

Analyzing Various Machine Learning Classifiers for the efficient Prediction of Student Mental Stress

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Abstract:

A prevalent societal issue that affects people nowadays is mental stress. Stress is typically felt when one feels that the amount of pressure or demand is more than one's ability to handle it. A person's thoughts, actions, emotions, and interpersonal communication can all be impacted by mental health problems. The major issues that student faces now a days that will suffer their mental health are Depression, Addiction, Anxiety, Eating Disorders, Substance Misuse and Suicidal Intent. Some Students also suffers from a Huge Academic Pressure. It might be from their own mind for gaining more & more in their Academics or might be from Parental Pressure. Accurate analysis and prediction of stress patterns may be possible with the use of machine learning techniques and enabling prompt responses. With an emphasis on the function of machine learning models, the influence of physiological and behavioral characteristics, this paper explores the important facets of mental stress detection. The search was conducted on several databases (IEEE, Scopus, Elsevier, and Web of Science). The topmost objective of the paper is to analyze various algorithms that are used to predict the level of stress among an individual. This Review paper is based on the analysis of various approaches and finally gives the most appealing among all. Random Forest & Gradient Boosting are the best algorithm with topmost accuracy that has been used in various papers and also helps in accurately predicting the level of stress among the individual.

Keywords: K Nearest Neighbor, Random Forest, Naïve Bayes, Regression, Decision Tree, Support vector machine, Gradient Boosting

1. Introduction

Anything that triggers a physiological response, whether internal or external, is considered stress. Stress is any exogenous or innate stimulation which causes a reaction to the body. Stress is typically felt when one feels that the amount of pressure or demand is more than one's ability to handle it. The item that stresses us out is known as a stressor because it grabs our attention and results in an emotional and physical response.

A stress reaction is a unique response, and what could be stressful for one person may be different for another. The type and intensity of a stress reaction also differ from person to person. Many different things might cause stress, such as a job that you can't finish or aren't qualified or prepared to accomplish, financial difficulties, personal and family health issues, workload and ability to handle it, etc. Even joyous occasions like holidays, weddings, and relocation may be stressful. A prevalent societal issue that affects people nowadays is mental stress. Stress decreases human performance at ordinary tasks and may cause serious health problems. According to research, 60% of college students experience anxiety, indicating the need to increase mental health services by 30% to 40%. Moreover, findings indicate that Students reported from mild to extreme stress in 88% of cases, from mild to extreme anxiety in 44%, and from mild to extreme depression in 36% of cases [1].

Based on these traits, one could assume that, despite its difficulties, their time in school would be one of well-being, contentment, and personal growth. Regrettably, research indicates that the existing educational system may unintentionally harm student mental health, as worry, stress, and sadness are very common. There is a heavy body of evidence that shows how stress affects both the physical and mental health, and that the right amount of stress improves learning while too much stress causes health problems. Workload, lack of sleep, financial worries, academic pressure, student abuse, and a covert cynical curriculum are some of the theories put out to explain this downturn in student mental health. Academic performance of students may suffer from stress, which can also lead to academic dishonesty and drug and alcohol abuse. Distress among students has also been linked to cynicism and a lack of concern, which kills empathy the foundational quality of humanity.

Nomenclature:

AB: Adaptive Boosting	LR: Linear Regression	DT: Decision Tree
RF: Random Forest	XG: eXtreme Gradient Boosting	KNN: K-Nearest Neighbor
NB: Naive-Bayes	SVM: Support Vector Machine	

2. Importance of Early Detection of Stress

Academic stress is another name for the stress that students experience. Worry resulting from education and schooling is known as academic stress. Acquiring a degree and furthering one's education can frequently entail significant strain. Managing time, finding time for extracurricular activities, and finishing all the work can be stressful. In various professions and activities, stress and its symptoms, including depression, anxiety & burnout as a prevalent issue. Concern has been aroused in the past few decades by the increasing number of workshops that are organised to help people deal with this condition, as well as the profiling of books, popular articles and research studies. In modern hectic life the stress is a great menace. The most unsatisfactory thing in modern life is that man is so busy with external matters that he has no time for himself. In the same way students are too busy with their work. They are preoccupied with their studies. They take a lot of stress of their work. So it is important to detect the stress in students at the earliest so that they can change their daily routine which will be beneficial for their future life.

