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A Survey on Deep Learning Based IoT Approach for Precision Crop Suggestion

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Abstract: ***Agriculture plays the main role in a country's economic development. In the recent agricultural practices, the variation in climatic phenomena affects the weather conditions in different regions and based on that the soil characteristics may also vary. This influences the crop to be sown for getting a better yield. In agriculture with the advent of new technology, farming practices are now converted into precision farming. It includes the use of modern technology such as the Internet of Things (IoT) and Data Analytics for optimal crop health and crop productivity. This improves the growth rate of the crops, but the problem among farmers is they are not choosing the right crop at right time. Although several algorithms are there the Deep Learning based Artificial Neural Networks is found to be more effective for prediction and modeling. The algorithm accuracy and the prediction level vary based on the type of parameters chosen. The proposed system helps the farmers by gathering information about the basic characteristics of their soil such as soil moisture level, temperature, pH, and humidity. In addition, the sensor provides valuable information about crops such as sowing time, fertilizer suggestion and real-time monitoring. These data can be collected using sensors and with the help of that data, the Deep Learning technique such as Deep Neural Network (DNN) which is an Artificial Neural Network (ANN) can be applied to end up with valuable decision making.***

Keywords: Crop, Agriculture, Deep Neural Networks (DNN), Artificial Neural Network (ANN), Deep Learning, Precision Farming, Sensor, Suggestion.

I. INTRODUCTION

In countries like India, the growing population needs sustainable agriculture since a majority of the population is occupied in agriculture. The agriculture offers employment to about fifty percentages of the people. But due to the technological development, the people have been moved from rural areas to urban for leading a sophisticated life. Therefore to satisfy food demand and to get maximum yield agriculture should be given importance because it is the prominent factor that influences the country's economy. Hence, to support this government organization is helping farmers by providing loan cancellation for the farmer's availed loan and subsidy for the fertilizer, etc. There are many steps have been carried out to improvise the crop yield, there are some factors such as soil characteristics and climatic phenomena which affect crop loss in various regions all over the place [1]. To overcome the disadvantages of traditional method precision agriculture can be used which is an alternative method for selecting crops. Precision agriculture is the use of technology such as sensors and applying it to agriculture. With the help of precision farming real-time data such as air, soil, and climate can be analyzed using the Internet of Things. Thereby, the precision farming improves the yield by utilizing the natural resources in an efficient manner. It involves combining data analytics and IoT for efficient crop selection. In recent days everything is made possible with the help of the "Internet of Things" which almost connects everything together via the internet. The recent technological development with the use of data transmission and electronic systems has introduced rapid changes in recent agricultural practices and forms an important role in decision making. The IoT or Internet of things will capture the real-time data and with the help of these data valuable information can be extracted. The smart farming is the incorporation of information into equipment, sensors, machinery and communication technology in the agricultural system, which allows a large volume of data to be generated [2][3].

II. LITERATURE SURVEY

In agriculture, various data mining approaches are used for agricultural related problems. One such approach used here is the classification for predicting crop loss, crop diseases, and crop production. In this work, it mainly predicts the crop loss caused by grass grub insect which uses classifiers such as Decision tree, Random forest, Naïve Bayes Support vector machine, and Neural Network are used. For that different evaluation criteria are used to select the best prediction model it includes, F1-score, accuracy, precision, recall etc. By applying the evaluation criteria to the classification algorithms the neural network and random forest

produce better output, but this work states that the result can be further improved by applying some hybrid approaches [4]. R. Ramya, C. Sandhya, R. Shwetha proposed Smart Farming using sensing technology. Their work used a smart farming system which uses different types of sensors to measure the moisture, pH, temperature, and intensity of light. These sensors will collect the information and the collected data helps the farmers to enhance the productivity by studying about the favorable environmental conditions.

The whole smart farming system is controlled by Arduino microcontroller which is quite commonly used microcontroller board. But this work suggests the use of a wireless sensor network and to use Raspberry Pi instead of Arduino due to the advancements that it is having in the field of IoT [2]. P. Bhargavi, S. Jyothi collected the soil database and soil classification is done using the various data relevant to the soil. In the initial step, the soil database is created and the soil samples had been taken from a particular district and to these soil samples, Naïve Bayes classification technique is applied. In addition to the Naïve Bayes other data mining techniques are also compared. The classifier classifies the soil type as clay, loam, sandy loam etc. The disadvantage here is the soil samples are tested in the laboratory and then based on that the properties of the soil the database are created. Hence this work suggests conducting soil tests in the field itself in order to improve the result of soil classification [5]. Niketa Gandhi, Leisa J. Armstrong, Owaiz Petkar, Amiya Kumar Tripathy uses a support vector machine (SVM) machine learning method to find the yield prediction of rice. The study area contains a dataset from Maharashtra state which includes precipitation, maximum, minimum, average temperature, cultivation area, and production etc. Generally, the SVM is used to create functions and in this Sequential Minimal Optimization (SMO) classifier algorithm is taken for the current study using WEKA tool. The results showed that compared to SVM other classifiers such as Naive Bayes and Multilayer perceptron produces better results in terms of specificity, accuracy, and sensitivity [6]. Niketa Gandhi, Owaiz Petkar, Leisa J. Armstrong predicted production of the rice yield using the Neural Network approach.

