Development of Body Stress Analyzer based on Physiological Signal

Nor Aini binti Abd. Majid1, Nan Md. Sahar*1,2, Suhaila Sari1, N. S. A. M. Taujuddin1, M.N. Nurliza3, Mohd Helmy Abd Wahab1, Radzi Ambar1, Syed Zulkarnain Syed Idrus4
1Faculty of Electrical and Electronic Engineering (FKEE), Universiti Tun Hussein Onn Malaysia, Parit Raja, Johor
2Microelectronics & Nanotechnology - Shamsuddin Research Centre (MiNT-SRC), Universiti Tun Hussein Onn Malaysia, Parit Raja, Johor
3Obstetrics and Gynaecology Department, School of Medical Sciences, Health Campus, Universiti Sains Malaysia, 16150 Kubang Kerian, Kelantan
4School of Communication and Human Development, Universiti Malaysia Perlis, Perlis, Malaysia

*nan@uthm.edu.my

Abstract. Ehealth is one of the systems that use modern technologies that are applied to the healthcare organization. This system allows the patient to access the system to monitor their health records and also by using the internet as a platform to communicate. Thus, this project is inspired by Ehealth system to making a hardware device with software application that acts as a monitoring system to the people. For the hardware, the user only needs to grasp the two terminals in the device that contains all the sensors for doing the testing procedure. Thus, all the data that are contained will be sent to the apps through the internet of things for storing them. This will help physical education and health teacher to do observation and record the data obtained from the apps. Besides, this way also will avoid any incident to occur towards the students if they carry out activities in abnormal conditions of their body system. The scope for this project is focusing on monitoring students body condition before they start their outdoor activities in the field. The way for sensing the parameters includes pulse sensor, LM35 and Galvanic Skin Response sensor with Arduino as a microcontroller to process the input and output signal.

1. Introduction

Body stress analyzer is one of the ideas that can be implemented in the home or school environment to check the condition of a person. This way will prevent any accident occurring involving the body system to work properly. The body stress analyzer allows performing the detection of physiological signals in the human body by applying the main concept of Galvanic Skin Response sensor or known as Electrodermal Activity (EDA) and Skin Conductance (SC). Besides, LM35 sensor and
pulse sensor be use to detecting body temperature and pulse rate of the user that should in normal condition before starting any challenging activities that required much of stamina.

Body stress is defined as a situation when human body fails to handling the pressure condition toward surrounding according to several aspects. [1] It also leads to the overload stress that may cause compression on spinal nerves. Result from that, the person who suffering from this condition will feel numbness, pain and weakness. In fact, this is the main factor of body stress towards people that effect decreasing of energy levels includes dehydration, low blood sugar, a poor diet or an under-active thyroid. For body reaction, stress can caused increasing of heart beat from normal reading, breath become quicker than usual and muscle will act based on instruction that being result from electrical impulse process from brain via nerve system. In context of over limitation of stress, it will exposed to health problem that may effected respiratory and cardiovascular systems, digestive system, muscular system, sexuality and reproductive system and immune system of human body in negative way.

To find the solver to this circumstances, body stress detector have being created for monitoring and show the result either a person can do physical activities or otherwise. The development of body stress analyser is desired to be the measurement tool for determine the healthiness of the normal condition for a person based on the pulse value, temperature and the conductance that be generate by the sweat gland through the hand. Each of the measurement will be state either the result is lie within the range of normal reading or otherwise. By applying to the students, the healthiness each of them can be monitor before the unexpected incident occurs during the outdoor activity. By getting the correct health services, screening and monitoring will be a first step to give chances to the patient for living a long time with healthy life style condition[2].

2. Body stress analyzer with IoT
2.1 Overview
The idea to develope a new device that is easy to use and user friendly. By only grapping to the terminal of the device that be install with all of the sensor will producing the result of the body condition based on their temperature, heart beat and resistance in their body. This is the easiest way to achieve immediate results before starting any activities that needed mych energy to be use.
2.2 Galvanic skin response (GSR)
According to the [3], a brief description on Galvanic Skin Response element be discuss deepest by the researcher. The galvanic skin response sensor is operating under the term of electro-dermal activity or known as EDA. This sensor has referring to the process of detecting the change of the sweat gland activity. The measurement is in Siemen which mean in conductance reading. By applying in this project, the GSR sensor is act as a medium to detect the condition of human body either the reading of the measurement is lie in normal reading of healthy person or not. If the reading show more or less than the range, it will give the meaning of the person body system is not in stable state.

