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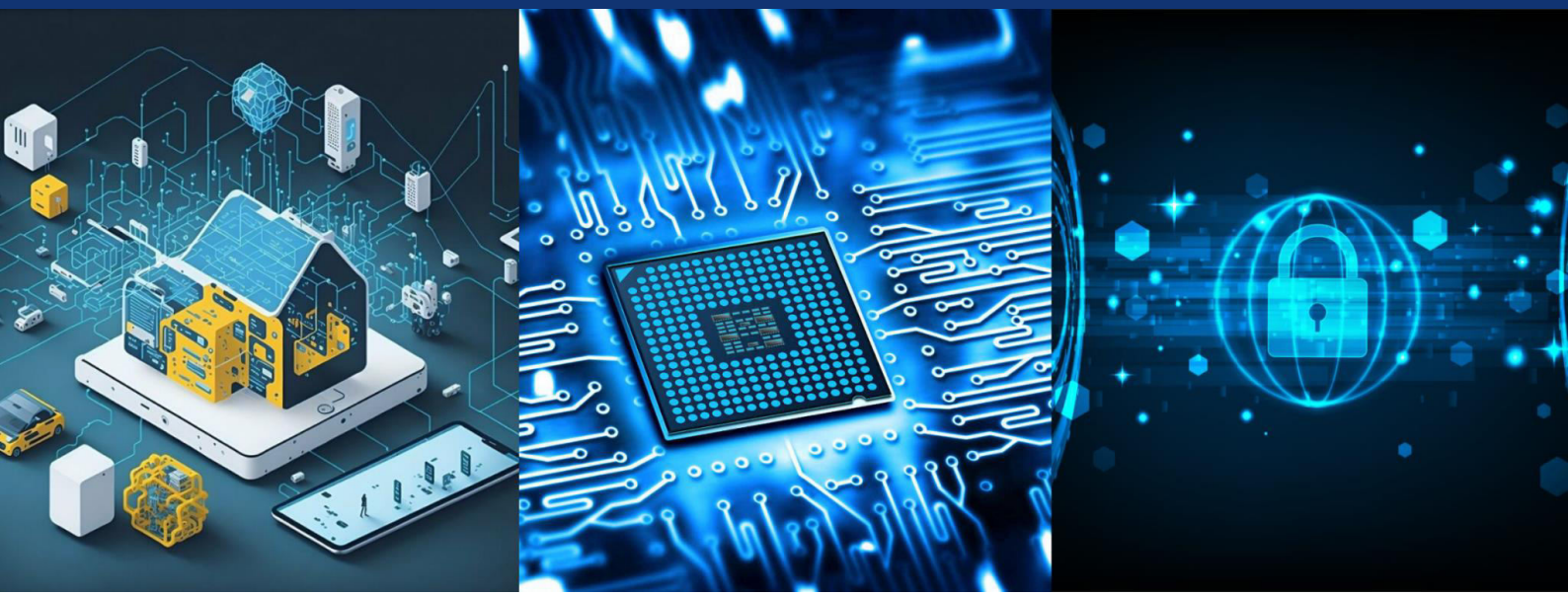

