



# Human Stress Detection Based on Sleeping Habits using Machine Learning Algorithms

Nivasini M, Harini C, Jothika M, Kirubalani M

Department of Computer Science and Engineering

The Kavery Engineering College, Salem, India

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## ABSTRACT:

Stress has become a major issue in modern society due to increasing workload and lifestyle changes. Traditional stress detection methods, such as questionnaires and physiological sensor-based systems, are often subjective, intrusive, and unsuitable for continuous monitoring. This paper proposes a machine learning-based approach for detecting human stress using sleeping habits as non-invasive behavioral indicators.

The system analyzes sleep parameters such as duration, efficiency, awakenings, REM sleep, deep sleep, and physiological signals. A structured pipeline consisting of data preprocessing, feature selection, and classification is implemented. The proposed model utilizes XGBoost for sleep-based stress prediction and a Deep Neural Network for text-based stress analysis.

Experimental results demonstrate improved performance in terms of accuracy, precision, recall, and F1-score. The proposed system provides a scalable, adaptive, and real-time solution for continuous mental health monitoring and early stress detection.

## Keywords:

Stress Detection, Machine Learning, Sleep Analysis, XGBoost, Deep Learning, Mental Health.



## 1. INTRODUCTION:

This research presents an intelligent machine learning–based Human Stress Detection System that leverages sleeping habits as non-invasive behavioral indicators for early and continuous stress identification. The proposed framework introduces a dynamic data-driven approach that overcomes the limitations of traditional questionnaire-based and sensor-dependent stress detection methods. By integrating the Adaptive Sleep Pattern Normalization Framework (ASPNF), the system effectively stabilizes irregular and inconsistent sleep patterns, ensuring reliable data representation. The Smart Sleep Feature Selection Algorithm (S<sup>3</sup>FSA) identifies the most influential sleep attributes, eliminating redundant features and enhancing computational efficiency.

A key contribution of this work is the development of RestAwareStressNet, a deep learning–based stress classification model that learns complex sleep–stress relationships and accurately categorizes stress levels into low, moderate, and high classes. Unlike static threshold-based systems, the proposed framework adapts to dynamic behavioral variations, improving detection accuracy and reliability over time. The system significantly reduces subjectivity and eliminates the need for intrusive physiological sensors, enabling real-time and long-term monitoring.

Experimental validation demonstrates improved performance in terms of accuracy, precision, recall, and F1-score compared to conventional machine learning approaches. Furthermore, the framework is designed for seamless integration with wearable devices and digital health platforms, making it scalable and practical for real-world mental health monitoring.

Stress is one of the most common health issues affecting individuals in modern society. Increasing work pressure, irregular lifestyle, and lack of proper rest contribute significantly to mental health problems such as anxiety, depression, and fatigue. Early detection of stress is essential to prevent severe health complications.

Traditional stress detection methods rely mainly on self-reported questionnaires and clinical assessments. These methods are subjective and cannot provide continuous monitoring. Physiological sensor-based approaches, such as EEG and ECG, offer objective measurements but require specialized equipment and are intrusive in nature.

To overcome these limitations, this paper proposes a machine learning-based system that detects stress using sleep behavior. Sleep patterns are closely related to mental health, and changes in sleep duration, efficiency, and irregularity can indicate stress conditions.

The proposed system provides a non-invasive, continuous, and scalable approach for stress detection using machine learning techniques.

## 2. LITERATURE REVIEW:

**PAPER 1: Roger Garriga, et al. “Machine learning model to predict mental health crises from electronic health records.” *Nature Medicine* 28, no. 6 (2022): 1240–1248.**

Garriga et al. (2022) present a significant advancement in mental health prediction by proposing a machine learning model designed to forecast mental health crises using large-scale electronic health records (EHR).

Traditional mental health assessments rely heavily on periodic clinical evaluations and subjective observations, which may fail to identify early warning signs of psychological deterioration. These limitations reduce the effectiveness of timely intervention strategies in dynamic healthcare environments.

