International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 03 | Mar 2021 www.irjet.net p-ISSN: 2395-0072

Stress Detection by Photoplethysmography and Context based Recognition

Dr.T.Chandrasekar[1], S.Dharshini[2], G.Visithra[3], M.Ragavi[4]

[1]*Associate Professor[1], EEE Department, Velammal College of Engineering and Technology, Madurai, Tamil Nadu.*
[2-4]*UG Student, EEE Department, Velammal College of Engineering and Technology, Madurai, Tamil Nadu.*

Abstract - *Stress is our body's reaction to a challenging or tense situations. It is a feeling of emotional or physical tension. It can arise from frustrating or disturbing negative thoughts .It can be either due to short term circumstances like taking up an exam, waiting for exam results ,etc., or long term pressures like unsatisfying career, difficulties in interpersonal relationships ,etc., It not only affects people mentally but also physically. It can produce effects like muscular ache, heat burn, menstrual problems, high blood pressure, etc., It also results in less productivity. In the worst cases, it results in suicides. So it becomes essential to monitor stress periodically and also to manage stress. The proposed idea aims in developing a stress detector device based on photoplethysmography and context based recognition . We will also be using activity recognizer for motion cancellation. The device would help people in self-assessment and self- management of stress, by providing the user with periodic stress evaluation charts. This stress data can also be used while consulting doctors, who can help us with stress management tips based on the stress chart or report .This would also help users to analyse and change their habits in order to avoid stress.*

Key Words: **photoplethysmography, context based recognition, activity recognizer, motion cancellation, productivity, etc.,**

1. INTRODUCTION

In today's fast moving and ever changing world, people face challenges regularly either in their families or work spot or both . While reacting to these changes, people fail to take care of themselves and they forget that their next day's efficiency and effectiveness depends on their current and stable physical and mental conditions. These challenges may have positive results like increase in growth and success in a process. Sometimes it could also turn into an aversive, by making the person feel more distressed. The effect of these challenges or changes also depends on the mental readiness of the person being exposed to it, to take up the challenge. Some people may face them confidently while others may start developing a negative feel towards the particular thing that poses the challenge. If this mental state continues, then it would affect the productivity, well-being and behaviour of the person. It might, at times, make the person feel more desperate and might result in suicides. Cigna's 360 wellbeing survey 2019 says that about 82% of Indian population suffers from high stress levels. On the other hand, an article in the New England Journal of Medicine noted that at least nine out of 10 people who survive a suicide attempt do not commit suicide at a later date. So, this makes us understand that the people's perspective on the thing that posed the challenge to them, has changed during the course of time i.e. after their first suicide attempt. But all suiciders don't get a second chance to live. It depends more on their physical conditions, degree of injury/effect, way of suicide and also their will to survive after it. Hence, if we are able to find or detect that a person is developing a negative feeling and becoming increasingly stressful, then it will help us in saving the person, before their physical and mental conditions become worse. And, it will also help us in reviving their hopes and inner spirits to live.

2. LITERATURE SURVEY

1. In 2013 Humaine Association Conference on Affective Computing and Intelligent Interaction, Akane Sano, Rosalind W. Picard came up with an idea titled as Stress Recognition using Wearable Sensors and Mobile Phones . They used wrist sensor (accelerometer and skin conductance sensor) , surveys and mobile phone usage as tools for their stress analysis. They adopted correlational analysis, machine learning and frequent mobile phone checks to find whether the user is stressed or not.

2. In 2017, Martin Gjoreski , Mitja Luštrek, Matjaž Gams and Hristijan Gjoreski published a research paper titled as 'Monitoring stress with a wrist device using context '.They intended to develop an unobtrusive device that would detect stress continuously and accurately. The device comprises of a laboratory based stress detector (that was trained on laboratory data),which produces an output for every 2 minutes , an activity recognizer and a context based stress detector which makes the final decision on classifying stressful and non-stressful situations, at an interval of 20 minutes.

