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A Comprehensive AI-Based Mental Health Monitoring Toward Nervous System Exhaustion

Aditi Rajesh[1], Bibi Ayesha[2], Nandini M R[3], Tulasi S[4]
Information Science and Engineering, Global Academy Of Technology, Bangalore, India

Abstract: Mental health conditions, including stress, anxiety, depression, and mental fatigue, continue to affect millions of people and have become an important area of research. The increasing availability of wearable devices, physiological sensors, and digital platforms has encouraged the use of artificial intelligence for automated mental health assessment. A wide range of computational techniques, including traditional machine learning, deep learning, multimodal learning, and transformer-based models, have been explored to analyze physiological, behavioral, and textual data for identifying mental health conditions. This review provides a comprehensive comparison of these approaches by discussing the datasets used, feature extraction methods, model architectures, performance, advantages, and existing limitations reported in recent studies. Although significant progress has been achieved in improving detection accuracy, several challenges remain, such as limited dataset diversity, poor model generalization, privacy concerns, computational complexity, and the lack of continuous long-term monitoring. The findings also indicate that current research primarily focuses on identifying an individual's present mental state rather than evaluating changes that occur over extended periods. By consolidating the existing literature, this review highlights unresolved research challenges and discusses future directions for developing intelligent, multimodal frameworks that can support Nervous System Exhaustion (NSE) assessment and facilitate early burnout prevention.

Keywords: Mental Health Monitoring, Artificial Intelligence, Stress Detection, Anxiety Detection, Depression Detection, Mental Fatigue, Wearable Sensors, Deep Learning, Transformer Models, Nervous System Exhaustion (NSE), Literature Review.

I. INTRODUCTION

The increasing prevalence of stress, anxiety, depression, and mental fatigue has made mental health monitoring an important area of research. These conditions significantly affect emotional well-being, cognitive performance, physical health, and overall quality of life. Recent advancements in wearable sensing technologies and artificial intelligence have enabled continuous monitoring of physiological signals, including electrocardiography (ECG), heart rate variability (HRV), photoplethysmography ((PPG), and electrodermal activity (EDA), along with behavioral data obtained from digital platforms. Conventional machine learning techniques such as Support Vector Machines (SVM), Random Forest (RF), and Decision Trees (DT), as well as deep learning models including Convolutional Neural Networks (CNN), Long Short-Term Memory (LSTM) networks, multimodal fusion models, and transformer-based architectures, have demonstrated promising performance in automated mental health assessment.

Despite these advancements, several challenges continue to limit the practical deployment of existing systems. Many studies rely on small datasets collected in controlled environments, resulting in limited generalization to real-world scenarios. Furthermore, issues such as noisy physiological signals, high computational complexity, limited model interpretability, privacy concerns, and the emphasis on detecting only the current mental state remain unresolved. This literature review presents a comprehensive analysis of recent AI-based mental health monitoring approaches by examining their methodologies, datasets, strengths, and limitations. It also identifies existing research gaps and highlights the need for intelligent systems capable of supporting long-term mental health assessment and the early detection of Nervous System Exhaustion (NSE).

II. LITERATURE SURVEY

A. Review of Existing Papers

1) Calibration of Transformer-Based Models for Identifying Stress and Depression in Social Media(2024)

This paper proposed an enhanced transformer-base framework for detecting stress and depression from social media posts by integrating linguistic features with BERT and Mental BERT models. The approach combined LIWC NRC Emotion Lexicon, LDA topic modelling, and Top2Vec features using a multimodal adaption gate, while label smoothing was applied to improve model calibration and prediction reliability. Experimental results demonstrated improved classification accuracy and better calibration compared to conventional transformer-based architecture required significant computational resources and lacked explainability for practical mental health application.

2) Analysis of Computer Vision-based Physiological Indicators for operator Fatigue Detection(2025)

In this study, the researchers investigated how computer vision can help identify signs of operator fatigue by examining changes in physiological indicators that are visible on the face. They used a Tabular Transformer model to categorize different levels of fatigue, and they applied SHAP and Permutation Importance methods to determine which factors had the most impact on the model's predictions. The integration of precise classification with explainable AI enhanced the framework's reliability for use in safety-critical scenarios. However, the use of several sophisticated models raised computational demands, which made it more challenging to deploy the system in real-time.

