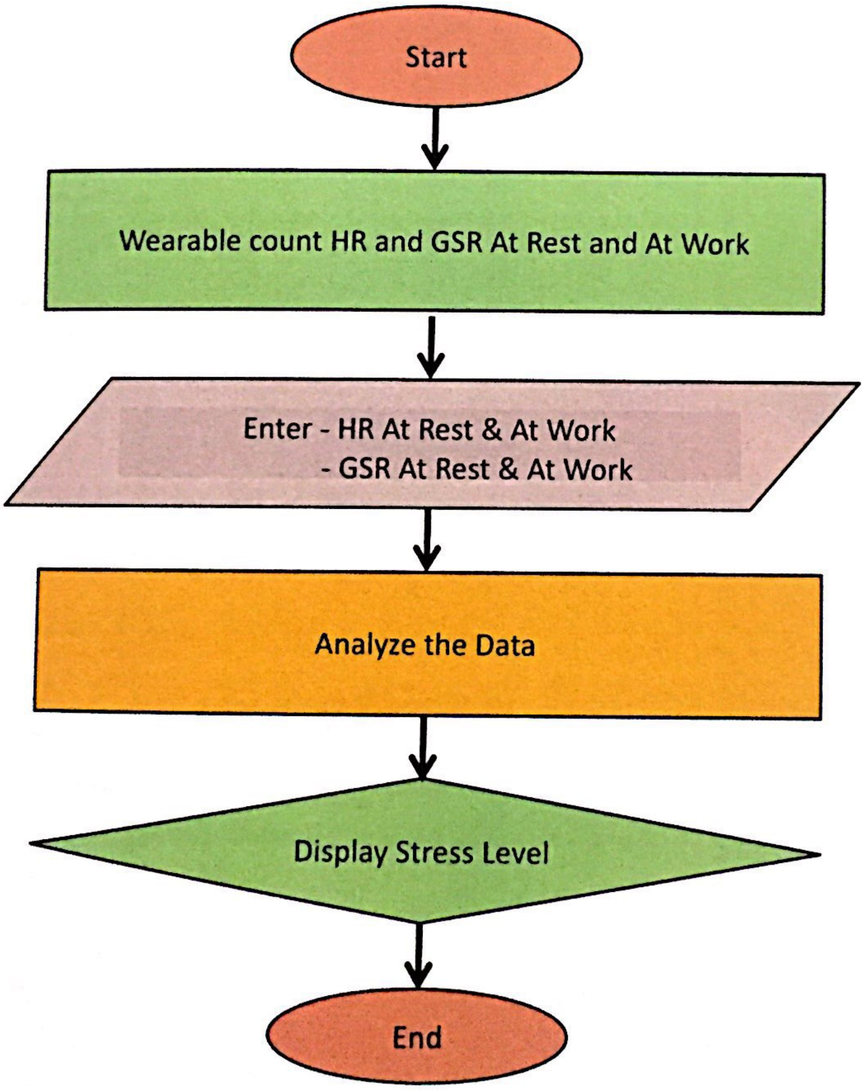


Figure 3.3: Flowchart of Decision-Making

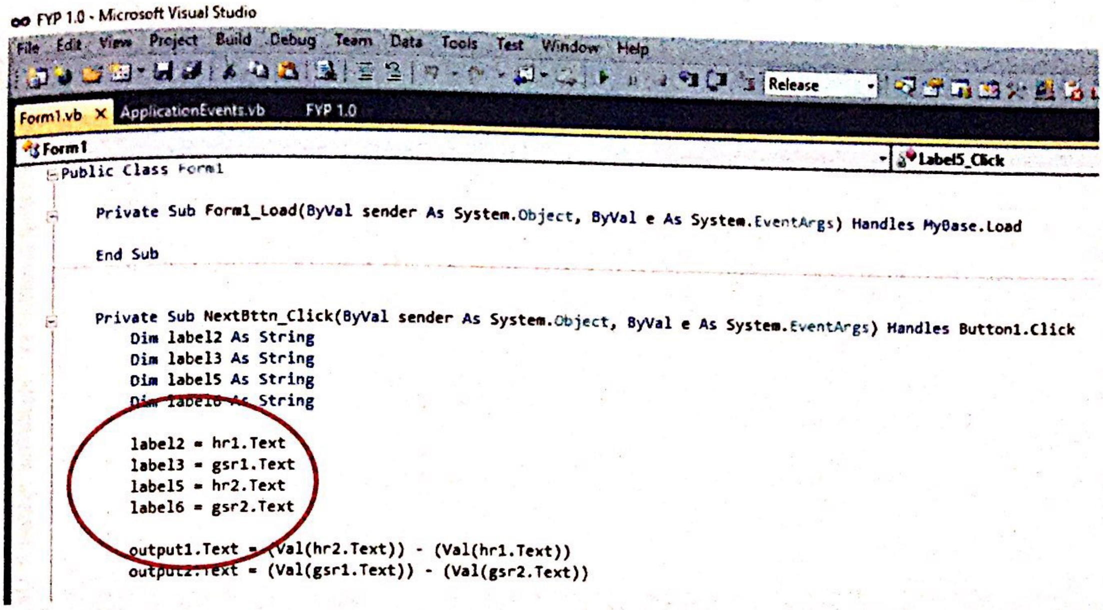


Figure 3.4: Declaration of Input Variables

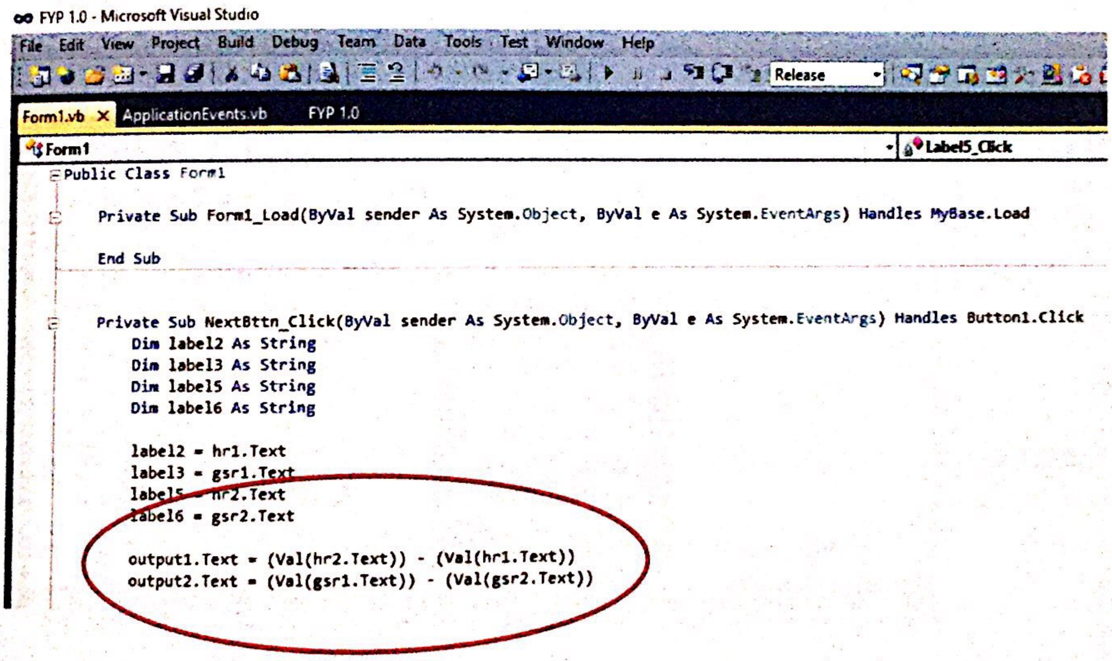


Figure 3.5: Command for calculate the Differences value, Δ

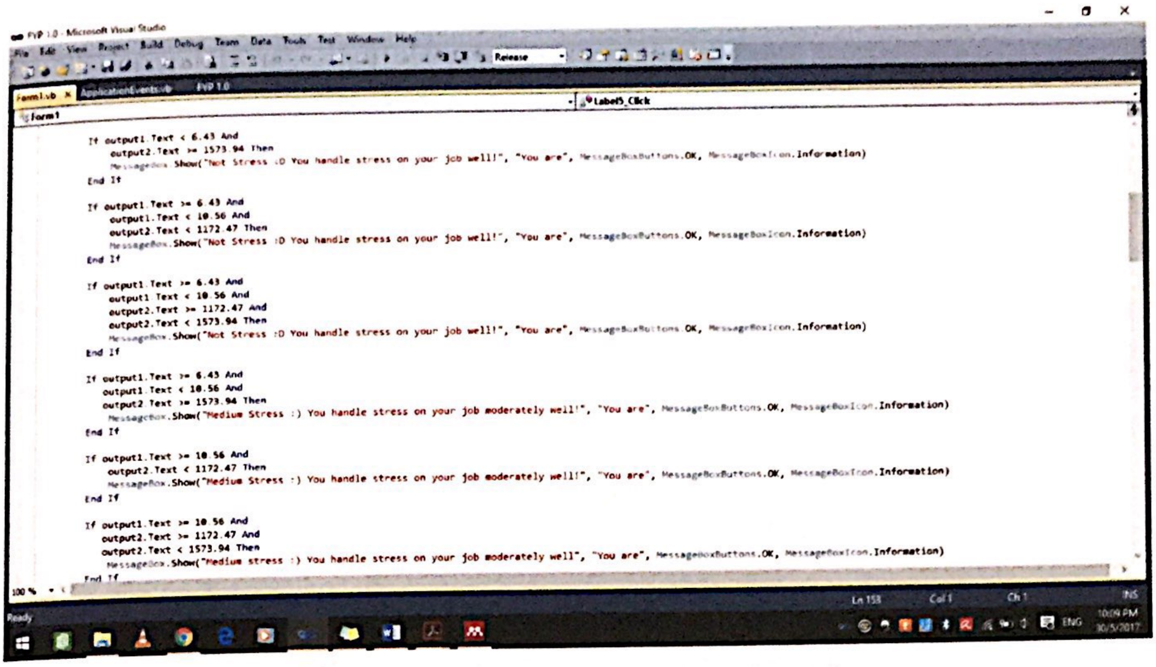


Figure 3.6: Command for Classifying Stress Level based on Nine Rules

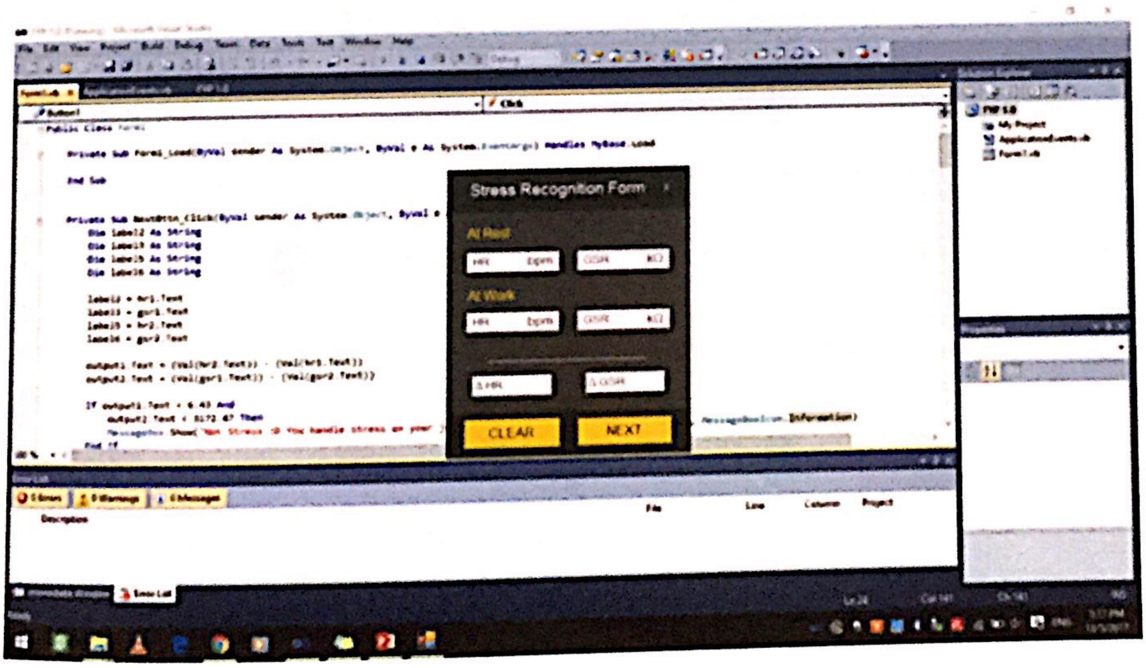


Figure 3.7: The Interface of Stress Recognition Form

The output of stress recognition form will appear such as one of the stress level as figures below:

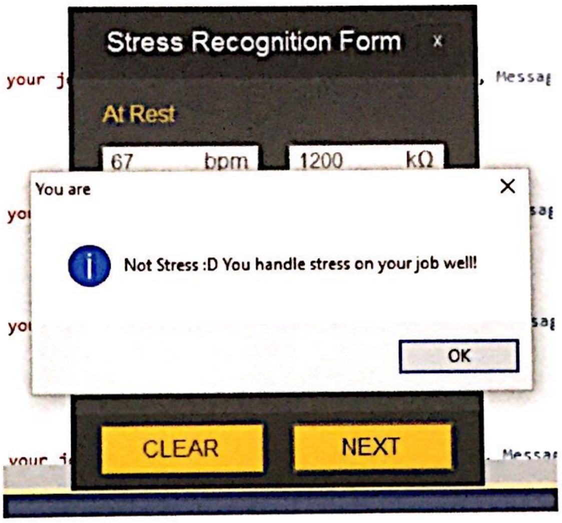


Figure 3.8: Output of "Not Stress"

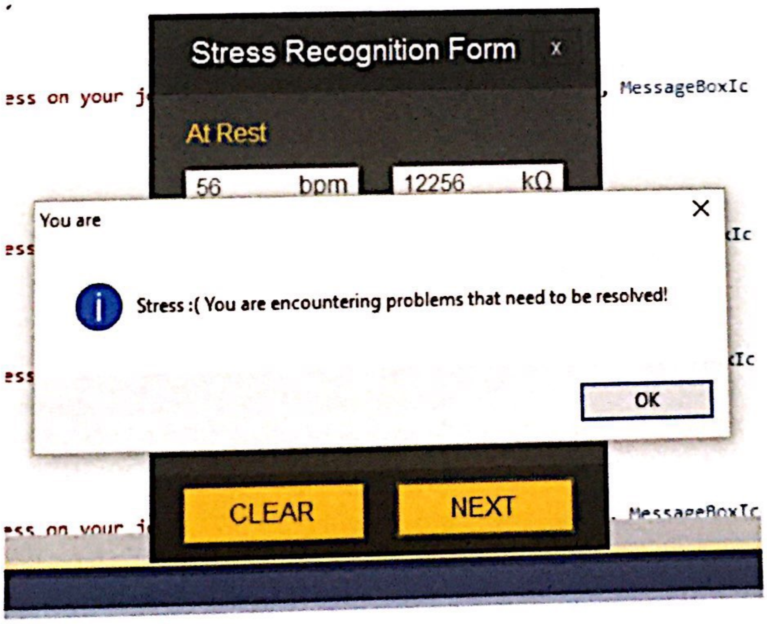


Figure 3.9: Output of "Stress"

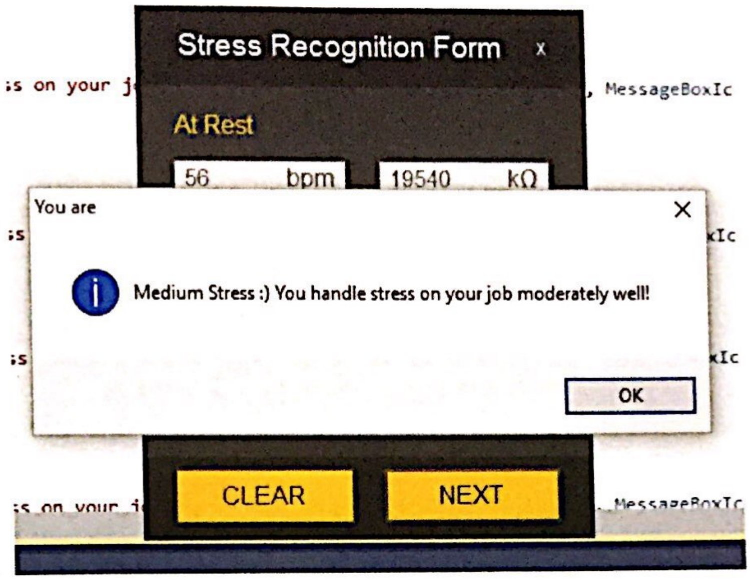


Figure 3.10: Output of "Medium Stress"

CHAPTER 4

DATA ANALYSIS AND DISCUSSION

4.1 INTRODUCTION

In this chapter, we will discuss about the result from pre-survey and post-survey which divided into two: Questionnaire method and Wearable physiological experiment method. All the survey and experiment is implemented among samples employees.

