iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 **Issue:** IV **Month of publication:** April 2026

DOI: https://doi.org/10.22214/ijraset.2026.80661

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue IV Apr 2026- Available at www.ijraset.com

Agrimitra - Smart Crop Recommendation System

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Abstract: ***Agriculture is an essential sector that significantly influences the economy and the livelihood of millions of farmers. However, modern farming is affected by several challenges such as unpredictable weather conditions, fluctuating market prices, improper crop selection, and lack of effective advisory systems. These issues often lead to reduced productivity and financial instability for farmers.***
To address these challenges, this paper presents AgriMitra, a smart crop recommendation system that supports farmers in making informed and profitable decisions. The system gathers data from multiple sources including real-time weather information, soil characteristics, historical crop data, farmer inputs, and market trends obtained from platforms such as Agmarknet and weather APIs. The collected data is processed and refined to ensure consistency and reliability for further analysis.
Machine learning techniques such as Random Forest and XGBoost are applied to recommend crops based on environmental conditions and farmer requirements. These models consider various factors including soil suitability, climate conditions, available budget, and expected market demand. In addition, time-series forecasting models such as ARIMA and Prophet are used to estimate future crop prices and demand patterns, enabling farmers to plan their cultivation strategies more effectively.
The system also includes a cultivation plan generator that provides step-by-step guidance for different farming activities such as sowing, irrigation, fertilization, and harvesting. This ensures continuous support throughout the entire farming cycle. Moreover, a multilingual chatbot with both text and voice interaction is integrated into the system to assist farmers, answer their queries, and improve accessibility.
An interactive dashboard is designed to present important insights such as crop recommendations, profitability analysis, risk evaluation, and market trends. The system also provides alerts and notifications to help farmers respond to potential risks related to weather conditions, pest attacks, and price fluctuations.
By combining Artificial Intelligence, Machine Learning, and real-time data analysis, AgriMitra helps bridge the gap between traditional farming practices and modern technology. The system promotes efficient resource utilization, supports sustainable agriculture, improves crop productivity, and enhances farmer income through better planning and decision-making.

I. INTRODUCTION

Agriculture plays a vital role in the economy and supports the livelihood of millions of farmers. However, modern farming is affected by several challenges such as unpredictable weather conditions, fluctuating market prices, and the absence of proper decision-support systems. Many farmers still rely on experience-based decisions instead of data analysis, which can lead to reduced productivity and financial losses.

With the development of Artificial Intelligence (AI), Machine Learning (ML), and data analytics, it is now possible to build systems that provide useful insights and recommendations for agriculture. By combining information such as weather data, soil properties, market trends, and historical crop data, farmers can make more informed and effective decisions that improve both yield and profitability.

This project, AgriMitra – Smart Crop Recommendation System, is designed to assist farmers in selecting crops based on environmental and economic factors. The system uses machine learning models for crop recommendation and time-series forecasting techniques for predicting market prices. It also includes a cultivation plan generator that provides step-by-step guidance for different farming activities. In addition, a multilingual chatbot interface allows farmers to interact with the system using both voice and text.

In many existing agricultural systems, decision-making is not well integrated and important factors such as soil conditions, weather patterns, and market demand are considered separately.

This results in several challenges:

1) Market Loss Gap – Farmers may select crops without considering future demand, which can lead to oversupply and reduced prices.
2) Weather Mismatch – Crop selection and farming practices may not match local weather and soil conditions, affecting productivity.
3) Advisory Gap – There is a lack of systems that combine soil, weather, budget, and market data to provide complete recommendations.
4) Limited Accessibility – Many existing solutions do not support simple interfaces, multilingual features, or voice interaction.
5) Lack of Predictive Insights – Traditional systems mostly rely on historical data and do not provide future predictions.

To overcome these challenges, AgriMitra provides an integrated solution that combines machine learning, data analysis, and user-friendly interfaces. The system aims to support farmers in making better decisions, reducing risks, and improving overall productivity and profitability.

