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DigiAddix: Smart Phone Addiction Predictor

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Abstract*—Smart Phone addiction is becoming a serious issue among school and college students. In today's digital world, early prediction of addiction is important to identify risks before they develop into serious mental health or academic problems. Many existing methods detect addiction only after it becomes severe. DigiAddix: Smart Phone Addiction Predictor is a system that identifies addiction risk using psychological and behavioral responses collected through questionnaires and converted into a machine-readable format. The system utilizes the CatBoost model to classify users into Low, Medium, or High-risk levels. It also calculates key behavioral indicators such as Attention Stability Index (ASI), Behavioral Drift Score (BDS), Control Impact Score (CIS), and Reliability Score (RS) to analyze user behavior. Based on these insights, users are further classified as Functional or Problematic. The system incorporates adaptive intervention strategies, including personalized reminders, notifications, screen dimming, and focus mode, to help users regulate their smartphone usage over time. Comparative analysis indicates that traditional models such as Decision Tree and Random Forest achieved accuracies of 74% and 82% respectively, whereas the proposed model outperformed them with an improved accuracy of 92%.

***Keywords*— Smartphone Addiction, CatBoost, Machine Learning, Behavioral Analysis, Adaptive Intervention, Attention Stability Index, Risk Classification, Mobile Application, ADASYN, SHAP**

I. INTRODUCTION

Smartphones have become an important part of daily life and are widely used for communication, education, entertainment, and social networking. However, excessive smartphone usage has led to increased concerns regarding smartphone addiction, especially among students and young adults. Continuous usage of smartphones can negatively affect concentration, academic performance, sleep quality, and mental well-being.

Existing systems mainly focus on screen-time tracking and basic usage monitoring, which are insufficient for identifying behavioural addiction patterns and providing personalized interventions. Recent advancements in Artificial Intelligence (AI) and Machine Learning (ML) have enabled the development of intelligent systems capable of analysing user behaviour and predicting addiction risk levels more effectively.

To address these limitations, this paper proposes DigiAddix, an AI-based Smartphone Addiction Prediction and Adaptive Intervention System. The system collects behavioural data through structured questionnaires and uses the CatBoost machine learning algorithm to classify users into Low, Medium, and High-risk categories. In addition, behavioural metrics such as Control Impact Score (CIS), Attention Stability Index (ASI), and Behavioural Drift Score (BDS) are analysed to understand user behaviour patterns. Based on the prediction results, the system provides adaptive interventions such as reminders, warning notifications, and focus mode activation to encourage healthier smartphone usage habits and improve digital wellness.

II. EXISTING WORK

Several research studies have focused on predicting smartphone addiction using machine learning and behavioural analysis techniques. Existing systems mainly use parameters such as screen time, social media usage, gaming behaviour, and psychological survey responses to identify addiction patterns among users.

Machine learning algorithms such as Random Forest, XGBoost, Logistic Regression, and K-Nearest Neighbours (KNN) have been widely used for smartphone addiction prediction. Some studies also incorporated personality traits and emotional behaviour analysis to improve prediction accuracy. In addition, deep learning-based approaches have been proposed for emotion recognition and addiction prevention.Most existing systems rely heavily on static questionnaire analysis and do not continuously adapt based on changing user behavior.Some approaches also require complex preprocessing techniques.

Although these systems achieved reasonable prediction performance, most of them focus only on addiction detection and lack adaptive intervention mechanisms. Many existing approaches do not provide real-time behavioural monitoring, personalized recommendations, or integrated digital wellness support. These limitations highlight the need for an intelligent and user-friendly system that combines behavioural analysis, machine learning prediction, and adaptive interventions in a unified platform.

III. PROPOSED METHODOLOGY

The architecture diagram of proposed system presents a complete pipeline for detecting and controlling smartphone addiction using behavioural data collected from a mobile application. The system integrates user responses, usage patterns, and machine learning techniques to assess digital addiction levels and provide adaptive interventions. This architecture ensures efficient complaint handling and improved decision-making.