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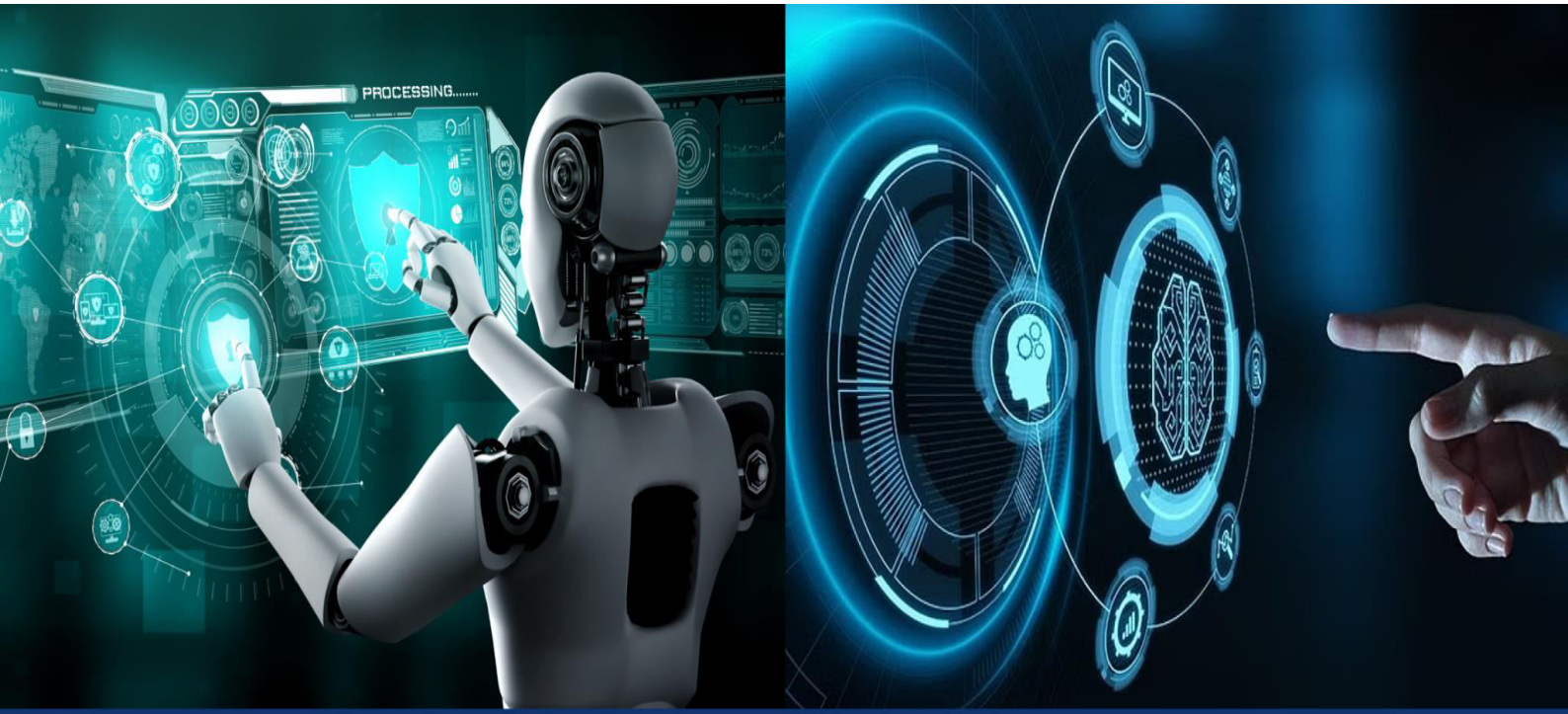

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Evolution of Stress Detection: A Comprehensive Review of Traditional Approaches and Technological Innovations

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ABSTRACT: Stress has become an omnipresent challenge in today's fast-paced world, affecting individuals across various demographics and professions. This review paper provides a comprehensive analysis of current methodologies for stress detection and management, synthesizing findings from recent literature. Stress, a pervasive issue impacting mental and physical health, necessitates effective detection and intervention strategies. The paper examines various approaches, including physiological, psychological, and technological methods, highlighting their strengths and limitations. We critically evaluate these studies, identify gaps in the existing research, and suggest directions for future exploration. Ultimately, this review aims to inform practitioners and researchers about the evolving landscape of stress management, promoting the development of more effective, personalized, and early interventions.

KEYWORDS: stress, detection, management, machine learning

I. INTRODUCTION

Stress has become one of the everyday challenges in modern fast-paced living, affecting both genders and any profession. Being defined as a reaction to threats or challenges, it can lead to serious health conditions, such as anxiety, depression, and heart diseases. Along with the growing statistics of stress-related disorders, the world is facing the need for practical stress detection and management methods.

In recent years, the concept of stress has started to evolve from purely psychological to broader physiological and environmentally based. With this changed perspective, diversified methodologies for evaluation of stress - from traditional mental health assessments by questionnaires, clinical interviews to innovative technological application - have fueled research. For example, old methods like self-reported questionnaires as well as traditional clinical interviews share some limitations where subjectivity limits the accuracy with respect to temporal considerations.

Research studies nowadays are focusing more on the integration of ML models with wearable sensors in detecting real-time stress. These have physiological data such as heart rate variability, skin conductance, and sleep patterns, which provide an objective understanding of the level of stress one may have. The use of an ML algorithm gives a better prediction and intervention that is tailored to stress management.

II. STRESS IN EVERYDAY LIFE

Stress detection has become an important and relevant subject because of the increasing prevalence that is being manifested in modern society. With dependence on technology coupled with increased professional and personal life pressures, there is a tremendous need to cope with stress to maintain health.

However, the challenge is to detect stress levels in real time, non-intrusively and continuously. Most of the methods that exist are not precise or require cumbersome equipment, which makes it difficult to apply in everyday scenarios.

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III. LITERATURE REVIEW

This chapter gives an overall overview of the previous work that has been conducted on Stress detection. Specifically, this is with a focus on making a comparison of all such works done to date. Through this review, the idea is to evaluate and contrast major findings of studies undertaken thus far and identify information pertinent to our own study. A diverse array of methodologies and theoretical frameworks should, in the end, bring trends and identify areas to further explore into the future. This synthesis will give a good basis for our research, which will be well-founded on the current body of knowledge.

