# A Comprehensive Literature Review of Machine Learning Algorithms for Stress Detection

**Mrs. Mohini Mukund Mohod[1], Dr. P. M. Jawandhiya[2]**

[1] Research Scholer, Pankaj Laddhad Institute of Technology and Management Studies, Buldhana, Maharashtra, India
mohinimohod02@gmail.com,https://orcid.org/0009-0007-5997-2671
[2] Principal, Pankaj Laddhad Institute of Technology and Management Studies, Buldhana, Maharashtra, India,pmjawandhiya@gmail.com

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**Abstract-** Stress is a major factor causing many diseases in today's society. In this survey, the paper explore recent research that focuses on detecting stress in everyday life using various techniques. While there are studies on stress detection in controlled lab settings, there's a shortage of research specifically looking at how stress is identified in real-life, day- to-day circumstances. A thorough review of machine learning-based stress detection is given in this research study. Various algorithms, ranging from traditional statistical methods to advanced deep learning models, are scrutinized for their effectiveness. By examining detection techniques, conducting a thorough literature survey, and evaluating the advantages and disadvantages of machine learning algorithms, the paper contributes to the evolving landscape of technology-assisted mental health interventions. The findings aim to guide future research endeavors, fostering responsible and impactful applications of machine learning in the domain of stress detection and mitigation.

**Keywords:** Stress Detection, Machine Learning, Literature Survey, Detection Techniques

## I. Introduction

Stress poses a crucial challenge in today's world, impacting human health, society, and the economy in meaningful ways [1]. Stress is like a disturbance in how person usually feel mentally. It happens when person can't handle the pressure from what's expected of us. This pressure can affect our mental health and cause stress. There are two types of stress: good stress, called eustress, and bad stress, called distress. Eustress is when stress is positive, and distress is when it has a negative impact on our lives [2]. How a person feels emotionally, like being stressed or anxious, can really change how well they live. Stress, which is when you feel overwhelmed and can't cope with what's expected of you, can mess with your mind and body. It can lead to issues like irregular heartbeats and feeling down or depressed. So, your overall well-being is closely tied to your emotional state [3]. Our bodies actually need a bit of stress to stay healthy and keep our organs working well. But too much stress that we can't handle can be bad for our health and make us more likely to have serious, long-term issues. So, it's important to have a reasonable amount of stress for our bodies to stay in good shape [4]

When anyone feel scared or worried, about their bodies and minds, it can react in different ways. Physically, it might have a fast heartbeat, sweaty hands, shaky hands, quick breathing, and a tight jaw. It might also struggle with speaking, like stuttering or avoiding eye contact. Mentally, it might feel overwhelmed or have a lot of racing thoughts. Some of us might worry about making mistakes in front of others. There are various ways people cope with stress, like talking to someone, using stress balls, trying holistic medicine, or reading books. Techniques such as cognitive therapy, conflict management, and the cranial release technique can also help. Spending time in nature, setting goals, making decisions, and having pets can also bring many benefits [5].


**Figure 1. Techniques of Stress Management**

## II. Literature Survey

H. M. Rafi Hasan's research uses machine learning algorithms to predict students' future performance on students' test scores, attendance, presentations, assignments, midterms, and final exams are gathered as part of the technique. K-nearest neighbors, SVC, Decision Tree Classifier, Random Forest Classifier, Gradient Boosting Classifier, and Linear Discriminant Analysis are among the techniques that are employed. The study aims to provide personalized support and improve academic outcomes for teachers and students. The Decision Tree Classifier and K-Nearest Neighbours models provide the most accurate predictions, with an accuracy of 94.44% and 89.74%, respectively [6].

Nur E Jannat Asha has developed a low-cost heart rate monitoring system using a PPG sensor and Arduino, which can detect mental stress through machine learning. The system uses hardware components like an Arduino Uno, a PPG sensor, and a Bluetooth module for data transmission. It uses software tools like Arduino IDE, Tera-Term, and Google Colab for data processing. The system uses a support vector machine (SVM) algorithm for mental stress prediction, with the SVM algorithm showing the best accuracy (82% in training and 62% in testing). The system aims to help individuals and healthcare professionals monitor heart rate and predict emotional conditions [7].

