



## A COMPREHENSIVE REVIEW AND ANALYSIS ON CLASSIFICATION TECHNIQUES TO DETECT STRESS IN HUMAN USING MACHINE LEARNING TECHNIQUES

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### **ABSTRACT:**

Stress is the most common and widespread psychological or mental disorder that changes people's moods and behaviours. In daily basis people can experience a moment of stress from different reasons, it can become dangerous to mental health when this moment of stress is frequently to a person. It can be varied among individuals in terms of amplitude, phase and frequency. According to the recent data studies, mental stress is on the rise in people all over the world. Exposure to mental stress for long period leads to the serious health Problems. Thus, the personalised diagnosis of the mental stress level is key to prevent mental stress related diseases. The main aim of this paper is to review and analysis about the various machine learning Classification techniques to predict the stress in Human through physiological signals. Through the physiological signals from the relevant sensors, we can determine the stress level of individual. Identified some dataset to gather data and applied data pre-processing on that data. This paper also give comparison on classification algorithms which is required for the classification. There are a diverse range of algorithms with different methodologies are available and it can be used to prevent or reduce stress level so automatically it can be reducing the health issues. The purpose of this analysis is to measure the stress type and its level through comparing the different classification algorithm with merit and demerits.

**Keywords:** Stress Detection, Machine Learning, Physiological Signals, Supervised Learning, Mental Stress, short term stress, long term stress.

### **INTRODUCTION:**

“As per the world Health Organization (WHO) Report, American Psychological Association” Stress detection was identified under top ten social demanding approaches under the healthcare problem [1]. The term ‘stress’ was introduced by Hans Selye with his General Adaptation Syndrome hypothesis, which suggested that the energy of person to adopt to an alarming situation is finite and varies depending on the individual [2]. Stress has become an integral part of our daily lives and is a well-known public health issue. Stress has recently become an integral part of professional life, particularly in today's competitive life. In the workplace, a person

must deal with a variety of situations on a regular basis, including work overload, job instability, a lack of job satisfaction, and the pressure to stay current. Stress can cause a variety of severe health impacts, including high blood pressure, lack of sleep, infection susceptibility, and cardiovascular disease. All these circumstances lead to mental stress, which is now the major cause of major diseases. As shown in Figure-1[29], The sympathetic nervous system (SNS) and Hypothalamus pituitary adrenal axis (HPA) are biologically important in generating stress reactions. cortisol, also consider as a key to detect the stress level. It is act as feedback for HPA activity. cortisol promotes chemical activity, which leads to the persistent biological changes, and itdelivered through the blood[20].

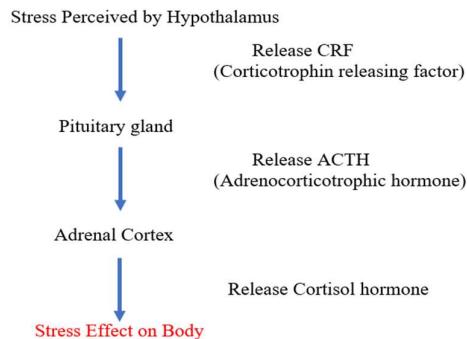


Figure:1 [Path Flow of stress in Human Body][20]

Stress can define as positive stress known as eustress, help to the people to stay concentrated to deal with the hash condition and negative stress known as distress, responsible for activation of HPA axis. Activation of the HPA axis for an extended period of time might lead to physiological and psychological disorders[3]. Positive stress can not affect to person's health, but negative stress can cause the major health problem. Negative stress has two unique impacts, which are as follows: 1) physiological stress, also known as objective stress; and 2) psychological stress, also known as subjective stress, also known as perceived stress[32]. Subjective stress has the problem of being subjective to the user's reported responses and only describing the current condition of the subject's stress level. Physical changes such as raised blood pressure, increased heart rate and increase cortisol level indicate objective stress. Subjective stress is a person's assessment of whether a situation is under stressful or not [3].