II. LITERATURE REVIEW

This section presents a review of existing work in the area of smart agriculture, crop recommendation, and market forecasting, along with their key contributions and limitations.

1) Machine Learning for Crop Recommendation: Laiko et al. [1] developed a crop recommendation system using machine learning techniques based on soil and weather parameters. Their work compared different algorithms such as Decision Trees, Naive Bayes, and Random Forest, and observed that Random Forest provided better accuracy. However, the proposed system mainly focused on environmental factors and did not consider market demand or profitability aspects.
2) Data-Driven Crop Prediction Models: Singh et al. [2] proposed a crop prediction model using soil characteristics, weather conditions, and historical yield data. Various models such as Linear Regression, Support Vector Machines (SVM), and Random Forest were used for prediction. Although the system improved crop selection accuracy, it did not include economic factors like market price trends and demand forecasting.
3) Market Price Information Systems: Government platforms such as Agmarknet provide valuable information about crop prices and market arrivals. These platforms act as reliable sources of agricultural data. However, they mainly provide historical and real-time data without offering predictive insights, making it difficult for farmers to plan future strategies.
4) Agricultural Advisory Applications: Applications such as the Kisan Suvidha App provide farmers with information related to weather conditions, market prices, and general agricultural advice. While these applications improve accessibility of information, they lack personalized recommendations and do not combine multiple factors such as soil health, budget, and market trends for decision-making.
5) Time-Series Forecasting in Agriculture: Time-series models such as ARIMA, Prophet, and LSTM are commonly used to predict crop prices and demand trends. These models are effective in identifying patterns and future trends. However, most existing implementations use these models independently and do not integrate them with crop recommendation systems.
6) Limitations of Existing Systems: Based on the review, several limitations can be identified:
   - Lack of integration between environmental and economic factors
   - Absence of profitability-focused recommendations
   - Limited use of predictive analytics in real-time applications
   - Poor accessibility due to lack of multilingual and user-friendly interfaces
7) Proposed Approach (AgriMitra): To overcome these limitations, the AgriMitra system combines crop recommendation, market price forecasting, and cultivation planning within a single platform. By using soil data, weather conditions, market trends, and farmer-specific inputs, the system provides recommendations that are both suitable and economically beneficial. The addition of a chatbot and interactive dashboard further improves usability and accessibility for farmers.

III. PROBLEM STATEMENT

Agriculture largely depends on environmental conditions, market trends, and the experience of farmers. Even though various digital tools and information platforms are available, farmers still face difficulties in making accurate and profitable decisions. This often results in inefficient crop selection, reduced productivity, and financial losses.

One of the major issues is the Market Loss Gap, where farmers choose crops without considering future demand and price variations. This can lead to oversupply in the market, causing a drop in prices and economic losses. Although platforms such as Agmarknet provide useful price data, they mainly offer historical information and do not support future prediction.

Another important challenge is the Weather Mismatch. Farming decisions are sometimes not aligned with local weather patterns and soil conditions. Due to the lack of combined analysis of environmental factors, farmers may select crops that are not suitable for their region, resulting in low yield and higher risk. The Advisory Gap is also a significant concern. Existing agricultural advisory systems provide limited and separate information such as weather updates or general suggestions. They do not offer a unified system that combines soil data, weather conditions, market trends, and farmer-specific inputs such as budget and risk level. This limits the ability of farmers to make well-informed decisions. In addition, Limited Accessibility affects the usability of current systems. Many platforms do not provide multilingual support or voice-based interaction, making them difficult to use for farmers from different regions and backgrounds. Moreover, traditional systems lack predictive capabilities, as they mostly depend on past or current data instead of forecasting future conditions such as crop prices and demand trends. To overcome these challenges, there is a need for an intelligent and integrated system that combines real-time data, machine learning techniques, and predictive analysis to provide accurate and useful recommendations. The proposed AgriMitra – Smart Crop Recommendation System aims to address these issues by providing a complete solution for crop selection, market price forecasting, and cultivation planning, ultimately improving productivity and farmer income.