Elahe Hosseini has developed a stress detection framework using Electrodermal Activity (EDA) signals and machine learning algorithms. The study segmented EDA data into 60- second sliding windows and extracted 87 statistical features. The authors used normalization per subject and feature selection to improve classification performance. The framework achieved an accuracy of 97.03% and an F1-Score of 97.36%. The study used three machine learning algorithms (AdaBoost, Random Forest, and SVM) to evaluate the extracted features. The WESAD dataset, containing physiological and motion data from wearable devices, was used to elicit affective states. The framework's results were compared with state-of-the-art research, showing a promising improvement with an accuracy of 97.03% [8].

Pramod Bobade and Vani M. conducted a study on Detecting stress with machine learning and deep learning methods. They used the WESAD dataset and various machine-learning algorithms for stress classification. The results showed high classification accuracy of up to 81.65% for three-class and 93.20% for binary classification problems, while deep learning achieved accuracy of up to 84.32% for three-class classification and 95.21% for binary classification [3].

Md Fahim Rizwan's research on stress detection using bio signals, specifically ECG, and machine learning techniques aims to prevent psychological and physiological problems like cardiac rhythm abnormalities. The best model achieved 98.6% accuracy using Gaussian Kernel function and all features. The study emphasizes the importance of respiratory information in stress detection and its potential applications in biomedical engineering, stress monitoring, and health complications prevention [2].

Sami Elzeiny's study explores machine learning methods for automatic stress detection, utilizing physiological signals and behavioral data. The results show high accuracy in detecting stress, with classification accuracy reaching 80.6% for stimulus and 88.9% for arousal. Another study achieved 90.10% accuracy using physiological signals and a support vector machine classifier. The study also achieved 92.4% accuracy for mental stress levels [4].

## III. Machine Learning techniques for Prediction of stress

Machine learning is a process where computers learn from examples without guidance, improving their skills over time. It simplifies the creation of complex or costly systems. Supervised, unsupervised, semi-supervised, and reinforcement learning are some of the various forms of machine learning. Usually, supervised or unsupervised learning techniques are used in the studies that are mentioned. [9][1].

- Supervised learning:

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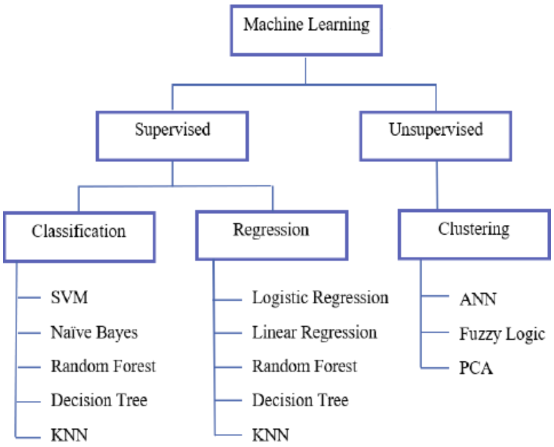
• Unsupervised learning:

Unsupervised learning is a method where computer models learn from data without specific instructions from a training dataset. It focuses on identifying hidden patterns and learning from the provided data without predefined categories. The main goal is to discover the data's structure, group similar data together, and simplify it. Various machine learning methods are used for this purpose [10][11].

**Figure 2. Classification Techniques of Machine Learning** [12]




**• Classification**

▪ Support Vector Machine

The Support Vector Machine (SVM) classifier is a key tool in mental stress detection, able to categorize stress levels based on physiological signals like ECG and EEG data. Its high accuracy rates, reaching up to 91%, make it a popular choice for stress level classification. When combined with speech features, it can achieve a 92.6% accuracy in distinguishing workloads. The SVM classifier is effective in processing and analyzing complex physiological data, aiding in early stress-related issues [14].

▪ Naïve Bayes

Naive Bayes is a type of probabilistic classifier widely used in machine learning for various applications [15][16]. Naive Bayes is a text classification method that uses probability theory and Bayes' Theorem to predict text tags. It calculates the probability of each tag and outputs the tag with the highest probability, making it popular for real-time classification in high-dimensional datasets [5]. Naive Bayes is a powerful supervised learning algorithm that excels in classification tasks like spam filtering, sentiment analysis, and document categorization, by predicting outcomes based on the probability of features under specific conditions.