3) Assessing Occupational Burnout in Psychiatric Professionals Using Multimodal Emotion Recognition Methods (2026)

This research focused on identifying occupational burnout among psychiatric professionals by combining physiological information with facial expression analysis. Signals obtained from ECG and PPG sensors were fused with facial video features to build a multimodal emotion recognition system. By using information from different sources, the model achieved better burnout assessment than methods relying on a single modality. The findings suggest that multimodal analysis provides a more complete understanding of emotional health. However, the prediction accuracy dropped noticeably when only one type of data was used.

4) Deep Learning Approaches for Stress Detection: A Survey (2025)

The authors presented a detailed review of recent deep learning techniques developed for stress detection using physiological, behavioral, and contextual information. Different architectures such as CNNs, LSTMs, Transformers, and multimodal learning models were discussed along with the sensors and datasets commonly used for stress analysis. The review showed that deep learning methods generally provide better accuracy because they automatically learn useful features from complex data. At the same time, it pointed out that limited datasets, inconsistent labeling methods, and poor generalization continue to restrict practical implementation.

5) Psychological Stress Prediction and Prevention in Higher Education Teachers Using a Bi-LSTM Based Multilayer Framework(2025)

The study introduced a Bi-LSTM-based framework to predict psychological stress among higher education teachers using sequential physiological and behavioral data. Since Bi-LSTM networks can capture relationships over time, the proposed model successfully learned temporal patterns associated with stress and produced encouraging prediction results. The framework demonstrates how deep learning can support early stress identification in educational environments. Despite these promising outcomes, the experiments were performed on limited datasets collected under specific conditions, making it difficult to confirm whether similar performance can be achieved in broader real-world situations.

6) Physiological Sening and Machine learning Approaches Towards Anxiety Detection: A Systematic Review(2025)

This systematic review examined how physiological sensing combined with machine learning is being used for anxiety detection. The authors analyzed studies involving signals such as EDA, ECG, HRV, PPG, EEG, and respiration, while comparing both traditional machine learning and deep learning techniques. The review concluded that wearable sensors and physiological measurements provide reliable indicators for recognizing anxiety, and that multimodal approaches often outperform single-sensor systems. Nevertheless, variations in datasets, labeling procedures, and evaluation methods remain major obstacles to developing standardized anxiety detection models.

7) Causal Inference of Construction Environmental Factors on Worker Health: Stress Probability Modeling via Gaussian Process Networks (2025)

In this work, the researchers examined how environmental conditions at construction sites influence workers' stress levels. They designed a prediction model using Gaussian Process Networks (GPN) and Gaussian Process Regression (GPR) to estimate stress probability while considering uncertainty in the collected data. The model was able to identify relationships between environmental factors and worker stress, making it useful for workplace health monitoring and risk assessment. However, since the study involved only a small number of participants, the findings may not accurately represent larger construction populations.

8) Extending Stress Detection Reproducibility to Consumer (2025)

This study explored whether stress detection models developed using research-grade devices could be reliably applied to everyday consumer wearables.

Physiological signals such as Heart Rate Variability (HRV) and Electrodermal Activity (EDA) were collected from different wearable devices and analyzed using machine learning techniques. The results indicated that consumer wearables can support continuous stress monitoring with promising accuracy. However, differences in sensor quality, hardware specifications, and device compatibility affected the consistency of predictions across various wearable platforms.

9) Toward Camara-PRV Based Early Warning in Hospital ICU: A Pilot Study (2025)

The authors introduced a contactless monitoring system designed for intensive care units by extracting physiological information directly from facial videos. Using remote Photoplethysmography (rPPG), the framework estimated pulse-related features without attaching any physical sensors to patients. Machine learning algorithms such as Support Vector Machine (SVM), Random Forest (RF), and K-Nearest Neighbor (KNN) were used for health assessment. Although the system demonstrated the feasibility of remote monitoring, its prediction of accuracy was only moderate, indicating the need for further improvements before routine clinical use.