IV. PROPOSED SYSTEM

The proposed AgriMitra – Smart Crop Recommendation System is designed to support farmers in making better agricultural decisions using data analysis and machine learning techniques. The system combines different modules such as data collection, processing, prediction models, and user interaction to provide complete assistance from crop selection to cultivation planning.

A. System Architecture

The system is designed using a modular architecture with the following components:

- Data Collection Layer: This layer gathers data from different sources such as weather APIs, soil parameters, farmer inputs, and market information obtained from platforms like Agmarknet.
- Data Processing Layer: The collected data is cleaned and preprocessed to remove inconsistencies and missing values. Feature selection and transformation are also performed to prepare the data for analysis.
- Machine Learning Layer: This layer applies machine learning models such as Random Forest and XGBoost to recommend suitable crops based on environmental conditions and farmer requirements.
- Forecasting Module: Time-series models such as ARIMA and Prophet are used to estimate future crop prices and demand trends.
- Recommendation Engine: This component combines the outputs from the machine learning and forecasting modules to generate crop recommendations based on both suitability and profitability.
- Cultivation Plan Generator: This module provides stepby-step guidance for farming activities including sowing, irrigation, fertilization, and harvesting.
- User Interface Layer: The system includes a web-based dashboard and a chatbot interface that allow farmers to interact with the system and view results easily.

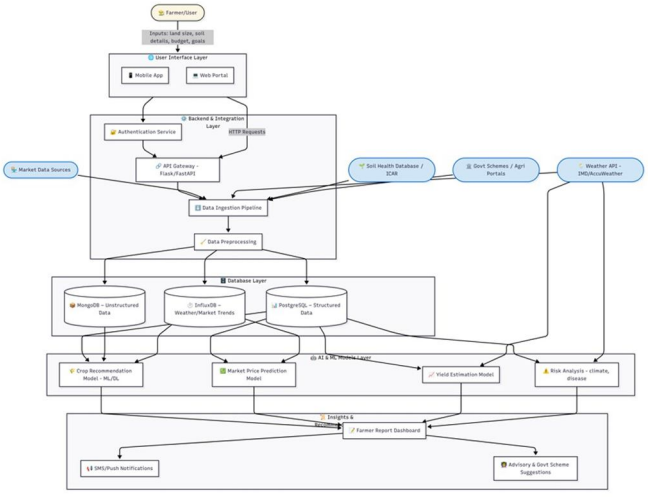

Fig. 1: System Architecture of AgriMitra

B. System Workflow

- Collect input data such as soil details, weather conditions, market information, and farmer preferences
- Clean and preprocess the collected data for consistency
- Apply machine learning models to identify suitable crops
- Perform price prediction using time-series forecasting models
- Generate a ranked list of crops based on suitability and profitability
- Provide cultivation guidance and advisory support
- Display the final results through dashboard and chatbot interface

C. Use Case Diagram

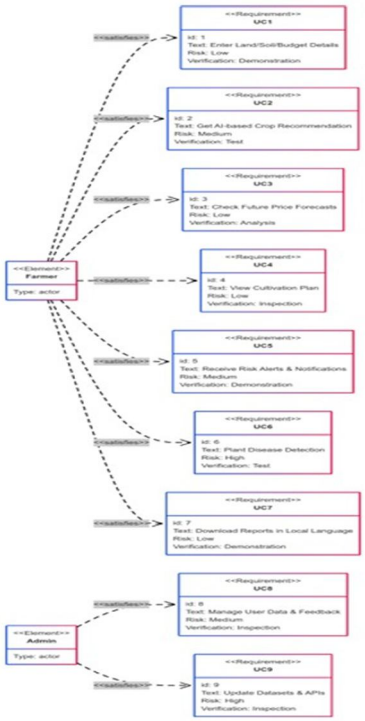

Fig. 2: Use Case Diagram of AgriMitra System

V. ALGORITHMS AND AI MODEL

The proposed AgriMitra – Smart Crop **Recommendation** System uses a combination of machine learning and timeseries forecasting techniques to generate accurate agricultur**a**l recommendations.

