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A Study and Predictive Analysis in Agriculture for Crop Yield using Machine Learning Techniques and IOT

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Abstract: Agriculture is analytically a large scale economic zone that holds a major part in socio-economic feature of our country. Agriculture mainly depends on proper weather condition, water for irrigation, aerated soil which are the noted facts for good farming as per our old system. But unfortunately, these factors are unforeseeable. Present technological development for better crop yielding is being incorporated in Machine learning Algorithm with IoT platform. Here, we will evaluate the comparative study of Machine Learning for productive crop yielding with IoT and predicting the yield of various crops, thus resulting in higher yield efficiency.
Index Terms: Agriculture, IoT, Machine Learning algorithm, crop yield

I. INTRODUCTION

Agriculture in India is the major source of economic progress of the country. Farmer's basic interest will be in predicting or knowing their maximum yield of their cultivated crops during their harvest season, since agricultural is more reliable on weather condition [1]. There are number of reasons for the loss of the crop, some of the most important factors is that the crops, fertilizers, and crop productivity not properly known to the farmers. Normally, farmers can guess the final yield by their experience of growing crop again and again. Farmers yield prediction accuracy is low and not cost effective [3].

The export of some agricultural products to other countries, it is important to practice modern methods of farming by using technology instead of practicing traditional farming methods. Modern methods allow the farmers to cultivate the crops in small area with minimum amount of water, fertilizers, and pesticides, which finally produces good yield and profit to the farmers. The crop yield with forecast of climate change will be more helpful for the farmers in cultivation. The major challenge of crop prediction is climatic change, weather decided the crops yield. When rainfall or humidity is weak, it is sometimes difficult to predict the crops on time and resolving food security problems to predict crop yields before harvest the crops.

The yield prediction could be more beneficial and extremely challenging factor in the crop productivity. Thus, crop yield prediction needed to analyze the various climatic parameters, to estimate the production of crop yields profits or loss. The main goal of crop yield prediction is achieving high agricultural crop productivity. Choosing a best crop which gives maximum yield and profit is very important to every farmer in agriculture field. Thus, by implementing technology in agriculture results in higher yields and improved quality of final product. Machine learning algorithms are exclusively used to predict and helps to handle the temperature and rainfall issues. It will provide a hands-on profit to all farmers and improve the growth of agriculture in India [1].

If farmers are aware of the crop prediction, they can invest their time in other series to improve their cultivation. Added, they can make a rough calculation about their crop yield in accordance with seasonable changes [1]. Example if a crop needs frequent flow of water, to gain better productivity it should be cultivated in rainy season r in the area of continuous water flow. In this way ML will help farmer to increase their productivity and set a new path for their agricultural development.

Our system will predict the most suitable and profitable crop and predicts yield per hectare and value of crop based on current market price taking into consideration of current weather and soil conditions [3]. Thus, farmers will benefit by using our system which will improve crop productivity and profit of farmers.

The objective of this research includes predict agricultural yield prior to harvest:

1) To educate with varies research work with Machine Learning Algorithm [6], IoT and predicting with data set with a comparative study of same research domain papers [4].
2) The proposed work predicts crop yield in India under different parameter area, season [5].
3) The solution proposed allows us to predict best

Suitable and profitable crops and estimates yield [5] and help in increasing productivity by using machine learning algorithm.

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II. BRIEF HISTORY ON MACHINE LEARNING

Over decades, fact-finding in Machine Learning has been traced with diversified source of applications, approaches, intensity and giving prominence on its different features and objectives [9]. For better understanding of its evolution, the flow on a historical sketch of machine learning has been illustrated. In later period the progression has got segmented into three prime period each with varying perspectives.

A. Neutral modeling and decision-theoretic techniques
B. Symbolic concept-oriented learning
C. Knowledge-intensive approaches combining various learning strategies [9].