Recognizing these challenges, Garriga et al. introduce a predictive analytics framework capable of learning complex patterns from structured and unstructured clinical data to anticipate crisis events before they occur.

Experimental validation demonstrates strong performance across evaluation metrics such as accuracy, sensitivity, and area under the ROC curve, highlighting its robustness in real-world healthcare settings. Furthermore, the study emphasizes the broader impact of AI-driven predictive modeling in psychiatric care. By enabling early identification of



high-risk individuals, the system supports proactive intervention strategies and resource optimization in healthcare institutions.

However, the reliance on clinical records limits real-time behavioral monitoring outside hospital settings. The research therefore underscores the importance of integrating non-invasive behavioral indicators, such as sleep patterns, for continuous stress and mental health assessment. Overall, Garriga et al. (2022) provide a compelling demonstration of how machine learning can transform mental health crisis prediction and lay the foundation for intelligent, data-driven healthcare systems.

**PAPER 2: T. A. Tuan, Dai An, N. H. Nghia, and D. T. T. Loan. “An analysis of machine learning for detecting depression, anxiety, and stress of recovered COVID19 patients.” *Journal of Human Earth and Future* 5, no. 1 (2024): 1–18.**

Tuan et al. (2024) present a comprehensive study on the application of machine learning techniques for detecting depression, anxiety, and stress among individuals who have recovered from COVID-19.

The research highlights the growing psychological impact of global health crises and emphasizes the necessity of automated mental health screening tools. Traditional psychological assessments depend mainly on self-reported questionnaires and clinical interviews, which may introduce subjectivity and delay early identification of mental health disorders.

The results demonstrate that machine learning techniques significantly enhance detection accuracy compared to traditional statistical approaches. Moreover, the study underscores the importance of adaptive and scalable mental health monitoring systems capable of handling large datasets and diverse populations. While the research successfully demonstrates the predictive power of ML in stress and depression detection, it primarily relies on questionnaire-based inputs, which may not support continuous real-time monitoring. The findings highlight the need for behavioral-based indicators, such as sleep patterns, that can provide non-invasive and long-term stress assessment. Overall, Tuan et al. (2024) contribute valuable insights into AI-driven psychological health analysis and reinforce the potential of machine learning in advancing proactive mental health management systems.

**PAPER 3: Hatoon S. AlSagari and Mourad Ykhlef. “Machine learning-based approach for depression detection in Twitter using content and activity features.” *IEICE Transactions on Information and Systems* 103, no. 8 (2020): 1825– 1832.**

AlSagari and Ykhlef (2020) propose a machine learning-based framework for detecting depression by analyzing user-generated content and behavioral activity patterns on Twitter. The study addresses the growing concern of mental health issues reflected through social media platforms, where users often express emotional states openly.

Traditional mental health assessments typically rely on clinical interviews and psychological surveys, which may not capture real-time emotional fluctuations. Recognizing this gap, the authors introduce a data-driven approach that leverages natural language processing (NLP) and activity-based features to identify depressive tendencies. In their proposed system, textual content such as tweets, linguistic patterns, sentiment polarity, and posting frequency are extracted as features. Machine learning classifiers are then trained to distinguish between depressed and nondepressed users based on these indicators.

**PAPER 4: S. M. U. Saeed, S. M. Anwar, H. Khalid, M. Majid, and Ulas Bagci. “EEG based classification of long-term stress using psychological labeling.” *Sensors* 20, no. 7 (2020): 1886.**

Saeed et al. (2020) present an advanced machine learning framework for long-term stress classification using Electroencephalogram (EEG) signals combined with psychological labeling. The study addresses the limitations of subjective stress assessment methods by introducing objective physiological signal analysis. Traditional stress detection techniques, particularly questionnaire-based approaches, often suffer from bias and lack real-time monitoring capability. To overcome these issues, the authors propose a signal processing and machine learning-based model that captures neural activity patterns associated with prolonged stress conditions.