4.2 PRE-SURVEY

The questionnaire is distributed among 10 random employees comes from various background of gender and job sector. The result acquired is shown in figures below:

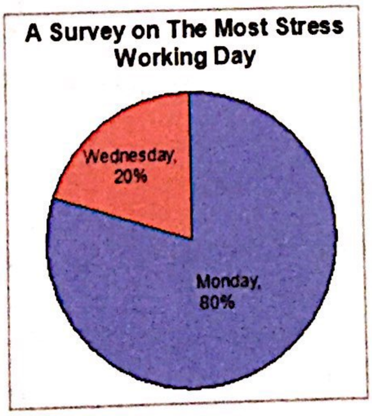


Figure 4.1: Results Of The Most Stress Working Day For 10 Subjects

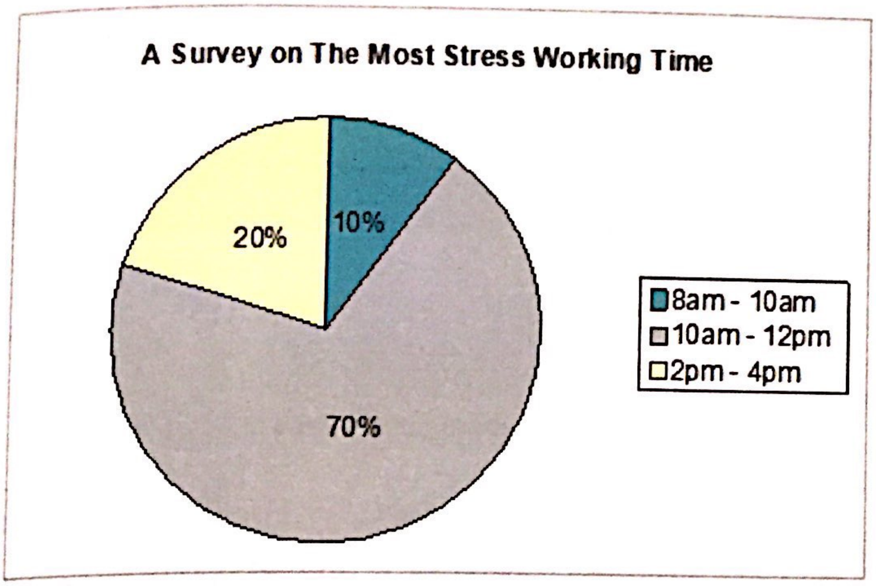


Figure 4.2: Results of The Most Stress Working Hours

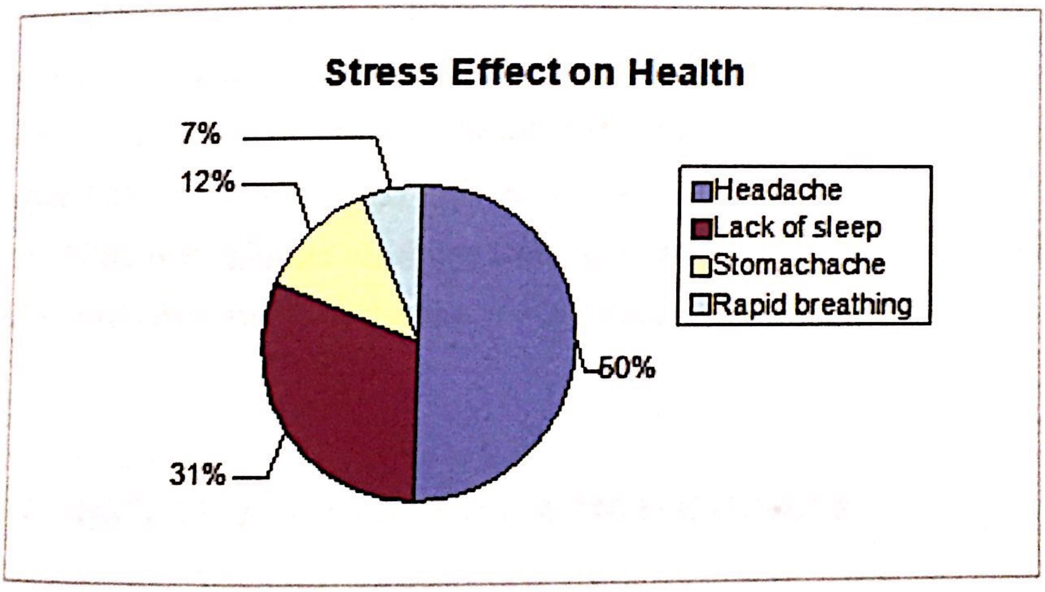


Figure 4.3: Results of Stress Effect on Health

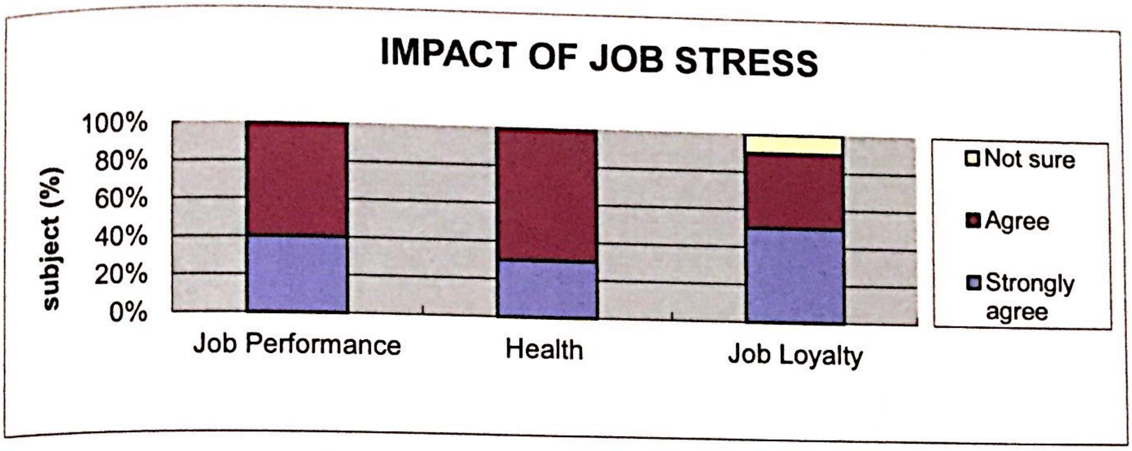


Figure 4.4: Results of Impact of Job Stress

Based on figure 4.1, it shows that Subjects feels most stressful on Monday with 80% and followed by Wednesday by 20%. For figure 4.2, the most stress working hours anwered by subjects is mostly on 10 a.m. to 12 p.m. with 70% followed by 2 p.m. to 4 p.m. with 20%. Then for figure 4.3, we can see that 60% of subjects have headache and then followed by lack of sleep with 31% when they going through stress effect on health. For figure 4.4, 50% of subjects agree that job stress will negatively give impact on job loyalty which means employees may have plan to change job in mind because of job stress. The least impact of job stress is on health with 30% means that 30% of subjects strongly agree that job stress will give impact on health. Thus, this pre-survey had discussed the likely of employees regarding their stress at workplace, how it will give impact and when do they usually feel stress at workplace.

4.3 ACCURACY TEST OF HEART RATE MEASUREMENT

Heart rate sensor and GSR sensor embedded in Wearable sensor is a ready-to-wear fitness band which is not quite suits with experimental research. Hence, an accuracy test is needed to identify the percentage accuracy of the Wearable sensor. For GSR, there is no standard device used by physicians or medical staff. In addition, the use of GSR is very new and not yet widely used by researchers and physicians in Malaysia. Hence, the accuracy test for GSR could not be implemented. For Heart rate, a standard device is acquired which is a Non-Invasive Blood Pressure Monitor that can measure blood pressure and also heart rate.

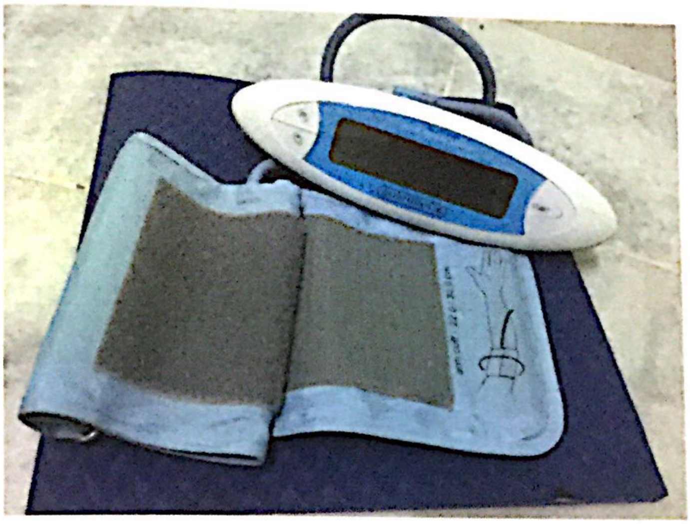


Figure 4.5: Non-Invasive Blood Pressure Monitor With Cuff

When implementing the accuracy test, an Experimental Protocol is built to get a proper reading from subjects. A total of 19 subjects volunteered to participate in this experiment. The Experimental Protocol followed is as below:

EXPERIMENTAL PROTOCOL

1. Subject is asked to sit comfortably and relaxed
2. Subject is asked to not talking
3. Standard device (NIBP) is placed properly on arm
4. Wearable is worn on another hand firmly
5. The heart beat reading is taken simultaneously with Wearable

