Health Monitoring and Stress Detection System

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Abstract:- *This paper presents a system that amalgamates a Health Monitoring System with a Stress Detection System in order to utilize the physiological data acquired for monitoring the personal health of a person to detect mental stress levels of that person and to reduce the production cost of the involved systems. Furthermore, the Accuracy of this approach of stress detection is comparatively high as it involves collective analysis of stress-related data, and brainwaves, that are representations of the mental state of the person in the form of patterns of electrical pulse activity that are studied using EEG. Since stress has become an important phenomenon that almost everybody in the modern world go through, its management or detection should be ascertained for reliability. Ultimately, this paper's proposal of a high-accuracy approach to stress detection alongside health monitoring could be more relevant and useful in the current scenario.*

Key Words: Stress Detection, Health, EEG Electrode, Brainwaves, GSR, ECG, Monitoring, Affective Computing

1. INTRODUCTION

Mental Stress, as a psychological phenomenon or emotional pressure, has a lot to deal with neurological and physiological aspects of the human body. There are experiments to determine stress using heart rate sensors (or) using physiological signals based on soft computing techniques (or) implementing wearable sensors around the body. However, the problem of wearing the sensors and electrodes around the body for a long time is present. These methods are not accurate as well. They are of invasive type. Our method is also of invasive type, but the accuracy is comparatively high as it implements Electroencephalographic electrodes (EEG). Using EEG, the mental state of a person can be easily studied with the help of brainwaves. Also, there is an effective formula for stress detection involving Evaluation Parameters (True Stress Detection Rate & True Non-Stress Detection Rate) and Temporal Parameters (Template Time & Acquisition Time). The physiological signals proposed by this paper are Galvanic Skin Response (GSR), also known as Skin Conductance (SC), and Heart Rate (HR). These two signals were selected based on their properties regarding non-invasivity when being acquired and because of their variation is strongly related to stress stimuli.

2. LITERATURE REVIEW

Mental Stress has been a recurring topic in research papers due to its increasing relevance in modern society and many methods have been proposed to cope with it. This work [**Error! Reference source not found.**] proposes ways to control work-related stress that can be beneficial to both employees and the organization itself. Comprised of three parts, it offers techniques for both employees and organizations to deal with dysfunctional stress. Then, this paper [2] reviews wearable sensor-based systems for Health Monitoring and Prognosis; various systems are compared to rectify the shortcomings of the current biosensor networks and provides reference and direction for future unobtrusive solutions. In this work [3], they investigate HRV patterns from normal healthy people during sleep. This is done to recognize stress. HRV is known to be an indicator of the autonomic nervous system activity. HRV reflects the variation of the beat-to-beat (RR) intervals.

This latest research paper [4] proposes a method of detecting stress with classified three levels (stress, relax, and neutral) with a resolution of a few seconds and 86% accuracy. They have designed a system called RABio w8 (real-time acquisition of bio signals, wireless, eight channels) with both hardware and software being implemented in their laboratory. The electronics of RABio is comprised of three blocks (Acquisition block, control block, and communication block). They conducted a study to validate their system involving ten volunteer subjects. The stress markers used here are the average relative gamma (RG), the average heart rate (HR), the average skin conductance (SC), and the average trapezius activity (TA).

3. PROPOSED METHODOLOGY

Our approach of stress detection involves measuring various health parameters such as the heart rate, body temperature, blood pressure, and skin conductance using appropriate biosensors and analyzes them to detect the stress level. Since these health parameters are also identified as stress markers, we use them all for this purpose alongside the health monitoring part of our project. We use Arduino UNO for the microcontroller which processes all the input data from various biosensors, analyzes and forwards the stress level along with a few health parameters as a Display Report (Analyzed Report) to the user. The "Stressed-out," condition is notified to the user using an Alert System.

