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Mental Workload Detection fromWESAD dataset Using Machine and Deep Learning Model : A Review

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Abstract- Mental stress is one of the major contributors to a variety of health issues. Various measures have been created by scientists and medics to determine the intensity of mental stress in its early phases. To assess mental stress in the workplace, several neuroimaging methods have been developed. One key candidate is the electroencephalogram (EEG) signal, which offers a wealth of information regarding mental states and conditions. We analyse trustworthy heart rate variability (HRV) metrics in order to detect stress in this study.We refer WESAD dataset, an experiment protocol was established including two different sensors which correspond to a range of everyday life conditions.We present our work on the development of a stress detection system based on heart rate by calculating and comparing HRV features from time and frequency domain analysis and classifying these features with the machine learning and deep learning algorithms.

Keywords-Mental Stress,Heart Rate Variability, Machine Learning, Deep learmoing, LSTM, WESAD

I. INTRODUCTION

In the current scenario, mental stress has become a social problem. It affects the daily routine work and economy ofan individual and a nation as well. Stressfulin the working style of human age from twenty-five to forty has the effectiveness of stress in their life. Stress has become the common part of daily life which most people struggle in different stages of life. Mental stress has grown to be a social difficulty and could turn out to be a cause of practical incapacity during hobbies work. Mental stress or pressure has been recognized as one of the major contributing variables that prompt different illnesses. The term pressure is characterized into two sections, for example, positive or negative.

Positive pressure consistently searches for a chance, development like improvement in execution, while negative pressure developes more serious conditions. Mental stress is one of the contributing factors to health problems. It is defined as the human body's response to mental, physical, and emotional stimuli, as controlled by the sympathetic nervous system (SNS) and the hypothalamus–pituitary–adrenocortical axis (HPA axis) [1].

This expression can be applied to both internal (personality structure) and external (problem solving) issues, resulting in a variety of physiological and negative emotional alterations [2]. Acute stress, episodic stress, and chronic stress are the three types of stress identified in the literature [3]. Acute stress is caused by a brief period of exposure and is not damaging. When a stimulus is more frequent for a short period of time, it is called episodic stress [4]. Chronic stress, on the other hand, is the most harmful, as it is caused by long-term stressors [5]. Mental stress has been linked to a variety of disorders, including stroke, cardiovascular disease, cognitive issues, speech abnormalities, and depression, according to various studies [6,7].

1.Wareable Sensor Description

WESAD provides data from two kinds of sensors: chest-worn (RespiBAN) and wrist-worn devices (Empatica E4). For the data collection, we used both a chest- and a wrist-worn devices: a RespiBAN Professional and an Empatica E4, respectively. The RespiBAN itself is equipped with sensors to measure ACC and RESP, and can function as a hub for up to four additional modalities. Using the four analog ports, ECG, EDA, EMG, and TEMP were recorded. All signals were sampled at 700 Hz. The RespiBan was placed around the subject's chest (see Figure 1). The RESP is recorded via a respiration inductive plethysmograph sensor.

The ECG data was recorded via a standard three point ECG. In order to allow the subject to move as freely as possible, the EDA signal was recorded on the rectus abdominis (the abdomen has a high density of sweat glands [8], hence suitable for EDA measurement) and the TEMP sensor was placed on the sternum. The EMG data was recorded on the upper trapezius muscle on both sides of the spine. In order to avoid wireless packet loss, the recorded data was stored locally and transferred to a computer for further processing after the experiment. All subjects wore the Empatica E4 on their non-dominant

hand. The E4 records BVP (64 Hz), EDA (4 Hz), TEMP (4 Hz), and ACC (32 Hz) are specidfied in Table 1. [9]

Table 1: Empatica E4 data modalities

Data	Sampling	Description
ACC	32Hz	Accelerometer data consists of 3 axis channels
BVP	64Hz	Data from a photoplethysmograph (PPG).
EDA	4Hz	Consists of a tonic (referred to as skin conductance level (SCL)) and a phasic (skin conductance response (SCR)) component.
TEMP	4Hz	Temperature in ˚C

Figure 1 Respi BAN.

2. Application of Stress Detection System

Stress is related to every aspect of human life but is applicable more for people with disabilities. Here are some examples, a stressful situation for a blind person can be as simple as requiring a decision while walking as to whether to change direction, when to cross a street, and how to avoid a sudden obstacle.Firefighters and smoke divers are constantly exposed to stressful situations as they engaged in rescue activities involving fire and poisonous smoke. Any stress in such situations may occur mainly due to lack of knowledge about the affected place, fast-changing conditions, time restrictions, exhaustion, disturbing sights, elevated level of heat, or smoke. This exposure to high-risk environments while performing their jobs, leads to various mental and health problems due to constant physical and psychological stress. A person who has attempted to carry out an attack previously. Such attacks can be avoided by measuring the levels of physiological stress of the suspected person using stress detection systems.