In 1943, neural network has been introduced by Warren McCulloch and Walter Pitts, they have created an experimental setup with electrical circuits. In 1950, Turing Test has been proposed by Alan Turing. First artificial Neural network has been invented by Frank Rosenblatt in 1958, which has been designed to recognize pattern and shape. In 1959, Bernard Widrow and Marcian Hoff has introduced two models ADELINE, which detect binary pattern and MADELINE, it eliminates echo on optical lines at Stanford University [9]. In 1982, neural network with bidirectional lines has been designed by John Hopfield [9]. Extension of Widrow and Hoff's algorithm has been insisted to allow multiple layers in neural network which got stated as 'slow learners.
In 21st century some large projects have being got into machine learning due to its increased calculation potential. Google Tensor Processing Unit (TPU) (2016) it allows neural network behind Google's service to run faster. Nvidia Tensor Cores (2017) has been used by Amazon to enrich their Amazon Web Service Machine Learning, which creates GPUs specifically. Intel-Nervana Neural Processor (2017) which is like Google's TPU has come into market which holds Matrix multiplication and convolution are the two core operations which has being performed [10]. Table.1 illustrates the flow of projects which secured the advancement of Machine Learning as its main source.

Table.1. List of projects with machine learning advancement

PROJECT	INVENTOR/ COMPANY	INVENTION
GoogleBrain (2021)	Jeff Dean (Google)	Pattern detection in images and videos, it also detects objects in YouTube videos.
AlexNet (2012)	Alexnet	Won ImageNet competition, it uses GPUs and[9] convolutional Neural Network.
DeepFace (2014)	Facebook	Recognize people with same precision.
DeepMind (2014)	Google	Plays video games equal to human
OpenAL (2015)	Elon Musk	Safe artificial intelligence.
Amazon Machine Learning Platform (2015)	Amazon web service	It explains about how MNC's has got into machine learning.
ResNet (2015)	CNN architecture	CNN architecture from Microsoft research
U-net (2015)	CNN architecture	Specialized in biomedical image segmentation.

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III. A STUDY ON MACHINE LEARNING

In the machine learning model, the input data set, historical data, and training algorithm are fed into machine learning model. As the result the model is being trained this is perfect for prediction analysis.

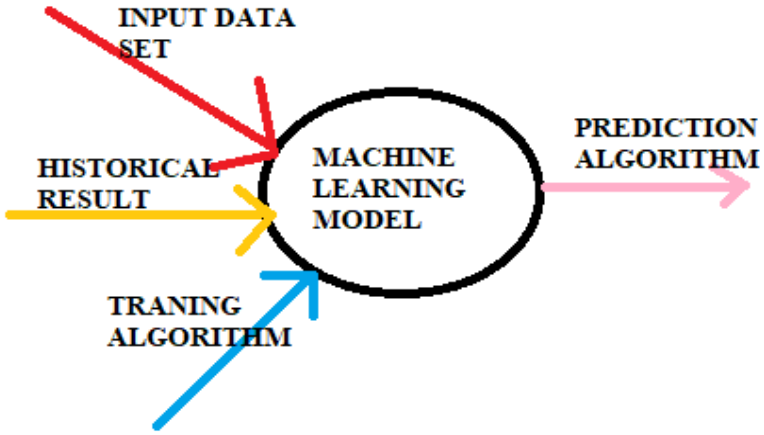

Fig. Machine Learning Mode

A. Machine Learning Algorithm

Machine learning is an approach which is insisting machine to perform intellectual activity. The word 'learning' symbolizes the process that the machine will review the existing data and will learn new ideas from the given data. The machine learning algorithm uses datasets which includes structures, unstructured data, audio, and video files. All machine learning algorithm will get comprised in the following two categories.

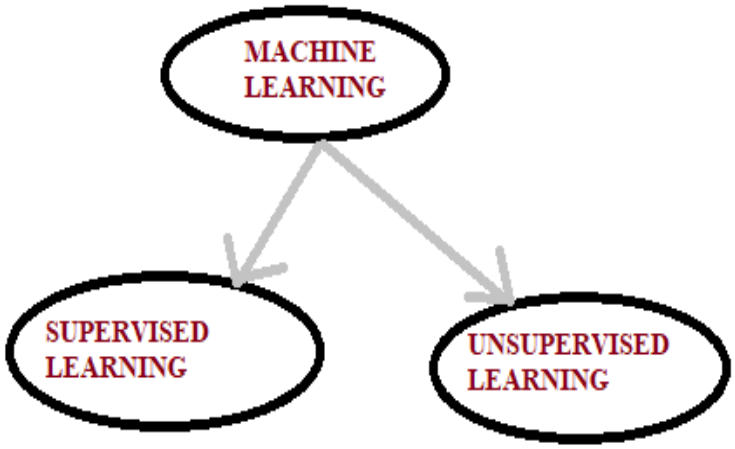

Fig.2 Machine Learning Algorithm

1) *Supervised Learning:* In this algorithm machines are exposed to the huge set of data, knowing the historical details, and predicting the data by adjusting the output till it satisfies the required results.it got typically classified under three categories:
   a) Prediction
   b) Regression
   c) Classification
2) *Unsupervised Learning:* In this algorithm grouping of data is carried out. Once the data has been collected it got gathered under its desired statistical properties. This algorithm is much faster and easy to compute. This includes the following method:
   a) Clustering