The unit of siemens make the process of interpretation of the signal become easier with the theoretical of the greater the activity of sweat gland, the higher the value that be producing by the skin conductance[4]. The sweat can be concentrated when the person in dehydration condition which is the body system is lack of water consumption. Therefore, the body system especially in heart system process will be disturbing because blood will be concentrated and make the heart more energy to pumping the blood. In fact, during dehydration, the pulse rate will be fastest than normal condition. In others word, the person that have concentrated in sweat can also lead to the disease of diabetes.

2.3 Temperature monitoring
Temperature of human body is commonly be lie in 36 celcius to 37 celsius. If the temperature is out of this range, this will cause by a fever, hypothermia, low blood proessure, unworking organ to functioning properly in human body and many else. LM35 is one of the sensors that use to detecting the temperature of the subject and can display it in Celsius or Fahrenheit. The range of the sensing measurement is from 55°C to 150°C. To producing the more accuracy of the result, the additional thermistor needs to be connected to the sensor. This type of sensor not requires any external calibration. By applying to this project as an input, this sensor acts as a medium to detecting the body temperature of the user. Therefore, during abnormal condition, the result will produce more or less from the range of normal temperature of the human body. At the same time, this device will give information to the user to not involving any activities that may effected their body system condition.

2.4 Heart rate monitoring
Pulse sensor also known as heart beat sensor is built with two sides of surface, on one side of the sensor the LED light is place that act as sensing element with an ambient light that be attaching to the user skin. In another side of it, there is a simple circuitry to be connected to the microcontroller. It also is use as an amplification element of the sensor and prevents the output from any noise. The ambient light of the sensor basically will be place on the vain of the human body. Vain can be easily find trough the fingertip or ear tips and the sensor must be attach directly on the top of the vain.

During this situation, the heart beat can be detect because the flow of the blood only can be done when the heart do the pumping process. This kind of parameter is one of the important things that need to be monitor. Irregular heart beat will cause the patient to fell dizzy, pain to their chest and effected the breath to be shorten than normal. This types of sensor be program by the microcontroller to observe either the user have normal heart beat condition during the testing by using the device. The paramete will be read in a minute and be produce in average of the reading for producing the result.

3. Block Diagram
Project system be devided into two parts which are hardware and software. By using internet of things platform, the data that consists of all parameter will be sending over the internet commucation and be stored in the Blynk Apss cloud. Body stress analyzer device contains of Arduino as microcontroller to process the input of the sensors. The data will be collect when LM35, pulse rate sensor and galvanic skin response sensor be attach to the users. The signal will be process by the system to evaluate the condition of the user either in normal condition or else.
This project consists of three inputs which is temperature sensor, pulse sensor and galvanic skin sensor (GSR). This all sensors are a types of analogue input that be connected to the terminal of analogue pin in the microcontroller. The input signal will be read when the entire sensors are attached to the user finger tips.

![Block diagram of the body stress analyzer device](image)

**Figure 2.** Block diagram of the body stress analyzer device

The range is set through the Arduino coding by following the normal reading of healthy person by referring to their temperature of their body, heart beating, and resistance of the hand that be produce by the sweat glands activity. The process is starting with the entire sensor are attached to the user finger tips. If the reading of the heart rate low or higher than 60 to 100 bpm; the temperature reading is low or higher than 36.5ºC to 37.5ºC ; and galvanic skin sensor give the reading of the conductance higher than 4 siemens, the output will show through the LCD which the statement of “Can do exercise” be display. While, in other condition, when the reading of one of the sensor or all are not be in the normal range value, the system will display “Take a rest!” through the LCD and the red LED will light up as indicator to the people. Besides, the data will be sent through Blynk apps to show the result from the measurement to those who want to monitoring the user measurement from far away.

4. **Hardware implementation and results**

The position of the finger tip is most of the important thing to be allert during collecting the data. It is depending on the contact of the finger to the sensor. The sensors that be use is sensitive toward light or surrounding. Therefore, it will give more previse result if there are no space or air gap between the sensor and the finger. By this way, sensor can be away from any disturbance singnal.