Different Stress Type according to the Time period can be consider as follow[31]:

- Acute stress (Short-term stress): It is a type of short-term stress that does not create permanent harm. It is easy to spot, and it is also treatable.
- Episodic acute stress: This causes people to become agitated.
- Chronic Stress (Long-term stress): This is considered a long-term stress, and it can cause severe damage. Finally, it is quite difficult to detect.

Acute stress has been shown to help individuals adapt to a wide range of dangerous conditions. It can also be used to identify individuals who are vulnerable to such pressures [6]. In contrast, when the human body is exposed to long-term stress (chronic stress), the psychological responses cause a new set of disorders such as anxiety, depression, autoimmune illnesses, and cardiovascular diseases, among others[6]. Chronic stress has a considerable psychological and physical effect on Health in psychology. Sometime Stress can be encouraging us to helps in discovering novel items, carry out everyday tasks and participating in new tasks and take part in creative thinking like short-term stress. Stress affects your interest, thinking ability,

objective, the effectiveness, and our actions. It could be eventually cause neural and muscular system damage under the long-term stress [4]. Owing to prominent levels of stress, mental illnesses such as anxiety and depression are often induced. Consistently and timely manner, acute stress can be easily assessed than chronic stress. Stress can be measures in terms of objective and subjective. In objective method all physiological signals consider detecting stress level whereas subjective measures mean in terms of questionnaire form detection of stress [29].

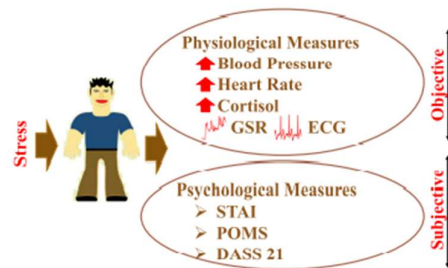


Figure:2 [ Measures of Stress][29]

The main reason behind increasing and decreasing body stress levels due to The Autonomic Nervous System (ANS) and HPA axis[4]. Psychiatrists, counsellors, or anyone who are experts in human psychology are usually in charge of stress diagnosis. Some of the key markers used in stress diagnosis include measuring blood pressure, heart rate, electroencephalogram (EEG) signals, galvanic skin response (GSR), electrocardiogram (ECG), finger temperature and watching behavioural data. Performance issues, family problems, mental disorders, anxiety, and depression are all examples of stress's effects [5]. Multiple biomarkers processing is projected to boost the classification work, accuracy, and resilience in this trend. As a result, classifying stress levels separately using various biomarkers (EEG and ECG), which is likely to increase classification accuracy. Physiological signals as follow[30]:

EEG: it measures the electrical activity of the brain. As the origin of stress response lies in the brain, EEG signal processing becomes a significant technique for the detection and analysis of mental stress[22].

ECG: Measures the electrical activity of the heart rate and rhythm (Normal Resting rhythm and stress rhythm). An electrocardiogram (ECG) is a simple test that can be used to check your heart's rhythm and electrical activity. Sensors attached to the skin are used to detect the electrical signals produced by your heart each time it beats.

HRV: Measures variation in the time interval between heartbeats. Heart rate variability (HRV) is the variance in time between successive heart beats. It's called RR Interval.

GSR: Measures the electrical activity of Sweat Secretion and when person is in stress the sweat glands will also be increased[23].

BVP: measuring the heart rate.

### LITERATURE REVIEW:

In paper [7], author has developed application to detect stress and suggested EEG signal comes under physiological signal to detect the stress level used by Neurosky Mindwave Mobile 2 device to collect the EEG signals. Author has developed application to detect stress. The human brain consists of millions of the brain cells called neurons. In brain waves, five types of the frequency can collect. Gamma wave – Frequency value between 27 Hz to above value and it is activated by the processes of thinking, learning, and communicating, Beta wave – Frequency

value between 12 to 27 Hz and it is activated when someone is evaluating something, gathering knowledge, or coming up with a fresh concept, alpha wave – Frequency value between 8 to 12 Hz and it is activated by closing one's eyes and thinking about something relaxing, theta wave – Frequency value between 3 to 8 Hz and it is activated by emotional stress, particularly feelings of irritation or disappointment, delta wave – Frequency value between 0.5 to 3 Hz. Author has performed three experiment to measure stress level. In 1<sup>st</sup> experiment that shown that increase value of theta and alpha were squeezed by stress, in 2<sup>nd</sup> experiment for classification using KNN machine learning techniques and in 3<sup>rd</sup> experiment related to meditation process. Using all this experiment result was using 4 frequency waves namely alpha, beta, theta and delta. K-NN algorithm with value of k is 3 has achieved a highest accuracy to detect stress through EEG signal.

