Real-Time Personalized Stress Detection from Physiological Signals

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***Abstract*—This is the era of modern life. The era of email, text messages, Facebook and Twitter, careers Crisis news coming from everywhere at any time. We (human) are assaulted with facts, pseudo facts, jibber-jabber, and rumour all posing as information. We text while we're walking across the street, catch up on email while standing in a queue. When people think they're multitasking, they're actually just switching from one task to another very rapidly. It has been found to increase the production of the stress that results overstimulate brains and cause mental fog or scrambled thinking. However, stress management should start far before the stress start causing illnesses. In this paper, a real-time personalized stress detection system from physiological signals is introduced. It is based on Pulse rate and temperature. That could record a person's stress levels.**

Keywords*— *Human stress, physiological signals, signal processing

I. INTRODUCTION

Stress is something that require by human to show or adjust in aspects of emotional, mental and physical then make physiological changes in the body as human beings try to adapt and adjust their environment. Identifying the human stress remains a major challenge in the computational field.. In the new era modern, high technology developing further, information and knowledge available increase at rapid speed cause people to always changing and updating lifestyle. Especially life in city, people always people learn and know more about how to stay up-to-date in all field. About half of medical problems faced by workers cause of higher stress levels identified by health professional [1]. Lifestyle can bring people to form of higher stress levels that cause a health problem. Due to stress, human daily activities will be get influence too cause of the body systems not working properly such as nervous system, cardiovascular system, endocrine system and reproductive system that contributes to physical and physiological health problems. Stress can be classed as chronic stress, episodic stress and acute stress [2]. Where each has owns approaches. The emotional and physical reactions faced by human for this type stress such as insomnia, unable to focus and headache [3][4]. So, to overcome this situation, a stress detector is need which can help people to precautions and keep of their stress level. Stress is depends highly on individualistic and how the individual respond on how anything comes to him. Therefore, human stress can be detected by captured some signals in human body called physiological signals such as skin temperature, galvanic skin response (GSR) and heart rate. This work is to design a system that can measure the level of stress using the physiological signals in human body that are heart rate, galvanic skin response, and skin temperature. Fuzzy logic is used to provide results with acceptable accuracy to the user.

II. RELATED WORK

Different methodologies and systems have been designed by researchers to approach the better type of research. For example, research to ensure is the GSR can be analyzed to detect human stress [5]. Detection is done for who are stressed especially the workers at their work place.

To obtain more accurate results of stress affective state analysis, the researchers used multiple physiological signals such as Galvanic Skin Response (GSR), Pupil Diameter (PD), Blood Volume Pulse (BVP) and Skin Temperature (ST) [6]. The physiological signals monitored have a strong correlation with emotional state and the stress stimuli may induce the changes in emotional state is proved by the result. The experimental setup is through non-invasive monitoring of physiological signals for detection in computer. The using of the contact sensor which can detect the heartbeat of a car driver is presented to detect the driver stress while driving [7]. To capture speed via skin vibrations near thyroid cartilage and carotid the skin of the driver is connected to the non-acoustic sensor. They introduce with alternative designs with attachable sensors at the seatbelt and seat of the car as drivers can be uncomfortable to contact the device at their body most time driving. But this proposal show only whether the driver was stressed or not and was not exactly measure stress level. Non-invasive stress detection with heart rate and galvanic skin response (GSR) proposed as physiological input is needed for testing and validating the proposed system [8]. It is required to measuring stress in individuals by perform a set of psychological experiments. As the result, with 10-seconds they recorded 99.5% accuracy and 90% when reduced to 5 seconds. The researcher also proposed mobile on-call system using heart rate, blood pressure and body temperature for senior citizens [9]. The advantage for this research is low cost device built, but limited to ages 65 years and above people only. Moreover, the using of the sensors connected to the chest can be improved by using electrode sticks. There are also research about using wearable sensors based on

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Electrocardiogram (ECG) wireless chest belt, conduction of skin, Electromyography (EMG), and respiration [10]. To extract features of the signals body the researcher uses the three different stress tasks which is calculation, logical and puzzle and also four schemes used to analyze the data which is K- Nearest Neighbour, Fisher's Least Square, Quadratic Bayes Normal and Linear Bayes Normal. It is not suitable for real-time applications because long data collection period was required as the research use the standard approaches to capture signal from body.