IV. REVIEW OF STATISTICAL AND TRADITIONAL APPROACHES

[1]Requirements and Design of Mental Health System for Stress Management of Knowledge Workers

This paper is a comparative study of several statistical methods used for research and the measures of stress that are generally used for the purpose. It aims to develop an effective, mobile, and robust system for organizations where knowledge workers work. The paper proposed system architecture for integrating the machine learning algorithm and the data collection source i.e., databases. Paper has given due consideration to every possible factor reacting to stress Comparative study is done between various machine learning models. Paper does not offer any definite architectural solution because its machine learning algorithm varies under various external influencing factors.

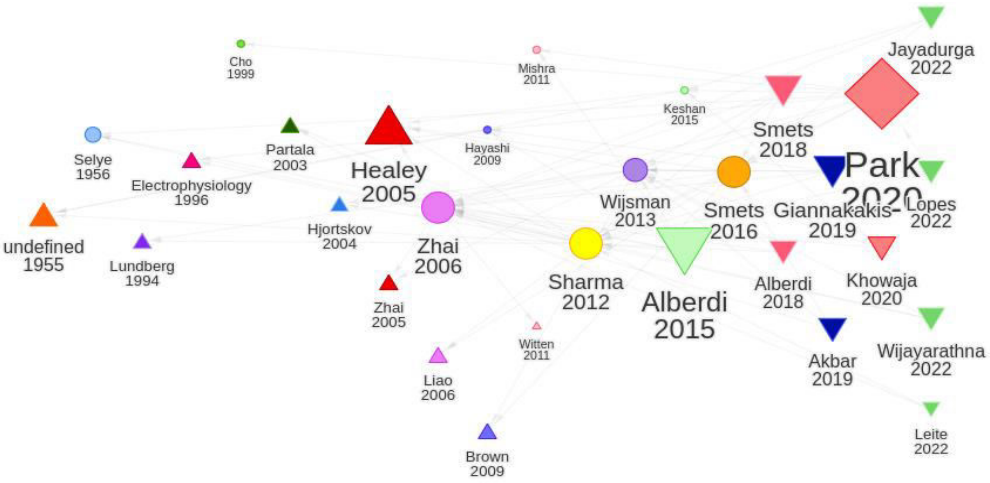

FIG.IV.I

[2]Towards Real-Time Automatic Stress Detection for Office Workplaces

The researchers used the arousal-based approach for real-time stress detection with minimal datasets. Physiological data is processed from E4-wristband through several steps: noise filtering of EDA signals, aggregation of data, discretization with the SAX method, and detecting stress through ADWIN change detection methods. The proposed stress detection system works without significant datasets, has real-time feedback, is flexible to workplaces, and uses the non-intrusive E4-wristband technology for non-intrusive monitoring.

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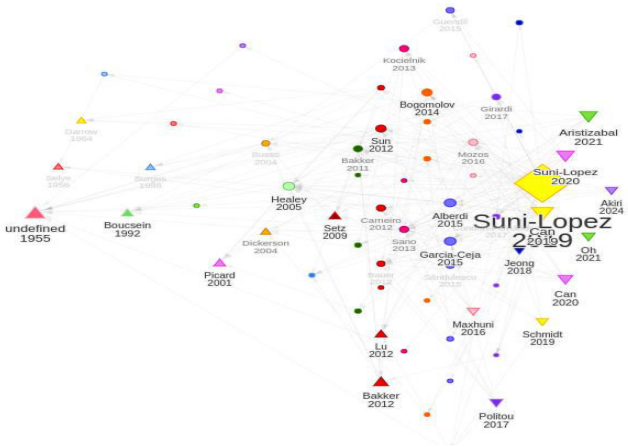

FIG.IV.II

V. REVIEW OF MACHINE LEARNING APPROACHES

[1] Classification of Pupil Diameter with Neural Networks [1]

Using binary and 4-way parallel classifiers to identify the origin of stress.The methodology under consideration was evaluated by measuring pupil diameter and electrodermal activity during a simulated driving exercise. Initially, participants engaged in a baseline session involving only the driving task. This was followed by three stress-inducing sessions where participants performed the driving task while also experiencing auditory alerts and the presence of two human evaluators. Both self-reported stress levels and pupil diameter served as indicators of stress manipulation, revealing significant correlations between these variables. 79.2 Precision. The sample size is just 36 participants. Pupil diameter may be increased due to positive stress (eustress) or negative stress.