In Maharashtra state 27 districts are chosen and in that, publicly available records were taken, these records include parameters like minimum temperature, average temperature, maximum temperature, area, and production. For this dataset Multilayer Perceptron, Neural Network is applied for processing with the help of WEKA tool. But this work suggests that in the Artificial Neural Network based model the prediction capabilities can be improved by considering additional parameters [7]. Amir Haghverdia, Robert A. Washington-Allenb, Brian G. Leibc predicted the cotton lint yield using remote sensing technology. The satellite remote sensing technology is primarily used for assessment and monitoring of the agricultural land in order to determine the area, amount and type of crop production. Deep Learning can be applied and used for this type of problems. In this Artificial Neural Network (ANN) approach is used to generate the models related to individual Crop Indices (CI) and CI phenology to map and predict the yield of cotton lint in two growing seasons.

Deep Learning is one of the techniques recently used for data analysis and for processing images. It provides better results and used for various purposes other than agriculture. The advantage of Deep Learning in agriculture is not limited. It has wide applications in agriculture like classifying images, data analysis and so on. The drawback found here is the training time taken by the Deep Learning algorithm, but it provides faster computation. The study area contains parameters like mean temperature and precipitation for the respective growing season.

This shows that the yield found using spatial data highly correlates with the earlier prediction. Hence ANN can be used for providing great yield prediction using remote sensing [8][9]. Umair Ayub, Syed Atif Moqurrab proposed a data mining technique for Predicting the Crop Diseases. In their method, the author focuses on the prediction of crop loss due to grass grub insect. They used different data mining techniques to overcome the problems faced in agriculture. The results suggested that classification which is one of the data mining approaches is very much effective one predicting crop-related problems and also helps the farmers to take decisions.

The techniques were evaluated based on some of the well-known evaluation criteria such as recall, precision, and accuracy etc. The Neural Network when applied with the evaluation criteria and compared with the other algorithms the results revealed that the better outcome was produced by the Neural Network. The work also suggests improving the results by applying some hybrid data mining approaches [10]. The farmers in the present are hunting for a revolution in the agricultural sector. They are in need of proper nutrients supply and other resistance to the climatic factors. The revolution that the farmers are expecting can be fulfilled with the help of Deep Learning. The Table I present a feature comparison of the algorithms that were mainly used in the agriculture sector for taking various decisions and for making the analysis. The comparison describes the advantages and disadvantages of the methods that had been already used in the agricultural field in various aspects. The work aims at providing better analysis result to the farmers with the help of Deep Neural networks.

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TABLE I Feature comparison of Algorithms