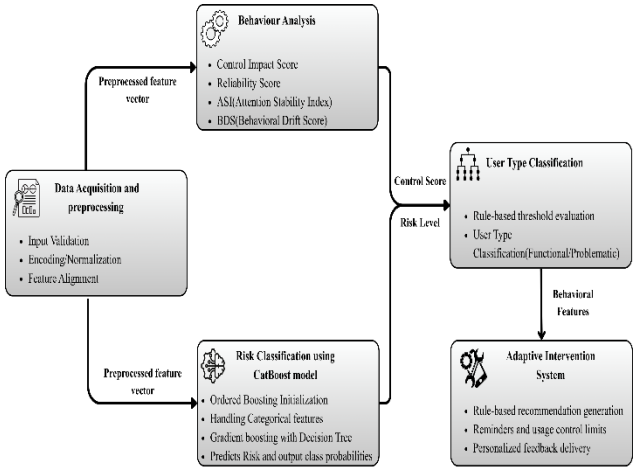

Fig. 1.System Architecture of DigiAddix:Smart Phone Addiction Predictor.

Fig. 2.

A. Data Acquisition Module

The Data Acquisition and Preprocessing module is the initial stage of the DigiAddix system, where behavioural and smartphone usage data are collected and prepared for analysis. The system gathers user responses through a structured questionnaire based on behavioural frameworks such as SAS, PMPUS, BFPT, and FoMo, using a five-point Likert scale to analyse screen time, social media dependence, gaming addiction, and self-control. In addition to questionnaire data, real-time usage information such as screen time duration, notification count, and device interaction frequency is collected to improve prediction accuracy. During preprocessing, all responses are converted into numerical values, categorical data is encoded, missing values are handled, and protective behavioural responses are reversed to maintain uniform interpretation. Relevant behavioural features are then selected and organized into a structured feature vector for accurate behavioural analysis and smartphone addiction risk prediction.

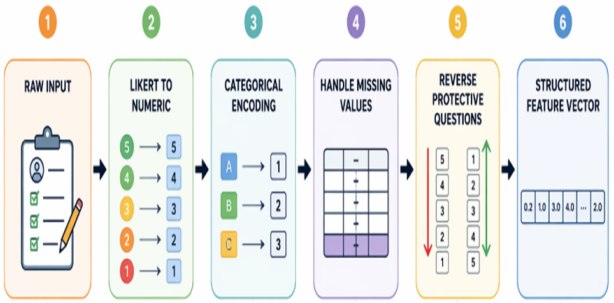

Fig. 3.Data preprocessing workflow.

B. Behaviour analysis Module

The Behavior Analysis module extracts meaningful behavioral insights from the preprocessed user data by computing important indicators related to smartphone usage patterns. The system calculates the Control Impact Score (CIS) to measure how effectively a user controls smartphone usage, the Attention Stability Index (ASI) to evaluate user focus and distraction levels, and the Behavioral Drift Score (BDS) to identify compulsive or excessive usage patterns based on high-intensity responses. In addition, a Reliability Score (RS) is computed to check the consistency and validity of user responses using statistical measures such as response variation and repeated answers. These behavioral metrics help the system understand user behavior more accurately and support effective addiction risk prediction and decision-making.

C. Risk Prediction Module

The Risk Classification module predicts the smartphone addiction risk level of a user using behavioral data collected from questionnaires. The system uses the CatBoost machine learning algorithm to analyze features related to screen time, usage frequency, social media dependency, and behavioral patterns. Based on the processed input data, the model classifies users into Low, Medium, or High-risk categories and generates probability scores for each class. The predicted risk level is then used for further behavioral analysis and adaptive intervention.