4.1 **Circuit design for the galvanic skin sensor**

This type of sensor act to give the measurement of human resistance through palm hand. Galvanic skin response is detecting the resistance value and converts it into the conductance measurement (in Siemens). This is because to convert into conductance value, the formula is 1 per resistance value from the measurement. The process of converting is use to make it easier to be interpreted which the greater the sweat concentration, the higher the skin conductance [5]. The conductance formula can be shown as below:

\[
\text{Conductance} = \frac{1}{R}
\]
By focusing on the body system before exercise, the measurement is taken to evaluate the condition of the body either in normal condition or else. By referring to [6], if someone in dehydration, the condition of their mind is also being change. Therefore, by referring to the fact of measurement of the resistance of human body during the mind state condition with the other two parameters of heart beat and temperature value will give the result of body stress condition of a person. Besides, the measurement of the galvanic skin response can also make people know that they need to rest a while if the result shows their body in unbalance condition. In fact, if someone suffering from stress, it will affect the overall system of the body includes the heart rhythm, blood pressure changing and exposed to the heart attack condition.

Table 1. Reading of the galvanic skin response in Siemens [7]

| Body condition   | The reading of the measurement in Siemens               |
|------------------|-------------------------------------------------------|
| Relax condition  | <2.0 Siemens and pulse rate at normal condition       |
| Normal condition | <4.0 Siemens and pulse rate at normal condition       |
| Abnormal condition | >4.0 Siemens and pulse rate above at normal condition |

The initial circuit design for this project was designed by using Proteus 8 professional. The design was unable to be completed in Proteus due to the unprovided galvanic skin response (GSR) module library or component in the software. In order to that, the block was designed for two inputs to the variable resistor that act as the metal that be attach to the human skin.

For the output part, it same as the real sensor which have input power, ground terminal and analogue input. The analogue pin is connected to the terminal A2 of the Arduino by following the coding that was done in the Arduino IDE software and was compiled inside the Arduino. Therefore, the project was done manually by using the coding and practical trying by referring to the internet source and others journal. Besides, some testing of the connection using multimeter also is done to do the testing for the connection of the installation of the component.

![Figure 3. Circuit design of the galvanic skin sensor using Proteus software](image-url)
The circuit be construct with the connection of the galvanic skin sensor, liquid crystal display (LCD), light emitting diode (LED), variable resistor and the microcontroller of the Arduino Uno. The functioning of the galvanic skin sensor circuit has been constructed and be tested. The true programmed that being upload into the microcontroller is being set with the range of the conductance voltage in condition of if conductance value > 4.0 siemens, the LCD will show as “take a rest!” with red LED will light up while for the sensor sense the value of conductance < 4.0 siemens, the LCD will show as “can do exercise” with red LED light off. This measurement is referring to the range that is state in [7]. The condition during the conductance value below than 4.0 Siemens, this will show that the body of a person in normal condition, while the result of measurement above 4.0 siemens, its means the body is in abnormal condition. Table 2 shows the data collection from 5 person with good health condition.

**Figure 4.** The result of the system when the measurement from the person is below than 4.0 siemens.

```
resistance_voltage = 2.15
resistanceMS = 215650.25

conductance_voltage = 1.17
conductanceMS = 1174349.75
CAN DO EXERCISE
```

**Figure 5.** The result of the conductance reading from the figure 4 when the body system in normal condition.
Table 2. Reading taken to the subject in normal condition.

| No of test | Subjects (siemens) | Subject 1 | Subject 2 | Subject 3 | Subject 4 | Subject 5 |
|------------|--------------------|-----------|-----------|-----------|-----------|-----------|
| 1          | 2.15               | 1.89      | 1.98      | 1.77      | 1.93      |
| 2          | 1.94               | 1.96      | 1.86      | 2.31      | 1.89      |
| 3          | 2.10               | 2.11      | 1.99      | 1.84      | 2.19      |
| 4          | 2.05               | 2.12      | 2.17      | 2.12      | 2.32      |
| 5          | 1.92               | 1.88      | 2.20      | 2.23      | 2.16      |
| Average reading | 2.03        | 2.0        | 2.04      | 2.05      | 2.09      |

4.2 Temperature and pulse sensor circuit

Pulse sensor is one of the examples of an analogue sensor. It have 3 terminal which is Vcc, ground and signal pin. The input voltage of the sensor can be either +5V or 3.3V from the microcontroller system. Once the signal pin gets the power source, the monitoring will be carry out in term of change in output voltage.