10) Ambient Stress Detection for Open Environment Using Hybrid Model (2024)

This paper proposed a hybrid stress detection model by combining Support Vector Machine (SVM) and Random Forest algorithms for monitoring stress in open and dynamic environments. The framework processed physiological sensor data to classify stress levels while improving prediction accuracy through hybrid machine learning techniques. Experimental evaluation demonstrated reliable real-time stress monitoring under different environmental conditions. The proposed approach offers potential for workplace and outdoor health monitoring applications, However, the model remained sensitive to sensor noise, environmental disturbances, and individual physiological differences, which affected its overall robustness.

11) Perceived Stress Prediction among Working Employees Based on CAT-DCNN Technique (2024)

This paper proposed a CAT-DCDNN framework for predicting perceived stress among working employees using physiological data collected from wearable devices. The system incorporated preprocessing, feature selection, and a Deep Convolutional Neural Network (DCNN) optimized with the Cat Swarm Optimization (CAT) algorithm to improve classification performance. Experimental results showed that the optimized model achieved higher stress prediction accuracy than conventional machine learning approaches while effectively extracting important stress-related features. However, the wearable devices used for data collection were affected by sensor limitations, and battery constraints, which may reduce the system's effectiveness during long-term real-world monitoring.

12) Personalized Stress Monitoring Using Wearable Sensors in Everyday Settings (2023)

This study presented a personalized stress monitoring system using wearable sensors to collect physiological signals such as heart rate (HR), Heart rate variability (HRV), during everyday activities. The proposed framework employed Active Learning along with machine learning classifiers including random forest and SVM to build user-specific stress prediction models while minimizing manual data labeling. Experimental results demonstrated improved personalized stress detection compared to generic models and highlighted the advantages of adaptive monitoring. However, motion artifacts, noisy physiological signals, and variations in daily activities reduced the model's accuracy under real-world conditions.

13) Stress Detection Using Context-Aware Sensor Fusion from Wearable Devices (2023)

This paper introduced the SELF-CARE framework, a context-aware sensor fusion approach for stress detection using wearable devices. The proposed modal combines multiple physiological signals through an ensemble machine learning architecture while adapting to different sensing conditions by identifying sensor noise contexts. The framework achieved high stress classification accuracy on the WESAD dataset and demonstrated the effectiveness of selective sensor fusion for wearable healthcare applications. However, the model was evaluated on a relatively small benchmark dataset and requires validation across a larger and more diverse population for practical deployment.

14) Review on Stress Detection and Management Techniques Using Non-EEG Sensors (2022)

This review paper presented a comprehensive overview of stress detection and management techniques using physiological signals obtained from ECG, EMG, GSR, HRV, Skin conductance, and other non-EEG sensors. It compared several machine learning algorithms including Random Forest, Support Vector Machine (SVM), K-Nearest Neighbor (KNN), Artificial Neural Networks (ANN), and Bayesian Networks for stress classification.

The review also discussed IoT-enabled healthcare systems and cloud-based stress monitoring applications. However, as a survey paper, it did not include experimental implementation, or performance validation of the reviewed techniques in real-world scenarios.

15) IoT-Driven GSR Stress Detection: Clinical, Physical, and Linguistic Innovations (2022)

This paper proposed on IoT-enabled stress detection framework using Galvanic Skin Response (GSR) signals combined with deep learning techniques such as Convolutional Autoencoders, LSTM Autoencoders, and clustering algorithms. The system continuously monitored physiological responses to identify stress patterns and supported remote healthcare applications through I0T connectivity. Experimental results demonstrated effective stress recognition from physiological data and highlighted the benefits of automated feature extraction. However, the deep learning models lacked clinical interpretability and transparency, making it difficult to explain the reasoning behind stress predictions in healthcare settings.

16) Multi-Modal Acute Stress Recognition Using Off-the-Shelf Wearable Devices (2021)

This paper developed a multimodal acute stress recognition framework using data collected from commercially available wearable devices. The proposed system combined multiple physiological signals and employed Random Forest and Support Vector Machine (SVM) classifiers to improve stress recognition accuracy. By integrating information from different wearable sensors, the framework achieved better classification performance than single sensor approaches and demonstrated its suitability for real-time monitoring. However, synchronization issues between different wearable sensors occasionally affected data quality, leading to reduced recognition performance under certain conditions.