3. Signs and Symptoms of recognising stress in yourself and others

In the fields of education and industry, stress detection is crucial for evaluating the effectiveness of instruction, making educational improvements, and lowering the possibility of human error brought on by stressful work environments. As a result, early mental health diagnosis is crucial to preventing disease and other health issues. Numerous physical, behavioural, and/or psychological symptoms can be signs of stress. Common signs & symptoms include:

1. **Physical symptoms** include headaches & Migraines, insomnia, nausea, increased heart rate and blood pressure, sobbing fits, sleep disturbances, aches and pains in the muscles, fatigue, a higher risk of infection and a rise in cold and flu-like illnesses, gastrointestinal issues etc.
2. **Behavioural issues** include difficulty focusing, forgetfulness, irritability, substance abuse (such as increased use of alcohol, coffee, or tobacco), changes in eating habits, tardiness, a rise in absenteeism, poor work performance, fidgeting, an inability to perform well at work despite well-laid plans, and withdrawal from regular social interactions.
3. **Psychological symptoms** include depression, misdirected anxiety, apathy, irritability and anger, difficulty focusing and remembering details, low self-esteem, fear of failing, and unusual behaviour.

4. Applications of Stress detection for students

Machine learning (ML)-based stress detection systems are revolutionizing the way that mental health issues among students are handled in educational settings. Students' stress levels are greatly increased by the demanding requirements of their coursework, extracurricular activities, peer connections, and career planning. The following are some ways that using ML-powered stress detection systems can offer customized solutions and enhance wellbeing:

1. Tracking Academic Stress

By examining behavioral and physiological data, stress detection devices assist in identifying students who experience difficulties with academic demands or exam pressure.

- To recommend adaptive learning techniques, machine learning models such as support vector machines (SVMs) examine performance data, study schedules, and sleep patterns.
- Before students experience burnout, early stress detection can lead to counseling sessions or relaxation exercises.

2. Programs for Mental Health and Wellbeing

Stress detection systems can assist educational institutions in establishing successful mental health initiatives by evaluating data from wearables or self-reported measures.

- By identifying patterns of social disengagement, anxiety, or depression, logistic regression models allow counselors to intervene in real time

- Based on insights from machine learning models like decision trees, suggestions for stress-relieving exercises like yoga or art therapy are made.

3. Enhanced Peer and Teacher Relationships

By locating the causes of relational stress, stress detection systems can enhance the relationships between students, teachers, and peers.

- Machine learning algorithms can identify bullying trends or communication breakdowns by examining text or audio data.
- By giving teachers feedback on how their methods impact students' stress levels, systems allow for modifications.

4. Career Guidance and Assistance with Decision Making

Uncertainty about their careers causes stress for many students. When paired with machine learning, stress detection systems can offer recommendations based on a student's preferences, strong points, and stressors.

- Making stress-free recommendations for professions or academic programs that play to a student's strengths.
- A real-time assessment of the efficacy of career training or counseling sessions.

5. Mitigation of Peer Pressure and Bullying

In order to identify kids who are being bullied or pressured by their peers, machine learning (ML)-based stress detection systems can examine contextual and behavioral data.

- Systems can assist in developing focused interventions for students who are at danger.
- Workshops and programs that teach kids how to deal with peer pressure are designed using insights from machine learning models.

6. Real-Time Feedback and Alerts

Stress detection systems that use real-time data analysis can notify parents or school officials about pupils' critical stress levels.

- Warning signs of extreme stress that allow for prompt medical attention.
- Guiding modifications to policies, such as cutting back on homework or rearranging class schedules.

5. Methodology

Search Strategy and Data Collection

A systematic and thorough approach was used in the methodology for this review in order to find, collect, and evaluate pertinent research papers and data on mental stress detection, with an emphasis on the incorporation of machine learning techniques. The search approach was created to cover a broad spectrum of interdisciplinary materials, guaranteeing the inclusion of research from a number of fields, such as computer science, psychology, and the medical sciences.