3. WORKING PRINCIPLE

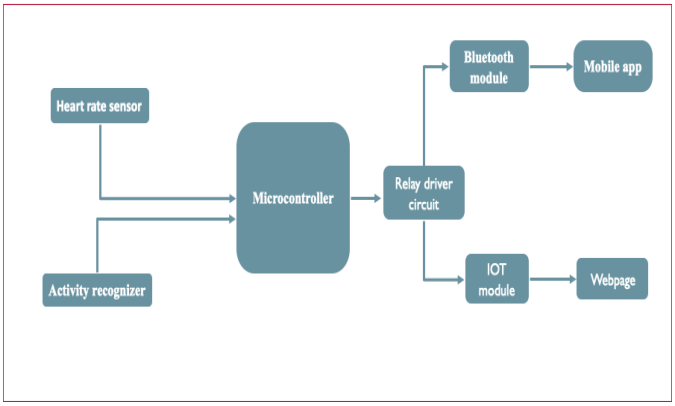

Figure 1- Block diagram for the proposed concept

The Heart rate sensor measures the heart rate of the subject (person under test) from his/her finger by using photoplethysmography technique. Our heart rate increases during both physical activity and mental stress. But, we don't need the physical activity related data . So, in order to isolate the physical activity data from mental stress data, we make use of a motion sensor (accelerometer), which measures the motion of the subject along x,y and z-axes. We also make use of a microcontroller, which recognizes and finds whether the subject is under mental stress or physical activity by analyzing the inputs from heart rate sensor and accelerometer. This process is called context based recognition. The stress data is transmitted to your mobile via a Bluetooth module(the data can be viewed by using an app). And, periodic stress reports and charts can be viewed online by making use of an IOT module and a third party website. The output of the microcontroller has to be sent to two devices- bluetooth module and IOT module. This can be realized by using a relay driver circuit. The overall working of the entire circuit is explained in the following tabular column (**Table 1**) and the block diagram is shown in **figure 1**.

Table 1- Overall working of the circuit

Overall working			
Cases	**Heart rate sensor output**	**Motion sensor output (Y/N)**	**Stressed or not**
1	Normal range (60-80 bpm)	Y	Not stressed
2	Normal range (60-80 bpm)	N	Not stressed
3	High heart rate (>80bpm)	Y	Not stressed
4	High heart rate (>80bpm)	N	Stressed

4. COMPONENTS DESCRIPTION

4.1 Power supply Circuit

4.1.1 Transformer

Transformer is static machine which is capable of increasing (in case of step-up transformer) or decreasing (in case of step-down transformer) the input voltages to the desired level. It works based on Faraday's law of electromagnetic induction. It consists of an input coil called the primary winding, which is connected to the input supply voltage and the output coil called the secondary winding which is connected to the output devices (devices which draw power from the transformer). The primary and secondary windings are wound on same soft iron core. They are electrically isolated from each other but they are linked to each other by alternating magnetic field. In the above mentioned/provided figure, the input 230V AC supply in the input side of transformer is stepped down to 12V AC supply at the output side of transformer.

4.1.2 Bridge rectifier

Rectifier is a power electronic module which converts alternating voltage (AC voltage) into direct voltage (DC voltage). It is of three types namely (i) half wave rectifier (ii) full wave rectifier (iii) bridge rectifier. Half wave rectifier converts only one phase of alternating (AC) voltage into direct (DC) voltage. Full wave rectifier and bridge rectifier converts both phases of AC voltage into DC voltage. But full wave rectifier makes use of two diodes only whereas bridge rectifier makes use of four diodes. The former uses a center-tapped transformer and the latter doesn't need the center-tapped transformer. In this

project circuit, we use a bridge rectifier for rectification process.

4.1.3 Smoothing Circuit

The smoothing circuit consists of a parallel electrolytic capacitor connected across the bridge rectifier terminals. It is used to supply current when varying DC voltage from the rectifier falls.

4.1.4 Voltage regulator

A voltage regulator is a device which produces constant voltage at the output side irrespective of input voltage values and load conditions. In this project , we get a output DC voltage of 5V with the help of IC7805. It has three terminals out of which, the first one is an input terminal, the centre one is ground terminal and the third one is output terminal.

4.2 Heart rate sensor

Heart rate is defined as the number of times our heart beats per minute. In this project, we use PPG sensor to measure heart rate. PPG stands for Photoplethysmograph sensor. Photo means light. It is called as photoplethysmograph sensor because it makes use of photoplethysmography technique, which is a non invasive technique for measuring heart rate by recording volumetric changes in blood circulation. PPG sensor consists of a light source and a photodetector. Light source emits Infrared light at the surface of the skin. The light gets absorbed by the blood and the remaining light gets reflected which is detected by the photodetector. The sensor computes the heart rate by measuring the amount of light reflected from the skin.

4.3 Motion sensor (Accelerometer)

Motion sensor is a sensor which detects the motion of the subject. Accelerometer is a type of electronic motion sensor , which measures the acceleration forces acting on an object to determine the corresponding object's position and movement. An accelerometer can make measurements along one or two or three orthogonal axis. Here, we use an accelerometer sensor which can make measurements along three orthogonal axis.

4.4 Microcontroller

In this project microcontroller acts as a decision making/Context recognition element. Here, we use Arduino/Genuino Uno microcontroller board which uses ATmega328P microcontroller. It is shown in **figure-2**. It consists of 14 digital input/output pins, 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. Moreover, it is an open source hardware. Microcontroller works based on the code in its memory (coded according to the project purpose).

Figure 2- Arduino UNO microcontroller

4.5 Relay driver circuit

Relay driver circuit is used to switch and pass the recorded stress data to mobile via Bluetooth module and web via IOT module.

