MENTAL STRESS CALCULATION USING FUZZY LOGIC ALGORITHM

BHAVYA LAKSHMI\(^1\), ELNA BOBAN\(^2\), NEHA SULPHIKAR\(^3\), T M APARNA\(^4\), DHANYA S\(^5\), ANJALY S V\(^6\)

Abstract

Stress is any change in our body to react and adjust in response. The body reacts to changes in physical, mental and emotional responses. Many events that happen and many things that we do ourselves put stress on our body. Workplace stress is the most harmful physical and emotional response that can happen. The high demands in a job and low amount of control over the situation can lead to stress. When stress occurs that you cannot handle, both mental and physical changes may occur to your body. In this work, we present a solution for assessing the stress experience of working individuals, using features derived from the wearable device and display it in a mobile application. In particular, we use information like heart rate variability, respiratory rate, peripheral capillary oxygen saturation (SpO2) and temperature data collected during the workday. We evaluate our system in a real work environment using the fuzzy logic algorithm and calculate the occupational stress index.

1. Introduction

Stress affects many people each and every day. Life is full of deadlines, frustrations, and demands. For most people, stress is as common as it is a way of life. Stress is very harmful and or helpful. It motivates you to meet a deadline and perform a task under immense pressure. Stress is also very harmful, and results in memory problems, moodiness, aches, and eating more or less. An estimated one in every four people worldwide experiences a mental health problem at some point in their life. When it comes to treating conditions like depression and anxiety, it makes us focus on the office as a breeding ground for the stressor. The World Health Organisation has classed workplace burnout as an official medical diagnosis. The International Classification of Diseases, the World Health Organization’s handbook that helps medical providers diagnose diseases, classifies burnout as “a syndrome conceptualized as resulting from chronic workplace stress that has not been successfully managed”. Excessive workloads, lack of administrative support, and bureaucratic constraints are stressful not only because systemic factors prevent professionals from using their skills but also the stressors give workers a feeling that what they do is insignificant [Schaufeli2017]. People with chronic stress can experience a range of physical and psychological symptoms. The most common include a rapid heart rate, fast breathing, or hyperventilation, nausea, digestive issues, feeling too cold or too hot, fatigue, weakness, dizziness, etc.

2. Problem Statement

Our project is to build an application, which works with a wearable. The wearable focuses on collecting passive data respiratory, SpO2, temperature rate and heart rate variability since these are some of the main parameters that get affected during stress. AI determines they need to work on the most and what they need to optimise. We collect psychological, physiological, and neurological data in one place to get a really comprehensive idea of the wellbeing of the user. We implement it using the Fuzzy algorithm. Fuzzy logic is based on their decisions based on imprecise and non-numerical information. Fuzzy models are mathematical means of representing imprecise information (hence the term fuzzy). These models have the capability of recognising, representing, interpreting, manipulating, and utilising data and information that are vague and lack certainty.

3. Related Work

Stress detection is one of the main research topics in the area of affective computing. However, the focus has shifted from controlled experiments to real-life scenarios today. Along this direction, mobile devices such as smartphones and wearable devices, mainly heart rate sensors, have become the main tools for analysis.

\(^1\)ECE Dept., MITS, Varikoli, bhavyaram98@gmail.com
\(^2\)ECE Dept., MITS, Varikoli, elnamaryboban@gmail.com
\(^3\)ECE Dept., MITS, Varikoli, nehasulphikar@gmail.com
\(^4\)ECE Dept., MITS, Varikoli, appumarch4@gmail.com
\(^5\)ECE Dept., MITS, Varikoli, dhanyas@mgits.ac.in
\(^6\)ECE Dept., MITS, Varikoli, anjalisv@mgits.ac.in
1. Stress Recognition Method Using Peripheral Physiological Signals:

A framework for real-time stress recognition using peripheral physiological signals, which aimed to reduce the errors caused by individual differences and to improve the regressive performance of stress recognition [Li2019]. The proposed framework was presented as a transductive model based on transductive learning, which considered local learning as a virtue of the neighbourhood knowledge of training examples [Li2019].