1. Search Approach

Several scholarly databases, including ScienceDirect, PubMed, IEEE Xplore, SpringerLink, Scopus, and Google Scholar, were used in the literature search. The following terms and phrases were used because they were pertinent to the research topic:

- "mental stress detection,"
- "machine learning and stress,"
- "physiological parameters in stress detection,"
- "ensemble learning techniques," and
- "wearable devices for stress monitoring."

In order to ensure that studies addressing physiological, behavioral, and contextual aspects in stress detection were included, boolean operators (AND, OR) were used to refine search results. To ensure accuracy and relevance, the search was restricted to papers released in peer-reviewed journals, conference proceedings, and reliable open-access platforms during the last ten years. Priority was given to articles that made substantial methodological or technical contributions.

2. Inclusion and Exclusion Criteria

- **Inclusion Criteria:**

Studies focusing on physiological and behavioral parameters for stress detection, and reviews summarizing existing methodologies and challenges. Papers employing multi-modal datasets and ensemble learning techniques were given priority to align with the study's objectives.

- **Exclusion Criteria:**

Studies without empirical evidence, papers in non-English languages, and articles focused on unrelated stress concepts (e.g., financial or ecological stress).

3. Data Collection

The collected data encompassed parameters (e.g., heart rate variability, blood pressure, respiratory rate) and behavioral indicators (e.g., sleep quality, activity levels, and academic workload). The main focus was given on studies these parameters with machine learning models, including logistic regression, support vector machines, decision trees, and gradient boosting. Additionally, ensemble learning techniques like random forests and AdaBoost were explored for their robustness in handling noisy and imbalanced datasets. Data from wearables and smart devices, such as ECG and GSR sensors, were particularly highlighted due to their practical applications in real-time stress monitoring.

4. Review and Analysis

All identified studies were subjected to rigorous screening and critical analysis. The extracted data were synthesized to assess trends, strengths, and limitations of various methodologies. Special attention was given to the scalability, accuracy, and real-world applicability of machine learning models in stress detection.

4. Challenges and Ethical Considerations

Ethical concerns, including data privacy and the interpretability of machine learning models, were documented. Future research directions were identified based on gaps and limitations observed in the existing literature.