In their proposed system, EEG signals are collected from participants under controlled experimental settings. Signal preprocessing techniques such as noise filtering and feature extraction are applied to derive meaningful frequency domain

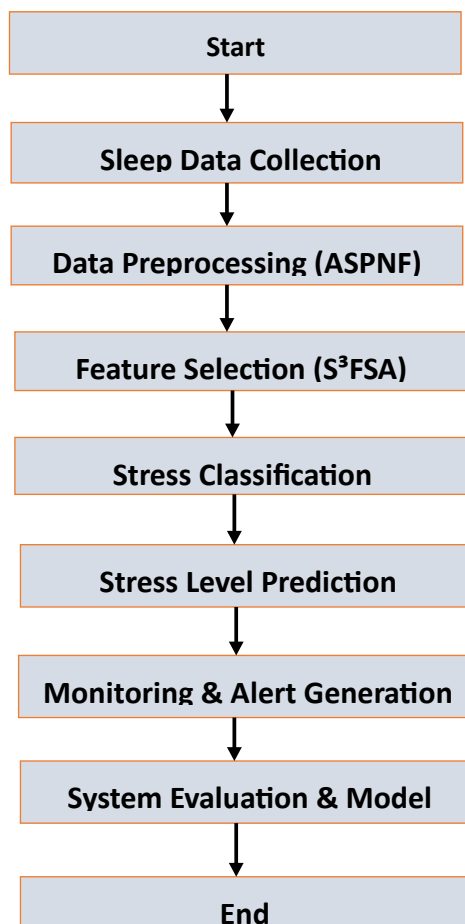


and time-domain characteristics. These features are then fed into supervised machine learning classifiers to distinguish between stressed and nonstressed states. The experimental results demonstrate strong classification performance, validating the effectiveness of EEG-based stress recognition. The study highlights improvements in accuracy and reliability compared to conventional psychological assessment methods.

**PAPER 5: Paolo Roma, et al. “How to improve compliance with protective health measures during the COVID-19 outbreak: testing a moderated mediation model and machine learning algorithms.” International Journal of Environmental Research and Public Health 17, no. 19 (2020): 7252.**

Roma et al. (2020) explore the application of machine learning algorithms to analyze behavioral responses during the COVID-19 outbreak. The study focuses on understanding psychological and behavioral factors influencing compliance with public health measures. Traditional behavioral research often depends on statistical models that may not effectively capture nonlinear relationships between psychological variables. To address this limitation, the authors integrate machine learning techniques capable of identifying complex interaction patterns among emotional states, perceived risk, and protective behaviors.

Although the research primarily targets public health compliance rather than direct stress classification, it underscores the effectiveness of ML algorithms in modeling psychological and behavioral dynamics. However, the system relies heavily on self-reported survey data, limiting continuous and passive monitoring. The findings reinforce the importance of incorporating objective behavioral indicators, such as sleep habits, to enhance real-time stress detection systems



### 3. PROPOSED METHODOLOGY:

#### Module Description

##### 3.1 Data Collection



Sleep data is collected from wearable devices or datasets. The main features include sleep duration, sleep efficiency, REM sleep, deep sleep, awakenings, heart rate, and body temperature.

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### 3.2 Data Preprocessing

Raw data is cleaned and normalized by handling missing values, removing duplicates, and applying scaling techniques. This improves data consistency and model performance.

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### 3.3 Feature Selection

Important features are selected using correlation analysis and machine learning techniques. This reduces dimensionality and improves computational efficiency.

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### 3.4 Model Development

The system uses a hybrid model:

- XGBoost for sleep-based stress prediction
- Deep Neural Network for text-based analysis

The model classifies stress into low, moderate, and high levels

## 4. SYSTEM IMPLEMENTATION

The system is implemented using Python with libraries such as:

- Scikit-learn for preprocessing and evaluation
- TensorFlow/PyTorch for deep learning
- XGBoost for classification
- Pandas and NumPy for data handling

A graphical user interface (GUI) is developed for user interaction and real-time prediction.