Authors(Year)	Purpose	Methods	Pros and cons
Umair Ayub, Syed Atif Moqurrab (2018)	To predict the crop diseases caused by grass grub insect using data mining approach.	Classification techniques such as Neural Network, Random Forest, Decision tree, Naïve Bayes, SVM are used.	Neural Network and Random forest produce better results but their work states to use some hybrid approaches and use of Deep learning.
P. Bhargavi, S. Jyothi (2009)	To classify the soil using data mining techniques.	Naïve Bayes, J48, Bayesian classifier are used to classify the soil as clay, loam and sandy loam.	Naïve Bayes correctly classifies the soil instances but it suggests soil test in the field.
Niketa Gandhi, Leisa J. Armstrong, Owaiz Petkar, Amiya Kumar Tripathy (2016)	Machine learning is used to predict the crop yield of rice.	Support Vector Machine is used for predicting the rice yield.	Compared to SVM other classifiers such as Naive Bayes and Multi-Layer perceptron produce better results.
Suhas Athani, CH Tejeshwar, Mayur M Patil, Priyadarshini Patil, Rahul Kulkarni (2017)	A soil moisture monitoring system is used to detect the needed soil moisture.	Sensors such as soil moisture, salinity, and pH are used and processed by Neural network algorithm.	The sensors correctly monitor and display the information. It also suggests that the Neural Network can be used for handling seasonal variations.
Niketa Gandhi, Owaiz Petkar, Leisa J. Armstrong (2016)	To predict the rice crop yield under different climatic conditions.	Artificial Neural Network is used with the help of WEKA tool.	The prediction capabilities can be improved by considering additional parameters.
Amir Haghverdia, Robert A. Washington-Allenb, Brian G. Leibc (2018)	To predict cotton lint yield using phenology of crop.	It uses satellite remote sensing technology and the model is generated using the ANN algorithm.	The work concludes that the yield found using spatial data highly correlates with ANN for yield prediction.
Hulya Yalcin (2018)	To recognize phenology of crop using crop monitoring.	Using Deep learning the features are extracted using CNN algorithm.	The results indicate that Deep learning based approach is more effective for agricultural data.
Andreas Kamilaris, Francesc X. Prenafeta-Boldu (2018)	A .survey of Deep Learning is made on Agricultural domain	A comparison study is made by comparing Deep Learning with the other existing techniques.	The survey concluded that Deep Learning offers better performance and outperforms well on other popular techniques.
Vijo T Varghese, Kalyan Sasidhar, Rekha (2015)	To chose the right crop at right time with the help of a wireless sensor network.	The sensors such as soil moisture, temperature, rainfall are used to monitor the changes in the environment.	It suggests developing a Decision Support System that could adapt to the changing weather conditions
Rekha P, Maneesha V. Ramesh, Venkata Prasanna Rangan, Nibi K V (2017)	Giving advice to the farmers with the help of agricultural characteristics.	An Android application is designed for the IOT framework to deliver the message to the farmers.	It suggests only the irrigation and farming practices. Hence analysis can be made to obtain better results.
Pramudyana Agus Harlianto, Noor Akhmad Setiawan, Teguh Bharata Adji (2017)	To classify soil type using machine learning algorithm.	Algorithms such as Neural Network, Decision tree, Naïve Bayes and SVM are used to classify soil.	Among the Machine Learning algorithm SVM and Neural Network, accuracy is better compared to other algorithms.
R. Ramya, C. Sandhya, R. Shwetha (2017)	To enhance the productivity of the crop using sensing technology.	It uses a sensor such as pH, moisture, and temperature to monitor plants with the help of Arduino.	It suggests analyzing the collected data to improve the productivity of agriculture.

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III.METHODOLOGY

In recent days everything is made possible with the help of the 'Internet of Things' which connects almost everything together via the internet. The recent technological development with the use of data transmission and electronic systems has introduced rapid changes in recent agricultural practices and forms an important aspect for making the decision. The IoT will capture the real-time data and with the help of these data valuable information can be extracted. The extracted data can be given to the Deep Learning algorithm, in which classification is used for comparing accuracy. Generally, the algorithm with the highest accuracy will predict better crop [1].

A. Importance of IoT for Prediction

The increase in the global population and change in drastic climatic condition has gained the importance of IoT towards the agricultural sector. Here the solution is provided with the help of smart farming. One of the applications of smart farming is called precision farming. An agricultural field using precision farming contains various sensing technologies that are used to measure the farming data. It overcomes the disadvantages caused by traditional farming practices. Owing to the advent of such technologies the crop cultivation can be optimized and productivity can be improved. This also improves the prediction accuracy of the crops. The sensor provides a cost-effective way to control and monitor the cultivation area. This helps the farmers to track the changing environmental parameters, and take necessary actions.

Smart farming allows data that can be sensed in real time and these data's are stored in remote storage systems with help of various communication technologies. Based on the values generated by the sensor there is a need for an effective technology to be used for improving agricultural productivity, sustainability, and profitability. It is also found that compared to the traditional practices the IoT has proved the importance of it towards agriculture. The farmers are getting better benefit due to the efficient management practices. This helps in analysis and smart decision making that results in smart cultivation. Fig. 1 shows the workflow of the model where the data are collected from the field using sensors by the microcontrollers, then with the help of communication technology the data can be analyzed. This minimizes the use of chemicals and frequent monitoring of the plant conditions thus helps to predict the best harvesting time [2].

