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Stress Measurement System Based on Heart Rate, Galvanic Skin Response and Electromyogram using IOT

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***Abstract*- Stress is a major problem in today's society which needs to be addressed. Stress can cause many health problems and has a major impact in our lives. Mobile technology use has grown drastically over the years in the healthcare field. This paper presents a model which is used to detect and measure the stress level based on the data obtained from different sensors. Heart rate variance, Galvanic skin response and Electromyogram are measured from their respective sensor and then the stress level is determined from the data obtained and the obtained data are send to the mobile application using the Wi-Fi module.**

Keywords- *Healthcare, Stress, Bio-signals, Heart rate variance, Galvanic skin response, Electromyogram, IOT.*

I. INTRODUCTION

Stress is defined as the feeling of emotional or physical tension. It is basically ones' reaction to any kind of demand or situation. Stress has a major impact in the lifestyle of the people of modern society. Stress affects the health of the individual not just mentally but also physically and emotionally. Stress can lead to serious health cardiovascular problems which even includes heart attacks. Even diseases which do not have direct cardiovascular connection like asthma and diabetes are linked to high levels of stress. Most of the diseases are lifestyle diseases and high levels of stress are one of the reasons for poor lifestyle choices. Stress is basically divided into three types which are Acute stress, Episodic stress and chronic stress. Acute stress is basically the short term stress causing transient emotional, muscular and mental stress to an individual. Episodic acute stress is an extended type of acute stress condition in which the patient experiences acute stress regularly. The person who experiences episodic acute stress generally gets stressed very easily making his/her lives chaotic. The third type of stress, Chronic stress is often the most harmful one and causes long term problems to an individual [1,2].

Several researchers have given different models for measuring the different bio-signals and the stress levels of the individual. Some papers also give formula for measuring the stress indicator by the use of heart beat [3]. Paper [6,7,9] presents a relation between HRV and stress conditions which is different from [3]. For the case of galvanic skin response, different papers present the relation between GSR values and the stress conditions using different algorithm but most of them gives a direct relation [10]. Similar to this there are different algorithms for stress detection using electromyogram data given by [13, 14,15]. All these papers gives separate models for measurement of stress level using different bio-signals. This paper presents a system which combines use of three different bio-signal sensors together in a single model to give the stress level of an individual.

This paper presents a portable system which measures the stress level of an individual assessing the data obtained using various bio-signal sensors such as heartbeat, galvanic skin response and electromyogram sensor and sending the data to the cloud. Bio-signals provide the possibility of in house assessment of an individual's health by monitoring the parameter such as heart rate variance, galvanic skin conductance and the muscle activity. These bio-signals also indicate the presence of stress in an individual's life since deteriorating health conditions are usually linked to stress. All the bio-signals used for the detection of mental and physical stress is explained below in the paper.

A. Heart Rate Variability

The heart rate (also known as a pulse) is one of the vital indicators of health in our body. It is the measure of heart contraction or simply the number of heart beats per minute. Heart rate variability is a value in milliseconds which is calculated as the time interval between two consecutive pulses. Heart rate variability plays a major role in determining the stress level of an individual. The relation of heart rate variance with mental stress has been clearly defined by many

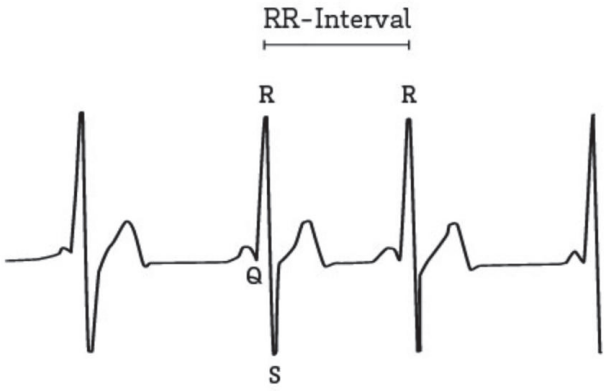


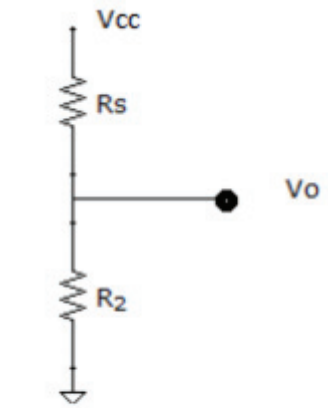
Fig. 1. R-R interval of the heart rate variance

researchers[3,4]. Researchers have been using HRV to measure mental stress since the last few decades[5,6,7,8]. Heart rate variability (HRV) can be used as a non-invasive tool which can be further used in accessing the autonomic nervous system state[9].

In an HRV test, the R wave is detected in the QRV region and the time interval is calculated between the two R waves to give the HRV data.