B. Machine Learning Techniques

Machine learning technique is being divided into following five segments:

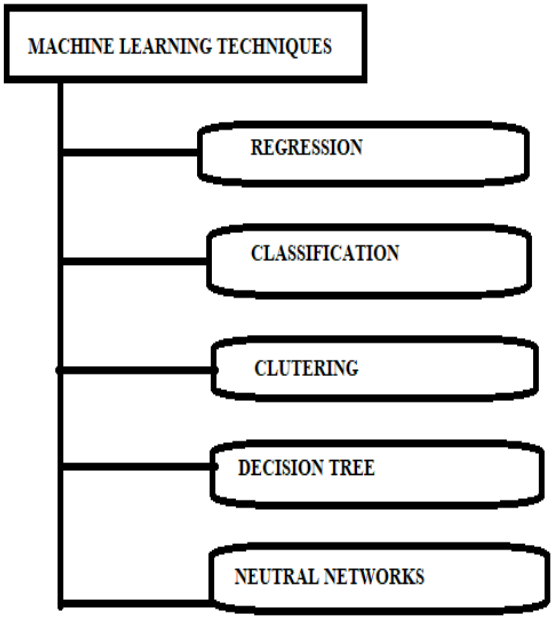

Fig.3. Classification of machine learning techniques

1) *Regression:* Regression algorithm is used to predict numerical values with reference to previous data set. I have its major application in demand forecasting by knowing the historical data. Linear regression is most used regression technique.
2) *Classification:* It is used to predict the class value, where it is essential in Al application especially for eCommerce. In classification algorithm, it answers the question like, the crop will be grown or not with Yes or No predictive statement. Logistic regression is the recommended for classification algorithm.
3) *Clustering:* The data are being grouped/clustered in accordance with their similar characteristics. It is an unsupervised learning method. Following are the some of the common algorithm s:

a) K-means
b) Mean-shift
c) Expectation-maximization

4) *Decision Trees:* This algorithm has been represented creating a decision tree by answering the question at each nodal point. The question has been asked continuously till the tree reaches it 'leaf' node. Thus, it states that the clarification has been made with the concepts with the answered question.
5) *Neural Network:* In this network one single neuron get connected with several other neuron, which transmit data from one network to the other thus numerous neuron cluster to form a cognitive multilayer structure.

IV. CROP MODELLING COUPLED MACHINE LEARNING

To improve the yield prediction and hybrid technique which includes coupling crop modelling technique with machine learning has been introduced, which has resulted providing an accurate result. It includes five machine learning patterns like linear regression, LASSO, LightGBM, random forest and XGBoost. In this study it has been proved that integrating crop model with ML will decrease the yield prediction root mean square error till 20% further drought stress and average water table stress are the top required input to Machine learning. Finally, it states that for better crop yield only the weather information is not sufficient more hydrological inputs like water occurrence, movement and transport plays a vital role.

In this model it is noted that yield data is not useful for prediction, just it will help to improve predicting crop model.

Agriculture production system simulator (APSIM) which is an open-source simulator that simulates the cropping system.in this case, output of APSIM is fed as an input to machine learning models. The output of APSIM includes 22 variables including crop yield, biomass, root depth, flower date, maturity date, LAI maximum, ET annual, Avg Drought stress, Avg Excessive stress etc.