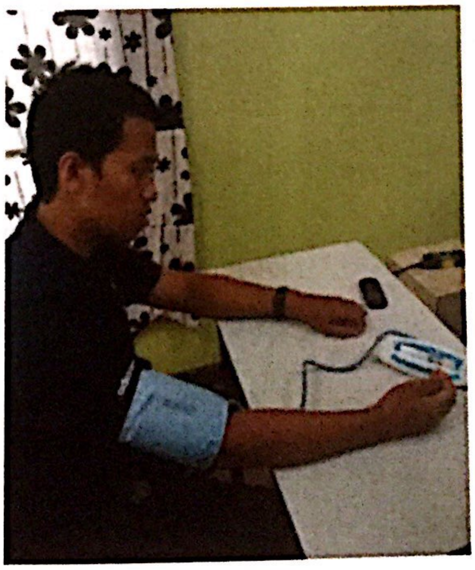


Figure 4.6: Subject is taking reading

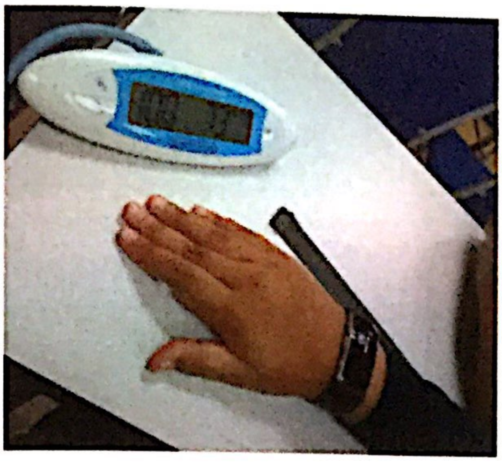


Figure 4.7: NIBP and Wearable Sensors on subject

Formula used for Error percentage and Accuracy percentage is as below:

$$\text{Error Percentage} = \frac{|theoritical - experimental|}{theoritical} x\ 100$$

$$\text{Accuracy Percentage} = 100 - Error\ Percentage$$

Table 4.1: Data of Theoretical value and Experimental Value for 19 Subjects

SUBJECT	THEORETICAL VALUE (bpm)	EXPERIMENTAL VALUE (bpm)
Subject 1	85	90
Subject 2	81	76
Subject 3	91	92
Subject 4	95	92
Subject 5	74	71
Subject 6	93	95
Subject 7	94	87
Subject 8	66	70
Subject 9	90	88
Subject 10	70	72
Subject 11	61	62
Subject 12	77	76
Subject 13	64	67
Subject 14	79	78
Subject 15	61	60

Subject 16	87	83
Subject 17	87	74
Subject 18	70	71
Subject 19	96	94
Average	80.05	78.84

Error (%) $= \frac{|80.05-78.84|}{80.05} x\ 100$

$= 1.51\%$

Accuracy (%) $= 100 - 1.51$

$= 98.49\%$

The Error percentage calculated for Heart rate sensor in Wearable Sensors is 1.51% and thus makes the Accuracy percentage as much as 98.49%.

4.4 POST SURVEY

In this post-survey experiment, it is divided into two: Questionnaire method and Wearable physiological experiment method. All the survey and experiment is implemented among samples employees.

4.4.1 QUESTIONNAIRE-BASED METHOD

For baseline stress level, this project using Workplace Stress Survey (WSS) published by American Institute of Stress (AIS). The sample Questionnaire can be viewed in Appendices. Consent form is distributed along with WSS Questionnaire among 15 employees. The stress level is classified according to score as Table 3.2.

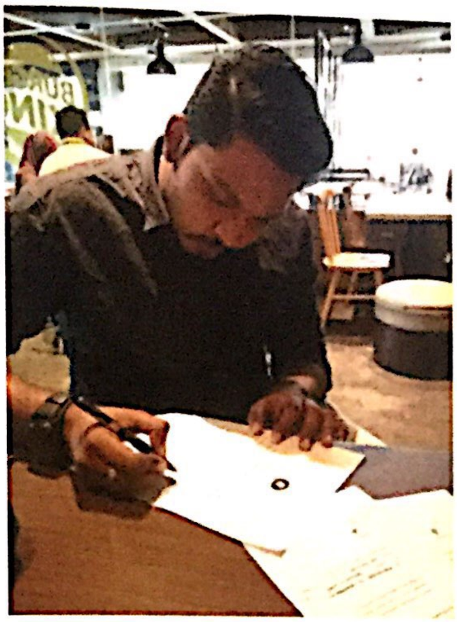
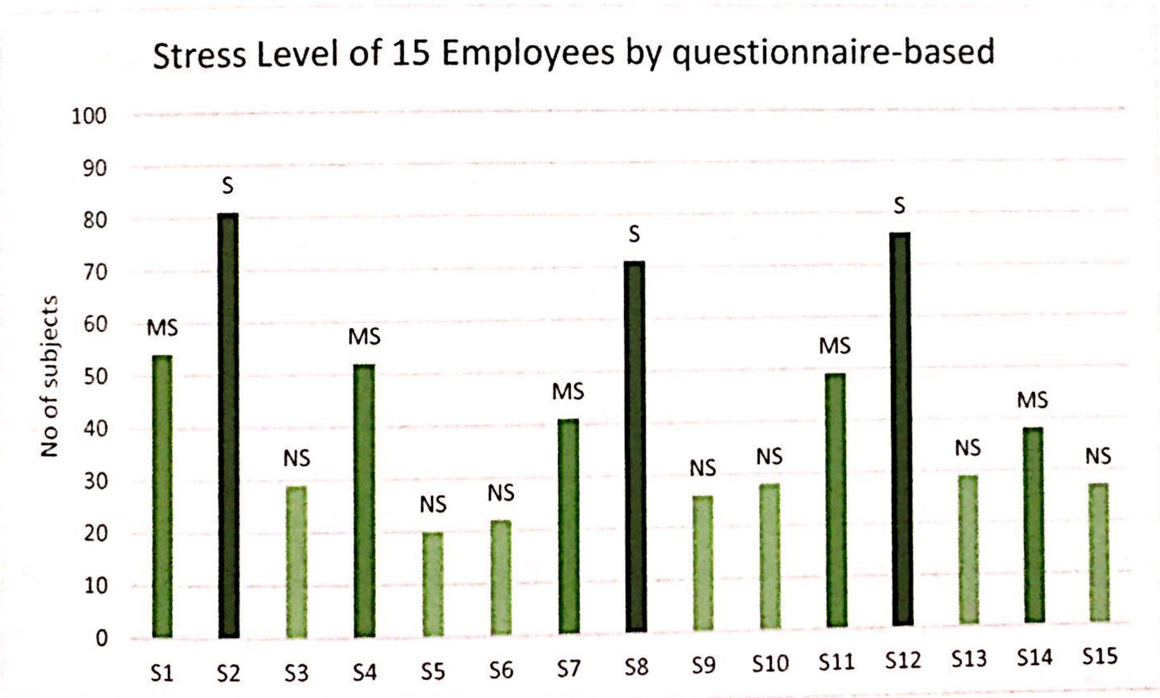


Figure 4.8: Subject fill in the Consent form and WSS Questionnaire



S: Stress MS: Medium Stress NS: Not Stress

Figure 4.9: Result of WWS Questionnaire for 15 Employees

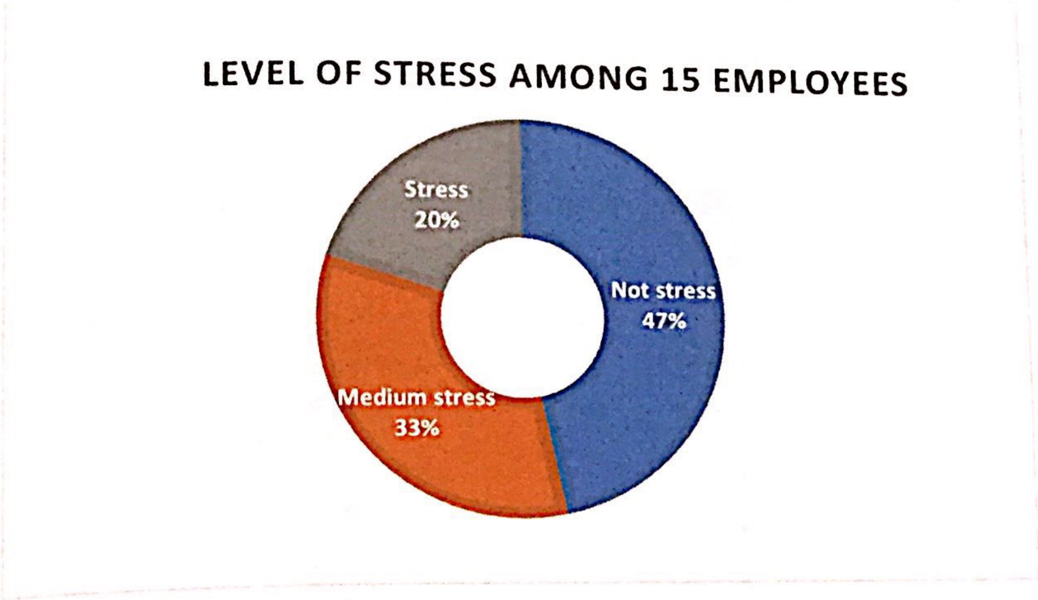


Figure 4.10: Percentage of Stress Level using WWS Questionnaire for 15 Employees

Based on Questionnaire method, 47% from 15 employees are considered not stress, 33% of them are considered medium stress and then followed by considered having stress with 20%. The subjects that considered having stress are Subject 2, 8 and 12. Thus, baseline of stress level for 15 employees is acquired by using this method.