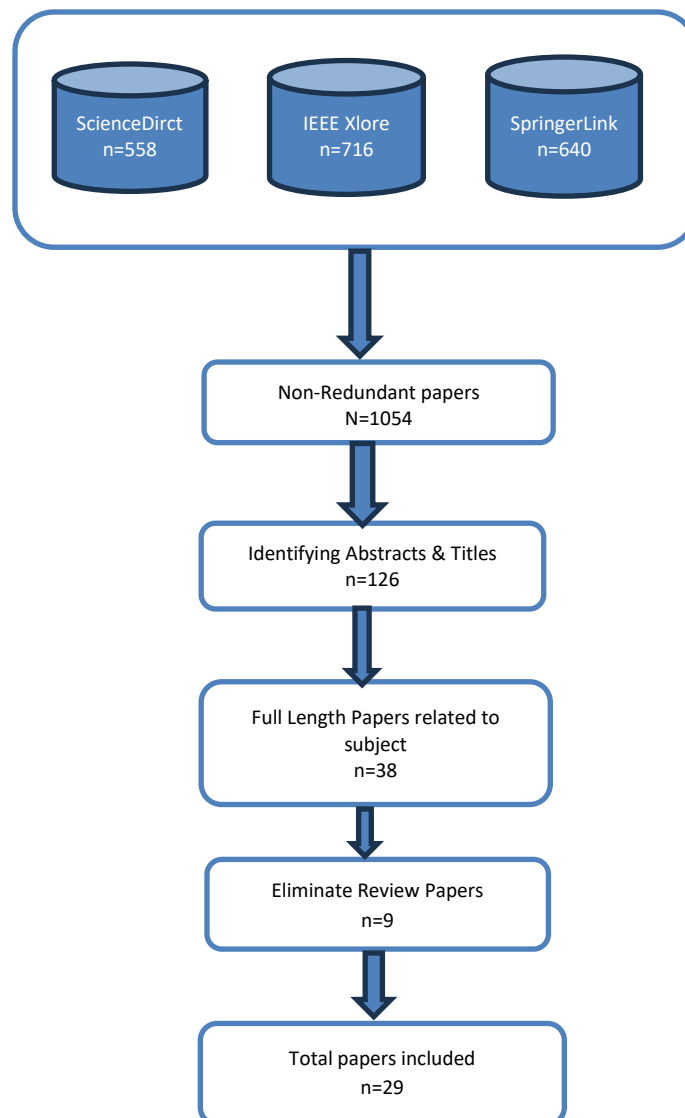


Fig 1: The flowchart elaborates the strategy for search used for the review paper

1. Literature Review

TABLE 1: Literature review and Overview of Recent Studies on Stress level Prediction Using machine learning classifiers

Sno	Author Reference	Year	Journal / Publisher Name	Dataset Used	Algorithms and Techniques Used	Results	Conclusion
1	[2]	2024	Elsevier	SWEET dataset of 240 healthy adult volunteers	K-Nearest Neighbors (KNN), Decision Tree (DT), Support vector classification (SVC), and Random Forest (RF)	RF gives 93.58 accuracy, DT performs 94.61, SVC gives 96.27 and KNN performs 98.44 of accuracy	KNN performs superior as compare with with SVC, DT and RF
2	[3]	2023	Elsevier	127 Students of Engineering	Random forest, Naïve Bayes, Decision tree and Support vector machine algorithms	Random Forest gives accuracy as 78.9%, Naïve Bayes as 71.05%, SVM as 75.5% and Decision Tree as 71.05%	The best accuracy obtained from Random Forest i.e 78.9%
3	[4]	2023	Elsevier Journal of Biomedical Informatics	Dataset of 90 Participants taken	Random forests, Support vector machines & gradient boosting models	Light GBM gives an F1 value of low Perceived Stress is 0.776, AUC is 0.741, Precision of 0.726	The Gradient Boosting model gives the best result
4	[5]	2022	Research Square	15,366 university Students with 20 factors	Bagging, k-nearest neighbor, Neural networks, Generalised linear models, random forest, naïve-Bayes & boosting algorithms	Random forest has accuracy 0.921, KNN gives accuracy as 0.775, Adaptive Boosting gives 0.893, and naïve-Bayes as 0.723	Adaptive boosting & Random forest algorithms achieved the topmost accuracy
5	[6]	2022	Hindawi	Historical data of 5 Years dataset of 1036 Students	Back Propagation Algorithm	The difference between Predicted and measured is 0.88%	The prediction model of the Back Propagation neural network avoids

							the tedious Traditional process of modeling
6	[7]	2022	AICECS Journal of Physics: Conference Series	A dataset of 1259 Entries with 27 attributes was taken	Decision Tree, K-NN Logistic Regression, Stacking & Random Forest	The Technique of Stacking achieved a Prediction accuracy of 81.75%. KNN, RF and SVM equally performed	The mean accuracy of all the classifiers is 79%.
7	[8]	2022	Hindawi Scientific Programming	A dataset of 280 undergraduate students	K means Clustering, NaïveBayes, Random forest, decision tree & BP Neural Network	According to experimental findings, mental health issues are recognized in 75% of students.	The decision Tree is best among five as it gives F1-measure 0.69, Recall 0.58 & precision 0.68
8	[9]	2022	Frontiers in Public Health	Time-series data on the COVID-19 pandemic's daily OPHS number were gathered in 2020.	The model consists of Random forest, LR, Ridge, LASSO, SVR	The mean Predictive Performance of LR is 25.945, Ridge 6.440, LASSO 8.307, SVR 6.018, RF 6.280	The OPHS value is 29.929 on a daily average.
9	[10]	2022	Rochester Institute of Technology, Rochester, New York	A dataset of 270 Participants had been collected from surveys & Structured Questionnaire	Two algorithms used in it SVM and RF	Performance evaluation was measured based on accuracy, precision, and recall	SVM gives better output at 80.2%
10	[11]	2022	Springer, Natural Medicine	The dataset is based on data of EHR 7 years (2012–2018) from 17,122 patients.	Deep learning-based classifiers, decision trees, and probabilistic ensembles	XGBoost Obtained ROC as 0.797, Precision 0.159, sensitivity 58% & specificity 85%	The most effective overall performance was shown by XGBoost.
11	[12]	2022	Tech Science Press	Dataset of adults between 2005 and 2018	LR, Elastic Net, RF, Extremely Randomized Trees Classifier, XGBoost, Linear	Random Forest (RF) gives 91% and Extra Tree Classifier gives 92%	The loss function has been optimized using the Frequent Model Retraining (FMR)& Ensemble

