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IoT BASED PHYSIOLOGICAL STRESS MONITORING AND MANAGING DEVICE

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Abstract - Physiological signals are significant indicators that can help anticipate harmful underlying conditions in humans. Recent advancements in medicine and electronics have allowed monitoring of physiological signals cost effectively and noninvasively. People living in remote areas are usually deprived of basic healthcare facilities and the available remote physiological signals monitoring techniques make use of Bluetooth and WLAN (Wireless Local Area Network) technologies which are inoperable in such areas. The system proposed in this paper solves this issue by making use of IoT (Internet of Things) and GPS (Global Positioning System) communication techniques due to their vast availability even at remote locations. The proposed system monitors three physiological signals namely heart rate, skin conductance and skin temperature non-invasively and also classifies stress levels. Finally, the physiological signals and stress levels data is stored for record maintenance and sent to a doctor so that he/she may monitor the patient remotely. A rule based fuzzy logic algorithm is used for stress classification and the results shows that it achieved the highest accuracy when compared to other algorithms found in previous works. In addition to that, a stress levels dataset is also presented in this paper which can be further refined in future research. Index Terms—Physiological signals, stress, healthcare, remote monitoring, heart rate, skin conductance, temperature, IOT, GPS.

1. INTRODUCTION

Healthcare is a basic and important part of everyone's life. But even after a lot of time, money, and research in the advancements of medical science, many people are still deprived of basic healthcare facilities. People affected by this problem are usually the ones who live in remote areas. In addition to that, medical professionals also prefer living in urban areas instead of rural areas due to certain benefits. In this era of technology, such problems can be reduced with the help of technology if not resolved completely by using remote physiological signals monitoring for people residing in rural areas. Physiological signals such as heart rate, perspiration, temperature, and respiration are governed by the Autonomic Nervous System (ANS) and their variation is considered as an indicator of some underlying problem or condition. For instance, variation in heart rate can indicate stress, arrhythmia, and stroke. This paper proposes a system using IoT and GPS (Global Positioning System) based remote physiological signals monitoring and stress classification system in real-time. The proposed system will not only overcome the problem of remote monitoring, but also reduce the shortage of Patient to doctor ratio. The currently available remote monitoring systems usually incorporate Bluetooth or WLAN technologies but in such remote areas these technologies are inoperable.

Therefore, the current system proposes an IoT and GPS (Global Positioning System) based multiple physiological signals monitoring system that can work almost everywhere. Such system can continuously record physiological signals data and the doctor can remotely monitor the patient. Along with that, current research also provides a stress levels dataset which is tested with multiple algorithms to find the algorithm with highest accuracy which can be implemented in the proposed system's prototype.

A. STRESS

The human stress essentially relates to a psycho physiological response of an individual as a reaction to an Unsafe or uncomfortable stimulus also known as stressor. Stressors have significant impact upon a person's state of mind, feeling of prosperity, conduct, and wellbeing. In any case, if the danger is unremitting, especially in people who are more prone to certain diseases, the long-haul impacts of stressors can unfavorably influence their well-being. The connection amongst stress and illnesses is influenced by the nature, number, and prolonged existence of the stressors and additionally by the person's immune system's vulnerability, for example, hereditary conditions.

B. EFFECTS OF STRESS ON HEALTH

It is known that when stress starts interfering with an individual's ability to live a normal life for an extended period, it becomes even more dangerous. The longer the stress lasts, the worse it is for an individual's mind and body. One might feel fatigued, unable to concentrate or irritable for no good reason and it causes wear and tear on the individual's body too. Over-stress has proven to be one of the major factors contributing to several serious health problems such as elevated blood pressure, headache, stomach upset and can worsen certain symptoms or diseases. It can be detrimental to both physical and mental health as it is a risk factor for hypertension, coronary heart disease, irritable bowel syndrome, gastro-oesophageal reflux and back pain. A survey conducted by American Psychological Association, indicated that stress is a leading cause of health problems. Furthermore, 94% of the people agree with that fact that stress is an essential factor in development of illnesses such as depression, heart diseases and obesity. Stress can also trigger heart attacks, arrhythmias and sudden death. Various research in the area of psychophysiology, show that variation in emotions of a human also accompany multiple physiological changes in the human body, for instance, blood pressure, blood volume, electro dermal activity, heart rate, size of pupil, skin temperature and brain waves. Such changes in physiological signals can be acquired with the help of physiological or biological sensors.

