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Machine Learning Based Assessment of Mental Stress Using Wearable Sensor Data

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Abstract: ***Mental stress is a major health issue that affects an individual's physical and psychological well-being. Conventional stress assessment techniques mainly depend on self-reporting methods and clinical evaluations, which are subjective and unsuitable for continuous monitoring. With the advancement of wearable sensor technology, physiological signals such as heart rate, electrodermal activity, skin temperature, and body movement can be collected in real time. This paper presents a machine learning-based approach for assessing mental stress using wearable sensor data. The proposed system involves data collection, preprocessing, feature extraction, and classification using machine learning algorithms. The developed framework can provide accurate and continuous stress monitoring, supporting applications in healthcare, workplace monitoring, and personal wellness management.***

Keywords: Machine Learning, Mental Stress Detection, Wearable Sensors, Physiological Signals, Stress Classification.

I. INTRODUCTION

Mental stress has become a common problem in modern society due to increased workload, lifestyle changes, and environmental factors. Prolonged stress conditions may lead to serious health problems such as anxiety, depression, cardiovascular diseases, and reduced productivity.

Traditional stress measurement methods use psychological questionnaires and interviews. Although these approaches provide useful information, they are dependent on user responses and cannot monitor stress continuously.

Recent developments in wearable sensor technology have enabled real-time collection of physiological parameters. Smart wearable devices can measure heart rate, electrodermal activity, skin temperature, and motion signals that are influenced by stress conditions.

Machine learning techniques can analyse these complex physiological patterns and automatically identify stress levels. This research focuses on developing a machine learning-based assessment system for detecting mental stress using wearable sensor data.

II. LITERATURE SURVEY

Several researchers have explored stress detection using physiological signals and machine learning methods.

Wearable sensor-based stress detection systems have demonstrated that physiological changes are strongly related to emotional states. Heart Rate Variability (HRV) is considered an important indicator because stress affects the activity of the autonomic nervous system.

Electrodermal Activity (EDA) measurements provide information about changes in skin conductivity caused by emotional responses. Other signals, such as temperature and acceleration, improve stress classification performance when combined with multiple sensors.

Machine learning algorithms such as Support Vector Machine (SVM), Random Forest (RF), Decision Tree (DT), and Artificial Neural Networks (ANN) have been widely used for stress prediction.

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III. PROBLEM STATEMENT

Mental stress has become a major challenge in modern society due to increased workload, academic pressure, lifestyle changes, and personal difficulties. Continuous exposure to stress can negatively affect physical and mental health, leading to problems such as anxiety, depression, cardiovascular issues, and reduced productivity. Therefore, early identification and continuous monitoring of stress levels are essential for improving overall well-being. Existing stress assessment methods mainly depend on self-reported questionnaires, interviews, and clinical evaluations. Although these methods provide useful information, they are subjective, require human involvement, and cannot provide real-time monitoring. The variations in individual stress responses make it difficult to accurately assess stress conditions using traditional approaches alone.

With the advancement of wearable sensor technology, physiological signals such as heart rate, heart rate variability, electrodermal activity, skin temperature, and body movement can be collected continuously. However, analyzing large amounts of sensor data and identifying stress-related patterns is a challenging task. Hence, a machine learning-based system is required to process wearable sensor data, extract important features, and accurately classify mental stress levels. Such a system can provide an efficient, non-invasive, and real-time solution for stress assessment in healthcare, workplace, and personal wellness applications.

IV. SYSTEM ARCHITECTURE

The proposed system architecture for Machine Learning-Based Assessment of Mental Stress Using Wearable Sensor Data is designed to collect, process, and analyze physiological signals for accurate stress detection.

The architecture consists of five major components: wearable sensor data acquisition, data preprocessing, feature extraction, machine learning-based classification, and stress level prediction. The system provides a continuous and non-invasive approach for monitoring mental stress.

In the first stage, wearable sensors are used to collect physiological parameters associated with stress conditions. These sensors measure signals such as heart rate, heart rate variability, electrodermal activity, skin temperature, and body movement. The collected data represents the changes occurring in the human body during different stress levels and is transferred to the processing system for further analysis.