4.4.2 WEARABLE SENSORS-BASED METHOD

This method is implemented in order to monitor a real-time working condition based on GSR and Heart Rate reading. In this Wearable Sensors-based experiment, it is divided into two: at rest situation and at work situation. The situation at rest is required in order to gain neutral baseline reading since everyone have different resting heart rate and resting GSR. For at-work situation, the real-time stimuli are exist. All the procedures and experiment is implemented among samples employees.

Figure 4.11: Respondent Taking Reading At Rest

Figure 4.12: Respondent wearing Wearable Sensors at work

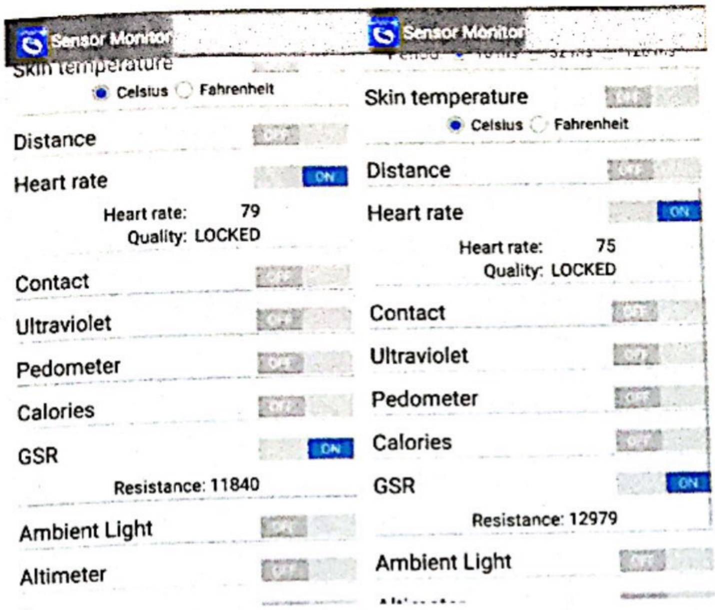


Figure 4.13: Example of readings on Phone Application

4.4.2.1 Heart Rate Reading

Table 4.2: Data of Heart Rate Reading for 15 Employees

SUBJECTS	AT REST	AT WORK	ΔHR	STRESS LEVEL
Subject 1	1. 73 2. 71 3. 72 Average = 72	Morning = 81 Afternoon = 87 Evening = 79 Average = 82.3	10.3	Medium stress
Subject 2	1. 78 2. 79 3. 77 Average = 78	Morning = 91 Afternoon = 89 Evening = 88 Average =89.3	11.3	Stress
Subject 3	1. 68 2. 67 3. 66 Average = 67	Morning = 68 Afternoon = 77 Evening = 68 Average = 71	4	Not stress
Subject 4	1. 63	Morning = 78	7	Medium

	2. 62 3. 65 Average = 63	Afternoon = 71 Evening = 61 Average = 70		
Subject 5	1. 93 2. 91 3. 89 Average = 91	Morning = 95 Afternoon = 89 Evening = 96 Average = 93.3	2.3	Not stress
Subject 6	1. 73 2. 71 3. 72 Average = 72	Morning = 80 Afternoon = 79 Evening = 75 Average = 78	6	Not stress
Subject 7	1. 63 2. 61 3. 62 Average = 62	Morning = 72 Afternoon = 68 Evening = 68 Average = 69.3	7.3	Medium
Subject 8	1. 83 2. 81 3. 82 Average = 83.3	Morning = 95 Afternoon = 96 Evening = 91 Average = 94	10.7	Stress
Subject 9	1. 60 2. 61 3. 59 Average = 60	Morning = 69 Afternoon = 64 Evening = 65 Average = 66	6	Not stress
Subject 10	1. 63 2. 61 3. 62 Average = 61	Morning = 63 Afternoon = 70 Evening = 62 Average = 65	4	Not stress
Subject 11	1. 76 2. 75 3. 74 Average = 75	Morning = 83 Afternoon = 90 Evening = 76 Average = 83	8	Medium
Subject 12	1. 67	Morning = 83	14.7	Stress

	2. 66 3. 69 Average = 67.3	Afternoon = 74 Evening = 89 Average = 82		
Subject 13	1. 59 2. 59 3. 60 Average = 59.3	Morning = 66 Afternoon = 74 Evening = 69 Average = 69.7	10.4	Medium
Subject 14	1. 66 2. 65 3. 66 Average = 65.7	Morning = 73 Afternoon = 74 Evening = 80 Average = 75.7	10	Medium
Subject 15	1. 72 2. 72 3. 73 Average = 72.3	Morning = 78 Afternoon = 75 Evening = 72 Average = 75	2.7	Not stress