The main contributions of this work are:

1) Proposed a transductive model to reduce the generalization error for stress recognition from the peripheral physiological signals [Li2019]
2) Extracting the non-linear peripheral physiological features, which can characterize the time-frequency features of small sliding windows to better support real-time stress recognition [Li2019]
3) The real interactive experiment was performed to explore the feasibility of this framework based on non-invasive sensors [Li2019]

Firstly, Stroop training was performed for real-time data collection to train the model for field studies. Then the trained model was used to recognize the subjects’ stress state in the learning scenario. It was done in the following manner. The subjects wore the wearable device on the non-dominant wrist, for recording the signals. The PC screen displayed a word, the meaning of which was one kind of colour, and its font colour was random. Subjects were asked to select the correct key that represented the font colour. The game comprised 4 levels, difficulty level ranging from simple to difficult. When the answer time was exceeded, the next word was taken, and the previous word was treated as an incorrect answer [Li2019]. In the simple model, we set the label equal to 1 when font colour and word were the same colour, and the label equal to 5 when font colour and word were a different colour, which was incremented respectively according to the difficulty level.

The peripheral physiological data like blood volume pulse and galvanic skin response of the subjects were measured and features were extracted from it. A transductive model was built combined with the optimization problem in the support vector regression, for local generalization.

2. Stress Detection Using Wearable Physiological and Sociometric Sensors:

In this paper, a novel approach for stress detection using a combination of wearable physiological and sociometric sensors is approached. The experiments were carried out under controlled conditions during different Trier social stress test sessions. The wearable system allows the state of a participant to be determined at any instant by providing an accurate decision regarding his/her stress state at any time. And classification results demonstrate that the method and analysis provide a useful tool for real-time stress detection.

Two sensor devices are used during experiments and the features extracted from them. From the electrodes situated on the fingers, the three different measurements are obtained: the skin conductance activity, the blood volume pulse and the beat-to-beat variability over a given period of time. The sociometric badge, worn around the neck is equipped with a microphone to record speech, an accelerometer to measure degree and direction of people’s movement, a Bluetooth transmitter to measure the proximity of other sensors, and an infrared transmitter to measure when two sensor wearers are facing one another. The TSST test consists of a neutral task followed by a public speaking task, a cognitive task, and a final neutral task. The synchronized signals recorded from each participant were stored in the corresponding dataset and classified using different classification approaches like support vector machine, AdaBoost, and K-nearest neighbour. The classification results for each personalized classifier are evaluated using accuracy, precision, and recall.

4. Proposed Solution

Data from the respiratory sensor and heartbeat sensor will be sent to the Arduino pro mini. We can monitor the value using a serial monitor. This will be sent to the application using the Node MCU wifi module. The output of the application will be stress index, mood tracker and suggestions. The functional block diagram for calculating stress is given in Fig.1. Inputs are provided to the Arduino pro-mini and calculated stress index. The index will be shown through a supporting android application.

Inputs will be collected to calculate the stress index. If there is an occurrence of stress. Then it will be classified into low, medium and high. According to the stress index, activities are provided by the application. If the stress index is low, the alarm is turned off.
Fig 1: Block Diagram

Fig 2: Algorithm
5. Scope of The Project

Levels are rising among employed Indians owing to growing uncertainty in jobs in a highly disruptive environment as well as increasing anxiety in personal lives, studies have revealed. Increasing stress has, in turn, led to a surge in the number of people who are suffering from depression and are at high risk of suicide. Thus the proposed project has high relevance in this scenario. The proposed project will reduce the number of people who suffer from diseases caused due to stress in the future. This project can be modified to make a health monitoring device in future by adding more features like heart attack detection, body temperature, etc.

6. Methodology

I. Hardware

The main components required for the wearable device are:

a. **Nano CH340 chipboard with Arduino**: This helps to program the collected data to calculate the stress index level. This can be used for any high-speed applications. Arduino can be used to connect to the software.

b. **ESP8266 Node MCU CP2102 board**: It is used to send the calculated stress index to the application. The board is based on the highly popular ESP8266 WiFi Module chip with the ESP-12 SMD footprint. It is open-source, Interactive, Programmable, Low cost, Simple, Smart, Wi-Fi enabled.

c. **The MAX30100 Pulse Oximeter and Heart-Rate sensor**: It is used to collect the SpO2 and heart-rate values. The MAX30100 operates from 1.8V and 3.3V power supplies and can be powered down through software with negligible standby current, permitting the power supply to remain connected at all times. It has High Sample Rate Capability and Fast Data Output Capability.

d. **3 Pin NTC Thermistor Temperature Sensor Module**: NTC Thermistor temperature sensor module is a low cost, small size module. It is very sensitive to ambient temperature. Through potentiometer adjustment, it is possible to change the temperature detection threshold. It collects the temperature of the body which is required to calculate the stress index.

e. **3.7V LiPo Battery**: It is a rechargeable battery of lithium-ion technology using a polymer electrolyte instead of a liquid electrolyte. These batteries provide higher specific energy than other lithium battery types. It is used to power the wearable device.