In this system, each input variable (health parameter) has a stress marker range. The data acquired below this range is considered Normal. In order to avoid the false alarm, the data from all the major biosensors have to attain their corresponding stress marker range. This ascertains that whether the user's mental condition is really stressed or not. We use electroencephalography (EEG) in our project to study brainwaves and to deduce the stress level of the user. The whole system is powered by a 9V rechargeable battery which lasts for nearly 2 days. The processed data from the Arduino UNO can also be transmitted to a remote hospital system when there is an emergency using GSM module (see Figure 1). For the large-scale implementation of our project, we can use Wi-Fi module to perform cloud computing.

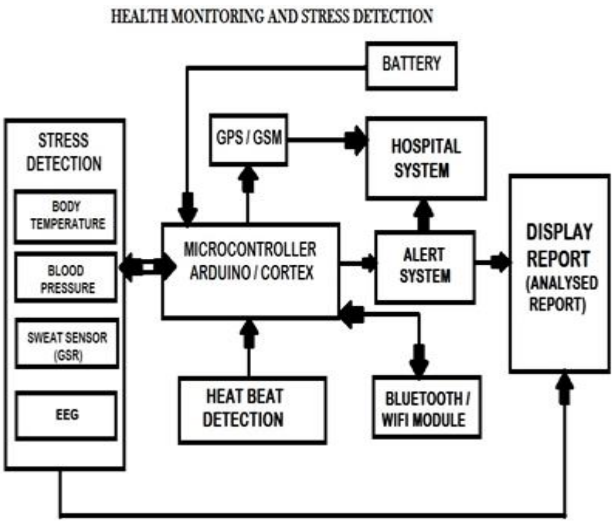

Figure 1: Block Diagram of Health Monitoring and Stress Detection System

4. PROJECT DEVELOPMENT

The development of our project can be explained in Four Stages.

They are,

1. Research
2. Back-end Development
3. Front-end Development
4. Testing and Implementation

4.1. Research

We began the research stage of our project by doing literature reviews in the mutually interested biomedical domain. We arrived at the idea of our project after we came across many research papers under the topic "Stress." After that, we studied about health monitoring systems and decided to use the same for detection of human stress level as many of the health parameters acquired in the health monitoring systems are also identified stress markers. This research has helped in guiding the project itself and in selection of appropriate modules that are beneficial and relevant according to the current technology standards.

4.2. Back-end Development

The back-end development stage of our project has involved PHP programming for web development in server-side scripting. This helps in collecting sensor data, generating dynamic page content, and analyzing databases. PHP supports any commonly available OS and most of the web servers available today. So, we utilized it to develop the back-end of our project. For the web server, we used *Jemi Cluster,* the private web server of Infoziant Technologies Pvt. Ltd.

4.3. Front-end Development

The front-end development involved coding with Embedded C in Arduino IDE (Integrated Development Environment). This programming helped in indicating the stress level after verifying the range of various stress markers. The display report is presented with a graph (between skin conductance and heart rate) using the stress coding algorithm that we have done.

4.4. Testing and Implementation

Our project implements statistical analysis of the collected data using previously identified effective formulae. These formulae consists of proven stress markers like the average relative gamma (RG) for EEG data which is used in emotion and stress studies, the average heart rate (HR) for ECG data, the average skin conductance (SC) for GSR data, and the average blood pressure (BP). The grand-average of the processed stress markers was computed. The signal processing equations for identifying various stress markers are as follows:

a. RG = AvPower (25–45 Hz) / AvPower (4–13 Hz)

where,

AvPower (25–45 Hz) - The power in gamma (25–45 Hz) bands

AvPower (4–13 Hz) - The power in theta-alpha (4–13 Hz) bands

b. HR (bpm) = 60/ AvRR

where,

AvRR – The average R–R interval length

c. SC = 2 * (AvVoltage – 0.5)/100,000

The SC is one of the most used stress markers in literature. Also, we use two assessment parameters: True Stress Detection (TSD) rate and True Non-Stress Detection (TNSD) rate. TSD can be described as follows in equation (1).

d. $$\text{TSD} = \frac{\#\text{True Positives}}{\#\text{True Positives} + \#\text{False Negatives}} \qquad (1)$$

Where, a True Positive means classifying as stressed an individual which is indeed under stress, and a False Negative means classifying as relaxed an individual which is under stressing situations.