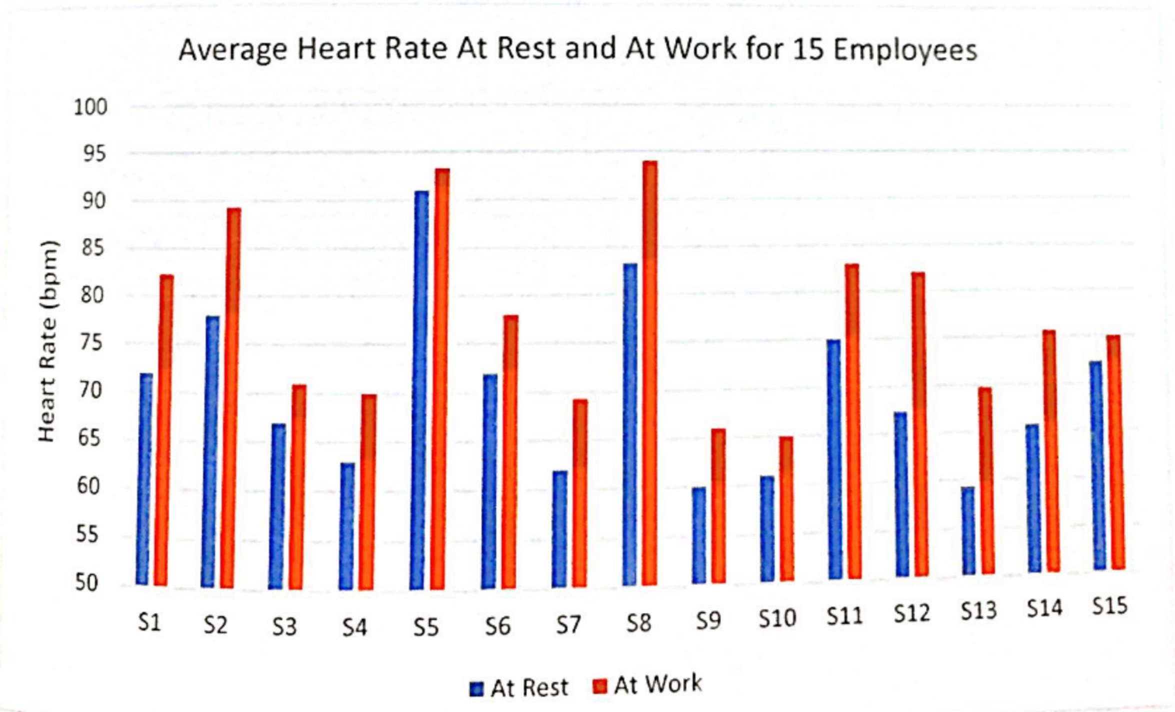


Figure 4.14: Average Heart Rate At Rest and At Work for 15 Employees

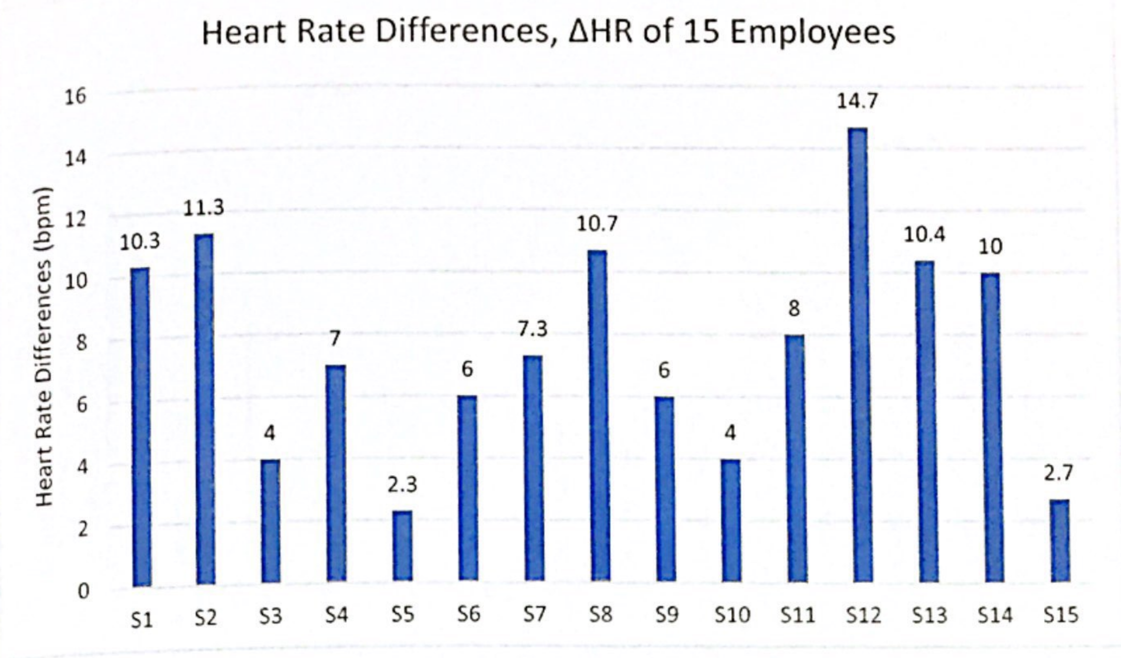


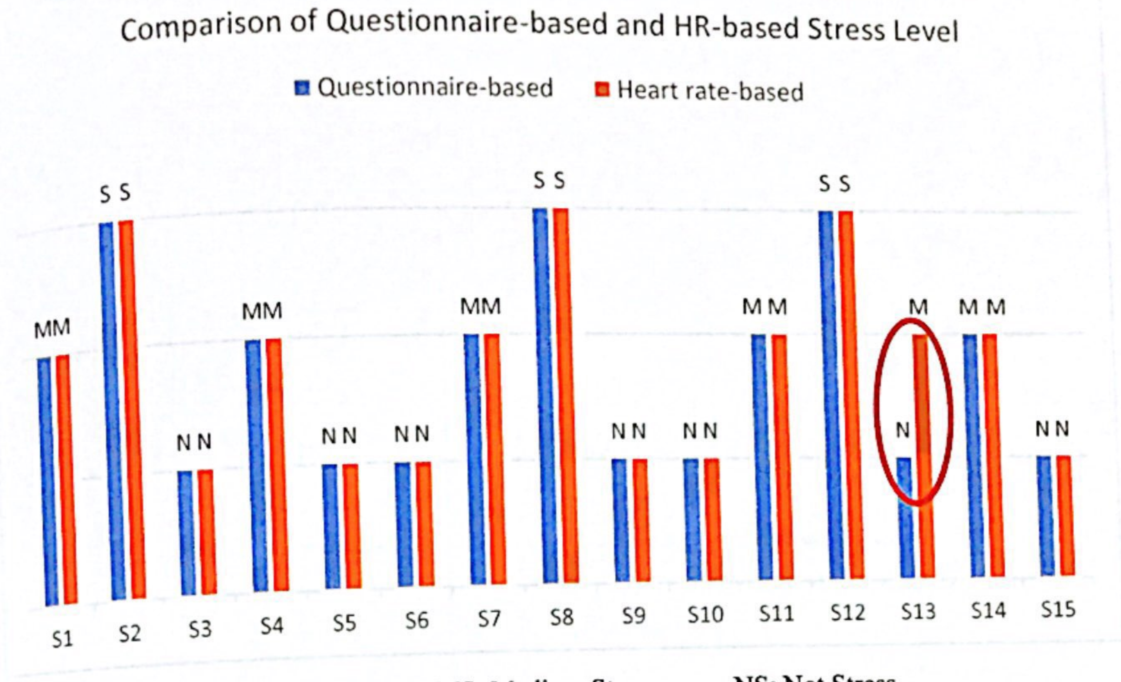
Figure 4.15: Heart Rate Differences At Rest and At Work for 15 Employees

Threshold value = (Max-min)/3

= (14.7 – 2.3) /3 = 4.13

Table 4.3: Δ HR range

STRESS LEVEL	Δ HR RANGE (bpm)
Not Stress	2.3 < ΔHR < 6.43
Medium Stress	6.43 < ΔHR < 10.56
Stress	10.56 < ΔHR < 14.69



S: Stress MS: Medium Stress NS: Not Stress

Figure 4.16: Comparison of Questionnaire-based and HR-based Stress Level

Accuracy of HR parameter = true subjects / total subjects x 100

= 14 / 15 x 100

= 93.33 %

For heart rate variability (ΔHR), the difference is calculated between resting heart rate and heart rate during working hours. The value of HR is collected three times throughout the day which is during morning (9.00 am), afternoon (12.00 pm) and evening (3.00 pm). Then the average is acquired from all three values. From the ΔHR calculated, the lowest and highest value is noted to determine the range of ΔHR for level of stress which is not stress, medium stress and stress.

By calculating the differences between heart rate at rest and heart rate at work, Δ HR, threshold value is acquired and divided into three level since stress level are in three level. After classifying the stress level of each employees, is it showed that Subject 13 has different results when compared with Questionnaire result as baseline. Hence, the accuracy of heart rate parameter as stress parameter is calculated as much as 93.33%.

4.4.2.2 GSR Reading

Table 4.4: Data of GSR Reading for 15 Employees

SUBJECTS	AT REST	AT WORK	Δ GSR (kΩ)	STRESS LEVEL
Subject 1	1. 9891 2. 9802 3. 9827 Average = 9840	1. 5647 2. 8553 3. 10934 Average = 8378	1462	Medium Stress
Subject 2	1. 8724 2. 7520 3. 8953 Average = 8399	1. 7250 2. 6802 3. 6087 Average = 6713	1686	Stress
Subject 3	1. 9209 2. 9860 3. 1154 Average = 9741	1. 9225 2. 9014 3. 8671 Average = 8970	771	Not Stress
Subject 4	1. 9503.8 2. 12253 3. 11905 Average = 11220.6	1. 11051 2. 10932 3. 9206 Average = 10396.3	824.7	Not Stress
Subject 5	1. 9940 2. 12741 3. 12869 Average = 11850	1. 13046 2. 10854 3. 8267 Average = 10722.3	1127.7	Not Stress
Subject 6	1. 7704 2. 8873 3. 8500 Average = 8359	1. 7409 2. 5940 3. 8837 Average = 7395.3	963.7	Not Stress

Subject 7	1. 6338 2. 6010 3. 5478 Average = 5942	1. 6839 2. 4034 3. 3866 Average = 4913	1029	Not Stress
Subject 8	1. 14023 2. 12471 3. 11077 Average=12523.7	1. 1820 2. 9281 3. 1544 Average=10548.3	1975.4	Stress
Subject 9	1. 7541 2. 7790 3. 8150 Average = 7827	1. 1700 2. 9953 3. 8751 Average = 6801.3	1025.7	Not Stress
Subject 10	1. 7293 2. 6704 3. 6796 Average = 6922	1. 3274 2. 2971 3. 1106 Average = 5750.3	1171.7	Not Stress
Subject 11	1. 8634 2. 7729 3. 6182 Average = 7515	1. 5602 2. 7903 3. 5117 Average= 6207.3	1307.7	Medium Stress
Subject 12	1. 14204 2. 15647 3. 14603 Average=14818	1. 15602 2. 15061 3. 9590 Average=13417.7	1400.3	Medium Stress
Subject 13	1. 9107 2. 8745 3. 8128 Average = 8660	1. 6656 2. 8388 3. 8091 Average = 7711.7	948.3	Not Stress
Subject 14	1. 7508 2. 8247 3. 7918 Average=7891	1. 6090 2. 6014 3. 7062 Average=6388.7	1502.3	Medium Stress

Subject 15	1. 8290 2. 9840 3. 9995 Average = 9375	1. 9863 2. 8137.5 3. 7167.5 Average= 8389.3	985.7	Not Stress