CATBOOST Algorithm:

The CatBoost algorithm is used in the DigiAddix system to predict smartphone addiction risk levels based on user behavioural data. The model takes a structured numerical feature vector generated from questionnaire responses related to screen time, social media usage, usage frequency, and self-control behaviour. CatBoost uses a gradient boosting approach with multiple decision trees, where each tree learns from the errors of the previous tree to improve prediction accuracy. The algorithm also applies ordered boosting to reduce overfitting and improve generalization. During prediction, the model processes the input data and generates probability scores to classify users into Low, Medium, or High-risk categories. The predicted results are further used for behavioural analysis, user classification, and adaptive intervention strategies.

```
Sample 1
RiskLevel: High | Confidence: {'Low': np.float64(0.002), 'Medium': np.float64(0.046), 'High': np.float64(0.952)}
ControlImpact: 56.25 | UserType: Problematic
Main usage: Entertainment

Sample 2
RiskLevel: Medium | Confidence: {'Low': np.float64(0.034), 'Medium': np.float64(0.935), 'High': np.float64(0.031)}
ControlImpact: 53.12 | UserType: Functional
Main usage: Communication

Sample 3
RiskLevel: Low | Confidence: {'Low': np.float64(0.998), 'Medium': np.float64(0.002), 'High': np.float64(0.0)}
ControlImpact: 34.38 | UserType: Functional
Main usage: Education / work

Sample 4
RiskLevel: Medium | Confidence: {'Low': np.float64(0.031), 'Medium': np.float64(0.958), 'High': np.float64(0.011)}
ControlImpact: 40.62 | UserType: Functional
Main usage: Communication

Sample 5
RiskLevel: Low | Confidence: {'Low': np.float64(0.982), 'Medium': np.float64(0.017), 'High': np.float64(0.001)}
ControlImpact: 50.0 | UserType: Functional
Main usage: Social media
```

Fig. 4.Risk Prediction output.

D. User Type Classification Module:

The User Type Classification module is responsible for categorizing users into Functional or Problematic types based on their behavioural patterns and predicted addiction risk level. This module combines the output of the CatBoost prediction model with behavioural analysis results to provide a more reliable classification of user behaviour.

The input to this module includes the predicted risk category and the Control Impact Score (CIS), which represents the user's ability to control and regulate smartphone usage. Higher CIS values indicate poor self-control and stronger dependency patterns. Using predefined threshold-based rules, the system evaluates both the addiction risk level and behavioral control factors to determine the final user type.

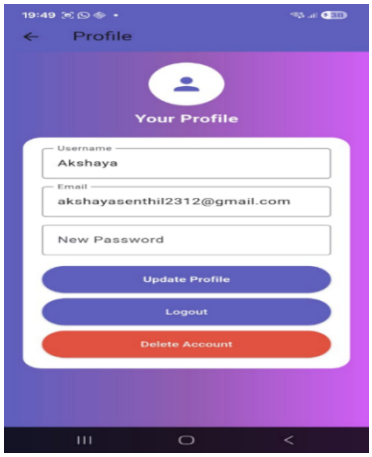

Fig.4Profile Screen

Users with higher addiction risk and poor behavioral control are classified as Problematic, while users who demonstrate controlled smartphone usage behavior are classified as Functional. This rule-based approach ensures that classification is not entirely dependent on machine learning prediction but also considers behavioral consistency and self-control patterns.