In paper [8], author suggested that HRV signals investigated as a tool of detecting the human stress and observing the study based on human stress changes. HRV signals related to stress can be examined in lab rather than to examine in real life. ECG is one kind of well-known physiological signals that shows the cardiac activity through its PQRST characteristic. As per authors suggestions, currently major interest is to be identifying the link between emotions and stress through the ECG signal.

In paper [9], author suggested stress can be calculated or measured by using heart rate, EMG, GSR sensors. author used ECG signals to predicts stress. in this paper author explain various pattern recognition algorithm to detect stress. data fetched from all sensors used to collect data and finally need to check the threshold value. That threshold value was used to detect the stress. Based on data derived from dataset of sixteen persons under four different stressful conditions, the author proposed the SMO, Bayesian Network and J48 algorithm for the prognosis stress in this research. This paper discusses many categorization methods, including Random Forest, Nave Bayes, K-Nearest Neighbour and Support Vector Machine algorithm.

In paper [10], The proposed system's main objective is to build a portable real-time EEG-based mental training neurofeedback system able to detect and assessing stress levels in real-time with high accuracy using mental arithmetic tasks. For this purpose, proposed method used a Hybrid feature-set and five classification algorithm is used to build a real-time system. A machine learning method is suggested to study the electroencephalogram (EEG) signal for 36 people. An effective mental stress detection (MSD) system requires the extraction of valuable features from EEG like frequency waves. As per discussion, this framework introduces a hybrid feature set that feeds five machine learning classifiers like random forest, LDA, Cubic SVM, Linear SVM and KNN to detect stress and non-stress situations, as well as to classify stress levels. The findings revealed that the proposed strategy based on the hybrid feature-set was capable of both identifying and classifying stress levels.

In paper [11], author has developed a system to detect long-term stress addressed by using PSS (Perceived stress scale) labels and expert evaluation. In this study author has collected the real time data through lab experiment through EEG without induce stress through induce stress techniques. Total 33 participants were involved in this study and labelling given by the psychological expert in terms of under stress group or control group. long-term stress classification and better performance using psychological expert labelling achieved through the traditional machine learning classifiers. Author has collected EEG signals frequency wave from 33 participants through EMOTIV Insight headset in a closed eye condition for three minutes

and then followed by PSS and interview by psychological expert. There were many types of symptoms evaluated by expert like Physical, Emotional, Cognitive and Behavioural which comes under stress condition. Through SVM and LR classifier gave a more accuracy as compare with another classifier. Author has also suggested to go further with more data set and features along with deep learning-based strategies can be applied to improved methods.

In paper [12], Main objective of author was to detect the stress level under the stressful situation through the recorded physiological data. Author has used the WESAD (Wearable stress and affect detection) dataset, for measuring the stress level in person. For collection of data, they had chosen Fifteen people and physiological signals applied on them respectively used by the RespiBAN and Empatica E4 on the chest and on the wrist. In that also used Acqknowledge Software to extract required values to detect the stress from physiological signals. In this paper author has used SVM classification method to calculate the accuracy.

In paper [13], the author calculated stress using the Confusion Matrix method. Using this method, the predicted values are measured by Precision and accuracy. Also calculate the stress using the classification machine learning algorithms and get the values from Confusion Matrix like Classification accuracy, Classification error, Sensitivity, Specificity, Precision, False Positive rate, True target values, Predicted target values. All this values particularly measured by using Heart rate and Hand GSR of the physiological dataset.