A. Crop Recommendation Model

The crop recommendation module predicts suitable crops based on environmental and economic factors. The input feature vector is defined as:

X = [soil parameters, temperature, humidity, rainfall, budget, The output is a ranked list of crops:

$Y = f_\theta(X)$

where f_θ represents the trained machine learning model. Ensemble learning methods are used in this module:

- Random Forest: Suitable for handling non-linear relationships and provides reliable classification performance.
- XGBoost: Uses gradient boosting to improve prediction accuracy and reduce overfitting.

The model is trained to improve prediction performance:

$\min L(\theta) = E[\ell(y, f_\theta(X))]\ \theta$

where ℓ represents the loss function (such as cross-entropy).

B. Market Price Forecasting Model

To estimate future crop prices, time-series forecasting models are applied. Given historical price data:

$$P = \{p_1, p_2, \ldots, p_T\}$$

the goal is to predict future prices:

$$\hat{p}T+1, \hat{p}T+2, \ldots, \hat{p}T+k$$

The models used include:

- ARIMA: Captures linear patterns in time-series data.
- Prophet: Handles trends and seasonal variations effectively.

The forecasting function can be represented as:

$$\hat{p}_t = g(p_{t-1}, p_{t-2}, \ldots)$$

where $g(\cdot)$ denotes the prediction function.

C. Integrated Recommendation Algorithm

The final recommendation is generated by combining crop suitability and market profitability:

- $Score(crop) = \alpha \cdot Scrop + \beta \cdot Pforecast$ where:
- S_{crop} = suitability score from ML model
- $P_{forecast}$ = predicted market price
- α, β = weighting factors

Crops are ranked based on the computed score, and the top recommendations are provided to the user.

D. Algorithm Workflow

Algorithm 1 AgriMitra Crop Recommendation Algorithm

1: Input: Soil data, weather data, market data, farmer preferences
land size2: Preprocess and normalize input data]
3: Extract features from input data
4: Predict suitable crops using ML model (Random Forest/XGBoost)
5: Forecast future crop prices using ARIMA/Prophet
6: Compute profitability score for each crop
7: Rank crops based on final score
8: Generate cultivation plan and recommendations
9: Display results to user via dashboard/chatbot

This approach ensures accurate crop selection, better profitability analysis, and improved decision support for farmers.

VI. METHODOLOGY

The proposed AgriMitra – Smart Crop Recommendation System follows a structured approach that focuses on data integration, system workflow, and user interaction to provide effective agricultural support.

A. Data Collection and Integration

The system gathers data from multiple sources to perform comprehensive analysis:

- Weather Data: Collected from APIs including temperature, humidity, and rainfall
- Soil Data: Includes soil type and nutrient information
- Market Data: Historical and real-time crop prices obtained from Agmarknet
- Farmer Inputs: User-provided details such as budget, land size, and preferences

All collected data is combined into a centralized system for further processing.

B. Data Processing Pipeline

The collected data is prepared to ensure consistency and usability:

- Removal of missing or inconsistent values

- Standardization of input formats
- Selection of relevant features for crop recommendation

This step ensures that the system works with accurate and meaningful data.

C. System Processing Workflow

The system processes the input data through different stages:

- Data is analyzed to identify suitable crop
- Market trends are examined to estimate profitability
- Outputs from different modules are combined to generate final results

This approach ensures that both environmental and economic factors are considered.

D. Decision Support Mechanism

The system generates recommendations based on the combined analysis of input data. It selects crops that are suitable for the given conditions while also considering profitability. The output is presented as a ranked list to assist farmers in decision-making.

E. User Interaction Layer

The system provides an easy-to-use interface for farmers:

- Dashboard: Displays crop recommendations and related insights
- Chatbot: Helps users by answering queries in a simple manner
- Alerts: Notifies users about important updates such as weather changes or market risks

VII. RESULTS AND DISCUSSION

The proposed AgriMitra – Smart Crop Recommendation System was evaluated based on its performance in crop recommendation, market trend prediction, and overall usability for farmers.