					SVM, Polynomial SVM		Learning Approach (ELA)
12	[13]	2022	International Research Journal of Modernization Engineering Technology and Science	The dataset has been imported from the Excel file	KNN, Naïve Bayes, Decision Trees, Boosting	The visual GUI Based system produced an accuracy of 87%	KNN and Boosting produced the highest accuracy
13	[14]	2021	International Journal of Perceptive & Cognitive Computings	The dataset of 219 university students for the year 2021 from India was acquired from Kaggle.	K-Nearest Neighbors, Naïve Bayes Decision Tree & Support Vector Machine are used in it.	Decision Trees has an accuracy of 0.64, KNN of 0.59, and SVM as 0.44	Decision Trees perform better
14	[15]	2021	Journal of Health, Population & Nutrition	355 Students from 28 different Bangladesh university using a questionnaire.	DT, RF, SVM, K-fold validation techniques.	DT has Macc(Mean of Accuracy scores) 0.8870, RF 0.8983, SVM (polynomial kernel) 0.7855, SVM (linear kernel) 0.8309, LR 0.7713 for 10 Fold	Random Forest Model has the highest accuracy
15	[16]	2021	Firouzabad Institute of Higher Education, Firouzabad, Fars, Iran	Twitter, Facebook, Biosensors, Students, SNS Post Dataset	SVM, Naïve Bayesian classifier	SVM is widely used in the health domain. ML Shows weak performance in large samples	Naïve Bayesian shows high accuracy in sentiment analysis of Facebook status
16	[17]	2021	Frontiers in Public Health	Dataset of 5,108 Chinese medical professionals based on 32 criteria	Binary Bat, Stepwise logistic regression, hybrid improved dragonfly algorithm	The proposed model gives 92.55% prediction accuracy.	The IGCBABPNN model of prediction can obtain better output results in the prediction of mental health
17	[18]	2021	International Journal of Engineering Research & Technology	Dataset of 91 students by using Binning method.	KNN Classification algorithm used in it	The model obtained an Accuracy of 94.5054945054945 %	The student can incorporate the work and solution towards maintaining his

							or her mental balance.
18	[19]	2021	scientific Report Nature Research	4284 UG Students for MDD and GAD	Logistic Regression, SVM, Random Forest, XG Boost, K Nearest neighbor & Neural Network algorithms	For GAD the values of AUC is 0.73(Specificity 0.7, sensitivity:0.66) & for MDD the values of AUC is 0.67(sensitivity:0.55 , Specificity 0.7)	The positive & negative predictive value was 16% and 96%
19	[20]	2021	European Journal of Medical and Health Science	Dataset of 30 final-year medical students including 19 males & 11 females	Average pre and post-test scores	Findings showed that the test group's average percentage coherence score was substantially greater ($p < 0.05$) than the control groups in the lowest cardiac coherence domain but lower ($p < 0.05$) in the highest coherence domain.	When compared to before the exam, when exam takers were showing signs of stress, the coherence score was significantly higher ($p < 0.05$) after the examination, indicating release from stress.
20	[21]	2021	IEEE	A dataset of 60 sample data points based on pulse rate, GSR, and skin temperature is taken	LR, SVM, NB, RF, DT and ANN approaches are used.	LR achieves 90%, KNN 83%, NB 87%, SVM 85%, RF 79% accuracy	ANFIS-FWGWO classification algorithm performs with an accuracy of 94%
21	[22]	2020	Springer	Dataset of 6630 Children of 2013-17	Classification and Regression tree Analysis Algorithm, Deep Multi-layer neural networks, Logistic Regression.	Regression tree analysis has AUC=.68, logistic regression model AUC=0.69, deep multi-layer NN AUC = .72, Ensemble model AUC=.71,	A Deep multi-layer NN with AUC=0.70 has Maximum Accuracy
22	[23]	2020	IEEE University College London	Dataset Collected from DDI (data Driven Investor) with a group of 752.	Logistic Regression, KNN, SVM, Naive Bayes, Decision Trees	The result shows Depressed Students are 135 in number	To determine whether a certain tweet is depressive or not, Twitter scraping tool