3. Section Organization

These remaining sections of the paper are organized as follows. In the next section, the relation between stress and diseases is presented. Related terminologies are shown in section 3. The proposed methodology for stress management is given in section 4. The obtained result analysis is shown in section 5. Finally, conclude this research article in section 6.

II.STRESS VS DISEASES

Stress will vary vastly from person to person and differs in line with our social and economic circumstances, the surroundings we tend to sleep in, and our genetic makeup.There area unit several things which will result in stress. The death of a beloved, divorce/separation, losing employment, and sudden cash issues area unit among the highest 10 causes of stress in line with one recent survey.But not all life events area unit negative and even positive life changes, like moving to an even bigger house, gaining employment promotion, or occurring vacation are sources of stress. The most significant health problems related to stress are:

1. Depression and anxiety
2. Pain of any kind- Headaches, Stomachache etc.
3. Sleep problems
4. Autoimmune diseases
5. Diabetes
6. Digestive problems, Gastrointestinal problems
6. Skin conditions, such as eczema
7. Heart disease
8. Asthma
9. Weight problems
10. Reproductive issues
11. Thinking and memory problems
12. Alzheimer's
13. Accelerated Aging
14. Premature Death etc.

Hence it is pertinent to be aware of the common warning signs and symptoms of stress overload. Table 2 lists the signs and symptoms of stress overload. Overload of stress can lead to major depression in susceptible people and health problems as mentioned above.

Table 2 Stress Symptoms and Signs

Symptoms	Signs
Cognitive symptoms	Inability to concentrate,Constant worrying,Seeing only the negative, Poor judgment, Memory problems, Anxious or racing thoughts,
Emotional symptoms	Loneliness and isolation, Anxiety and agitation, Moodiness, irritability, or anger, Depression or general unhappiness, Feeling overwhelmed, Other mental or emotional health problems
Physical symptoms	Diarrhea or constipation, Aches and pains, Nausea, Frequent colds or flu, dizziness, Chest pain, rapid heart rate, Loss of sex drive

Behavioral symptoms	Withdrawing from others, Eating more or less, Sleeping too much or too little, Using alcohol, cigarettes, or drugs to relax, Procrastinating or neglecting responsibilities, Nervous habits (e.g. nail biting), pacing.

III.RELATED WORK

An algorithmic rule for stress level recognition from the graphical record is planned. To validate the algorithmic rule, an associate degree experiment is intended and disbursed, increasingly, people are collecting detailed personal activity data from commercial trackers. Such data should be able to give important awareness about their activity levels. Millions of people track their physical activity and this data is usefull for analysis of stress detection for daily life of human [10]. [11] provides an effective method for the detection of cognitive stress levels using data provided from a physical activity tracker device developed by FITBIT. The major goal of this system was to use sensor technology to identify stress using a machine learning method.

The effect of each stressor was tested separately using logistic regression, and then a combination model was developed and analysed using ordinal logistic regression models such as logit, probit, and complementary log-log. The novelty of this work lies in the fact that a stress detection system should be as non-invasive as possible for the user.In [12] author proposed a system using Internet of Things architecture where we adopted an activity tracker as our sensing device to reduce cumbersome for daily use.Among the total of 17 features extracted from activity tracker, five features belong tosleep data and six features belong to heart rate data that were proposed to develop the stress recognition model.

In the evaluation of our system, we achieved the accuracy as high as 81.70\% on the cross validation and 78.95\% when tested on the test set. In [13] the authors objective is to investigated the mediating role of work and family activity conflicts (WFC) and family and work activity conflict (FWC) on the effects of workload and life style of the family.Using AMOS 20 through bootstrap analysis for indirect effect, this study assessed the above mentioned relationships based on data collected from 258 respondents in the hospitality industry in Quebec. By highlighting the cross-domain effects, the present research contributes to the existing knowledge by testing the mediating role of WFC and FWC in the effects of workload and various resources of social support on job stress social support in job stress.

IV. METHODOLOGY

In the proposed methodology is divided into different levels like dataset description, analysis of various Machine Learning algorithms and Figure 2 illustrates a flow chart of proposed methodology.