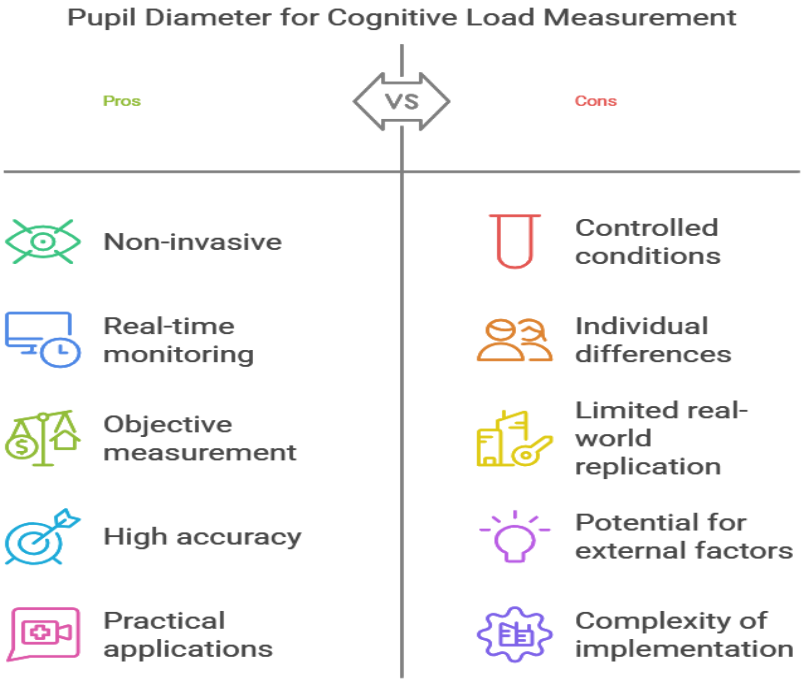

FIG. V.I

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[2] Stress and Heart Rate Variability: A Meta-Analysis and Review of the Literature

THE PAPER IS A META ANALYSIS of presented different papers relating to correlation between heart rate variability and stress. The database sources used were from Google Scholar, Pubmed, and Web of Science. After passing through rigorous filtering with multiple parameters, 37 papers in total were processed and researched. Manual reports, AI assistant based comparison and deductions are compared. Inter-database evaluation is done. All the papers are from reputed associations and authenticated.

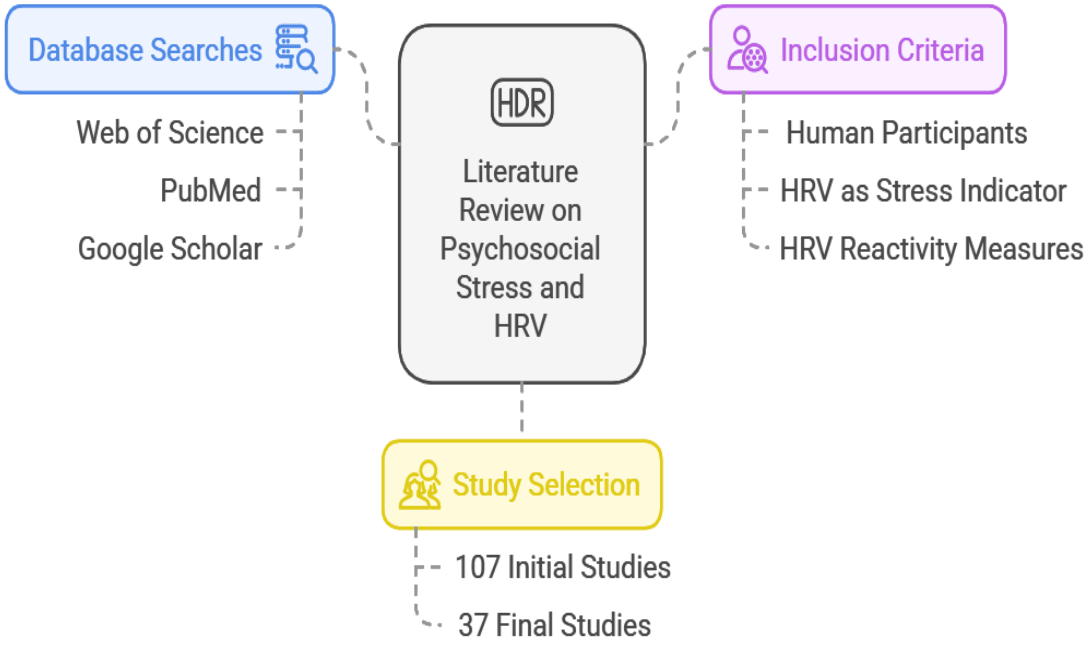

FIG. V.II

[3]A Machine Learning Approach for Stress detection using wearables sensors in free living environment