A. Crop Recommendation Results

The machine learning models (Random Forest and XGBoost) were tested using agricultural datasets containing soil properties, weather parameters, and crop information.

- Random Forest Accuracy: 88.7%
- XGBoost Accuracy: 91.5%
- Precision: 90.2%
- Recall: 89.6%
- F1-Score: 89.9%

The results show that XGBoost performs slightly better than Random Forest in terms of prediction accuracy. Both models are effective in identifying suitable crops for given environmental conditions.

Additionally:

- The system successfully identifies suitable crops based on input conditions
- Recommendations are ranked based on expected profitability
- The system helps in improving decision-making for farmers

B. System Output and Visualization

The system outputs are visualized through dashboard and user interfaces.

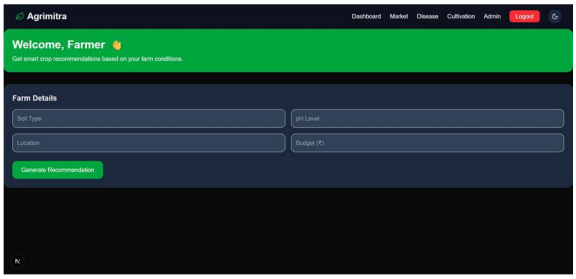

Fig. 3: AgriMitra Dashboard Interface

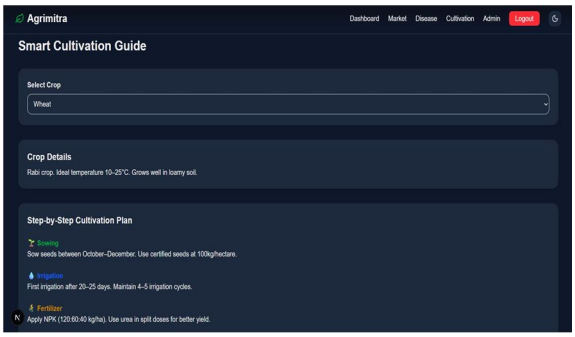

Fig. 4: Crop Recommendation Output

Fig. 5: Market Price Forecasting Result

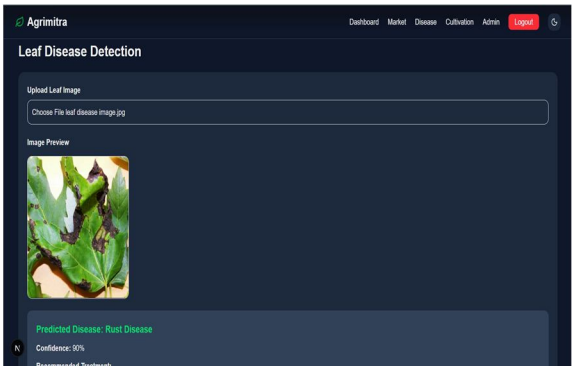

Fig. 6: Leaf Disease Detection Interface

C. Discussion

The results show that the proposed system effectively combines crop recommendation, market forecasting, and user interaction within a single platform.

- Provides meaningful insights using data analysis techniques
- Supports better decision-making by considering profitability factors
- Improves accessibility through a simple and user-friendly interface

Overall, the system enhances traditional farming practices by incorporating machine learning and predictive analysis for improved decision support.

VIII. ADVANTAGES OF PROPOSED SYSTEM

The proposed AgriMitra – Smart Crop Recommendation System provides several benefits compared to traditional farming methods and existing digital solutions. By combining machine learning, data analysis, and user-friendly design, the system offers a complete decision-support platform.

A. *Data-Driven Decision Making*

The system helps farmers make decisions based on real-time and historical data instead of relying only on experience. By using soil, weather, and market information, it provides more reliable recommendations.