The collected sensor data is then passed through the preprocessing stage, where noise and unwanted variations are removed using filtering and normalization techniques. This step improves the quality of the data and prepares it for analysis. After preprocessing, important features are extracted from the physiological signals, including statistical, time-domain, and frequency-domain features that help identify stress-related patterns.

V. METHODOLOGY

The proposed methodology for Machine Learning-Based Assessment of Mental Stress Using Wearable Sensor Data involves collecting physiological signals, preprocessing the data, extracting relevant features, and applying machine learning models for stress classification. Different machine learning techniques are used to analyse patterns in wearable sensor data and predict the mental stress level of an individual.

A. Machine Learning Models

1) Support Vector Machine (SVM): Support Vector Machine is a supervised machine learning algorithm widely used for classification problems. In the proposed system, SVM is used to classify stress levels by creating an optimal decision boundary between different stress categories. It identifies patterns in extracted physiological features and separates low, moderate, and high stress conditions effectively.

2) Random Forest (RF): Random Forest is an ensemble learning algorithm that combines multiple decision trees to improve classification performance. Each tree provides a prediction, and the final output is generated based on the majority voting process. Random Forest can handle complex wearable sensor data and reduce overfitting while providing reliable stress prediction.

3) K-Nearest Neighbor (KNN): K-Nearest Neighbor is a simple supervised learning algorithm that classifies new data based on the similarity between existing samples. In stress detection, KNN compares extracted physiological features with previously labeled data to determine the most suitable stress category.

4) Artificial Neural Network (ANN): Artificial Neural Network is a computational model inspired by the human brain structure. ANN consists of interconnected layers that learn complex relationships between input physiological signals and stress levels. It is capable of identifying hidden patterns in wearable sensor data and improving prediction accuracy.

5) Decision Tree (DT): Decision Tree is a supervised learning algorithm that uses a tree-like structure for classification. It divides the dataset into different branches based on feature values and makes decisions to classify stress levels. The model is easy to interpret and suitable for analyzing physiological features.

6) Gradient Boosting Machine (GBM): Gradient Boosting Machine is an ensemble learning technique that combines multiple weak prediction models to create a stronger classifier. It improves classification accuracy by reducing errors from previous models and can effectively analyze complex stress-related patterns.

B. Model Training and Testing

The collected wearable sensor dataset is divided into training and testing samples. The training data is used to develop machine learning models, while testing data is used to evaluate their performance. The trained models learn the relationship between physiological features and stress levels to provide accurate predictions.

C. Performance Evaluation

The performance of different machine learning models is evaluated using metrics such as accuracy, precision, recall, and F1-score. The model with the best performance is selected for effective mental stress assessment using wearable sensor data.
Get smarter responses, upload files and images, and more.