The SWEET dataset is used by the researchers. The data are obtainedData were collected from 240 participants using electrocardiography (ECG), skin temperature (ST), and skin conductance (SC). Four distinct machine learning models were evaluated: K-Nearest Neighbors (KNN), Support Vector Classification (SVC), Decision Tree (DT), Random Forest (RF), and XGBoost (XGB), across four different configurations. The analysis encompassed two binary classification scenarios (one utilizing SMOTE and the other not) as well as two multi-class classification scenarios (again, one with SMOTE and one without).. The Paper tests the data on many prominent machine learning algorithms. The data is of normal living conditions. it was not collected in some Test environment. The SMOTE bolstered the performance of some models.The trade-off frequently resulted in diminished precision and overall accuracy, as evidenced by our research findings.

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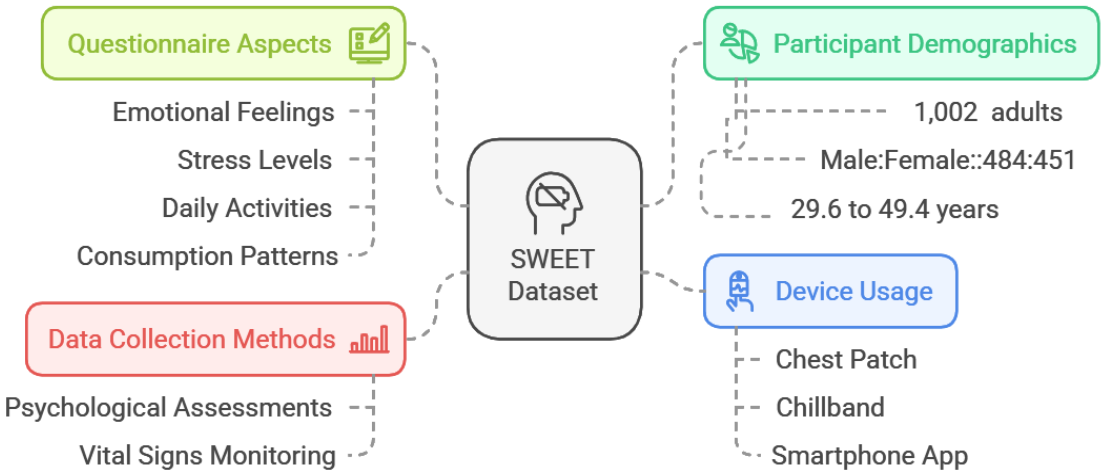

FIG. V.III

[4]A Review on Mental Stress Assessment Methods Using EEG Signals

Preprocessing EEG signals are also important for the removal of noise and artifacts. It is achieved using regression, wavelet transforms, and independent component analysis (ICA). The commonly used power spectral features are PSD, AP, and WT to detect stress. Advanced techniques are GMM and SM that have been further applied to enhance stress quantification accuracy. EEG can provide high resolution in time for capturing fast electrical activity changes within the brain, which is used to track instant fluctuations related to mental stress. Since the features associated with EEG are complex and highly diverse, this calls for combining different methods toward understanding the relation with mental stress. Differences in data analysis that result in controversial findings