In Paper [14], the author has proposed a system for stress classification through EEG signals in terms of stress and non-stress labelling. EEG signals obtained from interaxon Muse 4-channel commercially on handscarf device. Author has collected data of 35 participants through lab experimental setup, used LSTM method to classify the model for classify the stress participants from nonstress participants and achieved maximum accuracy 93.17% by using two-layer LSTM architecture. Author suggested proposed work based on increasing the number of subject to detect the stress level to improve accuracy.

In Paper [15], This paper's work proposes a comparative analysis of different methods of classification and signal processing for stress detection, with a focus on stress detection approach utilising EEG data, as EEG is a perfect non-invasive technology that is frequently used in clinical and research areas. The study explored various machine learning algorithms like fractional dimensional method, for stress assessment based on physiological responses in controlled environments. To improve accuracy, signal-processing techniques such as Fast Fourier Transform or Discrete Wavelet Transform are suggested, fused with statistical features acquired from EEG signal time-frequency analysis. The study illustrates a novel system architecture for monitoring health and wellness, as well as reviewing treatment efficacy through early diagnosis of physiological abnormalities utilising the EEG approach, as well as its benefits over other existing stress detection methods.

In paper [16], author has developed an experimental protocol to get participants to become stressed while performing mental arithmetic tasks under time constraints and negative feedback. Multi-domain features from many EEG channels are extracted and fused to provide a vast pool of feature vectors. Propose mRMR-PSO-SVM, a new EEG feature selection approach that improves the search for local best and fit for binary feature selection. The mRMR-PSO-SVM was evaluated using four datasets and compared with existing methods based on selected features and classification performance. Validate the recommended method by comparing its performance to that of different metaheuristic algorithms using same dataset

and three other public datasets of EEG on mental stress state.

In Paper [17], This study uses a non-invasive EEG device to collect brain signals, which are evaluated using a modified Welch's fast Fourier transform (FFT) algorithm to extract the power spectral density (PSD) of each frequency band and calculate the power ratio of Alpha to Beta and Theta to Beta. The k-Mean clustering method is used to divide power ratio in subgroups to predict stress level. The power ratio analysis confirmed that the Theta/Beta power ratio can be used as a stress feature and thus its dataset imported into k-means clustering to divide the subjects into three categories low\_stress, moderate\_stress and high\_stress. Author has proposed to combine this power ratio with other EEG features to develop a more efficient stress level classification system which is useful in the implementation of stress monitoring system to provide better health care.

In Paper [18], proposes a method to detect the stress level in human using physiological signal EEG and introduce stress reduction techniques to decrease stress level. For classification purpose use K-Mean clustering method. It's a kind of product prepared by the author to detect stress level. It is mandatory to design the database in greater detail so that detailed data analysis can be performed in easier manner and accuracy may be improved. Author suggested that also add more classification techniques to improve result and instead of DWT- feature classification techniques, use another one to compare the result.

In paper [19], studies the detection of stress/anxiety state by using EEG signal during video session. In this study total 18 participants were involved. From EEG signals, temporal, spectral and non-linear EEG features were evaluated. For the feature selection, SBS (Sequential Backward Selection) and SFS (Sequential Forward Selection) methods were used and for classification purpose machine learning method SVM used. As per comparison with SBS and SFS method, SFS can minimize objective function, so it was considered for the analysis purpose. Limitation of this study is limited data but if we continue with a larger dataset, it should be investigated to valid result.

In Paper [24], used a variety of sensors to analyze the stress level of working people and classify individual stress level based on SVM and ANN algorithm. This study extracts the SWELL-KW dataset to achieve a maximum accuracy. Variety of NLP (Natural Language Processing) devices and methods to reveal examples [25].

In Paper [26], design a system was developed using machine learning approach to predict user mental distress. Data obtained from SVM and RF classifier. Finally, it turns out that the SVM offers better accuracy as compare with RF.

In Paper [27], propose a mental state classification model based on either person is under stress condition or normal condition by hybrid feature pool for selection of features and for classification purpose it has been used K-NN classifier. DEAP dataset used to detect stress level through EEG signals. Author shown that if we were not used hybrid approach for selecting feature then result was 69.26% but after using feature pool approach it was improved 4.12%. To validate the proposed model's performance and highlight the significance of designing a hybrid feature pool, it was compared to non-linear dimensionality reduction techniques as well as those without feature ranking.