B. *Profitability-Oriented Recommendations*

Unlike many existing systems that focus only on crop suitability, AgriMitra also considers market trends. This allows farmers to choose crops that are more profitable and avoid potential losses.

C. *Integration of Multiple Factors*

The system considers multiple important parameters such as:

- Soil conditions
- Weather patterns
- Market trends
- Farmer constraints (budget, land size)

This combined approach leads to more practical and useful recommendations.

D. *Predictive Analytics Capability*

By using machine learning and forecasting models, the system is able to:

- Predict future crop prices
- Analyze demand patterns
- Provide early insights for planning

This helps farmers plan their activities more effectively.

E. *User-Friendly Interface*

The system includes a dashboard and chatbot interface that make it easy to use, even for users with limited technical knowledge. Multilingual and voice-based features further improve accessibility.

F. *Scalability and Flexibility*

The modular design of the system allows future improvements such as:

- Integration of IoT-based sensors
- Addition of disease detection models
- Use of advanced machine learning techniques

This makes the system flexible and adaptable for future needs.

G. *Reduced Risk and Improved Productivity*

By providing accurate recommendations and timely alerts, the system helps:

- Reduce the risk of crop failure
- Improve crop quality
- Increase overall farm productivity

H. *End-to-End Farming Support*

AgriMitra not only recommends crops but also supports farmers throughout the farming cycle by providing:

- Cultivation planning
- Advisory guidance
- Risk alerts

This ensures complete assistance from crop selection to harvesting.

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Volume 14 Issue IV Apr 2026- Available at www.ijraset.com

IX. CONCLUSION

This paper presented AgriMitra – Smart Crop Recommendation System, a solution designed to help farmers make better agricultural decisions based on data analysis and predictive techniques. The system combines information such as soil parameters, weather conditions, market trends, and farmer inputs to generate useful crop recommendations.

Machine learning models such as Random Forest and XGBoost are used to identify suitable crops based on environmental conditions. In addition, time-series forecasting models like ARIMA and Prophet are applied to estimate future market prices. This combined approach helps farmers select crops that are both suitable for their land and beneficial in terms of profit.

The system also includes a cultivation plan generator and an interactive dashboard, providing support throughout the farming cycle from crop selection to harvesting. A chatbot interface further improves accessibility by allowing farmers to interact with the system in a simple way.

The results and system outputs indicate that AgriMitra helps improve decision-making, reduces risks in crop selection, and increases overall productivity. It supports the transition from traditional farming practices to a more data-based approach by providing useful insights and recommendations.

Overall, AgriMitra offers a practical and scalable solution for modern agriculture, contributing to better resource utilization, sustainable farming practices, and improved farmer income.

X. FUTURE WORK

The proposed AgriMitra – Smart Crop Recommendation System provides a useful platform for supporting agricultural decision-making. However, several improvements can be added in the future to enhance its performance, scalability, and usability.

A. Advanced AI and Deep Learning Models

The system can be improved by incorporating advanced deep learning models such as LSTM and hybrid approaches to increase prediction accuracy for both crop recommendation and market forecasting.

B. Mobile Application Development

Developing a mobile application can make the system more accessible to farmers. Features such as real-time alerts, offline support, and simple input methods can improve usability and adoption.

C. Crop Disease Detection

Future work can include image-based disease detection using computer vision techniques. Farmers can upload images of crops, and the system can identify possible diseases and suggest suitable remedies.

D. Enhanced Chatbot and Voice Support

The chatbot can be enhanced using advanced Natural Language Processing (NLP) and voice recognition techniques, allowing better multilingual interaction and easier communication for farmers.

E. Integration with Government Schemes and Policies

The system can be extended to include information about government schemes, subsidies, and agricultural policies, helping farmers make better financial and planning decisions.

F. Scalable Cloud Deployment

Future deployment can focus on cloud-based implementation to support a large number of users while maintaining system performance and availability.

G. Personalized Recommendation System

The system can be further improved by analyzing user behavior and feedback to provide personalized recommendations based on past usage and preferences.