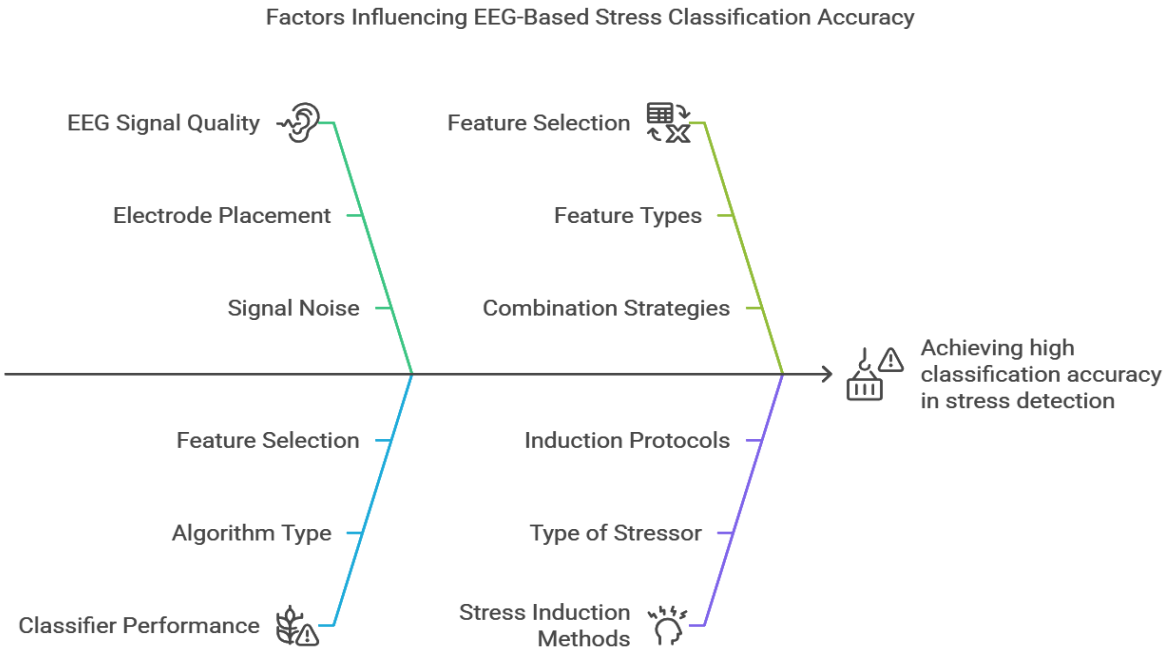

FIG. V.IV

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[5]Employing Multimodal Machine Learning for Stress Detection

A multimodal AI-based framework is proposed for monitoring working behavior and stress levels of an individual. A methodology for the efficient detection of workload-induced stress through the concatenation of This paper proposes the utilization of diverse raw sensor data streams, including facial expressions, body posture, heart rate, and computer interaction metrics. Such data can be securely stored and analyzed to identify and uncover individualized behavioral patterns that may contribute to mental stress and fatigue. The approach achieved an accuracy of 96.09% in the detection and classification of stress within the test set. It may not work well with lesser modalities. The model is highly specific, and lack of even one modality can lead to huge errors.

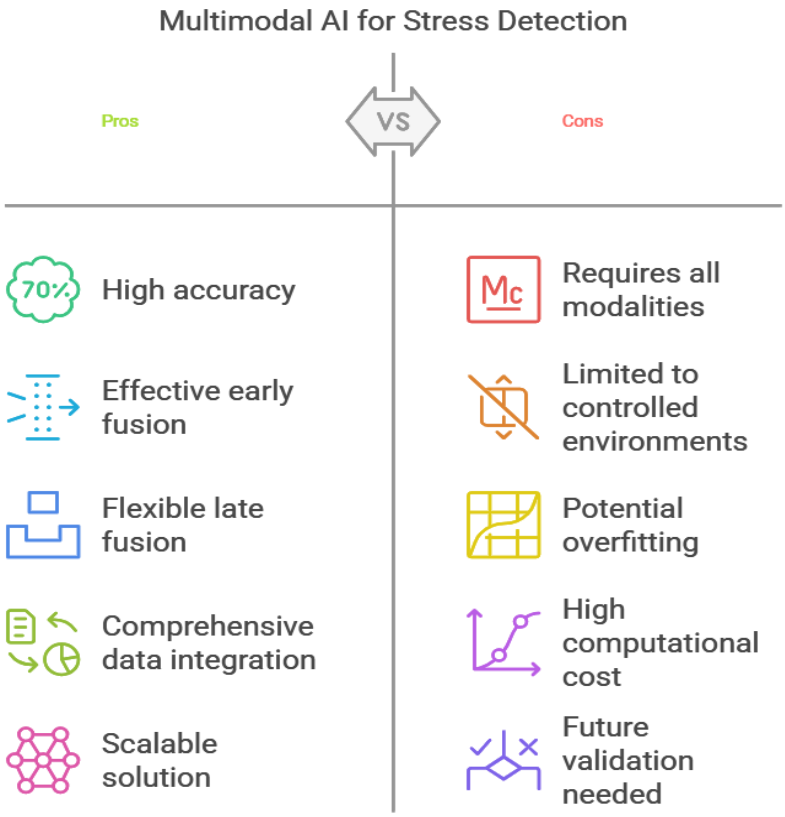

FIG.V.V

[6]Stress detection using natural language processing and machine learning over social interactions

Data preprocessing steps include tokenization, stop word removal, and stemming. The Bag-of-Words method is used for feature extraction. In sentiment analysis, Logistic Regression, Decision Trees, and Random Forest models were trained, where Random Forest provided the best results. Emotion detection was carried out using a fine-tuned BERT model, which makes use of the bidirectional nature of the BERT model for emotion classification from tweets. Model performance is rated using accuracy, F1 score, and confusion matrix. Employs Latent Dirichlet Allocation for the topic modeling which predicts that topic which is more related to textual data. Machine learning models, particularly the BERT model, demonstrate a high efficacy in detecting indicators relevant to mental health well-being. Given that the data involved can be both unstructured and voluminous, it necessitates the application of methodologies such as big data analytics, machine learning (ML), and natural language processing (NLP) to derive insights concerning stress and other mental health challenges.