C. CURRENT WORKS AND THEIR LIMITATIONS

Various researchers have contributed in the field of Physiological signals monitoring and stress levels Classifications, resulting in development of various techniques, devices and algorithms for this purpose. For instance, skin conductance and heart rate signals were measured in this research. Interestingly, subjects were unaware of the fact that their stress levels were being measured as the subjects were told that they would participate in a game and will receive prize money. This was done to induce the stress naturally into the subjects. A Linear Discriminant Analysis (LDA) based classifier was used in this research for stress classification. However, the research needs to be done on a wider population. Moreover, in data fusion technique was used for the purpose of stress detection. The researcher obtained stressed levels by only using Electro Encephalogram (EEG) signal while achieving an accuracy of 79%, whereas after fusing the EEG and Electromyography (EMG) signals, the achieved accuracy was 92%. Fisher Discriminant Analysis (FDA) was used as a classifier in this research. The achieved accuracy is impressive however; the use of EEG signal is not suitable for continuous monitoring due to the size and complexity of the device. In the accelerometer, Galvanic Skin Response (GSR) and ECG signals are used to measure stress. The measured stress is during three daily common activities namely sitting, standing, and walking to differentiate between stress and physical states.

The stress classification was done with the help of fuzzy logic. The achieved accuracy was impressive but the use of such device for data acquisition is not suitable for remote application. Also, the algorithm uses a fixed stress template, but the physiological signals vary from person to person. Furthermore, wireless chest belt and hand sensors were used for the purpose of stress detection. The chest belt consisted of piezoelectric film sensors and gel electrodes for measuring ECG and respiration whereas for skin perspiration, hand sensor for used. For stress classification, Bayes and k-Nearest Neighbours (k-NN) classifiers were used. Though, the ECG and respiration are significant indicators of stress but for continuous and remote monitoring, such device is uncomfortable and impractical. An Eye gaze tracking system (ASL-504) for measuring pupil diameter, GSR sensors for measuring skin conductance and BVP sensors for measuring blood volume pulse but this device is also neither wearable nor portable. In this research, support vector machines were used for decision-making. A fuzzy influenced system as a decision-making module in this research for stress classification. The respective electronic sensors helped measure blood pressure, heart rate variations, skin conductance and body temperature. The accuracy found was good but it is still a software based computing technique.

II. PROPOSED SYSTEM

The generalized framework of the proposed system is shown in Figure 1. In the input phase, the three physiological signals are collected from the patient with the help of heart rate sensor, skin conductance sensor and temperature sensor. Later, in the pre-processing stage the obtained signals are filtered of any spikes or noise due to environmental factors with the help of a moving average filter. In the classification stage, the pre-processed data is sent to a stress classification algorithm which is a rule based fuzzy logic system that classifies the stress levels based on the input signal values. Finally, in last stage the output stress levels and physiological signal levels are shown on the LCD display and sent to the doctor with the help of IOT and GPS modules for remote monitoring of the patient. In addition to that, the output levels are also stored in a SD card which is already installed in the system in order to maintain the record for future references. Moreover, in cases of emergencies, when the output levels are too high, the patient's location along with an alert is sent to the doctor or caregiver. The data collection is based on the work of and further analysis of stored physiological signals data is done in MATLAB which is discussed in detail in coming sections.

C. PROTOTYPE DEVELOPMENT

The block diagram of the prototype for the proposed system is shown in Fig 2. The hardware consists of an Atmega328 microcontroller, heart rate sensor, galvanic skin response sensor, temperature sensor, IOT module, GPS module, LCD module and a SD card module. The moving average filter is programmed in the microcontroller for filtering the input data signals and the fuzzy logic algorithm is implemented in microcontroller with the help of embedded Fuzzy Logic Library (eFLL) along with eight rules for stress classification. The sensors collect the physiological signals data from the patient and send to the microcontroller which then passes through a filtering stage. The filtered data is then fed to the fuzzy logic algorithm which classifies different levels of stress based on the pre-defined rules. Finally, the output physiological signals and the classified stress level are displayed on the LCD (Liquid Crystal Display) module and sent to the doctor or caregiver using the IOT module along with the location data in case of emergencies. In addition to that, the output data is stored in the SD card for record maintenance and further analysis.

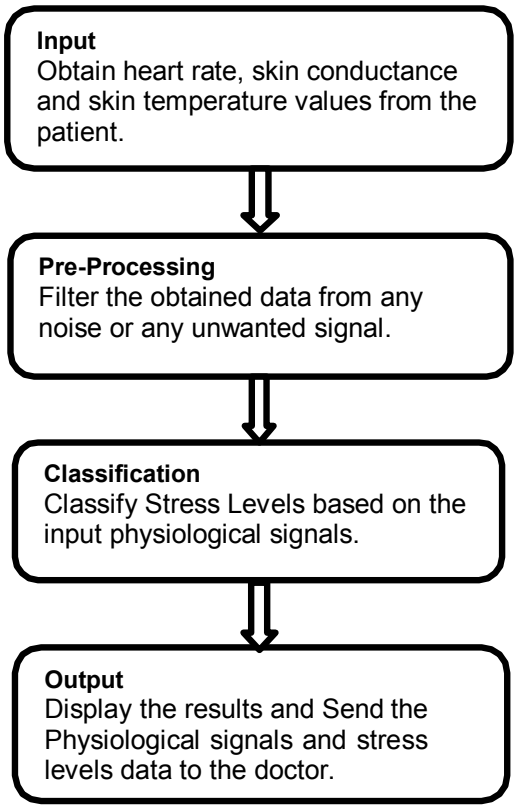

Fig.2.1 Generalized framework of the proposed system.