							Twint is used in it.
23	[24]	2020	PLOS National University of Science and Technology	7,638 twins were included in the children and adolescent twin study.	XGBoost, Logistic Regression, Neural Network, Random Forest, SVM	RF AUC = 0.739, 95% CI, SVM (AUC = 0.735, 95%	Logistic Regression has the best AUC 0.750
24	[25]	2020	International Journal Education & Management Engg	Analysis of Factors Affecting Mental Health resulting lack of financial and social support	Decision tree, SVM, and neural network	With a score of more than 70%, these three are extremely accurate.	SVM achieved the highest accuracy between 70% to 96%
25	[26]	2020	IEEE	WESAD Dataset is used.	Linear Discriminant Analysis, K-Nearest Neighbour, Random Forest, Decision Tree, Kernel Support Vector and AdaBoost	Machine Learning techniques gives Accuracy of 81.65% and 93.20 % on a three-class and binary classification problem	The achieved accuracy ranges from 84.32% and 95.21%
26	[27]	2020	International Journal of Mechanical and Production Engineering Research Development	The dataset of 200 university students was collected using PSS Scale, ADULT ADHD Self-Report Scale and Weka Tool	Linear Regression, Naive Bayes, Random Forest, Multi-Layer Perceptron, Bayes Net, and J48 algorithms used	Bayes net gives accuracy as 88.59%, Multilayer Perceptron as 85.43%, Naive Bayes as 84.2105%, Logistic Regression 84.9649, J48 gives 86.42, Random Forest 83.333%	Bayes Net Classifier give the maximum Accuracy at 88.5965%
27	[28]	2020	International Journal of Engineering and Advanced Technologies	A dataset of 220 UG and PG was collected by using PSS Scale through google dox	SVM, KNN, RF, Naive Bayes, Logistic Regression, Decision Tree	Bayes net gives accuracy as 88.59%, Multilayer Perceptron as 85.43%, Naive Bayes as 84.2105%, Logistic Regression 84.9649, J48 gives 86.42, Random Forest 83.333%	Baye's Net classifier produces the highest 88% of accuracy.

7. Findings and discussions

The integration of machine learning (ML) into stress detection has opened new possibilities for understanding and managing mental health challenges in diverse environments. This study explored the applications of stress detection technologies in driving conditions and academic environments, highlighting their potential to enhance safety and well-being. However, the adoption of these technologies is not without its challenges, including data privacy, ethical considerations, and individual variability in stress responses.

1. Effectiveness of ML in Stress Detection

By analyzing physiological parameters such as heart rate variability (HRV), electrodermal activity (EDA), and respiratory rate, ML models have shown robust performance across different scenarios. Behavioral indicators, including driving patterns and academic workload, further enhance these models' predictive capabilities when combined with physiological data.

2. Real-Time Monitoring and Interventions

The implementation of real-time stress monitoring systems has proven particularly effective in dynamic environments such as driving and academics. For drivers, real-time alerts based on physiological data can prevent accidents by encouraging breaks or activating automated driving modes. Similarly, in academic settings, real-time feedback allows students to manage stress during high-pressure situations, such as exams or deadlines.

3. Challenges in Implementation

Despite promising results, stress detection systems face several hurdles:

- **Data Privacy:** Continuous monitoring involves collecting sensitive physiological and behavioral data, raising concerns about data security and misuse.
- **False Positives and Accuracy:** Ensuring high precision in stress detection is crucial to avoid unnecessary interventions, which may cause further distress.
- **Adaptability:** Stress responses vary across individuals due to genetic, cultural, and situational factors. Models must account for these differences to provide personalized solutions.
- **Resource Constraints:** Implementing wearable devices and monitoring systems on a large scale can be cost-prohibitive, particularly in educational institutions.