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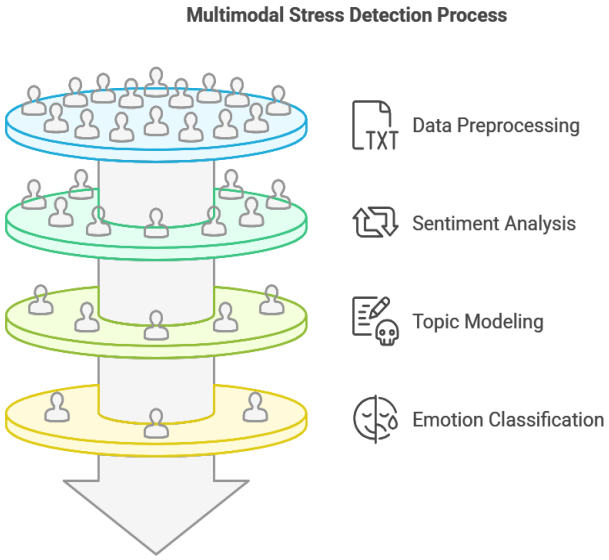

FIG. V.VI

VI. COMPARATIVE STUDY OF ALL PAPERS

Sr No.	Title	Year	Methodology	Strengths	Weakness
1	[1]Requirements and Design of Mental Health System for Stress Management of Knowledge Workers	2020	The paper does comparison study of various machine algorithms, and the measures of stress which are widely used for research purposes. The purpose is to design an effective , mobile and robust system for organisations , where knowledge workers work. The paper suggests system architecture for integration of the machine learning algorithm and data collection sources i.e. databases.	The paper has considered every possible factor which reacts to stress. Comparative study between machine learning models has also been carried out.	The study's weakness includes inaccurate data and insufficient stress models, needing more complex algorithms.

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2	[2]Towards Real-Time Automatic Stress Detection for Office Workplaces	2019	The researchers used an arousal-based approach for real-time stress detection without extensive datasets. Physiological data from the E4-wristband is processed through several steps: noise filtering of EDA signals, data aggregation, discretization using the SAX method, and stress detection through the ADWIN change detection method.	The stress detection system operates without large datasets, offers real-time feedback, is adaptable to workplaces, and uses non-intrusive E4-wristband technology for seamless monitoring.	Weaknesses include a small sample size, controlled lab setting, variability in emotional triggers, and reliance on the E4-wristband, limiting comprehensive stress detection.
3	[3]Automatic Stress Classification With Pupil Diameter Analysis	2014	[3]CLASSIFICATION OF PD WITH NEURAL NETWORKS using binary and 4 way parallel classifiers , to detect the source of stress. The suggested approach was evaluated by measuring pupil diameter and electrodermal activity during a simulated driving exercise. Participants initially completed a baseline run involving only the driving task, which was succeeded by three stress runs that incorporated sound alerts, the presence of two human evaluators, or both elements simultaneously.	Self-reports and pupil diameter were used to assess stress manipulation, revealing significant correlations between these two measures . 79.2 Precision.	The sample size is of 36 participants only. Pupil diameter could increase because of positive stress (eustress) or negative stress,
4	[4]Stress and Heart Rate Variability: A Meta-Analysis and Review of the Literature	2018	THE PAPER IS A META ANALYSIS of various papers related to correlation between heart rate variability and stress. The papers were sourced from databases of Google Scholar, Pubmed and Web of Science. After an intensive screening process with various parameters, a total of 37 papers were processed and studied. Manual reports, AI assistant based comparison and deductions are compared.	Inter-database evaluation is done.	The study's weaknesses include methodological variability and stress definition issues.