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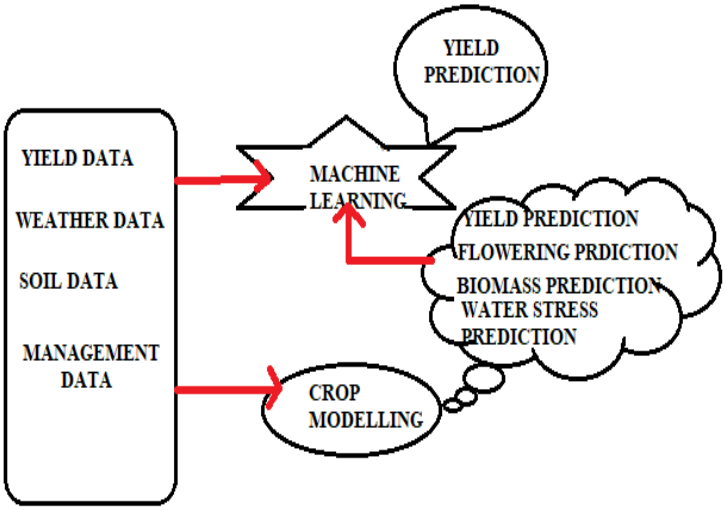

Fig.4 Conceptional Integration Of Machine Learning And Crop Modelling

V. WORKING METHODOLOGY

A. Data Collection

In this phase, we collect data from various sources and prepare datasets. And the provided dataset is in the use of analytics (descriptive and diagnostic). There are several online abstracts sources such as Data.gov.in and indiastat.org. For at least ten years the yearly abstracts of a crop will be used. These datasets usually accept behavior of anarchic time series. The data for this research has been acquired from the Indian Government Repository [5].

B. Data Pre-processing

The dataset contains missing values, so these missing values need to be properly handled to apply models. The pre-processing technique of backward filling is used to check and remove the null values [4] . Once the null values are removed it can be fed into the model to predict the crop yield

C. Machine learning and Prediction Algorithm

Machine Learning techniques includes prediction, classification, regression, and clustering are utilized to forecast crop yield [6]. Here, we apply various ML algorithms on available dataset to evaluate their performance. In the prediction algorithm transform new input data set into predictions. It is a mathematical expression resulting when parameter values of models are fixed.

D. Performance Evaluation

In this phase, prediction accuracy is ensured by different metrics as Mean Absolute Error (MAE) [4], Root Mean Squared Error (RMSE), Mean Absolute Error(MAE) of different machine learning algorithms and select appropriate prediction algorithm [5].

Table. 2 Performance Metrics

RMSE	Square root of average deviation from actual value.
RRMSE	Normalized by mean of actual value.
MBE	Average bias in the prediction.
R^2	Proportion of variance in dependent variable [7].

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VI. SMART AGRICULTURE

In this growing technology Internet of Thing (IoT), connected devices and tools have imprinted their growth in home automation, automotive and agricultural sectors also.it is the method of connecting each and everything to internet. It is a relation with people-people, people-things, things- things. In this technology, objects, animals, people are being equipped with unique identifier [5]. It is about the rapid technology turn from plows and horse to virtual reality.by making use of smart agricultural gadgets, getting it more predictable and enhancing its efficiency [9]. Purpose specific sensor are being connected to wireless modems, where they send periodic environmental data to user, over internet. The person can analyze the data and remotely adjust the plant environment.