B. Galvanic Skin Response

Galvanic skin response is defined as the measure of the continuous variation in the electric conductance of the skin which is due to the sweat of the human. Human body consists of many sweat glands which are present across the human body. When the sweat glands are triggered, they release moisture through the pores of the body. This causes a change in the presence of negative and positive ions in the body and changes the electrical conductivity of the body. The increased skin conductance causes the skin resistance to decrease and the change in skin conductance is usually termed as the galvanic skin response.



$$Vo = \frac{R2}{Rs + R2} Vcc$$

Fig. 2. Voltage divider circuit used for GSR sensor

The galvanic skin response of an individual depends upon the skin resistance which in turns depends on the conditions of the sweat glands in the skin. The average skin conductance is measured in Siemens and depends upon the sweat secretion of the human body. Mental stress has a direct relation with the galvanic skin response value. The presence of stress causes the increase in skin conductance and thus more value of galvanic skin response. It has been used by various researchers over the years to detect the mental stress[10,11,12].

Galvanic skin response sensor is designed on the principle of voltage divider circuit. Heart rate variance along with the galvanic skin response is used to measure the mental stress of an individual.

C. Electromyogram

Electromyogram is a test which measures the electrical activity of a muscle. Electromyogram is used to access the condition of the muscles and the motor neurons cells that control it. The muscles that are active produce electrical current. This electric current is usually proportional to the muscle functioning. The data from the muscles are obtained in the form of graphs and the numerical values in millivolts. The value obtained can be interpreted and the physical stress could be detected from the data. Many researchers have given the relation of physical and mental stress with the electromyogram data[14,15]. Electromyogram plays a major role in determining the physical stress in an individual body.

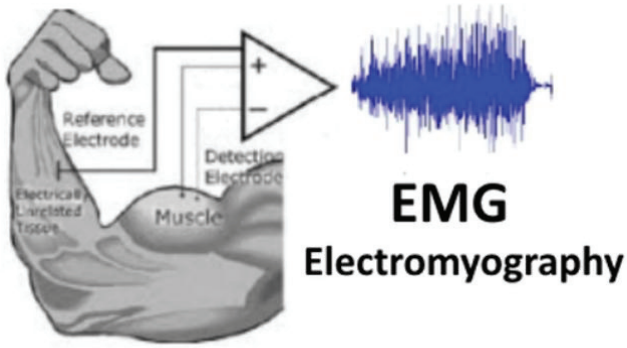


Fig. 3. Placement of electrodes on the muscle.[Ref: hackaday.io]

II. PROPOSED SYSTEM

The generalized work of the system is shown in the figure below. In the first stage the data is obtained from the three sensors which are Heartbeat sensor (MAX30100 sensor), Galvanic skin response sensor, Electromyogram sensor(Muscle sensor module V3.0). In the second stage the data obtained is processed to get rid of the noises due to environmental factors and the clear data is obtained. In the next stage the algorithms are applied to mark the stress level or the presence of stress. Then the data is displayed on an LCD screen. The connection of a Wi-Fi module enables the data to be sent to a cloud platform where it can be accessed by the doctor to monitor the health of his/her patient. In case of any high stress levels the doctor could take the necessary steps to stop it and provide solutions to it.

A. Prototype Development

The prototype model of this system consists of a microcontroller board to which the three sensors that are Heartbeat sensor(MAX30100 sensor), Galvanic skin response sensor, Electromyogram sensor(Muscle sensor module V3.0) are connected. The data obtained from these sensors are displayed on the Liquid Crystal Display(LCD) screen. The setup has a Wi-Fi module connected to it which sends the data to a cloud platform associated with the mobile application.

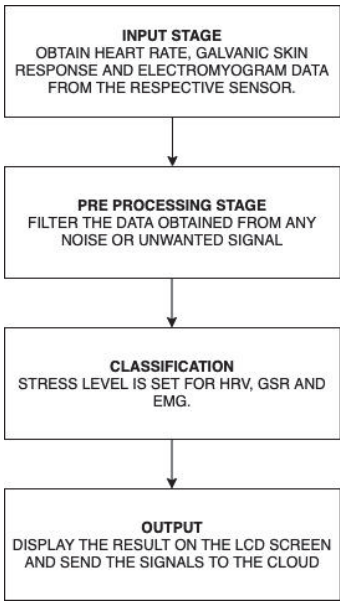


Fig. 4. Flow chart of the proposed system

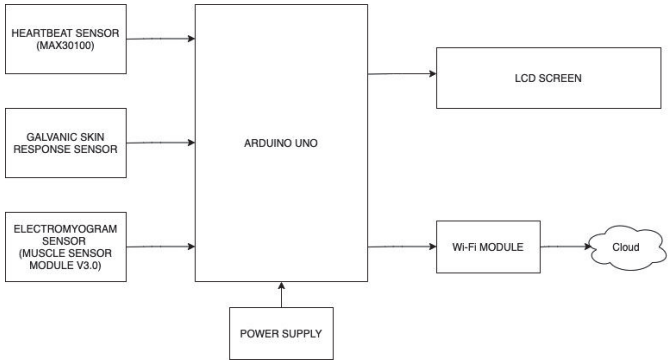


Fig. 5. Block diagram of the proposed system

B. Data Acquisition

The data used to give the stress level is acquired from three different sensor which is stated below:

(i)Heartbeat sensor(MAX30100): Heartbeat sensor is put on the fingers of an individual and then the data is obtained. The heartbeat sensor is used to measure the heartbeat along with the heart rate variance. The time interval between two heartbeats which is the R-R interval is acquired from the sensor. The value obtained from the sensor is in microseconds. Based on the readings obtained from the sensors the mental stress levels are set[6].