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5	[5]A Machine Learning Approach for Stress detection using wearables sensors in free living environment	2024	The researchers used the The SWEET dataset comprises data from 240 individuals gathered through electrocardiography (ECG), skin temperature (ST), and skin conductance (SC). The study evaluated four machine learning models: K-Nearest Neighbors (KNN), Support Vector Classification (SVC), Decision Tree (DT), Random Forest (RF), and XGBoost (XGB) across four distinct configurations. The analysis encompassed two binary classification scenarios (both with and without SMOTE) and two multi-class classification scenarios (also with and without SMOTE).	The Paper tests the data on many prominent machine learning algorithms. The data is of normal living conditions. it was not collected in some Test environment.	The SMOTE bolstered the performance of some models However, the trade-off often involved reduced precision and overall accuracy, as observed in our study.
6	[6]A Review on Mental Stress Assessment Methods Using EEG Signals	2021	EEG signal preprocessing is essential to remove noise and artifacts, using methods like regression, wavelet transforms, and independent component analysis (ICA). Power spectral features, such as power spectral density (PSD), absolute power (AP), and wavelet transform (WT), are widely used to detect stress by analyzing neural rhythms. Advanced techniques like Gaussian mixture models (GMM) and spectral moments (SM) further improve stress quantification, offering varying levels of accuracy.	EEG provides high temporal resolution, making it ideal for capturing fast changes in electrical activity in the brain. It helps track immediate fluctuations related to mental stress.	Complex and diverse range of EEG features require integration of various methods for understanding associations with mental stress . Variations in data analysis methods leading to contradictory results
7	[7]Employing Multimodal Machine Learning for Stress Detection	2023	In this study, a multimodal artificial intelligence framework is introduced to assess an individual's work behavior and stress levels. The research outlines a methodology for effectively identifying stress related to workload by integrating diverse raw sensor data streams, such as facial expressions, body posture, heart rate, and computer interactions. This information can be securely archived and analyzed to gain insights into and identify personalized behavioral patterns that contribute to mental strain and fatigue.	96.09% accuracy on the test set in stress detection and classification Comparative study between various models and the model generated by the research workers.	It may not work well with lesser modalities. The model is highly specific and lack of even one modalities can lead to significant errors

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8	[8]Stress detection using natural language processing and machine learning over social interactions	2022	The methodology involves data preprocessing steps such as tokenization, removing stop words, and stemming. Feature extraction is done using the Bag-of-Words method. For sentiment analysis, Logistic Regression, Decision Trees, and Random Forest models are trained, with Random Forest showing the best performance. Emotion detection is performed using a fine-tuned BERT model, leveraging its bidirectional capabilities to classify emotions from tweets. Model performance is evaluated using accuracy, F1 score, and confusion matrix.	Employs Latent Dirichlet Allocation (LDA) for topic modeling to predict which topic is linked to the textual data . ML models and a BERT model have a very good detection rate, useful for mental health well-being	Data may be unstructured and huge, requiring techniques like Big data, Machine Learning (ML), Natural Language Processing (NLP) to get inferences for stress or other mental health issues

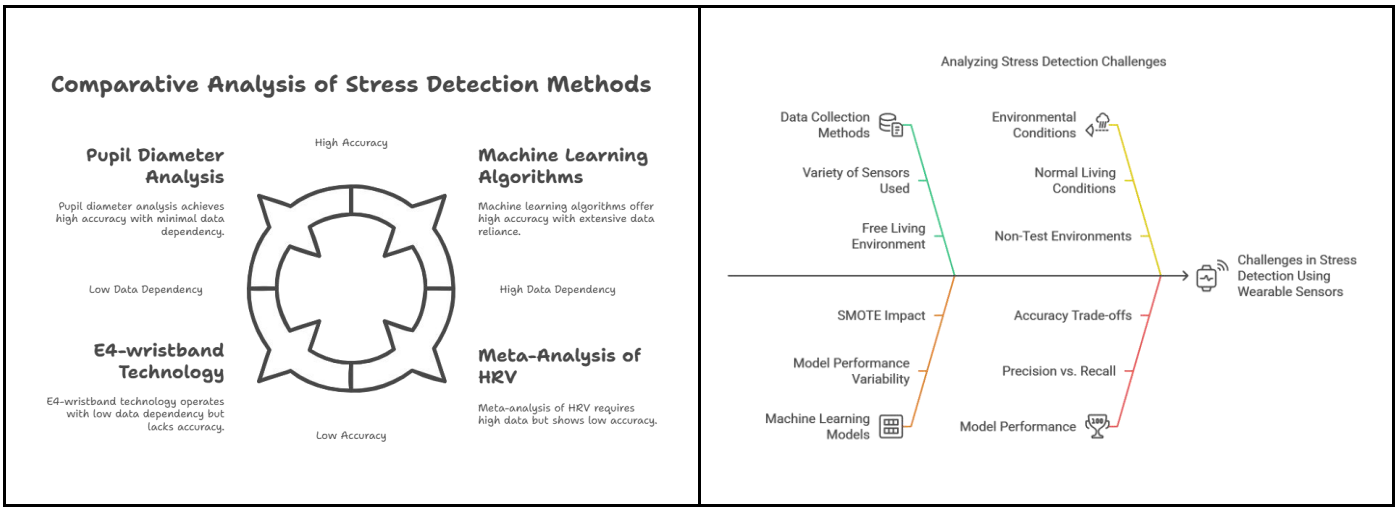

FIG. VI.1

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