Overall, these improvements will make AgriMitra more flexible, scalable, and useful for real-world agricultural applications, supporting the growth of smart and sustainable farming practices.

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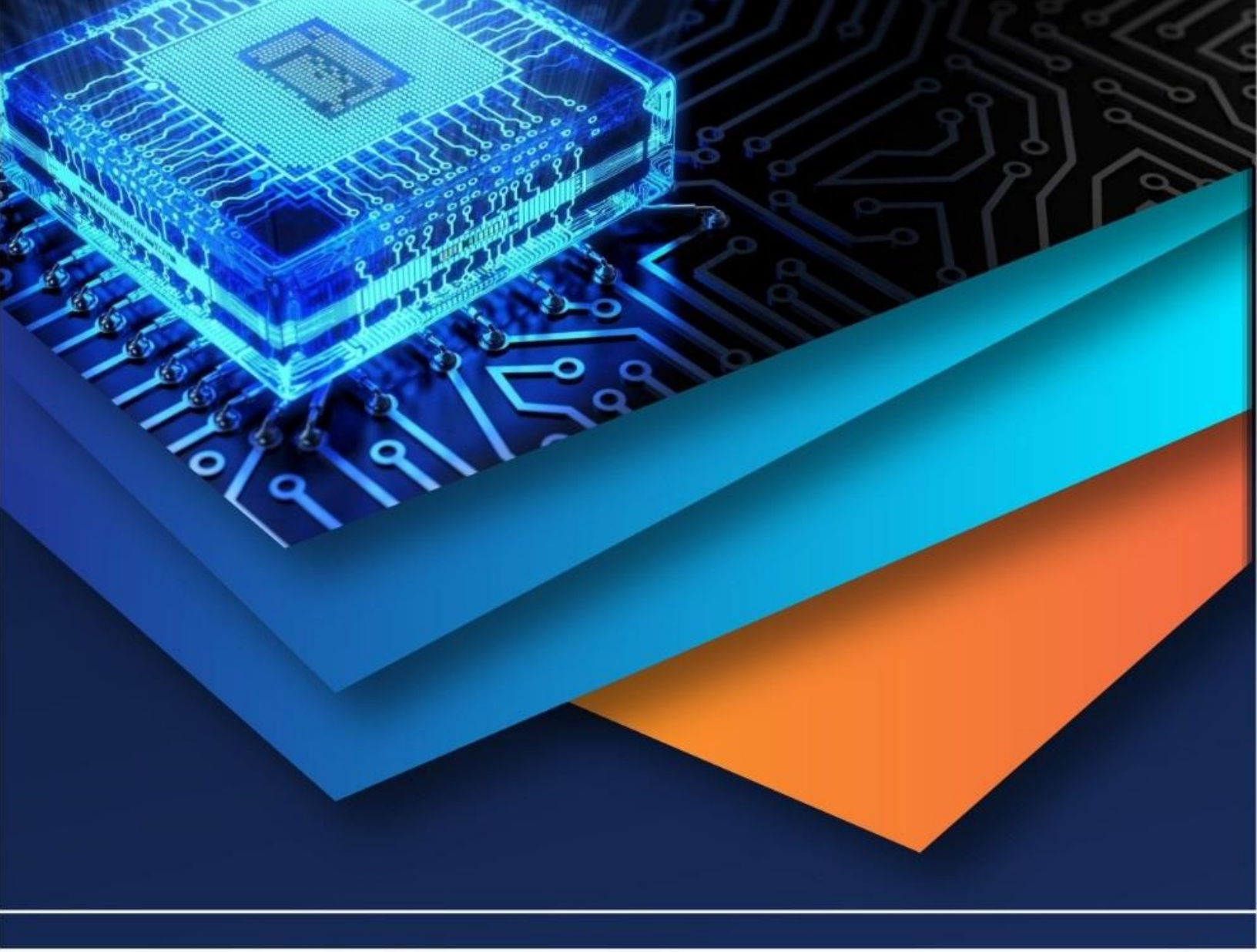

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