(ii)Galvanic skin response sensor: The GSR sensor is put on the two fingers of an individual to measure the variation in the electric conductance of the skin. The value obtained from the sensor is in micro-siemens. Based on the data obtained the mental stress levels are set[11].

(iii)Electromyogram Sensor(Muscle sensor module V3.0): The surface EMG sensor is used, which consists of three electrodes: positive, negative and ground. The electrodes are put on the muscles to get the graph and the numerical values. Based on the numerical values obtained, the physical stress is detected[13].

III. RESULT

The data from various sensors is successfully recorded and the stress level is determined. Readings of some students were taken from the device for two intervals which are: (i) During the mid-term examination; (ii) After the mid-term examination. The results are recorded and can be used to determine the mental as well as the physical stress.

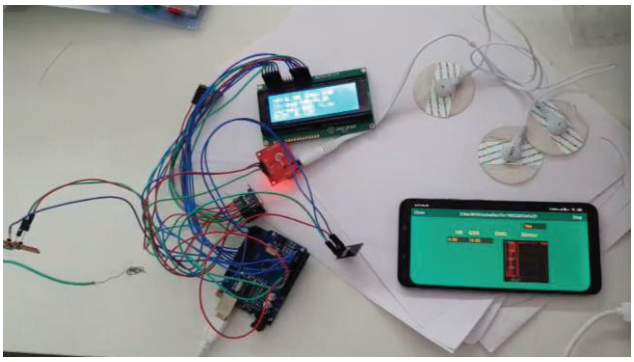


Fig. 6. Experimental Setup

Fig. 7. Display of the data recorded from the sensors on the LCD screen

Fig. 8. Display of data recorded from the sensor on the mobile application

TABLE I. READINGS OF THE SYSTEM DURING THE MID-TERM EXAMINATION.

[L-LOW, M-MEDIUM, N-NO]

USER	HEARTBEAT (bpm)	STRESS LEVEL (HRV)	GALVANIC SKIN RESPONSE (micro-siemen)	STRESS LEVEL(GSR)	ELECTROMYOGRAM (micro-volts)	STRESS(EMG)
1	104	M	1.30	L	540	N
2	94	M	1.10	L	555	N
3	98	M	1.08	L	460	N
4	103	M	2.00	M	589	N
5	75	L	0.04	L	537	N
6	88	L	0.50	L	490	N
7	90	L	0.40	L	567	N

TABLE II. READINGS OF THE SYSTEM AFTER THE MID-TERM EXAMINATION

USER	HEARTBEAT (bpm)	STRESS LEVEL (HRV)	GALVANIC SKIN RESPONSE (micro-siemen)	STRESS LEVEL(GSR)	ELECTROMYOGRAM (micro-volts)	STRESS(EMG)
1	101	M	1.28	L	523	N
2	80	L	1.00	L	575	N
3	95	M	1.06	L	490	N
4	79	L	1.50	L	567	N
5	70	L	0.20	L	522	N
6	80	L	0.23	L	487	N
7	89	L	0.35	L	569	N

From the above results which are obtained, we can see that during the period of mid- term examination there is clearly the change in health parameter of the users which gives a possibility of increased stress in the individual. By knowing the possibility of increased stress, the users can work on preventive measures or take advices from the counselor to avoid any chances of this stress getting long term or into situation of chronic stress. In the above observation no individual was highly stressed which was a good thing, but in case of high stress there is more chances of long term stress which can avoided if proper monitoring is there. The stress due to electromyogram was not affected as the users did not have any muscle problems. So only the mental stress of the individual was affected in the above observation and no indication of physical stress. But when there is physical stress the values of electromyogram would vary and there is most chance that there would be variation in the values of the mental stress parameters as both are related [15].

In [16], stress measurement is done through a created environment using mood videos, while in this work real stress scenario for students is considered to measure the impact of stress on health.

IV. CONCLUSION

In this paper, a real time stress measurement model was proposed. The methodology and its validation was presented. The readings obtained from the students can be utilized to check their mental and physical stress level. The system can also be used for monitoring the stress level of working people in the corporate field, older people, pregnant women, aircraft pilots and in people from other fields also. Future work can be done to include more bio sensors in the system to make the system more efficient. The system has some limitations which include non-measurement of chronic stress (long-term stress). Furthermore, works can be done on the system by including more types of bio-signal sensors.

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