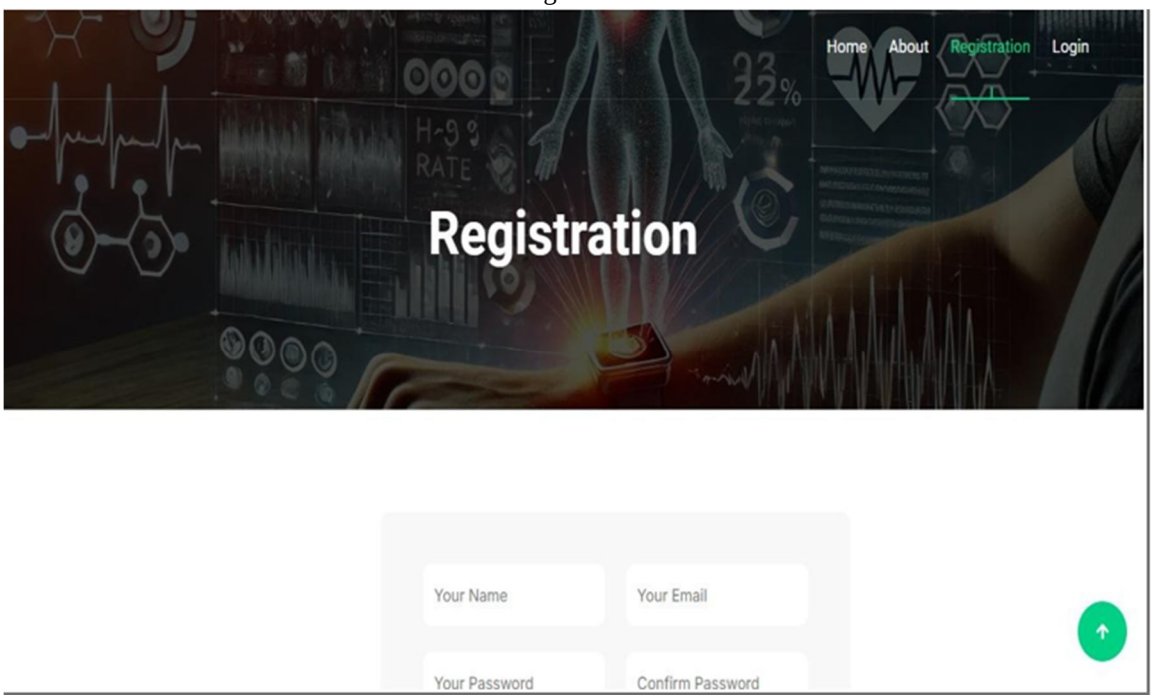
VI. TECHNOLOGY

The proposed system integrates various advanced technologies, including wearable sensor technology, machine learning, artificial intelligence, IoT, and signal processing techniques, to assess mental stress using physiological data. These technologies work together to collect, analyze, and classify stress-related patterns from wearable sensor signals.
Wearable Sensor Technology is the primary technology used for collecting real-time physiological information from individuals. Wearable devices equipped with sensors measure parameters such as heart rate, heart rate variability, electrodermal activity, skin temperature, and body movement. These physiological signals provide valuable information about changes in the human body during stressful situations.
Internet of Things (IoT) technology enables communication between wearable devices and processing platforms. The collected sensor data can be transmitted through wireless communication technologies such as Bluetooth, Wi-Fi, or cloud-based networks. IoT helps in continuous monitoring and remote access to stress assessment information.