II. Hardware Interfacing

Hardware interfacing includes interfacing of Node MCU ESP8266, Arduino NANO, MAX30100, NTC Temperature Sensor, Lipo battery 3.7V. Outputs of MAX30100 and NTC Temperature Sensor will be processed using Arduino NANO, while Node MCU will help to send the value to the android application.
III. Matlab Simulation

Table 1. Inputs and their ranges [Levitt1991]

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
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<tbody>
<tr>
<td>Heartbeat</td>
<td>&gt;60</td>
<td>60-100</td>
<td>100&lt;</td>
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<tr>
<td>Respiratory</td>
<td>&gt;12</td>
<td>12-20</td>
<td>20&lt;</td>
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<td>SpO2</td>
<td>&gt;.95</td>
<td>.95-1</td>
<td>1&lt;</td>
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<tr>
<td>Temperature</td>
<td>&gt;36</td>
<td>36-37.5</td>
<td>37.5&lt;</td>
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Table 2. The ruleset for deciding stress index

<table>
<thead>
<tr>
<th>Heartbeat</th>
<th>Respiratory</th>
<th>SpO2</th>
<th>Temperature</th>
<th>Stress index</th>
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7. Results

Stress index is calculated using a fuzzy toolbox. The inputs are the heartbeat, respiratory, SpO2 and temperature and output is stress index. Using membership function, ranges for each input are set. Rules for fuzzy simulation were also done and this can be viewed in Fig. 6.

In Fig. 3, four inputs are the heartbeat, respiratory, SpO2 and temperature which are shown on the left side and only one output stress index on the right side are added for simulation work.

Membership function of stress index: in figure 4, 3 variables of output stress index low, medium and high. The x-axis represents the value of the stress index and y-axis represents the degree of membership from 0 to 1. The first column of the rule viewer represents the rate of change of heartbeat, the second column represents the rate of change of respiratory, third column represents the rate of change of SpO2 and the last column represents the rate of change of stress index.
Fig 4. Fuzzy logic designer

Fig 5. Membership function
Using Fuzzy logic, the system can calculate the mental stress considering four inputs mainly and they are respiratory, SpO2, temperature rate and heart rate variability. Since heart rate, skin temperature, respiration and blood pressure rises during stress. So the wearable device with sensors will collect the required data from the body of the user and will calculate the stress using the microcontroller and will be sent to the android application, where the user will be alerted. With the help of results of fuzzy logic, we can compare the calculated stress index with optimum value obtained from fuzzy logic. Here we designed the system to calculate the mental stress of employers with age limit 21-55. Small doses of stress can be handled by the body. But we are not equipped to handle long-term, chronic stress without ill consequences. Long-term stress affects the cardiovascular system and heart health. Some studies suggest that stress and anxiety due to stress increases the risk of heart diseases in healthy people. A person with chronic stress disorder may experience nausea, diarrhoea, and a feeling that the stomach is churning. They may also lose their appetite. This system will help them to reduce stress to a great extent and thus the consequences it can create in their health and life.

8. Conclusion

Using Fuzzy logic, the system can calculate the mental stress considering four inputs mainly and they are respiratory, SpO2, temperature rate and heart rate variability. Since heart rate, skin temperature, respiration and blood pressure rises during stress. So the wearable device with sensors will collect the required data from the body of the user and will calculate the stress using the microcontroller and will be sent to the android application, where the user will be alerted. With the help of results of fuzzy logic, we can compare the calculated stress index with optimum value obtained from fuzzy logic. Here we designed the system to calculate the mental stress of employers with age limit 21-55. Small doses of stress can be handled by the body. But we are not equipped to handle long-term, chronic stress without ill consequences. Long-term stress affects the cardiovascular system and heart health. Some studies suggest that stress and anxiety due to stress increases the risk of heart diseases in healthy people. A person with chronic stress disorder may experience nausea, diarrhoea, and a feeling that the stomach is churning. They may also lose their appetite. This system will help them to reduce stress to a great extent and thus the consequences it can create in their health and life.

Reference