TNSD can be described by equation (2).

e. $$\text{TNSD} = \frac{\#\text{True Negatives}}{\#\text{True Negatives} + \#\text{False Positives}} \qquad (2)$$

Where, a True Negative means classifying as non-stressed an individual which is not under stress, and a False Positive means classifying as stressed an individual which is calm and relaxed.

The performance of the system (TSD and TNSD) depends on two temporal parameters: Template time (t_T) and Acquisition time (t_{acq}). The former time regards the required time to obtain the template, and the latter is related to the time demanded to acquire stress information from an individual. The longer t_T and t_{acq} are, the more accurate the system is. In order to save the time, a balance among t_T, t_{acq}, TSD and TNSD must be achieved.

5. CONCLUSION

As of now, even with our technological advancements, there is no low-cost reliable solution available for detecting stress. Although there are many mobile applications available regarding e-Health, there is no application to measure stress accurately. Our work uses previously identified stress markers to determine the stress level with low-cost hardware and comparatively higher accuracy. Since this approach involves EEG, we analyze the exact mental condition of the user with the help of their brain rhythms. This is the reason behind improved accuracy and, in the near future, there will be unobtrusive solutions to detect stress levels with less hardware. We have reduced the hardware modules required by coding effective programs to analyze the stress level and by hitting a tradeoff with higher accuracy at the expense of sophisticated devices.

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REFERENCES

1. Matteson, Michael T.; Ivancevich, John M.; Controlling work stress: Effective human resource and management strategies. San Francisco, CA, US: Jossey-Bass. **1987**
2. Alexandros Pantelopoulos; Nikolaos G. Bourbakis; A Survey on Wearable Sensor-Based Systems for Health Monitoring and Prognosis. IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews); Volume: 40, Issue: 1. **2009**
3. Amir Muaremi; Bert Arnrich; Gerhard Troster; Towards Measuring Stress with Smartphones and Wearable Devices During Workday and Sleep. Zurich, Switzerland. **2013**
4. Jesus Minguillon; Eduardo Perez; Miguel Angel Lopez-Gordo; Francisco Pelayo; Maria Jose Sanchez-Carrion; Portable System for Real-Time Detection of Stress Level. Sensors **2018**, 18(8), 2504.
5. Victor Custodio; Francisco J. Herrera; Gregorio Lopez; Jose Ignacio Moreno; A Review on Architectures and Communications Technologies for Wearable Health-Monitoring Systems. Madrid, Spain. **2012**
6. Black, A.D.; Car, J.; Pagliari, C.; Anandan, C.; Cresswell, K.; Bokun, T.; McKinstry, B.; Procter, R.; Majeed, A.; Sheikh, A. The impact of ehealth on the quality and safety of health care: A systematic overview. PLoS Med. **2011**, 8, e1000387.
7. Chandiramani, S.; Cohorn, L.C.; Chandiramani, S. Heart rate changes during acute mental stress with closed loop stimulation: Report on two single-blinded, pacemaker studies. Pacing Clin. Electrophysiol. 2007, 30, 976–984.
8. Lorenz, A.; Oppermann, R. Mobile health monitoring for the elderly: Designing for diversity. Pervasive Mob. Comput. **2009**, 5, 478–495.

9. Dimitriev, D.A.; Saperova, E.V. Heart rate variability and blood pressure during mental stress. Ross Fiziol Zh Im I M Sechenova **2015**, 101, 98–107.

10. Ranganathan, G.; Rangarajan, R.; Bindhu, V. Estimation of heart rate signals for mental stress assessment using neuro fuzzy technique. Appl. Soft Comput. **2012**, 12, 1978–1984.

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