VII. RESULT

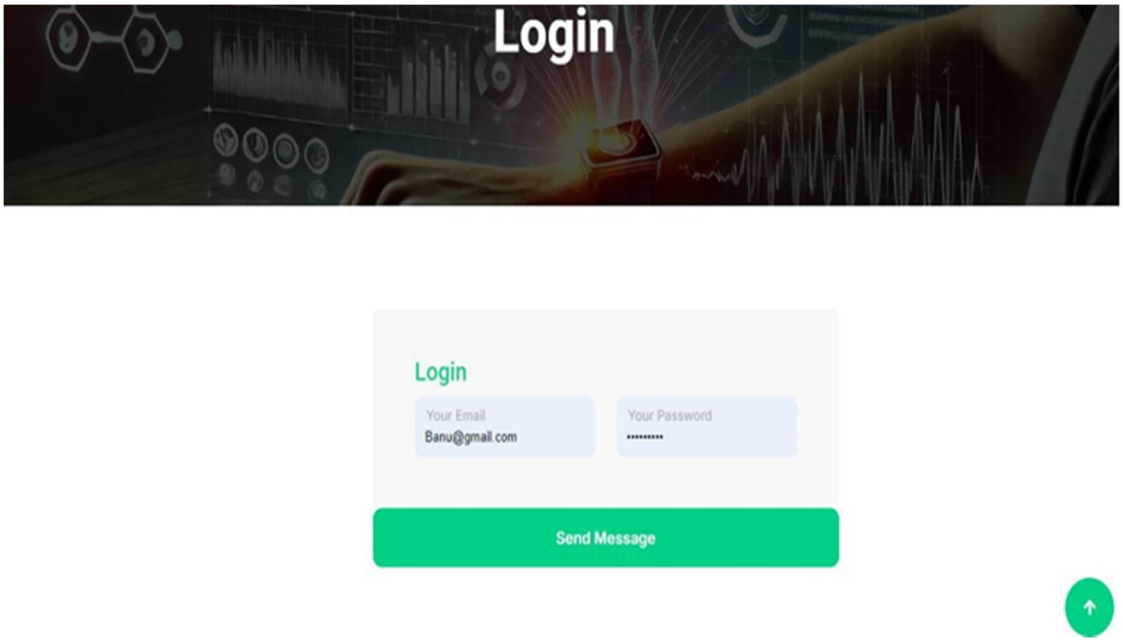
A. Input

Registration



The registration page allows users to create an account by providing basic details such as name, email ID, and password.It provides secure user authentication and enables personalized access to the mental stress monitoring system.

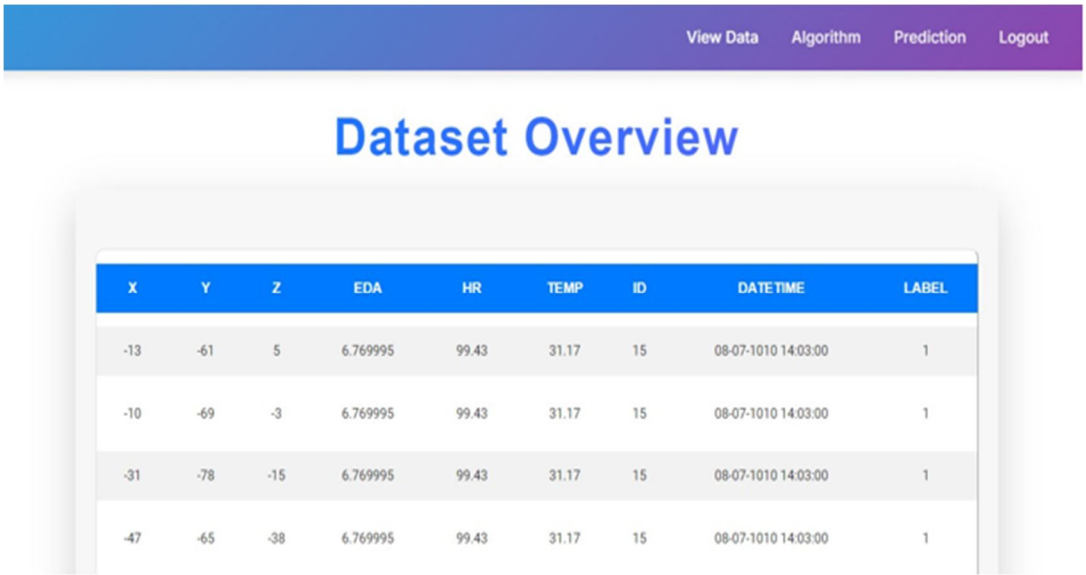
Login



The login page allows registered users to access the mental stress assessment system using their username/email and password.
It provides secure authentication and ensures that only authorized users can view stress monitoring features and results.