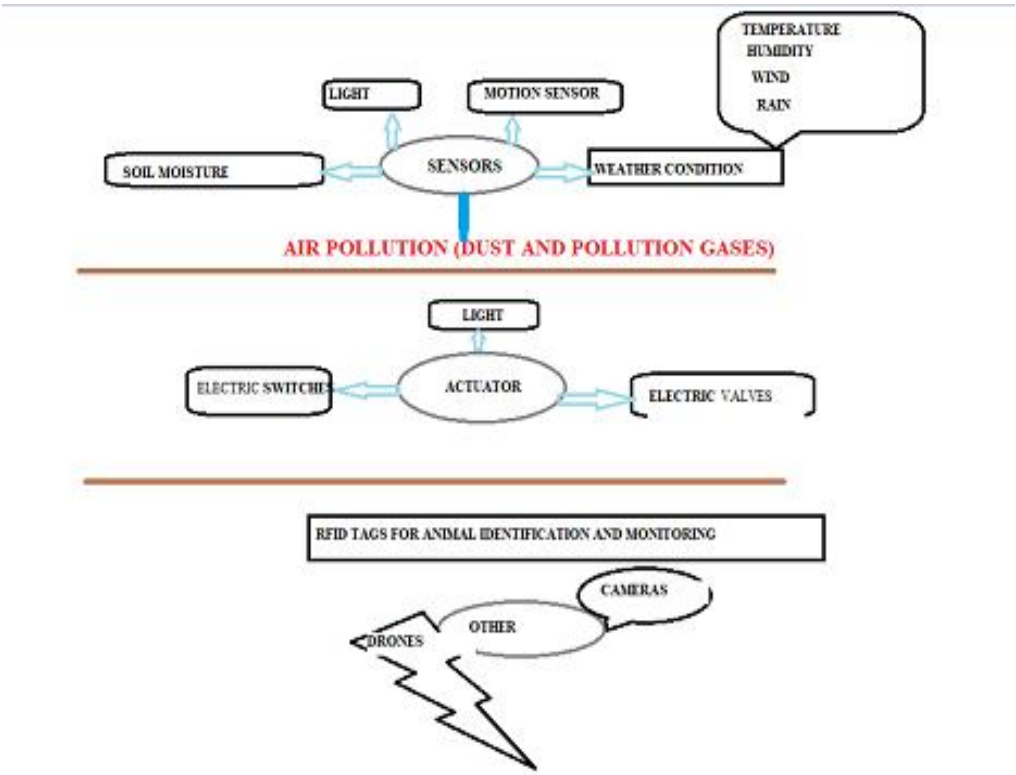

Fig.5 IoT In Agriculture

IoT agricultural resource holds different monitoring, controlling, and tracking applications which will provide a path to measure other streams like temperature monitoring, air monitoring, humidity, soil, water monitoring, location tracking, fertilization, pest control. The spitted percentage have been illustrated in Fig.6

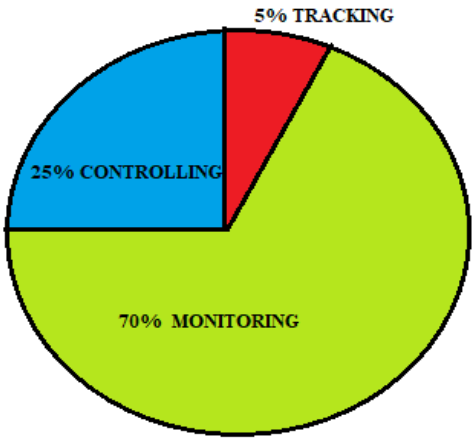

Fig.6 Application Domain

Table.2 Main Classification of Applications [2]

APPLICATIONS	PERCENTAGE
Irrigation monitoring and controlling	16%
Precision farming	16%
Soil monitoring	13%
Temperature monitoring	12%
Humidity monitoring	11%
Animal monitoring and tracking	11%
Water monitoring and controlling	7%
Disease's monitoring	5%
Air monitoring	5%
Fertilization monitoring	4%

Smart farming contains five major component classifications, which includes data acquisition, common platform, data processing, data visualization and system management [2]. In data acquisition, video, audio data have been formed by multiple communication networks. It includes wired technology like controller area network (CAN), wireless technology like ZigBee, Bluetooth etc. the components in common platform are responsible for decision making, data storage, statistical analysis, and algorithm for agricultural production process [2]. Data processing includes audio, video, text image processing and some processing techniques. Actuators, sensors, microcontrollers, and drone controllers are included in system management. The sensor will collect various information about the agricultural variables and process through embedded device for better analysis of smart farming

Table.3 Industries Initiated for IoT Agriculture.

INDUSTRIES	INITIATIVES
Samsung	Samsung Data System (SDS) IoT platform [connect multiple devices with protocols]
Aero Farms	Big data, imaging and artificial intelligence technology are being used for indoor farming.
Microsoft	Data-driven farming
R-Style Lab	Provide predictive maintenance, drone inspection, crop monitoring
Intel	Infiswift has been developed to increase the efficiency of agriculture.
Google	Joined MIT Media Lab Agriculture Initiative to provide organic food [2].

A. Applications of IoT in Agriculture

1) They are specifically used for soil moisture and temperature monitoring.
2) It controls irrigation process.
3) It provides an efficient usage of inputs like water, fertilizer, pesticides etc.
4) Wirelessly connected sensors control the water flow in the field.
5) It provides a connected green house and stables.
6) Provides an effective Livestock monitoring.
7) It reduces the cost of production.

B. Constraints for implementing IoT in Indian Agriculture Scenario

1) We have a small, dispersed land holding.
2) It is complex, scalability and affordability of the technology.
3) Due to privacy and security concerns.
4) Need a very good internet connectivity and availability.
5) Low awareness of IoT devices and system among consumers.
6) Lack of proper investment.
7) Environmental impact.