17) EmoCv: Towards Physiological Signals-Based Stress Detection (2020)

This study proposed the EmoCv framework for stress detection using physiological signals and time-domain feature extraction techniques. The system utilized ensemble machine learning algorithms such as Gradient Boosting and Random Forest to classify stress levels from physiological measurements. Experimental evaluation demonstrated high classification accuracy and robust performance across different stress conditions, showing the effectiveness of ensemble learning for physiological signal analysis. However, the framework relied on relatively short observation windows, which increased the likelihood of false alarms and reduced stability during continuous real-time stress monitoring.

18) Stress Detection Using Deep Neural Networks (2020)

This paper developed models for stress detection using physiological sensor data collected from wearable devices. The proposed approach employed a One-Dimensional Convolutional Neural Network(1D-CNN) and a Multilayer Perceptron (MLP) to automatically learn discriminative features without requiring manual feature engineering. Experimental results demonstrated high stress classification accuracy and showed that deep neural networks outperformed several traditional machine learning techniques. However, the models required large volumes of labelled training data and considerable computational resources, making deployment difficult in data-constrained and resource-limited environments.

19) Mental Fatigue Prediction Model Based on Multimodal Fusion (2019)

This paper proposed a multimodal fusion framework for predicting mental fatigue by combining EEG signals, physiological measurements, and workload indicators. The system integrated information from multiple data sources to improve fatigue prediction accuracy and support continuous real-time monitoring of mental workload. Experimental results showed that multimodal fusion significantly enhanced prediction performance compared to single-modal approaches and provided more reliable fatigue assessment. However, individual physiological differences among users affected prediction consistency, indicating the need for personalized calibration to improve generalization across diverse populations.

20) Design and Implementation of a Real-time Stress Monitoring system with the help of ECG using MATLAB tool (2017)

This paper presented a real-time ECG-based stress monitoring system developed using the MATLAB platform. The proposed framework analyzed ECG signals through peak detection and threshold matching algorithms to identify stress levels and generate immediate alerts. The system demonstrated a simple, low-cost, and efficient approach for continuous stress monitoring, making it suitable for basic healthcare applications. However, the use of fixed threshold values limited the model's adaptability to individual physiological differences, reducing its effectiveness for personalized stress assessment in real-world scenarios.

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III. COMPARATIVE ANALYSIS OF THE PAPERS

SL No.	PAPER	TECHNIQ-UES USED	STRENGT-HS	LIMITATIONS
1	Analysis of Computer Vision-Based Physiological Indicators	Tabular Transformer + SHAP	Good fatigue detection, explainable model	High computational cost
2	Occupational Burnout Using Multimodal Emotion Recognition	ECG/PPG + Facial Features	Uses multimodal information	Accuracy drops with single modality
3	Deep Learning Approaches for Stress Detection	Multimodal Deep Learning	High detection performance	Small benchmark datasets
4	Psychological Stress Prediction in Teachers	Bi-LSTM Framework	Handles sequential data well	Limited real-world validation
5	Anxiety Detection Systematic Review	ML/DL+ HRV + EDA	Comprehensive analysis	Dataset heterogeneity
6	Construction Worker Stress Modeling	Gaussian Process Network	Models' uncertainty effectively	Very small sample size
7	Wearable Stress Detection Reproducibility	HRV + EDA + ML	Suitable for wearable devices	Device compatibility issues
8	Camera-PRV Based Early Warning	rPPG + SVM/RF/KNN	Non-contact monitoring	Moderate accuracy
9	Ambient Stress Detection	SVM + Random Forest	Real-time stress monitoring	Sensitive to sensor noise
10	Transformer Models for Stress Identification	BERT + MentalBERT	Improved classification performance	Computationally expensive
11	Perceived Stress Prediction	CNN + Cat Swarm Optimization	High prediction accuracy	Battery and sensor limitations
12	Personalized Stress Monitoring	Active Learning + RF/SVM	Personalized predictions	Performance varies in daily life
13	Context-Aware Sensor Fusion	Sensor Fusion + RF	Effective multimodal analysis	Small participant group
14	Review on Stress Detection Techniques	RF, SVM, KNN, ANN	Compares multiple methods	Review-based, not practical implementation
15	IoT-Driven GSR Stress Detection	CAE + LSTM Autoencoder	Supports IoT monitoring	Limited explainability
16	Multimodal Acute Stress Recognition	RF + SVM Fusion	Good multimodal performance	Synchronization issues
17	EmoCv Physiological Stress Detection	Ensemble Learning	High accuracy	False alarms possible
18	Stress Detection using Deep Neural Networks	CNN + MLP	Learns features automatically	Requires large training data
19	Mental Fatigue Prediction Model	Multimodal Fusion	Real-time prediction	Individual variability affects results
20	Real-Time Stress Monitoring System	ECG + Threshold Algorithms	Simple and real-time	Less adaptive and flexible