1. Dataset Description

WESAD is a publicly accessible dataset for detecting wearable stress and affect. This multimodal dataset contains physiological and motion data collected from 17 people during a lab research using both a wrist- and a chest-worn device. Blood volume pulse, electrocardiogram, electrodermal activity, electromyogram, respiration, body temperature, and three-axis acceleration are among the sensor modalities provided. Furthermore, by covering three separate affective states (neutral, stress, amusement), the dataset bridges the gap between past lab investigations on stress and emotions. In addition, the dataset contains the individuals' self-reports, which were acquired using a variety of standard questionnaires. Details can be found in the readme file for the dataset, as well as in [29]

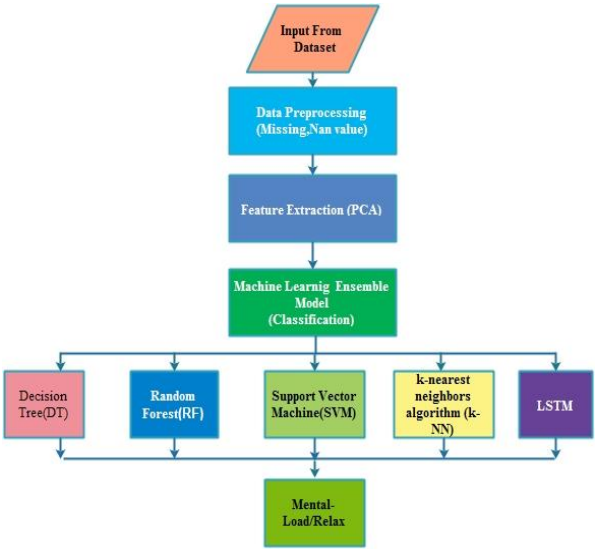

Figure 2 Proposed Flow Chart

Table 3 Dataset Description

Dataset Description	
Data set Characteristics	Multivariate, Time Series
Number of Instances	63000000
Attribute Characteristics	Real
Number of Attributes	12
Missing Values?	In 2 subject, exempted
Number of Subjects	17

2. Machine Learning Algorithm

The Machine Learning (ML) has prompted a new concepts and technologies, including supervised, unsupervised and reinforcement learning, new algorithms for robots, the Internet of Things, analytics tools and many more. The Figure 2 shows the machine learning algorithms based on

the learning; supervised and unsupervised and problems; classification, regression and clutering. The paper specifies classification problem for stress detection using WESAD dataset. SVM offers high accuracy compared to other classifiers such as logistic regression, and decision trees. It is known for its kernel (linear , polynomial, radial basis function) trick to handle nonlinear input spaces. It is used in a variety of applications such as face detection, intrusion detection, classification of emails, news articles and web pages, classification of genes, and handwriting recognition [14]. SVM is considered to be a machine learning approach, which can be employed in both types of classification and regression problems. It can easily handle multiple, continuous and categorical variables.

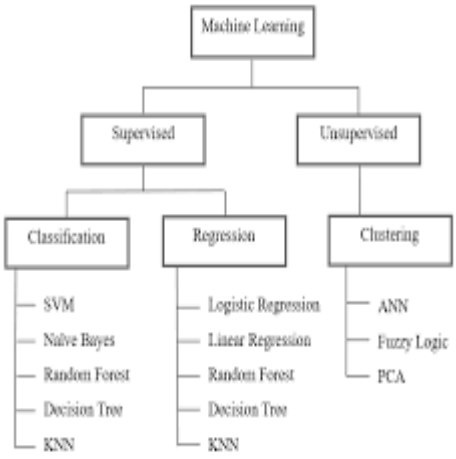

Figure 3 Machine Learning Algorithms

Decision trees are individual learners that are combined. They are one of the most popular learning methods commonly used for data exploration [15]. One type of decision tree is called CART, classification and regression tree.

Random forests is a supervised classification learning algorithm. It is also the flexible and easy to use algorithm. Random forest (or random forests) is an ensemble classifier that consists of many decision trees and outputs the class that is the mode of the class's output by individual decision trees [16]. K Nearest Neighbor(KNN) is a very simple, easy to understand, versatile and one of the topmost machine learning algorithms. KNN is used in a variety of applications such as healthcare, image recognition, finance, political science, handwriting detection and video recognition [17]. KNN is a non-parametric and lazy learning algorithm. Non-parametric means there is no assumption for underlying data distribution. That is, the model structure is determined from the dataset.Lazy algorithm means it does not need any training data points for model generation.

V.CONCLUSION

Machine Learning has been broadened an excessive number of zones of diseases through the outstanding headway of Machine Learning. Heaps of data mining and Machine studying techniques have been applied tothe WESAD dataset for push and loosen up state forecast. In this paper,WESAD dataset was used.The information was recorded from 17subjects, excepted 2 subjects data due to loss of record. Our next step will be to build ML models, we will apply four celebrated AI calculations specifically, Random Forest, K Nearest Neighbor, Support vector machine, and Extra tree classification. Accuracy, precision, recall and F1 socre will be the compairing parameters based on confusion matrix. Our ultimate objective in this study would be to develop a high-accuracy model based on real-time data by overcoming unresolved challenges to alleviate the stress of the users.

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