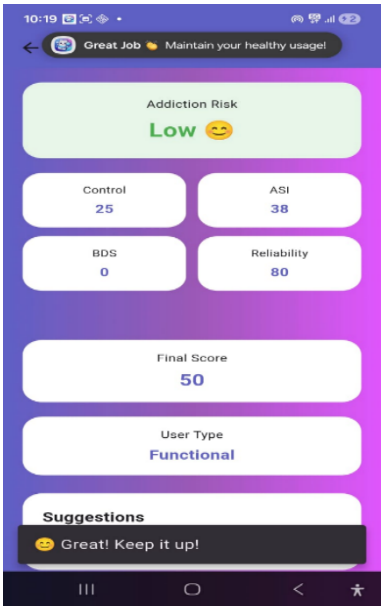

Fig.5Low Risk Screen

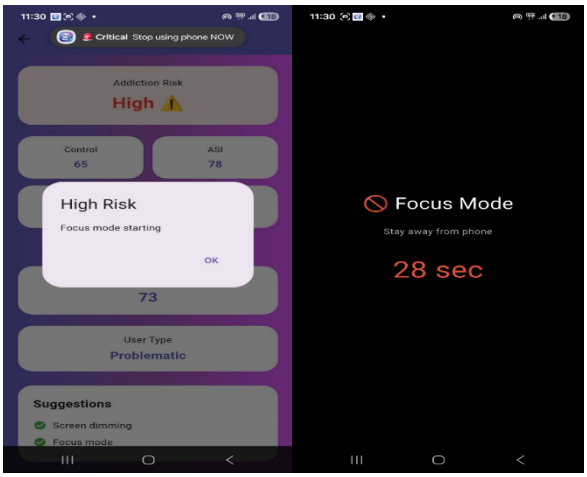

Fig.6 High Rish screen

The intervention mechanism for users classified under high addiction risk. At this state, the system detects severe smartphone dependency. The application generates frequent and high-priority notifications to alert the user about excessive usage. Strong warning messages are displayed, indicating the need for immediate action. For users classified as functional, the system provides strict reminders and encourages the use of focus mode to reduce distractions. For users identified as problematic, the system applies more intensive interventions such as repeated alerts, screen dimming, and enforced focus mode to limit usage.

The output of this module helps the system identify users who require behavioral guidance and intervention support. The classified user type is further utilized in the Adaptive Intervention module to provide personalized notifications, reminders, warnings, and focus mode activation based on the user's behavioral condition.

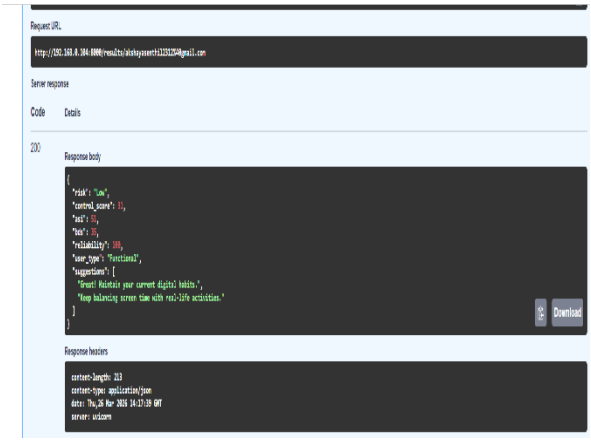

Fig.7 Backend API Response output

E. Adaptive Intervention Module :

The Adaptive Intervention module is the final stage of the DigiAddix system and is responsible for helping users regulate excessive smartphone usage through personalized actions and real-time behavioral support. Unlike previous modules that mainly focus on analysis and prediction, this module actively influences user behavior by providing notifications, alerts, behavioral suggestions, and usage control mechanisms.

The module utilizes outputs generated from earlier stages, including behavioral indicators such as Control Impact Score (CIS), Attention Stability Index (ASI), Behavioral Drift Score (BDS), and Reliability Score (RS). These metrics help the system understand user behavior, self-control ability, attention consistency, and compulsive usage patterns. In addition, the predicted addiction risk level generated by the CatBoost model and the classified user type are also considered during intervention.

The system further incorporates real-time smartphone usage information such as screen time duration, application usage frequency, and user interaction patterns collected from the device. By combining behavioural analysis, machine learning prediction, and real-time usage monitoring, the module determines the severity of smartphone dependency and applies suitable intervention strategies.

The intervention process continuously operates within the application and periodically monitors user activity to ensure timely behavioral guidance. This adaptive approach helps users improve self-control, reduce smartphone dependency, and promote healthier digital wellness practices.

TABLE 1. ADAPTIVE INTERVENTION DECISION MATRIX

Risk Level	User Type	In-app action	Global action	Advanced action
Low	Any	Snack bar message	Positive notifications	Nil
Medium	Functional	Suggestion message	Reminder notifications	Navigate to tips screen
Medium	Problematic	Alert dialog	Warning notifications	Navigate to tips screen
High	Functional	Strong warning dialog	Warning notification	Navigate to focus mode
High	Problematic	Alert+Screen dim	Critical notification	Focus mode

IV. RESULTS AND DISCUSSION

A. *Performance Evaluation*

The model performance is evaluated using standard metrics such as Precision, Recall, F1-score, and Accuracy.The system achieves an overall accuracy of 91% on the test dataset.