4.6 Bluetooth module

Bluetooth is a communication protocol, which enables wireless exchange of information between devices within a short range of distance, using radio transmissions. It makes use of Personal Area Networks (PANs). In the above project, we make use of HC-05 bluetooth module, which is an easy to use module. It is based on serial port protocol.

4.7 IOT module

ESP 8266- 12E NODE MCU acts as IOT module. Node MCU, an open source platform includes hardware and firmware. The firmware runs on ESP8266 Wi-Fi SoC . The hardware is based on the ESP-12 module. It receives data from microcontroller via the relay driver and transmits it to the webpage.

4.8 LCD display

LCD stands for 'Liquid Crystal Display'. LCD display is used to display the heart rate values and notifies if you are stressed. Here, we use 16 x 2 display. It uses backlight to produce images.

5. RESULT AND DESCRIPTION

Whenever the user's heart rate soars past 80 beats per minute in the absence of motion, then the microcontroller or the context based recognizer throws a message on the LCD display , which alerts the user. At the same time , user also gets notified about this through the mobile app, which is shown in **figure 3**. If the user makes use of the device for a considerable period of time, then heart rate value vs time charts are plotted. This will aid the user not only in the self-assessment and self-management of stress but also during doctor's consultation.

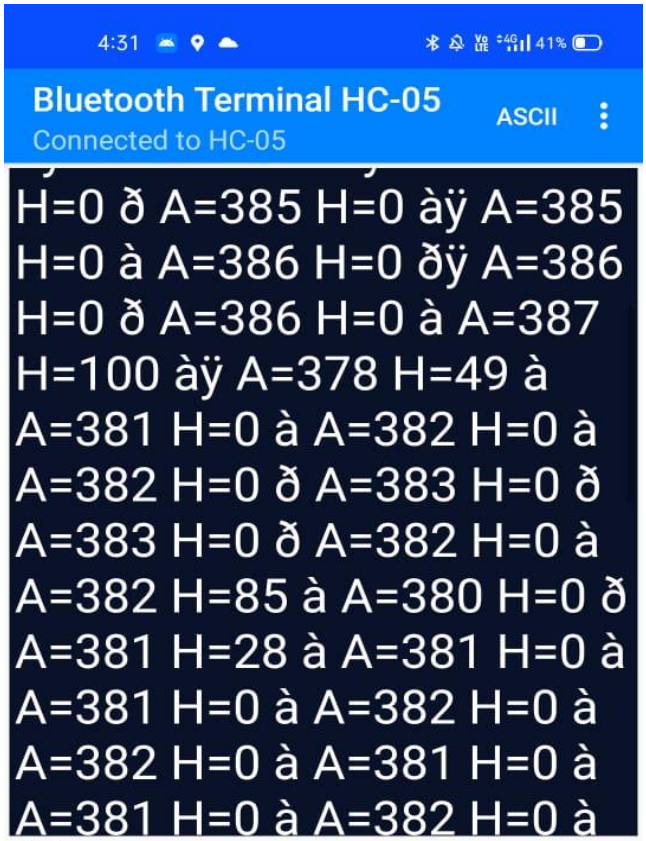

Figure 3- Output values in the mobile app

The developed hardware module for stress detection by photoplethysmography and context based recognition is shown in **figure 4**.

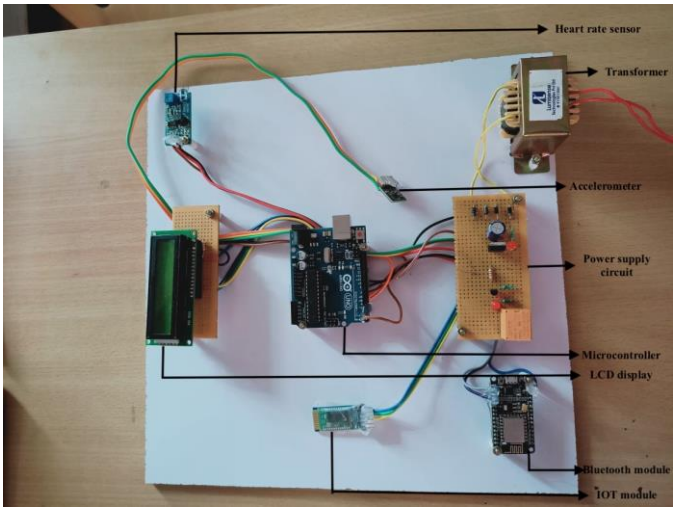

Figure 4- Hardware module

6. CONCLUSION

In the above study, we have proposed a way to detect stress by making use of physiological signal like heart rate. This will aid in improving the mental health of users. Utilized software and hardware tools have been presented.

7. REFERENCES

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