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III. STRESS DETECTION AND CLASSIFICATION

To analyze the data from the stress detection system and generate result, the decision making module is needed since the physiological signals data read from the body has large scope. It also can analysis the value of each signals and state whether stress or not for the individual. Decision making module is of better ways to give accurate result together with signal processing and feature extraction. The common techniques used are K- Nearest neighbor (k-NN) [11]. Support Vector Machine (SVM) [12]. Bayesian Network and Fuzzy Logic. However, k-NN has slower character compared to others due to extensive use of memory. There are two types of SVM which is linear and non linear. These two types handle based on situation and equation. They can be used to predict future trends after the SVM classifier are trained. The researcher succesfully obtained 84% accuracy by using 10 fold cross validation [12]. But, SVM is ineffective because it required more kernel elaborations. In this work, Fuzzy Logic was used.

IV. METHODOLOGY AND IMPLEMENTATION

In this work, two physiological signals have been used, Skin temperature and Human Pulse Rate. Skin temperature detect by temperature sensor which function to sense the ambient temperature and get an output. The temperature of the surface of the skin can provide attractive data about the individual health, including stress. The stress detector able to accurately detect the temperature gradients present across its surface in real time application. This project prefer to use LM35 as it is user friendly, lower cost and stable of accuracy.The temperature range to be measured are about 25 degree Celcius to 40 degree Celcius.

For heart rate, the tool to detect it also known as pulse sensor is capable to detect the electrical activity of the heart by attaching electrode at select locations such as fingertip, legs, chest and arms. It is exactly pumping blood flow through the body, while the heart is beating cause the blood volume in the body artery to vary also. The signal can be analyzed furtherfor the microcontroller to calculate the heart rate. Figure xx shows the proposed scheme for this work.

A. PROPOSED SCHEME

Arduino Mega board is connected to the LCD to show the output of the system as shown in Figure 1. After captured the signal using the pulse rate sensor and temperature sensor, the data will be processed by the controller. The controller works with C programming and for this project there are three parts of coding which include pulse sensor, temperature sensor and fuzzy logic

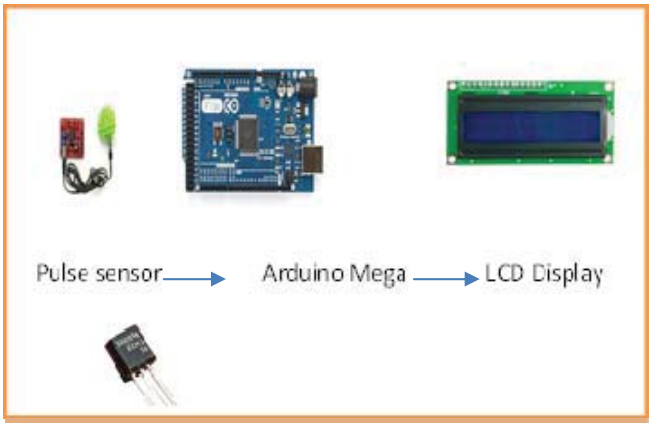

Figure 1 : Block diagram of stress detection system

V. RESULTS AND ANALYSIS

From the Arduino system, the results are obtained and the important information including heart rate, temperature and stress level which is output of the system. To make the project more real application the information is displayed on LCD. It also can be displayed on PC by using Arduino software monitor as shown in Figure 2.

```
60bpm , 41.02 *C
Temperature: 0.49, 0.01, 0.00
Heart rate: 1.00, 0.00, 0.00
Stress rate: 24.27

56bpm , 41.50 *C
Temperature: 0.25, 0.25, 0.00
Heart rate: 0.93, 0.00, 0.00
Stress rate: 31.46

54bpm , 41.50 *C
Temperature: 0.25, 0.25, 0.00
Heart rate: 0.90, 0.00, 0.00
Stress rate: 31.46

59bpm , 41.02 *C
Temperature: 0.49, 0.01, 0.00
Heart rate: 0.98, 0.00, 0.00
Stress rate: 24.27

61bpm , 41.50 *C
Temperature: 0.25, 0.25, 0.00
Heart rate: 0.90, 0.00, 0.00
Stress rate: 31.46
```