VII. CONCLUSION

Agricultural system is a prime sector where specific developments must be made. In this paper we have discussed evolution of machine learning, some important machine learning algorithms, crop prediction techniques and the application-oriented advancement of IoT in agriculture crop yielding. The machine learning algorithm results in providing a high rate of crop yields both in quality and quantity-based parameter. In futuristic point, advancement should be made for small scale farmer to implement in their area of limited filed with affordable investment. Thus, application of IoT is user friendly which helps the farmers from better understanding.

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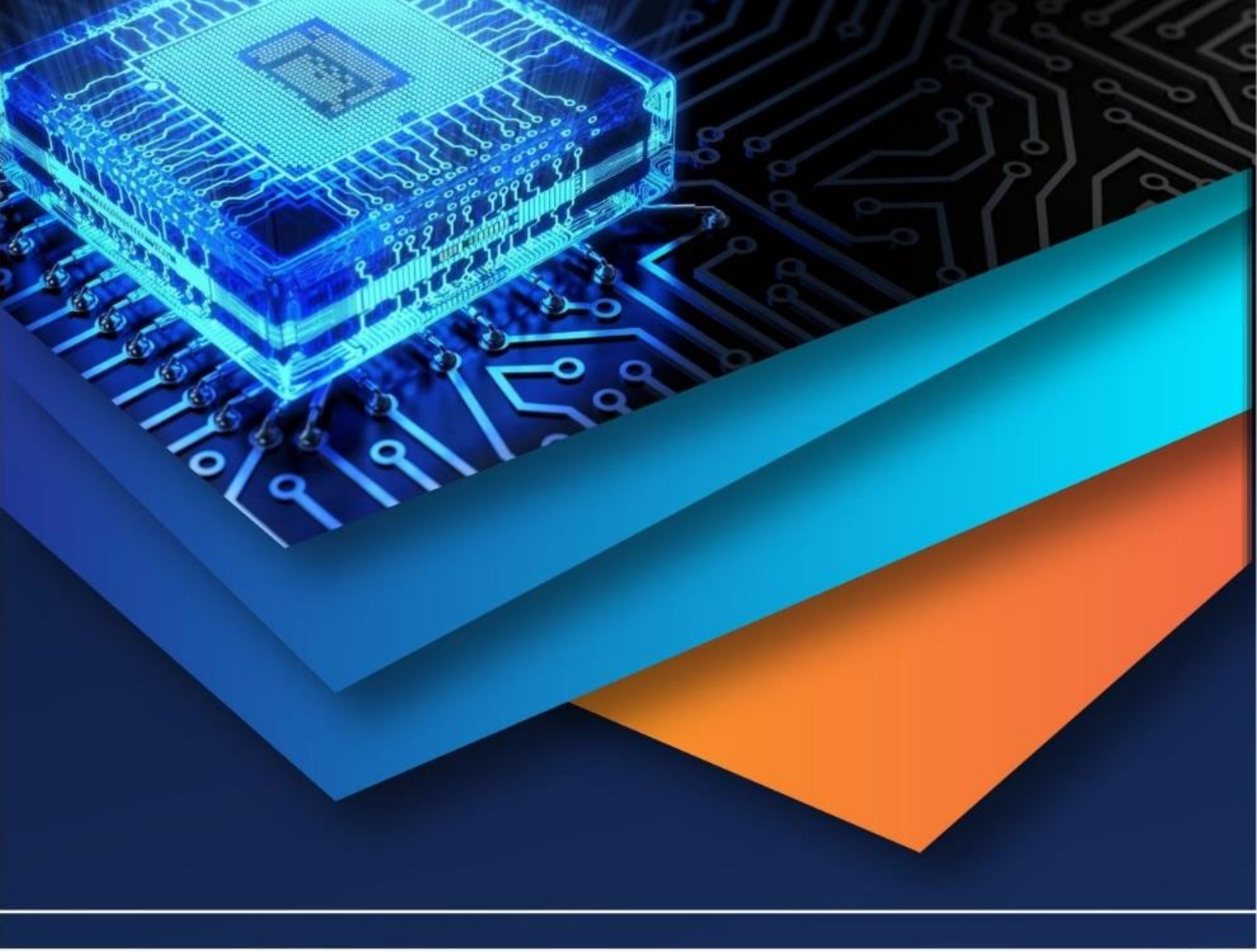

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