4. Ethical Considerations

The ethical implications of stress detection systems are profound. While these technologies can improve well-being, they also pose risks of surveillance and misuse. Ethical frameworks must guide their development to ensure they prioritize user consent, transparency, and inclusivity.

Based on Literature Review which is done of papers from 2020-2024, we find that SVM & Random Forest algorithm are best among all techniques. More than 25 research papers were reviewed of recent years. These papers showed some important and relevant details of the algorithm were included in literature review. Supervised machine learning algorithms are applied for Stress level Prediction.

8. Conclusion

To conclude, we can say the Stress has major detrimental effects on both academic and physical. It results from poor nutrition poor sleeping habits, unhealthy eating habits and academic pressure. All the efforts of both the educators and parents to make ensure that student do not feel a great deal of tension. This study highlights how machine learning can revolutionize stress detection in a variety of settings. By offering individualized support and facilitating stress-free learning environments, these tools help students in academic contexts deal with mental health issues. The results show that the best outcomes for stress detection come from combining behavioral and physiological data. When compared to single-feature models, multi-modal systems—which incorporate data from wearables, in-car sensors, and academic tracking tools—perform better. Additionally, by using ensemble learning approaches, predictions become more robust and generalizable, which makes these systems suitable for practical uses. By Reviewing above mentioned papers, we concluded that Ensemble learning techniques, which combine the predictions of multiple base models, have shown superior performance in stress detection tasks. Methods like random forests, AdaBoost, and gradient boosting have been applied to improve the robustness and accuracy of predictions. By aggregating the strengths of individual models, ensemble methods reduce overfitting and enhance generalizability, making them particularly effective in handling noisy and imbalanced datasets common in stress detection research. For instance, gradient boosting has proven effective in capturing non-linear relationships between features, such as the interplay between mental health history and academic performance in stress prediction. SVM, Random Forest algorithm, Gradient Boosting & Decision Tree are best among all techniques. To be more precise Gradient Boosting & Random Forest are the best algorithms that have been used in various papers and also help in accurately predicting the level of stress among an individual. The potential

effects of this psychological issue on students' health, academic achievement, and ability to advance in their professional lives make it extremely dangerous. The three most prevalent factors - a poor learning environment, a lack of social support, and financial difficulties have been identified. Furthermore, the scope of this issue must be recognised and comprehended. To identify the research gaps, several research publications have been compared. The investigation of predictors of receiving psychosocial treatment was aided by machine learning models. To get predictive performance, further data and data pre-processing methods should be investigated for other models.

Future Directions

Technologies for stress detection are revolutionizing the way mental health issues are handled. These systems provide promising solutions for improving well-being, productivity, and safety in a variety of settings by utilizing machine learning and sophisticated data collection techniques. But in order to reach their full potential, a concentrated effort is needed to solve existing constraints, guarantee moral application, and promote interdisciplinary cooperation. Stress detection systems will improve in accuracy, accessibility, and impact as technology advances, fostering a society that is healthier and more robust.

- Future studies should examine stress detection in various contexts, such as workplaces, healthcare facilities, and sports, even though this study concentrated on academic settings. Future initiatives should concentrate on making sure systems are impartial and inclusive, as well as expanding datasets to encompass a variety of demographic groupings. utilizing multi-modal datasets, which include environmental, behavioral, and physiological data by improving methods for preparing data in order to reduce noise and increase signal clarity.
- Individualistic stress reactions are a result of a variety of factors, including personality, life experiences, and heredity. Adaptive algorithms that learn from unique patterns and offer customized interventions should be a part of future systems. Real-time personalization may be made possible by methods like deep learning and reinforcement learning, which would improve user effectiveness and experience.
- Advanced anonymization approaches can preserve the usefulness of stress data for analysis while safeguarding user privacy.
- ML and AI-powered virtual assistants working together could give consumers dynamic, situation-specific stress-reduction techniques. AI systems might, for instance, suggest customized relaxation techniques based on past data and present stress levels.

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Competing Interest: The authors declare that they have no competing interests.

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