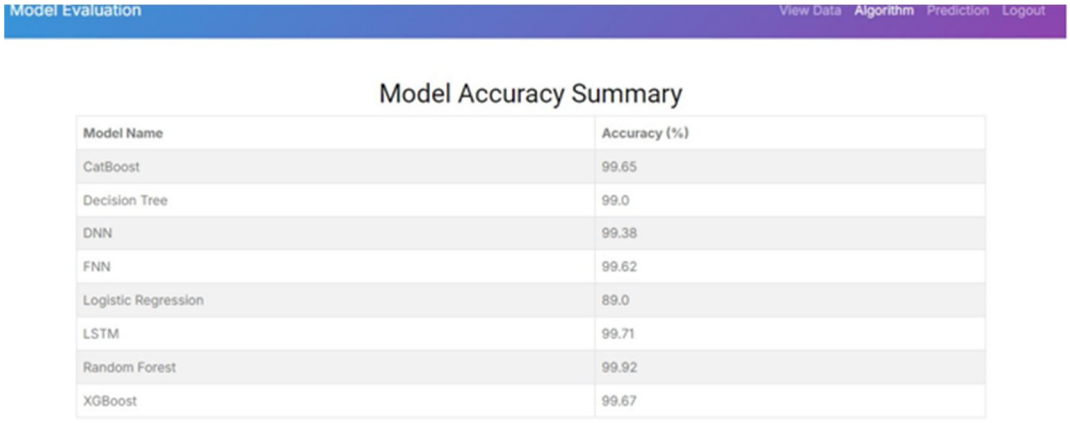
B. Output

View data

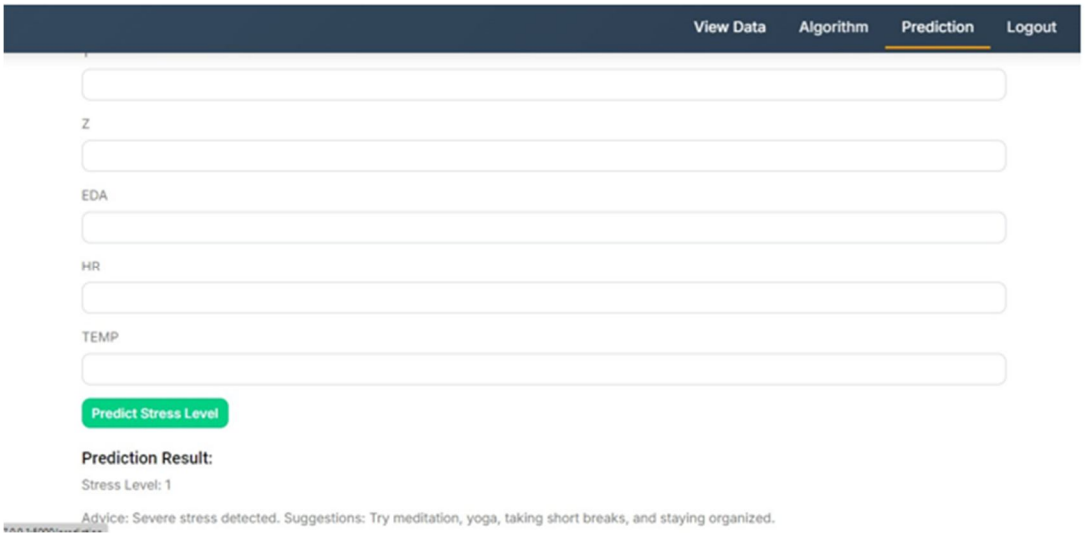


The view data page allows users to access and monitor the collected wearable sensor data such as heart rate, electrodermal activity, and temperature values.
It displays the recorded physiological information in a structured format for analyzing stress patterns and prediction results.

Algorithms



Prediction



The prediction module analyzes the processed wearable sensor data using the trained machine learning model to identify the user's mental stress level. The extracted physiological features such as heart rate, electrodermal activity, and temperature variations are provided as input to the model for classification.

VIII. ADVANTAGES

The proposed Machine Learning-Based Assessment of Mental Stress Using Wearable Sensor Data provides an efficient and reliable approach for continuous stress monitoring. Unlike traditional assessment methods, the system uses wearable sensors to collect physiological signals automatically, reducing the need for manual evaluation and providing real-time stress analysis.

The system is non-invasive and user-friendly, as it can monitor stress levels through wearable devices without causing discomfort. Machine learning algorithms analyze complex patterns in physiological data and improve the accuracy of stress classification by identifying changes in parameters such as heart rate, electrodermal activity, and temperature.

IX. FUTURE SCOPE

The future scope of the proposed Machine Learning-Based Assessment of Mental Stress Using Wearable Sensor Data focuses on improving the accuracy, reliability, and real-time capabilities of stress monitoring systems. Advanced deep learning techniques can be integrated to analyze complex physiological patterns and provide more accurate stress predictions.

Future systems can include personalized stress detection models that adapt to individual physiological responses. Integration with IoT and cloud computing can enable continuous remote monitoring and real-time data analysis through smart devices and mobile applications.