▪ Random Forest

A potent classification model called Random Forest makes predictions by combining several decision trees. [17][5]. It is particularly effective when the class division is well-defined [17]. In stress detection studies, Random Forest has shown high accuracy, sensitivity, and specificity, outperforming other algorithms like Naive Bayes, Support Vector Machine, and K-Nearest Neighbours [15]. Random Forest classifiers are robust and versatile tools for various classification tasks, including stress detection. They can provide precise estimates by training on labelled data and iteratively adding confident predictions, ensuring stable and reliable results. However, testing results can impact their ability to identify stress levels.

▪ Decision Tree

A decision tree is a supervised machine-learning technique that builds a tree-like model of decisions based on data attributes for categorization tasks. [18]. Decision Trees are a valuable tool for interpreting data by dividing a dataset into subsets based on significant attributes, creating a tree structure with each internal node representing a feature, each branch representing a decision, and each leaf representing a class label.[19]. Decision Trees are renowned for their simplicity, interpretability, and effective handling of numerical and categorical data, making them a popular choice for predictive modeling tasks in various fields [17] .

▪ K-Nearest Neighbours (KNN)

K-Nearest Neighbours (KNN) is utilized in stress prediction by analyzing physiological signals to automate stress detection [20]. KNN is a non-parametric learning technique that predicts values of new data points based on 'feature similarity,' determining how closely they resemble points in the training set [21]. Regarding the identification of stress, KNN is employed alongside SVM to cluster dominant features for stress detection, achieving classification accuracies of 66.52% and 72.82% respectively [21]. Additionally, in the realm of working professionals, KNN is used to predict if a person requires treatment based on the similarity of independent variables to known data, highlighting its role in identifying factors influencing stress levels [22]. Overall, KNN proves to be a valuable tool in stress prediction, aiding in the identification and management of stress-related issues.

- **Regression**

▪ Logistic Regression

Logistic Regression is a commonly used method for stress detection, especially in analyzing physiological responses like skin conductance and heart rate variability [23]. Logistic regression is used to predict outcomes with binary values, achieving high accuracy rates of up to 91.66% in stress detection without regularization [24]. Additionally, wearable devices incorporating heart rate variability measurements can help monitor stress levels, although relying solely on heart rate may lead to misclassification [5]. Logistic regression, using machine learning algorithms and sensor data, can accurately and efficiently detect stress levels, aiding in the prevention of stress-related health issues. [5].

▪ Linear Regression

Research on stress detection uses machine learning algorithms like Naive Bayes and SVM, focusing on physiological markers like heart rate, GSR, and respiratory parameters [5][23]. Research on stress detection focuses on analyzing social interactions and microblog data, using machine learning algorithms and physiological markers for accurate stress assessment [25].

▪ Random Forest

Random Forest models, utilizing physiological signals like EDA, skin temperature, and heart rate, have demonstrated superior performance in stress detection, achieving high F1-scores [5][26]. Random Forest algorithms categorize stress levels into classes using physiological markers, aiding early detection and mitigation. They are robust and efficient, particularly in well-defined class boundaries, contributing significantly to mental health research.

- **Clustering**

▪ Artificial Neural Networks (ANN)

Artificial Neural Networks (ANN) have been utilized in stress detection research. Various studies have explored the use of machine learning techniques, including ANN, for stress detection [19]. Using physiological markers like heart rate and GSR, and machine learning algorithms like ANN, accurate stress levels assessment is achieved through sensor data analysis [23]. ANN has demonstrated potential in predicting stress levels through social interactions and microblog data, providing an efficient method for detecting psychological stress [27]. ANN significantly enhances stress detection accuracy and offers valuable insights into emotional well-being in individuals.

▪ Fuzzy Logic

Fuzzy Logic enhances stress detection accuracy by incorporating physiological signals like GSR and HR, achieving a 99.5% accuracy rate in Sugeno-type fuzzy logic design [5]. Stress detection systems use machine learning algorithms and bio-signals to detect stress levels, preventing psychological and physiological issues. Integration of fuzzy logic algorithms enhances precision, improving well-being and quality of life [2].