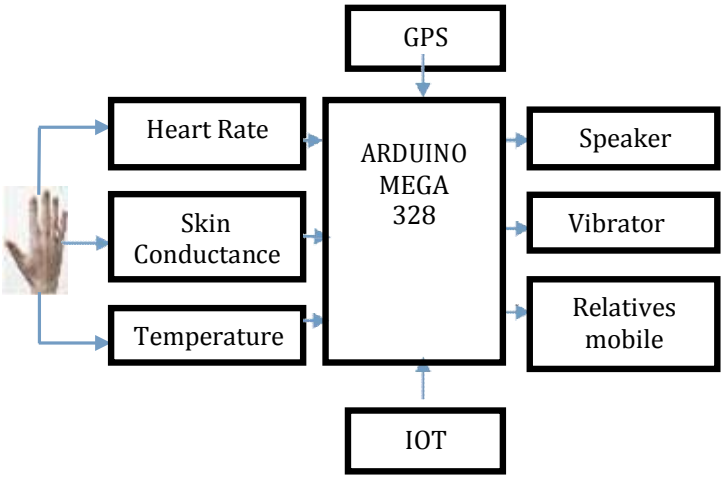

Fig.2.2 Block diagram of Proposed System.

D. DATA COLLECTION

In the data collection phase, the prototype was tested on real subjects and their physiological signals were analysed in terms of stress. For the evaluation, 35 subjects were chosen among which 16 were females and 19 were males. The heart rate, skin conductance and temperature sensors were attached to the fingers of subjects with the help of Velcro straps. The experiment was divided in to three phases; P-1 for low stress or no stress phase also known as training phase, P-2 for medium stress phase and P-3 for high stress phase. An evaluation form was made to evaluate the subjects which consisted of four pages. First page contained the information regarding the patient such as age, gender and medical history. This page was being used by the evaluator as it also contained a table to note the sensor readings obtained from the subjects. The second page was given to the subjects after P-1, P-2 and P3 were finished which contained the general psychological questions asked by psychiatrists for stress, anxiety and depression evaluation. The third page contained the arithmetic game which was the main part of this experiment. In this game the subject was given five arithmetic problems which he had to solve by using four basic arithmetic operations. The objective of this game was to get the result as close as possible to the target number. Though, there is no time-limit for this part. This was the phase 2 (P-2) of the experiment which was to test the medium stress. The fourth page of the evaluation form was given in the third phase (P-3) of the experiment for testing high stress. It also contained five arithmetic problems but with an increased difficulty level along with a time-limit of two minutes. The entire data collection was done in a controlled environment and under the supervision of a medical professional.

E. DATA ANALYSIS

Initially, only fuzzy logic was used to classify the stress levels and the decision was based on a fixed stress template defined by the eight rules programmed in the microcontroller as shown in Table I. The ranges of heart rate in Beats Per Minute (bpm), skin temperature in centigrade (°C) and skin conductance in micro-Siemens (µS) signals are shown in Table II . The stress levels were classified in a manner that, if the levels are 10 – 40 then Low Stress, if 40-70 then Medium Stress and if 70-100 then High Stress. In addition to that, the stored physiological signals data was also fed to Decision Tree, k-NN and Naive Bayes algorithms which were implemented in MATLAB and their accuracies were recorded. In addition to that, a statistical T-test was performed on the data using Microsoft Excel, to find if the stress levels of males and females have any significant difference. If the result of T-test is lower than 0.05, then it is significant but if the result is higher than 0.05, then it is insignificant. The accuracy of stress classification results obtained by fuzzy logic was calculated by using the formula given in Equation (1).

$$\text{Accuracy} = ((v1-v2)/v1)*100\ \% \quad \text{--- (1) Where,}$$

V1 = Total values. V2 = False Values.

2. CIRCUIT DIAGRAM

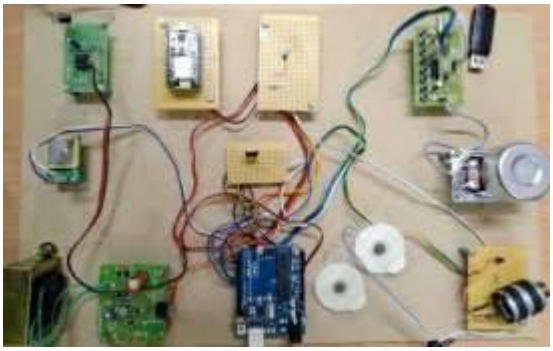

Fig 3.1 Circuit diagram of Proposed System

IV.CONCLUSION

This research proposed a real time physiological signals and stress levels classification system that can remotely monitor the parameters and send them to relatives and doctors. The GSM(Global System for Mobile) communication is highly suitable for remote monitoring due to its ease of use and its vast availability as compared to WLAN (Wireless Local Area Network).This system also achieved higher accuracy as compared to other classification techniques found in previous research.

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