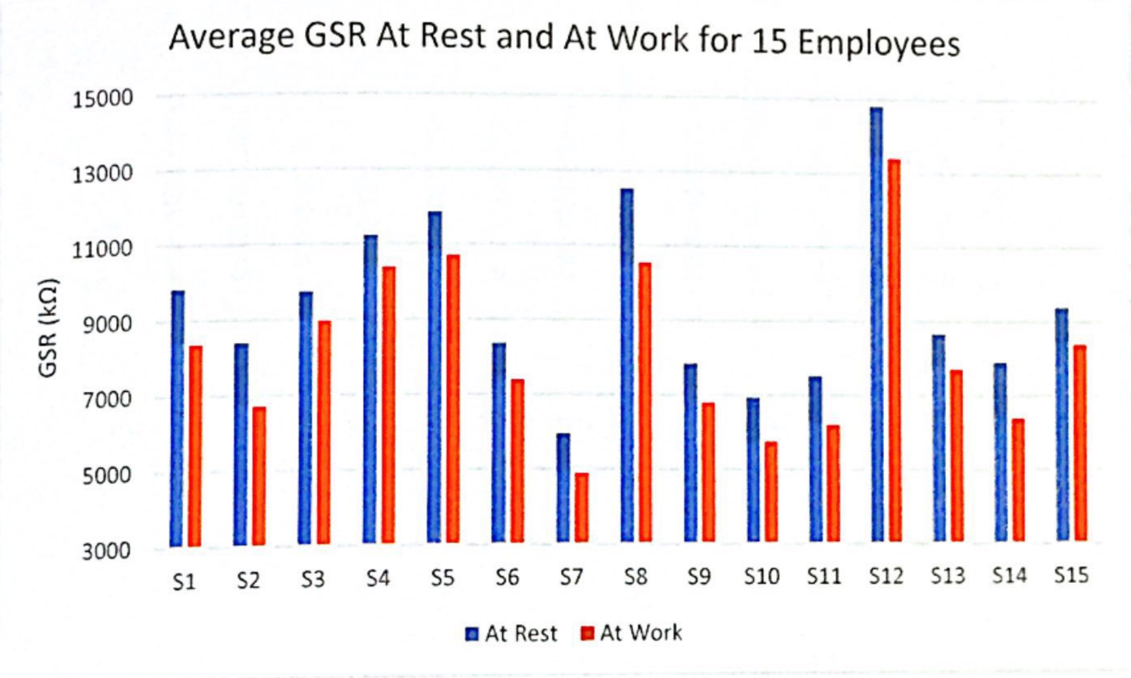


Figure 4.17: Average GSR At Rest and At Work for 15 Employees

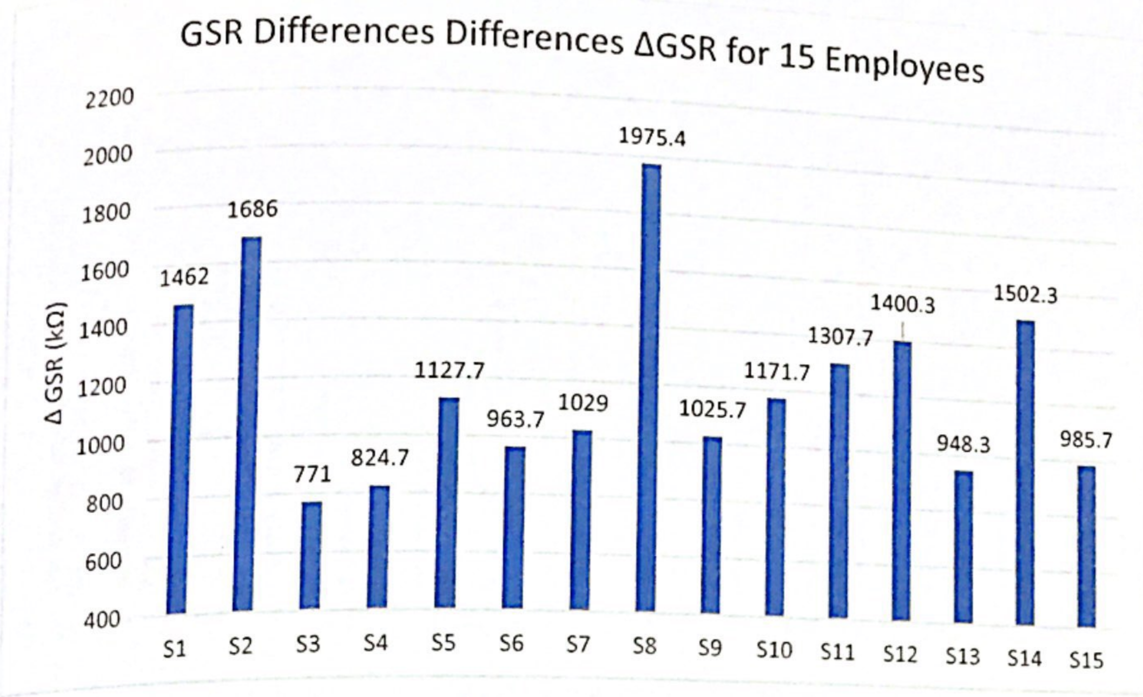


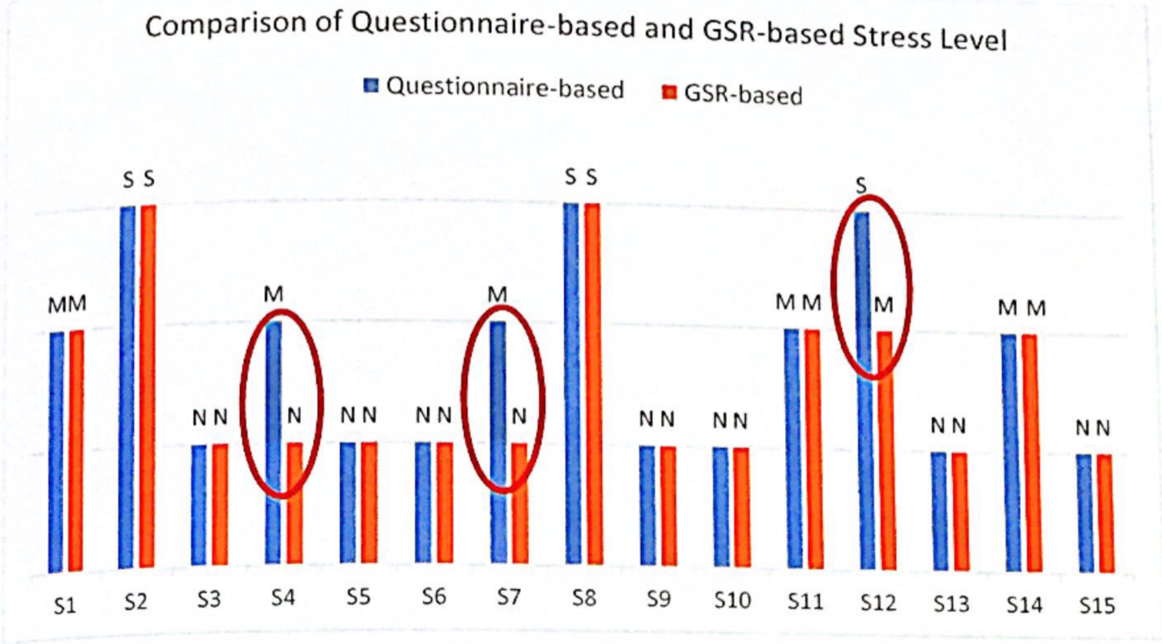
Figure 4.18: GSR Differences At Rest and At Work for 15 Employees

Threshold value = (Max ΔGSR – min ΔGSR)/3

$$= \frac{1975.4-771}{3} = 401.47$$

Table 4.5: Δ GSR Range

STRESS LEVEL	Δ GSR RANGE (kΩ)
Not Stress	771 – 1172.47
Medium Stress	1172.47 – 1573.94
Stress	1573.94 – 1975.41



S: Stress MS: Medium Stress NS: Not Stress

Figure 4.19: Comparison of Questionnaire-based and GSR-based Stress Level

Accuracy of GSR = true subject/total subject x 100

= 12/15 x 100 = 80.00 %

The variability of GSR which symbolized as ΔGSR is calculated by calculating the difference between resting GSR and the GSR during working hour. The value of GSR is collected three times throughout the day which is during morning (9.00 am), afternoon (12.00 pm) and evening (3.00 pm). Then the average is acquired from all three values. From the ΔGSR calculated, the lowest and highest value is noted to determine the threshold value for level of stress which is not stress, medium stress and stress.

By calculating the differences between GSR at rest and heart rate at work, Δ GSR, threshold value is acquired and divided into three level since stress level are in three level. After classifying the stress level of each employees, is it showed that Subject 4, 7 and 12 has different results when compared with Questionnaire result as baseline. Hence, the accuracy of GSR parameter as stress parameter is calculated as much as 80.00%.

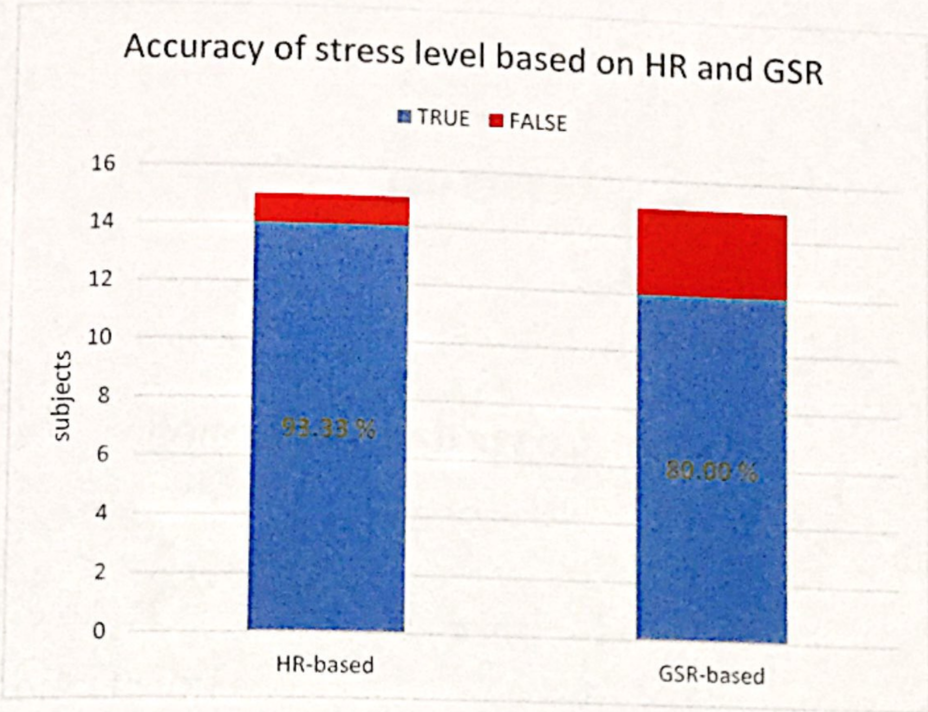


Figure 4.20: Accuracy Percentage of Stress Parameter, HR and GSR

In this paper, the human stress computation is elaborated experimentally using multiple physiological signals as to locate the more dominant stress-relevant features in each signal. Dominant features were individually identified in HR and GSR. Finally, the maximum classification accuracy obtained was 93.33% in the basic HR features. Similarly, GSR shows the lowest accuracy of 80.00% compared to other signals. Hence, Heart Rate shows more dominant features as stress parameter compared to GSR.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

This project succeed to achieve the objectives planned beforehand. In details, this project succeed to detect stress level by using Questionnaire and using Wearable Sensors. Then this project have built stress recognition system successfully. The Interface built are able to be used by users who works and want to identify their stress level. Lastly, this project succeed to determine the accuracy of HR and GSR stress parameter based on comparison results of 15 employees

In this research paper, this project experimentally elaborated the human stress computation using two parameter which is Heart Rate and Galvanic Skin Response (GSR) as to locate the more dominant stress-relevant features in each results. Dominant parameter is were identified between HR and GSR based on the accuracy percentage which obtained from result of stress level. Finally, the accuracy obtained was 93.33% and 80.00% respectively in the basic HR and GSR. This concludes that, HR shows the higher accuracy when compared to GSR parameter. Hence, Heart Rate parameter is more dominant parameter compared to GSR in measuring stress level.