IV. RESEARCH GAP

The studies reviewed demonstrate considerable progress in the application of artificial intelligence for stress, anxiety, depression, and mental fatigue detection. Machine learning, deep learning, wearable sensing technologies, multimodal fusion, and transformer-based models have significantly improved the accuracy of mental health assessment. However, several limitations continue to restrict their effectiveness in real-world applications.

A common challenge observed across the literature is the reliance on small or controlled datasets, which limits the ability of models to generalize across diverse populations. Physiological signals obtained from wearable devices are often affected by noise and motion artifacts, while social media-based approaches may not accurately represent an individual's actual mental state. Furthermore, many existing methods focus primarily on identifying the current physiological condition instead of analyzing long-term physiological and behavioral changes that gradually develop over time.

In addition, issues such as limited model interpretability computational complexity, privacy concerns, and insufficient integration of multiple data sources remain largely unresolved. These challenges highlight the need for more robust and intelligent monitoring frameworks capable of continuous assessment using multimodal information. Such systems can support the early identification of Nervous System Exhaustion (NSE), enable timely intervention and reduce the risk of prolonged mental health complications and burnout.

V. FUTURE RESEARCH DIRECTIONS

The growing adoption of artificial intelligence has significantly advanced mental health monitoring; However, several challenges continue to provide opportunities for future research. One important direction is the development of models that can generalize across diverse populations and perform reliably in real-world environments rather than only under controlled experimental conditions. Expanding the availability of large, diverse, and publicly accessible datasets which also improve the robustness and reliability of future based mental health systems.

Future studies should focus on integrating multimodal data from physiological signals, wearable devices, behavioral patterns, and contextual information to obtain a more comprehensive understanding of an individual's mental health. Advance in sensor technology, cloud computing, and edge intelligence can further support continuous, real-time monitoring while reducing computational overhead. At the same time, improving model interpretability, ensuring data privacy, and developing energy-efficient solutions will be essential for increasing user trust and enabling large-scale deployment in healthcare settings.

Another promising research direction for immediate mental health conditioned to understand long-term physiological and behavioral changes. Rather than identifying only the current level of stress or depression, future intelligent systems should continuously monitor recovery patterns and cumulative changes over time. Such an approach could support the early assessment of Nervous System Exhaustion (NSE), facilitate timely intervention, and contribute to more personalized, preventative and sustainable mental healthcare solutions.

VI. CONCLUSION

This survey looked into recent research on how artificial intelligence and machine learning are being used to monitor mental health conditions such as stress, anxiety, depression, and mental fatigue. The studies reviewed show that there has been considerable progress using wearable sensing technology, analyzing physiological signals, applying multimodal learning methods, and using transformer-based models. These advances have led to better prediction abilities and more efficient ways to assess mental health. However, the analysis also points out several ongoing challenges, such as not having diverse enough datasets, poor performance across different individuals, high computational needs, limited model transparency, privacy issues, and not enough testing in real-world settings.

A comparison of the selected studies shows that most current systems are built to detect immediate psychological states rather than tracking long-term physiological and behavioral changes linked to nervous system health. Moreover, many approaches focus heavily on stress detection but pay less attention to the full assessment and management of Nervous System Exhaustion (NSE).These findings suggest the need for smart frameworks that combine various physiological and behavioral indicators, offer clear and understandable predictions, and allow for continuous health monitoring in everyday situations.