▪ Principal Component Analysis (PCA)

The research papers discuss various methods for stress detection, including machine learning techniques, physiological markers, and social media data analysis, although Principal Component Analysis (PCA) is not explicitly mentioned[5]. The research uses sensor data, physiological signals, and social media posts to detect stress levels. PCA, a dimensionality reduction technique, is used in data pre-processing and feature extraction, but its direct application in stress detection algorithms is not discussed.

## IV. Machine Learning Algorithm with its Benefits & Limitation

### TABLE 1. MACHINE LEARNING ALGORITHM WITH ITS BENEFITS & LIMITATION

| Name of Author | Machine Learning Algorithm Used | Benefits | Limitation |
|---|---|---|---|
| Aristizabal et al., 2021 [28] | Deep Learning Algorithm | Deep learning methods combined physiological and behavioral measures for stress detection. | Detection accuracy drops due to unknown situational context and data quality. |
| Srirampraksh et al., 2017 [21] | K-Nearest Neighbors (KNN) and Support Vector Machines (SVM) | Corroborates how to select dominant features | The research paper lacks detailed discussion on real-world stress detection applications. |
| Goumopoulos & Menti, 2019 [29] | Decision Trees, Support Vector Machines (SVM), and Naive Bayes | Study focuses on seniors, a group not adequately examined in past. | Limited sample size due to screening requirements and sensor inconvenience. |
| Sasikala et al., 2022 [5] | AdaBoost, Random Forest, K-Nearest Neighbors (KNN), Support Vector Machine (SVM), and Decision Tree | Various biosignals like EDA and cardiac signals are used for stress detection. | Limited discussion on the effectiveness of stress reduction strategies. |
| Jain & Kumari, 2022 [30] | Support Vector Machine (SVM),KNearest Neighbour(KNN), CNN, Random Forest | IOT devices in healthcare improve patient monitoring and communication. | Lack of detailed comparison between various IOT devices for stress detection. |
| Acikmese et al., 2019 [31] | LSTM, CNN, CNN-LSTM, Logistic Regression, K-Nearest Neighbour (KNN), Artificial Neural Networks | The research focuses on predicting stress levels using mobile sensor data. | Limited data diversity and size hindered LSTM model generalization. |
| Ahuja & Banga, 2019 [15] | Random Forest, Naive Bayes K-Nearest Neighbors (KNN), and Support Vector Machine (SVM) | Perceived stress scale test helps in initial stress analysis. | Limited dataset size with 06 students may affect generalizability. |
| Subhani et al., 2017 [32] | Naive Bayes, Random Forest, Support Vector Machine (SVM), and Logistic Regression | The research focuses on EEG-based ML framework for stress detection. | No detailed comparison of EEG-based ML framework with existing methods. |
| Ghaderi & Frounchi, 2015 [33] | Decision Trees, Support Vector Machines (SVM), and Naive Bayes | Stress detection accuracy of 98.00 % to 99% for different time intervals. | Limited information on the impact of stress on driving performance. |
| Reddy et al., 2018 [22] | Logistic Regression, Random Forest , Naive Bayes , K-nearest Neighbours (KNN), Decision Tree , Bagging,Boosting | Machine learning techniques applied to analyze stress patterns in working adults. | No specific mention of the impact of lifestyle changes on stress. |
| Asha, 2021 [7] | K-nearest neighbors (KNN), decision trees, and support vector machines (SVM) | The research focuses on heart rate monitoring and mental stress detection. | No specific limitations mentioned in the provided research contexts. |
| Jayawickrama & Rupasingha, 2022 [13] | Random Forest, Naive Bayes, K-nearest neighbors (KNN), Decision Trees, Support Vector Machines (SVM), and Logistic Regression | Previous research lacked focus on sleeping habits in relation to stress. | Lack of focus on association between stress and sleeping habits. |
| Manimeghalai et al., 2022 [16] | Logistic Regression , Naive Bayes | Classification of ECG signals as stress or normal with high accuracy. | No specific limitations of the ecg-based stress detection method provided. |
| Rizwan et al., 2019 [2] | Support Vector Machine (SVM) | Model accuracy improved with three ECG features. | Linear SVM shows poor accuracy in detecting stress. |
| Kumar et al., 2020 [34] | Bayes, Neural Network, Lazy, Decision Tree | Multiclass classification for anxiety, depression, and stress severity levels. | The research lacks detailed comparison with other similar studies. |
| Wang et al., 2019 [17] | Random Forests | Stress detection framework based on smartphone sensing data. | Limited sample size affects personalized model creation for stress prediction. |
| Srinivasan et al., 2023 [20] | K-Nearest Neighbours (KNN) | The research focuses on stress, hair loss, and machine learning techniques. | Trichoscopy method results were unclear when predicting hair loss. |
| Rafiul Amin et al., 2022 [35] | Support Vector Machine (SVM) | Offers publicly available dataset for researchers to analyze and develop algorithms. | Limited dataset size may affect classification accuracy. |
| Vuppalapati et al., 2018 [36] | Montreal Imaging Stress Task (MIST) | Stress detection system using EEG biosensor and machine learning models. | Privacy, security, and ethical concerns regarding data usage. |