5.2 RECOMMENDATION

This project measure GSR parameter based on sweat density on wrist. For more accurate data, future research should be implemented by measuring GSR on finger or palm which has more density of sweat glands and thus will provide better result. Future research may be implemented using more physiological parameter to recognize an efficient parameter of stress level. Apart from that, number of subjects with different age ranges are considered to develop the stress identification system. Later on, it will be extended to the stress level classification system. This project also may be improved by implementing the research on specific occupation such as nurses, doctors or lecturers to determine their stress level during working.

REFERENCES

[1] D. Published and D. Sobri, "' Working To Death ': Recent Study Shows More Malaysians Getting Stress - Related Illnesses," no. June, 2015.

[2] P. Karthikeyan, M. Murugappan, and S. Yaacob, "Multiple Physiological Signal-Based Human Stress Identification Using Non-Linear Classifiers," pp. 80–85, 2013.

[3] S. N. Z. Sahiera, "UNIVERSITI TEKNOLOGI MALAYSIA DECLARATION OF THESIS / UNDERGRADUATE PROJECT PAPER AND Universiti for Faculty of Electrical Engineering Engineering (Electrical- Microelectronic," vol. 16, no. June, 2013.

[4] J. Cacioppo, L. G. Tassinary, and G. G. Berntson, "Handbook of Psychophysiology," 3rd ed. University of Cambridge, 2007.

[5] R. Sioni and L. Chittaro, "Stress Detection Using Physiological Sensors," vol. 48, no. 10, pp. 26–33, 2015.

[6] iMotions, "GSR Pocket Guide," 2015.

[7] "Workplace Stress Survey." The American Institute of Stress (AIS), 2014.

[8] P. Karthikeyan, M. Murugappan, S. Yaacob, "A review on stress inducement stimuli for assessing human stress using physiological signals", in *Proc. of 2011 IEEE 7th Int Colloquium on Signal Processing and its Applications (CSPA)*, 2011, pp. 420–425.

[9] K. P, M. M, and S. Y, "Descriptive Analysis of Skin Temperature Variability of Sympathetic Nervous System Activity in Stress," 2012.

[10] W. S. Liew et al., "Classifying Stress From Heart Rate Variability Using Salivary Biomarkers as Reference," pp. 1–12, 2015.

[11] "The Brief Job Stress Questionnaire English version."

[12] K. Wada, T. Sairenchi, Y. Haruyama, H. Taneichi, Y. Ishikawa, and T. Muto, "Relationship between the Onset of Depression and Stress Response Measured

by the Brief Job Stress Questionnaire among Japanese Employees: A Cohort Study," PLoS One, vol. 8, no. 2, 2013.

[13] Karasek, Robert A. 1985. Job Content Instrument: Questionnaire and User's Guide. Revision 1.1. University of Southern California. Los Angeles, California. 15p.

[14] Williams, Cara. 2003. "Sources of workplace stress." Perspectives on Labour and Income. Vol 4, no. 6. June.

[15] Jungwee Park, Work stress and job performance, Perspectives, Statistics Canada - Catalogue no. 75-001-XIE, December 2007.

[16] F. Mokhayeri, M-R. Akbarzadeh-T and S.Toosizadeh, Mental Stress Detection using Physiological Signals based on Soft Computing Techniques. 18th Iranian Conference on BioMedical Engineering, 14-16 December 2011

[17] Understanding and managing stress, Australian Psychological Society, 2012

[18] Explain. Managing stress. The Patient Education Institute. 1995-2010

[19] Fernand-Sequin Research Centre of Louis-H. Lafontaine Hospital Quebac, Canada. Centre for Studies on Human Stress, 2007

[20] Jorn Bakker, Mykola Pechenzkiy and Natalia Sidorova,. What's your current stress level? Detection of stress pattern from GSR sensor data. Department of Computer Science Eindhoven University of Technology

[21] Jacqueline Wijsman, Bernard Grundlehner, Hao Liu, Hermens and Julien Penders,Towards Mental Stress Detection Using Wearable Physiological Sensors. 33rdAnnualInternational Conference of the IEEE EMBS. 2011

[22] Dhvani Parekh, Designing Heart Rate, Blood Pressure and Body Temperature Sensors for Mobile On-Call System. EE 4BI6 Electrical Engineering Biomedical Capstones.Paper 39, 2010

[23] Dr. Thomas F. Burgess, A general introduction to the design of questionnaires for survey research, Edition 1.1, University of Leeds, May 2001.

APPENDIX A

Consent Form

Title of Study: Recognition of Stress Level among Employees Using Wearable Physiological Sensors

I understand about the information of this study and received explanation from the investigator about the purpose of the investigation including benefits and risks

I am ______________________________________. IC number ______________________. Phone number______________________________.

"Agree/Disagree to participate in the studies as described above.

Signature,

____________________,

Date:

APPENDIX B

POLITEKNIK
Sultan Salahuddin Abdul Aziz Shah
Jabatan Pengajian Politeknik

QUESTIONNAIRE

I am the student of Polytechnic Sultan Salahuddin Abdul Aziz Shah, Shah Alam, Department of Electrical Engineering, and presently doing a project on "Recognition of Stress Level among employee in TTDI Jaya using Wearable Physiological Sensors". I request you to kindly fill the questionnaire below and assure you that the data generated shall be kept confidential.

SECTION A : PERSONAL DETAILS

Please mark (√) on box below

1. Gender	i) Male	☐
	ii) Female	☐
2. Age range	i) 21 - 30 years	☐
	ii) 31 - 40 years	☐
	iii) 41 - 50 years	☐
	iv) 51 years and above	☐
3. Job sector	i) Organizationally-employed	☐
	ii) Self-employed	☐
4. Job experience	i) Less than 1 year	☐
	ii) 1 - 5 years	☐
	iii) 6 - 10 years	☐
	iv) 11 years and above	☐

SECTION B

1. What time do you think is the most stress ?

8am - 10am ☐ 10am - 12pm ☐

2pm - 4pm ☐ 4pm - 5pm/5.30pm ☐

2. Which day do you think is the most stressful ?

Monday ☐ Tuesday ☐ Wednesday ☐ Thursday ☐ Friday ☐

3. Does stress give negative effect on your health ? If yes, please tick the on what kind of effect does you going through. (Can tick more than one)

Headache ☐ Lack of sleep ☐ Stomachache ☐

Backache ☐ Rapid breathing ☐ Pounding heart ☐

Others ; _____________

SECTION C

Please tick (√) once only for each questions

QUESTIONS	Strongly disagree	Disagree	Not sure	Agree	Strongly agree
Stress at work can give negative impact on job performance					
Stress at work can give negative effect on health condition					
Stress at work can cause employee to resign or changes job					

Comment / suggestion for this research :

____

____

____

THANK YOU FOR YOUR COOPERATION.

APPENDIX C

Workplace Stress Survey

Enter a number from the sliding scale below, which best describes you.

STRONGLY DISAGREE				AGREE SOMEWHAT			STRONGLY AGREE		
1	2	3	4	5	6	7	8	9	10

I can't honestly say what I really think or get things off my chest at work. ______

My job has a lot of responsibility, but I don't have very much authority. ______

I could usually do a much better job if I were given more time. ______

I seldom receive adequate acknowledgement or appreciation when my work is really good. ______

In general, I am not particularly proud or satisfied with my job. ______

I have the impression that I am repeatedly picked on or discriminated against at work. ______

My workplace environment is not very pleasant or safe. ______

My job often interferes with my family and social obligations, or personal needs. ______

I tend to have frequent arguments with superiors, coworkers or customers. ______

Most of the time I feel I have very little control over my life at work. ______

Add up the replies to each question for your TOTAL JOB STRESS SCORE ______

If you score between 10-30, you handle stress on your job well; between 40-60, moderately well; 70-100 you are encountering problems that need to be resolved.