**DISCUSSION:** As per above literature survey, there are many classification methods of machine learning are described but all classification methods have its pros and cons. This is as

per given below table:

Classification Algorithm	Pros	Cons
Support Vector Machine (SVM)	In general, it's work relatively accurate in practice	A data-processing is required to correctly analyze complicated data. Also need to choose correct or suitable kernel to analyze complicated data.
Kernelized SVM	In a range of datasets, it performs well and work well for both the low and high dimensional data	Efficiency decrease as the size of the training set increases.
Gradian Boosting Method (GBM)	In general, it's work relatively accurate in practice	It takes relatively more time as compare with other algorithm for training learners.
Random Forest (RF)	The algorithm itself automatically covers its previous weakness in dealing with some attributes by adding more weak learners.	Difficult to interpret the relationship between attributes and the target, Prediction Speed relatively slow.
Naïve Bayes (NB)	requiredless time for Prediction and training	Unrealistic assumption: independency of all attributes.
K- Nearest Neighbour (KNN)	Training process is not required for KNN	Prediction time rapidly increase as number of data or attributes increase, highly dependent on the distance metric to be used.
Linear Discriminant Analysis (LDA)	It reduces resources and dimensional costs when convert higher dimensional space to lower dimensional space.	LDA fails in some cases where the Mean of distributions is shared

Table:1 [Pros and Cons of Different Classification algorithm]

Some paper has suggested that if want to use KNN need to taken care of value of k to get good accuracy. SVM, Cubic SVM and Linear SVM has also some outstanding characteristic so based on that also result can be improve. If need to work on liner data, simply go through SVM but for non-leaner data need to apply kernel tricks to convert non-liner data in liner form. Stress can be measure through subjective and for that some standard questionnaire like PSS (Perceived stress scale) which is already available to measure stress classification based on the score and parallely also objective measures are also available. Along with objective measures collect the data through the physiological signals like ECG, GSR, EDA, EEG etc. all physiological signals have its own characteristic, but EEG give the commendable result for stress detection as its measure the brain wave and collect the frequency band. Based on the value it can be decide level of stress type in terms of low, moderate, and severe. Due to unavailability of the real

patient data for stress, perform laboratory task in which stress induce techniques applied on volunteer person who wants to take a part for this laboratory experiment like TSST (Trier Social Stress Test), Mental Arithmetic Task etc to Collect the dataset by using various device which is easily available in market. Devices are:

Name of Device	Physiological parameters collected
Emotive	EEG (Electroencephalography)
Waveguard EEG cap	EEG
Empatica E4	Heart Rate
BrainLink Headset	EEG
Shimmer 3+ GSR	GSR and PPG (Galvanic Skin Response, Photoplethysmogram)
Zephyr BioHarness 3.0	HR, HRV, GSR
Pulse Sensor	Heart Rate
Wearable Device	Heart Rate
FITBIT	Heart Rate
Infrared Temperature Sensor	Skin Temperature
RespiBAN Professional	ECG, EMG, Accelerometer, Respiration

Table:2 [Popular Commercially available device for collect Dataset]

So finally, this paper reviews all classification techniques along with dataset and available devices to collect data at real environment.

### **FINDINGS:**

We find that the scope is open to do research on stress detection. Among all physiological signals EEG gives the best result with Frequency Band along with Hybrid classification techniques by Machine Learning to improve accuracy of the model.

### **CONCLUSION:**

The primary goal of this study is to review and analyze different classification algorithm. after consideration point of pros and cons (Advantage & Disadvantage), different characteristic of classification algorithms described in this paper so based on that we need to select best classification algorithm to detect/predict stress level by using Machine Learning. As per Literature Review SVM is consider Better to choose for classification to improve the efficiency. In Future we Need to add one more classification technique or prepare a hybrid classification approach to improve model accuracy as compare with only work with single classification techniques.Finally, we need to Detect or predict stress level through machine learning by using authenticate available dataset or real dataset.

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