TABLE 11. CLASSIFICATION REPORT OF DIGIADDIX

Risk Level	Precision	Recall	F1-Score	Support
High	0.92	0.83	0.87	123
Low	0.96	0.88	0.92	225
Medium	0.92	0.97	0.94	417
Accuracy			0.93	652
MacroAvg	0.93	0.89	0.91	652
WeightedAvg	0.93	0.93	0.93	652

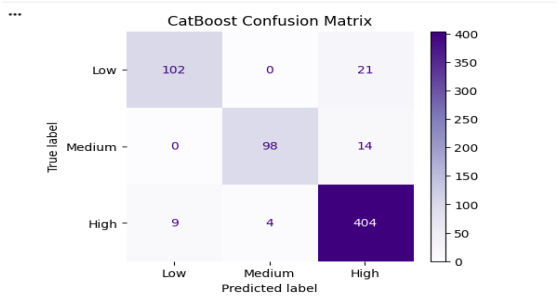

Fig.8Confusion matrix of DigiAddix

The confusion matrix of the DigiAddix model. The diagonal values represent correct predictions, while off-diagonal values indicate misclassifications. The model shows good performance with minor confusion between adjacent risk levels. This visualization highlights the effectiveness of the classification model.

B. *Model Analysis*

The DigiAddix system demonstrates strong performance in predicting smartphone addiction risk levels, achieving an overall accuracy of 92%. The model effectively classifies users into Low, Medium, and High-risk categories based on their behavioural patterns and smartphone usage data. Evaluation metrics such as Precision, Recall, and F1-score show balanced and reliable performance across all classes, indicating the consistency of the prediction model.

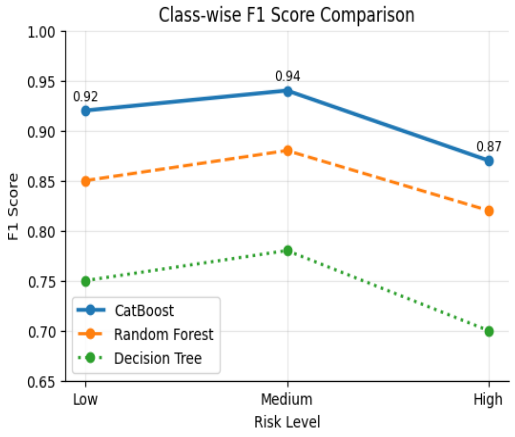

Fig.9F1-Score Comparison Graph

The comparison of CatBoost, Random Forest, Decision Tree models based on F1-score across different risk levels. The CatBoost model consistently achieves higher F1-scores compared to Random Forest and Decision Tree indicating better classification performance across all categories.

The important features used by the model for prediction. It highlights key behavioural factors such as usage habits and self-control patterns that significantly influence smartphone addiction risk.

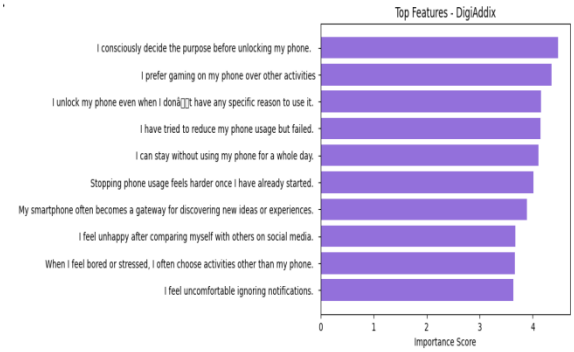

Fig.10Feature Importance Graph

V. CONCLUSION

The DigiAddix system provides an effective solution for predicting and managing smartphone addiction using behavioural analysis and the CatBoost machine learning algorithm. The system classifies users into different addiction risk levels and provides adaptive interventions such as reminders, alerts, and focus mode activation to encourage healthier smartphone usage habits. With reliable prediction performance and behavioural monitoring capabilities, DigiAddix supports digital well-being and offers a practical approach for reducing smartphone addiction.