This sensor is designed with the super bright yellow LED and light detector that be mounted on the sensor side by side. The LED characteristic of the light must super brightness because the sensor will transmit the light through fingertip and detected by the detector. During the condition of the pumping of the heart process through the blood vessel, the finger becomes marginally denser and affecting the light becomes less to reach the detector. To do a measurement to the user, the sensor need to be attached and pressed closely to the finger tip of the user and must directly on top at their vain. The parameter of the condition of the heart beat per minute can be described as the table below. In this project, the reading is only focusing on the normal range parameter. If the parameter shown more or less than that, it means the user body system is not be categorized in normal condition. The measurement of the heart pulse is taken in beats per minute (bpm).

Table 3. Reading of pulse sensor based on the condition of the heart beat

| Heart beat condition | The reading of the measurement per minute |
|---------------------|-------------------------------------------|
| Normal condition    | 60 – 100 bpm                               |
| Bradycardia         | < 60 bpm                                   |
| Tachycardia         | > 100 bpm                                  |

Temperature sensor is the condition during the variation of the temperature across the sensor. LM35 sensor is one of the types of temperature sensor that act to sense the temperature measurement in degree Celsius and Fahrenheit. The output of the voltage is linearly proportional to the temperature condition. The fact of LM35 be described as the temperature increasing, the voltage that across through the diode will also increase due to the change of the temperature.
Table 4. Reading of the temperature of human body

| Body temperature condition | The reading of the measurement in Celsius |
|----------------------------|------------------------------------------|
| Hypothermia                | < 35°C                                   |
| Normal condition           | 36.5°C to 37.5°C                         |
| Fever / Hyperthermia       | >37.5°C to 38.3°C                        |
| Hyperpyrexia               | >40.0°C to 41.5°C                        |

The circuit of the pulse and temperature sensor is connecting together to producing the result by displaying the value of the measurement. The result of the pulse sensor had shown slightly same as the theoretical value during a person in healthy condition.

Figure 6. The connection of the temperature and pulse sensor to the Arduino Uno

Figure 7. The result of the healthy subject with temperature sensor pulse sensor result

5. Conclusion

In conclude, a development of body stress analyzer be created to detecting the resistance of the skin, temperature of the body and the heart pulse of the human body in normal condition. This system will greatly help students for be a monitoring device for their health level. Thus, any unexpected incident can be avoid to occur during outdoor activities.
6. Acknowledgement

First and foremost, I would like to express my warmest and deepest appreciation to my supervisor, Dr. Nan bin Mad Sahar for the continuous support throughout this research. All of the kindness including guidance, motivation, patience and knowledge helped me a lot during the duration of the research to be completed. Not to forget, special acknowledgement for my parents Abd Majid bin Adam and Nor Rahimah binti Abu Bakar and friends for their helps and support from the beginning of my study until the end. Last but not least, I would like to express my thankful to those who provide all the opportunity to complete this project.

References

[1] D. Bhargava and H. Trivedi, “A Study of Causes of Stress and Stress Management among Youth,” vol. 11, no. 03, pp. 108–117, 2018.

[2] CDC Office of Women's Health, “Health Equity”. [Online]. Available: https://www.cdc.gov/family/checkup/index.htm [Accessed: August 2, 2017]

[3] M. Sharma, S. Kacker, and M. Sharma, “A Brief Introduction and Review on Galvanic Skin Response,” Int. J. Med. Res. Prof., vol. 2, no. 6, 2016.

[4] Bryn Farnsworth, “What is GSR (galvanic skin response) and how does it work.” [Online]. Available: https://imotions.com/blog/gsr/ [Accessed: July 17th, 2018]

[5] Bryn Farnsworth, “What is GSR (galvanic skin response) and how does it work.” [Online]. Available: https://imotions.com/blog/gsr/ [Accessed: July 17th, 2018]

[6] Y. Women et al., “Mild Dehydration Affects Mood in Healthy,” 2012

[7] Pradhipa Kresna Hadya, “RANCANG BANGUN ALAT PENGUKUR TINGKAT STRES”. Online]. Available: https://docplayer.info/44973200-Journal-of-control-and-network-systems.html [Accessed: 2015]