In short, this literature review highlights where current research stands, points out the main shortcomings of existing methods, and stresses the importance of creating reliable and personalized systems for detecting and managing Nervous System Exhaustion. Future research should aim to develop scalable, explainable, and multimodal machine learning models that can provide early prediction, ongoing monitoring, and personalized interventions to enhance long-term neurological and mental health.

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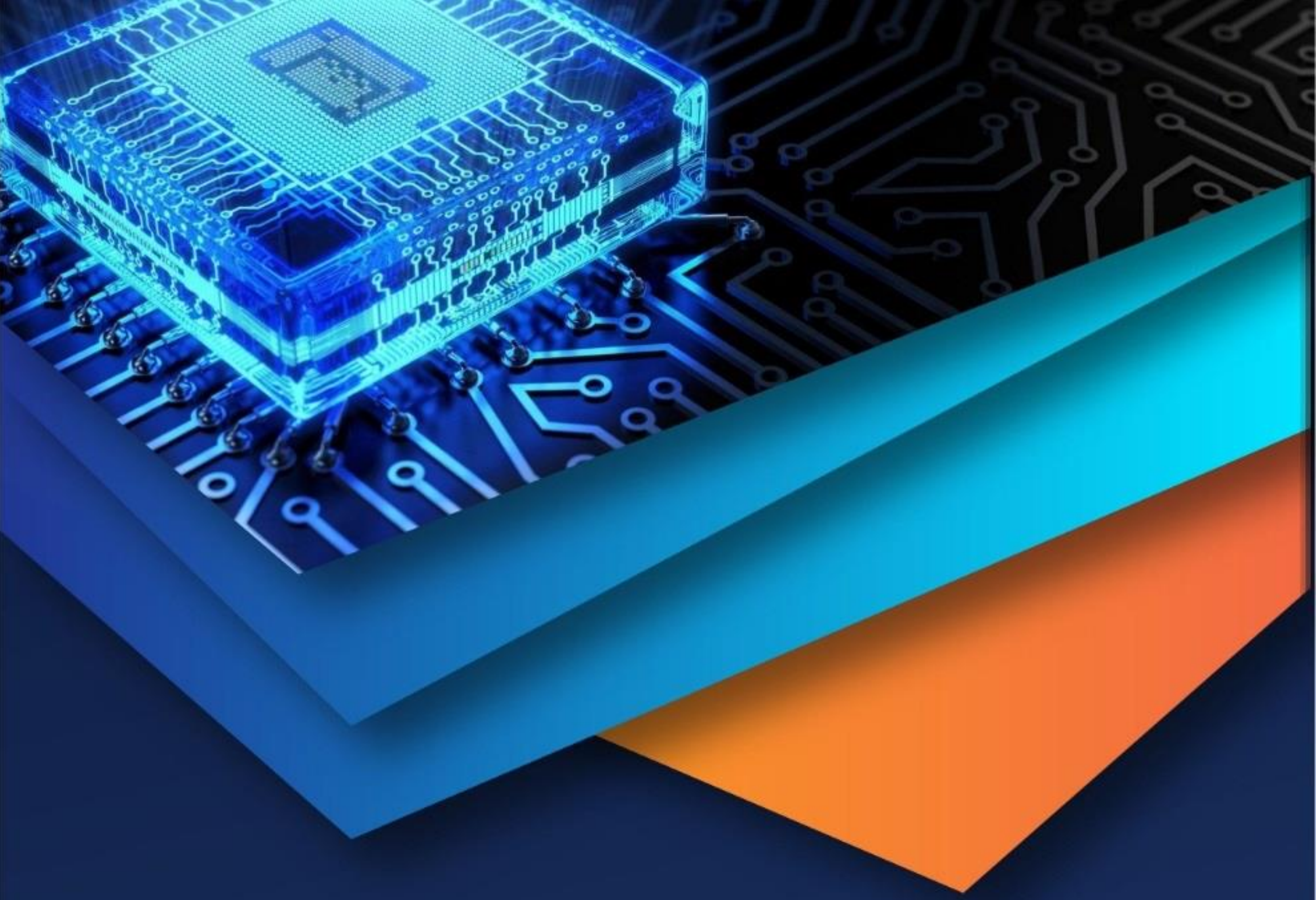

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