Figure 2: Serial monitor display

A. BODY TEMPERATURE SENSOR OUTPUT RESULT

The body temperature differs among different people because it depends on the individual metabolism, conditions and activities. Figure 3 shows the body temperature measurement as measured by the temperature sensor and displayed on monitor.

Figure 3: Body temperature output result

B. PULSE RATE SENSOR OUTPUT RESULT

To test the pulse sensor is functioning by test with Oscilloscope. The figure.4 shows the pulse rate frequency which is 1.209Hz per second.

Figure 4: Pulse rate sensor with oscilloscope

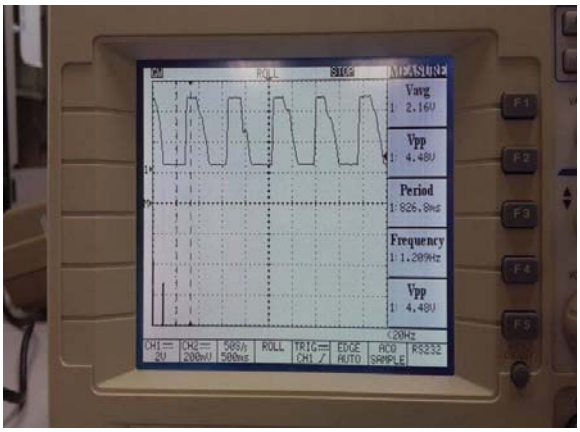

Figure 5: Pulse rate frequency

VI. PROTITYPE DESIGN AND TESTING

Figure 4.5 shows the prototype with Arduino Mega controller. The LCD displayed the ouput stress level and the input of physiological signal values. The level of stress is determined by showing in percentage.

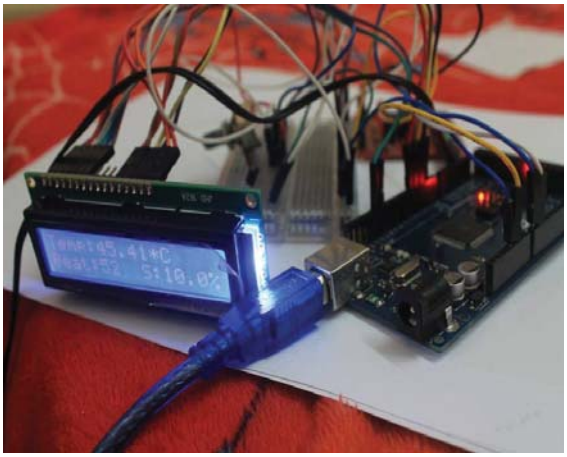

Figure 6: Prototype with Arduino Mega

For table 1 shows the reading of low, medium and high stress according to the temperature and heart rate value. A fuzzy logic rule is stated in table 2 and it is used by the fuzzy logic system to get the value of stress level. We can see for the high level of stress stated when temperature lower and beat per minute (BPM) is higher while other consist of medium and low level of stress.

Table 1 Two physiological signals threshold values

	Low Stress	**Medium Stress**	**High stress**
Temperature (C)	> 44	41 ~ 44	< 41
Heart rate (BPM)	< 70	70 ~ 90	> 90
Stress level	0-50	50-80	80-100

Table 2: Fuzzy logic rules

BPM	Temperature	Stress
L	L	L
L	M	M
L	H	H
M	L	L
M	M	M
M	H	M
H	L	L
H	M	M
H	H	M
H : High	**M** : Medium	**L** : Low

VII. SIMULATION RESULTS

In Arduino based system, the execution speed can be measured by timer function included in Arduino. Figure 4.5 shows the result of the stress level. The advantage of the Arduino also is be able to generate the output almost instantly.