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|---|---|---|---|
| Saravanan & Sujatha, 2018 [12] | Boosting | Supervised ml approaches used for data classification. | The Bayesian network classifier is computationally complex and not recommended. |
| Hosseini et al., 2022 [8] | Adaboost , Random Forest , Support Vector Machine (SVM) | Low-cost stress detection system using EDA sensor with effective feature selection. | The study focuses on EDA sensors, limiting other physiological signals. |

## V. Analysis and Discussion

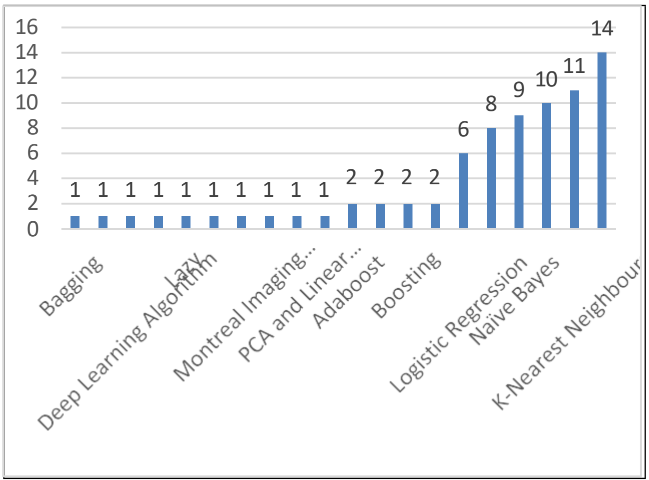


**Figure 3. Machine Learning Algorithm Used for stress Prediction**

The prediction algorithm is the figure that researchers in health care mining most frequently employ for stress prediction, according to the summary table above. The prediction algorithm mostly employed for stress prediction is depicted in the figure. In order to predict stress, researchers typically employ the Support Vector Machine (SVM), which is followed by Logistic Regression, Decision Tree, Naive Bayes, Random Forest, and K-Nearest Neighbour. Some researchers combine these methods to achieve superior results.

## VI. Conclusion

The Stress, a prevalent aspect of daily life, was examined with a focus on understanding its impact and identifying effective ways to manage it. The research paper concludes with the introduction, detection techniques, stress management strategies & the classification of machine learning approaches provided insights into the various methods utilized in stress research, emphasizing the significance of selecting appropriate models for specific applications. Moreover, the paper explored stress management techniques, emphasizing the importance of a holistic approach that encompasses both physical and psychological aspects. Strategies such as mindfulness, exercise, and social support were discussed as effective means to mitigate stress and enhance overall well-being. Continued research and collaboration between the fields of stress science, machine learning, and psychology hold the potential to significantly advance our ability to detect, understand, and manage stress in diverse populations.

## Corresponding author

Mrs. Mohini Mukund Mohod,
Research Scholer, Pankaj Laddhad Institute of Technology and Management Studies, Buldhana, Maharashtra, India
mohinimohod02@gmail.com
https://orcid.org/0009-0007-5997-2671

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