VI. FUTURE WORK

Future versions can focus on cross-platform compatibility and integration with wearable devices to collect richer behavioral data. These enhancements will make the system more intelligent, adaptive, and effective in managing smartphone addiction.

VII. ACKNOWLEDGMENT

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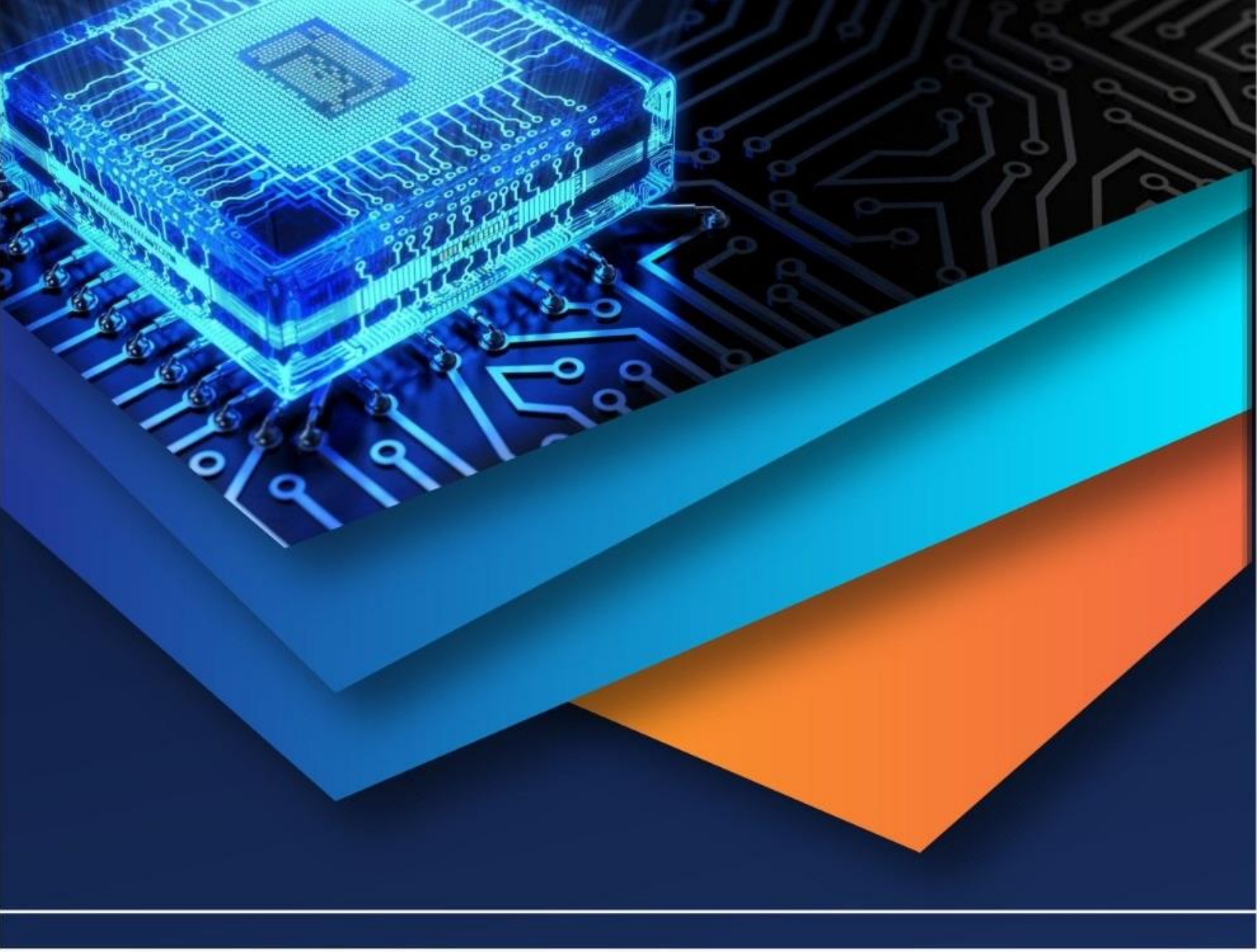

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