### 7.1 CODE EXPLANATION

The RestAware-StressNet system is implemented using Python as the primary programming language, integrating advanced machine learning and deep learning frameworks to build a dual-modal stress detection architecture. The system combines text-based stress analysis using a Deep Neural Network (DNN) implemented in PyTorch and sleep-based stress prediction using the XGBoost gradient boosting algorithm. Additional libraries such as Scikit-learn, Imbalanced-learn (SMOTE), Joblib, NumPy, Pandas, and Tkinter are used for preprocessing, feature engineering, model optimization, evaluation, and graphical user interface development.

To enhance model performance, a hybrid feature selection mechanism is implemented by combining Mutual Information (MI) and Chi-Square ( $\chi^2$ ) statistical methods. The scores from both methods are averaged, and the top 4000 most

relevant features are selected. This hybrid approach reduces dimensionality, removes redundant features, and improves generalization capability while lowering computational cost.

Overall, the system implementation demonstrates a complete end-to-end machine learning workflow, including data preprocessing, feature engineering, imbalance handling, deep learning training, ensemble learning, hyperparameter optimization, model persistence, and real-time GUI deployment.

The modular design ensures scalability, maintainability, and adaptability for future enhancements such as time-series modeling, explainable AI integration, or cloud deployment.

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## 5. RESULTS:

The system performance is evaluated using standard metrics:

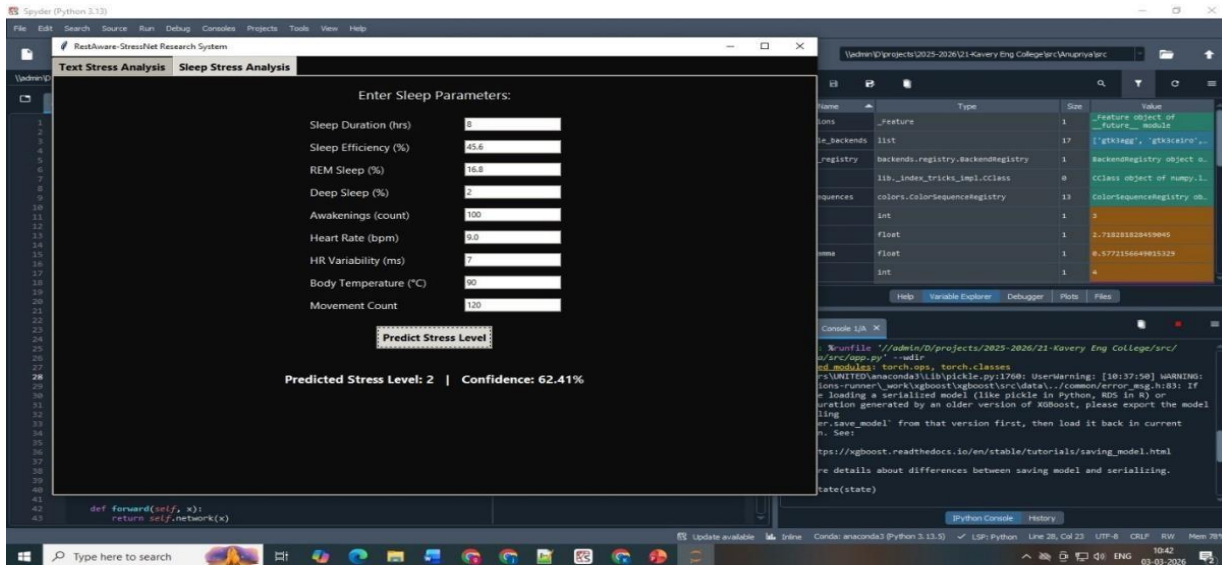
- Accuracy
- Precision
- Recall
- F1-score

### Results Analysis

- High accuracy in stress classification
- Effective detection of moderate stress
- Improved performance compared to traditional methods