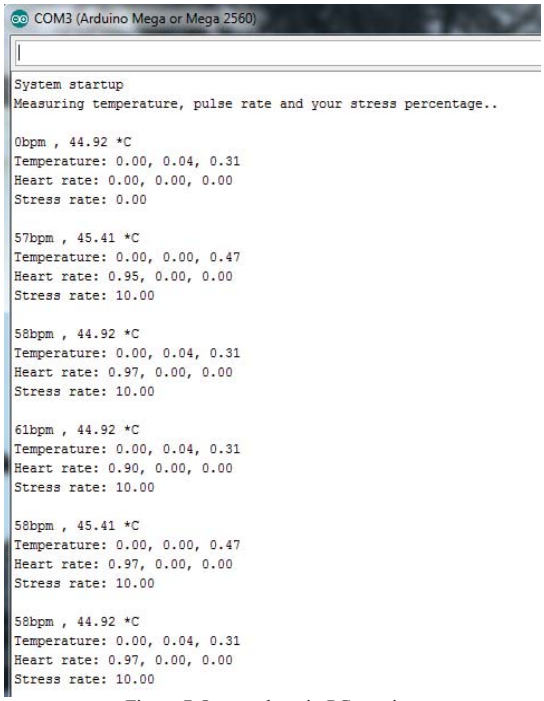

Figure 7 Output show in PC monitor

A. Physiological Signals

The experiment is setup by collect physiological signals from 4 participants aged between 21 and 24 (2 women and 2 men). To be recorded by the stress detector system, individuals attatched the sensors to their fingers acquiring at the same pulse rate and body temperature to be recorded.
The physiological signals are obtained in 3 minutes with 5 seconds sample time for each stage. There are 3 stages in the experiment, which are initial, game and relax.

In the initial stages, the participants are ready and start to use the prototype. Game stage is done by the participants play a tricky games and the relax stage refer to the period where the participants will breathing slowly and deeply in 2 minutes. The position of the participants must be in correct ways to ensure the sensor get the right physiological signals from the body.

Table 3 show the summaries of the physiological responses over 3 minutes for initital ,game and relax stage. The heart rate show increased obviously after playing the game and reduced after relaxing while temperature not change obviously.

Table 3 Summaries of the physiological responses

	Initial			Game			Relax		
Participant	T	B	S	T	B	S	T	B	S
A	43	80	17	42	100	60.7	42.6	87	24.3
B	42	85	12	41	107	64.4	41.4	80	22
C	43.5	60	10	41.5	87	47.8	42	62	15.6
D	43.8	70	11	41.8	82	45.1	42.3	66	17
T: **Temperature** B: **Beat** S: **Stress**									

The important part in this project involved design of prototype which is able to detect pulse rate and body temperature in different situations. It also show an initial threshold between being relaxed or being stressed. It can be determined that signals increase or decrease depending on the mental effort and the situation of the user with the differet data measured.

Conclusion

Stress detection system can help people to manage their stress level espcially the person who suffer the episodic and chronic stress. The development of fuzzy logical is proposed as it is capable to determine based on the readings from the physiological sensors whether the user is under stress or not. Moreover, it can captured the signals from the real time information on the person by using Arduino Mega board with three type of sensorswhich are temperature sensor and heart rate sensor. The algorithm may helps to get their stress level with processing of fuzzy logic system and some numbers of fuzzy rules.

As a conclusion, based on the results obtained from the project, a protoype of stress detector has been successfully developed. It showed that the project achieved the proposed objective. The signals measured by the stress detection system on the state of mind of the human contain real time information. Apart from that, the prototype is designed to use low cost equipment and create a real time application.

In addition, Arduino Mega microcontroller is portable, affordable and easier used can help to implement such system in real time application. The visual output also make the system look useful and the important is more attractive.

People can handle it to manage their stress level with understand what stressor cause the stress problem by creating a stand-alone stress detector. This system also suitable to be experimented for pregnant women, autistic children and others who in high level of stress which can be in danger.

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