X. CONCLUSION

This paper presents a machine learning-based approach for mental stress assessment using wearable sensor data. The integration of wearable technology and artificial intelligence enables continuous and objective stress monitoring. By analyzing physiological signals, machine learning models can identify stress patterns and provide valuable support for healthcare and wellness applications.

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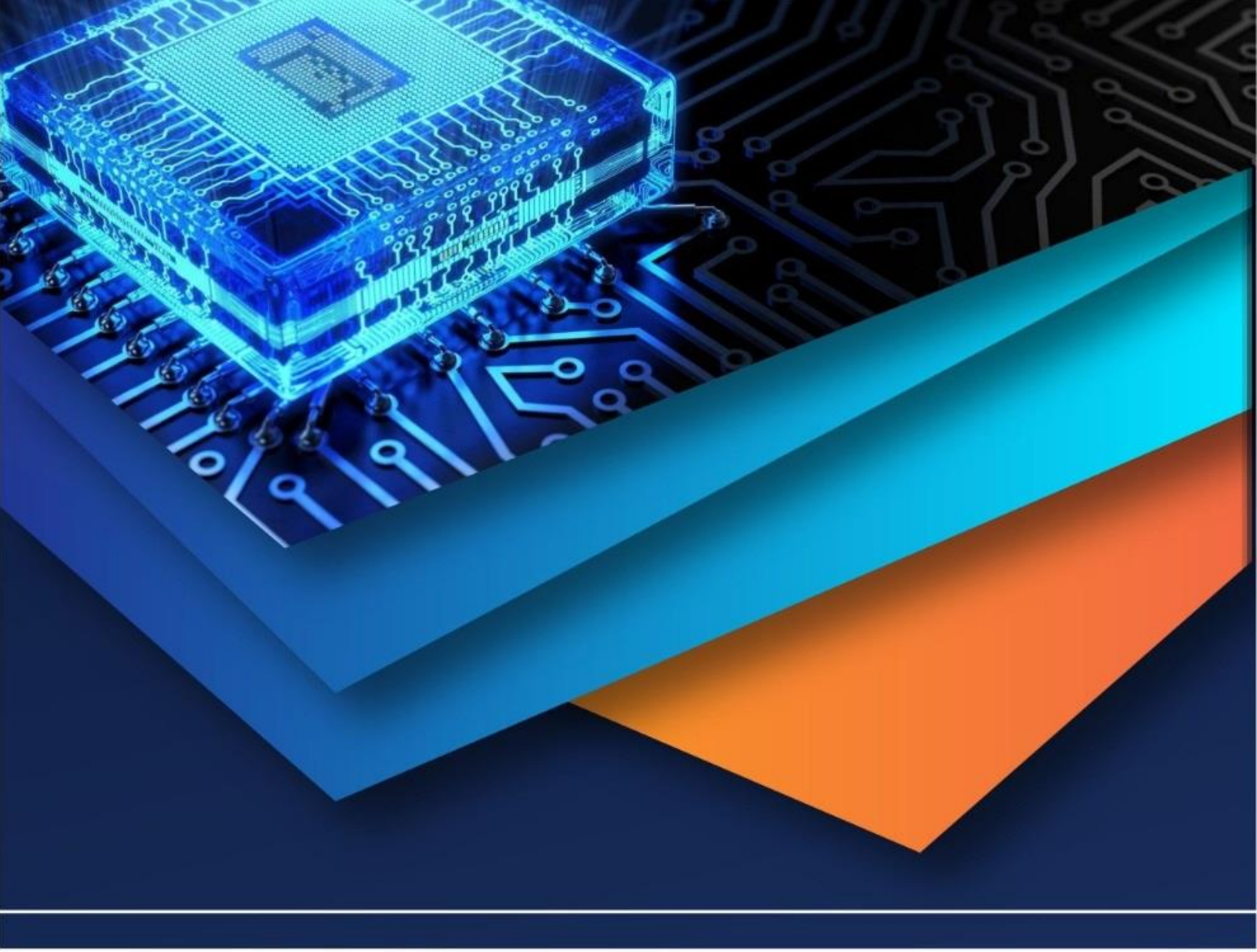

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