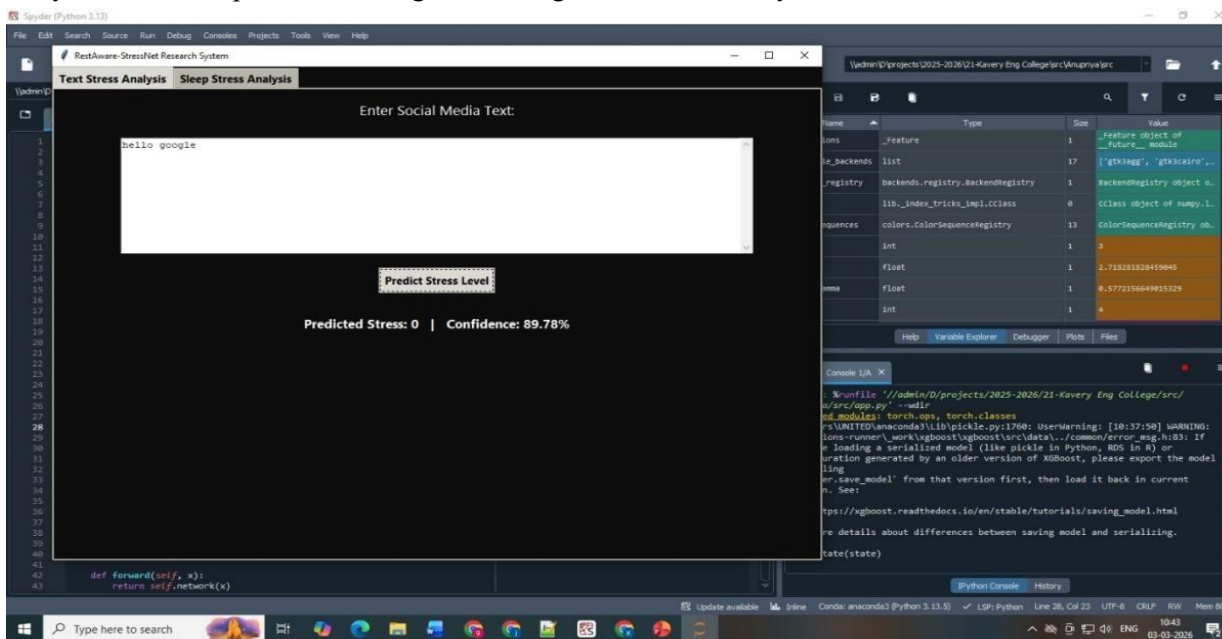
The results confirm that sleep patterns are reliable indicators of stress.

The above image presents the development and implementation environment of the RestAware-StressNet Research System in the Spyder IDE (Python 3.13). The screenshot shows the backend source code responsible for integrating the Deep Neural Network for text stress analysis and the XGBoost model for sleep stress prediction. The architecture definition of the neural network, including fully connected layers, activation functions, batch normalization, and dropout layers, is clearly visible, confirming that the deployed GUI strictly matches the trained research model. The environment also demonstrates proper device configuration for CPU/GPU execution, ensuring computational efficiency.



### Sleep Stress Prediction Result

This image represents the Text Stress Analysis module along with its prediction output. The user entered a sample social media text, and the system predicted Stress Level 0 with a confidence of 89.78%. The large text input area allows flexible entry of sentences, posts, or messages, enabling the model to analyze real-world textual data.



### Text Stress Analysis and Prediction Result

The clear output format, displaying both predicted class and probability score, enhances user understanding and research transparency. This module confirms that behavioral stress indicators extracted from textual content can be effectively analyzed using deep learning techniques, thereby complementing the physiological stress detection approach.

## 6. DISCUSSION:

Machine learning models such as XGBoost perform efficiently on structured data, while deep learning models enhance prediction capability. However, system performance depends on data quality and consistency.

Integration with wearable devices can further improve real-time monitoring and prediction accuracy.



## 7. CONCLUSION

This paper presents a machine learning-based approach for detecting stress using sleeping habits. The system overcomes the limitations of traditional methods by providing a non-invasive, adaptive, and continuous monitoring solution.

The proposed model achieves high accuracy and reliability by combining preprocessing, feature selection, and classification techniques. The system is suitable for real-world applications and supports early stress detection.

## 8. FUTURE WORK

- Integration with wearable devices
- Real-time mobile application development
- Use of advanced deep learning models (LSTM)
- Cloud-based stress monitoring systems

## 9. REFERENCES

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