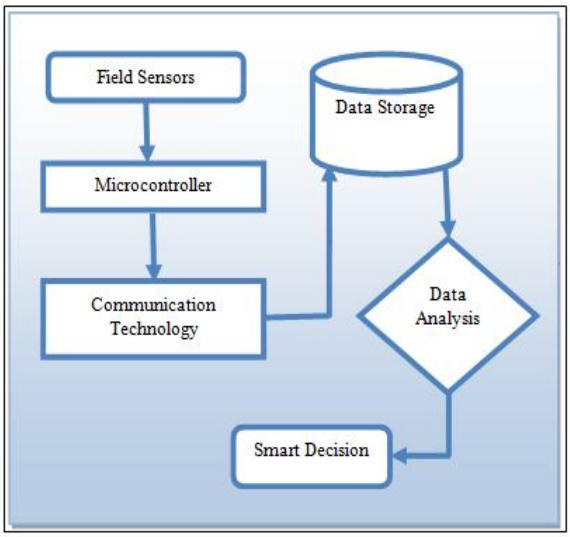

Fig. 1 System design

B. Microcontroller Used for Data Collection

The sensor can be chosen based on the type of microcontroller board, for example, Arduino. An Arduino is used for building IoT related projects. It consists of a microcontroller board which can be programmable based on the requirements and IDE an integrated development environment that is software. The software helps the programmer to feed the code from the computer to the board with the help of a USB cable. The board then performs an action according to the command such as switching on the LED etc. The Arduino IDE uses a more simplified C++ language which is very easy to learn and code. The advantage of using Arduino boards in the proposed system is that they are open source, very easy to get started, it doesn't require much programming knowledge, it can be used for developing real-time applications since the hardware software and IDE is open source, it can be used in places where there are more interactions with the external hardware.

C. Communication Technology Used for Data Storage

The sensor like soil moisture and pH sensor are selected based on the type of microcontroller and for measuring temperature and humidity there is a common sensor for measuring both these can give a relative reading about temperature and humidity. The data generated from sensors can be collected using communication technology, the most common well-known communication technologies are Wi-Fi, ZigBee, Bluetooth, etc. Among the communication technology, Wi-Fi can be used for the proposed model. The Wi-Fi offers data transfer at a faster rate and it can handle a large amount of data. It can be used for exchanging data between various devices such as sensors and computers. The main focus of using sensing technologies is to introduce new technology into the agriculture for better crop production by collecting real-time status of cultivation area and to provide information to the farmers [11][12].

D. Sensors Used In Land Area

The plant and soil characteristics monitoring seems to be simple, but it makes a great change in the agricultural pattern. There are many sensors used in IoT for agricultural fields which are greatly helpful in sensing the nutrients in soil and soil moisture, reporting the weather conditions, determine the suitable time for harvesting and planting of crops. The various sensors available include the temperature sensor, soil moisture sensor, humidity sensor, and pH sensor, etc. These sensors can be utilized for different farming requirements such as for producing timely reports and earlier identification of the land area characteristics. The application of sensors in agriculture is shown in Table II [2][13].

TABLE II
Sensors and its Applications

Sensor	Applications
Soil moisture sensor	Measures moisture level in under irrigation and Over irrigation.
Temperature sensor	Measures radiation from the sun.
Humidity sensor	Measures air temperature and moisture.
pH sensor	Measures pH of the soil.

IV. PROPOSED SYSTEM

The machine learning is the one which makes predictions based on the experience it had learned. This uses training data to train a model and when an input is given the model will make predictions accordingly. Deep Learning is one of the parts of machine learning, in which the data processing takes place through a number of layers and it has the ability to learn about features that can be applied at each level for improving the performance. A system is proposed using Deep Neural Network. It works on a way in which a Neural Network concept works.

The Artificial Neural Network (ANN) is a supervised machine learning algorithm. The ANN contains a system of neuron which is similar to the human brain. Each neuron accepts an input with weight and processes them and it responds with an output. The IoT system measures the parameters related to crop cultivation such as soil moisture, temperature, pH and humidity from the cultivation area. These data are collected from the field with the help of sensing technology. The data collected by the sensors are then are transferred with the help of communication technology such as Wi-Fi. These data will be getting stored in a database in excel format with the help of a Wi-Fi module.

The training data can be collected from a database or it can be manually created. While creating a training dataset in the initial step the data should be gathered, the gathered data should be then subjected to preprocessing. During the preprocessing phase, the missing values in the database can be filled and noisy data can be removed. The preprocessed data can be later given to the algorithm for training. Once the algorithm is trained it can be used for extracting knowledge. The dataset along with the training data will be given as an input to the Deep Neural Network for training.

The processing will be made under the PyCharm which is an integrated development environment for developing python related projects. For training and making the prediction over this classifier algorithm PyCharm IDE can be used this uses python language and it contains many open source libraries for performing Deep Learning task. It also contains advanced debugging options and supports advanced programming of the web. The proposed model is shown in Fig. 2. The proposed system can be further enhanced by giving suggestion to the farmers about the appropriate amount of fertilizers to be added for boosting up the plant growth.

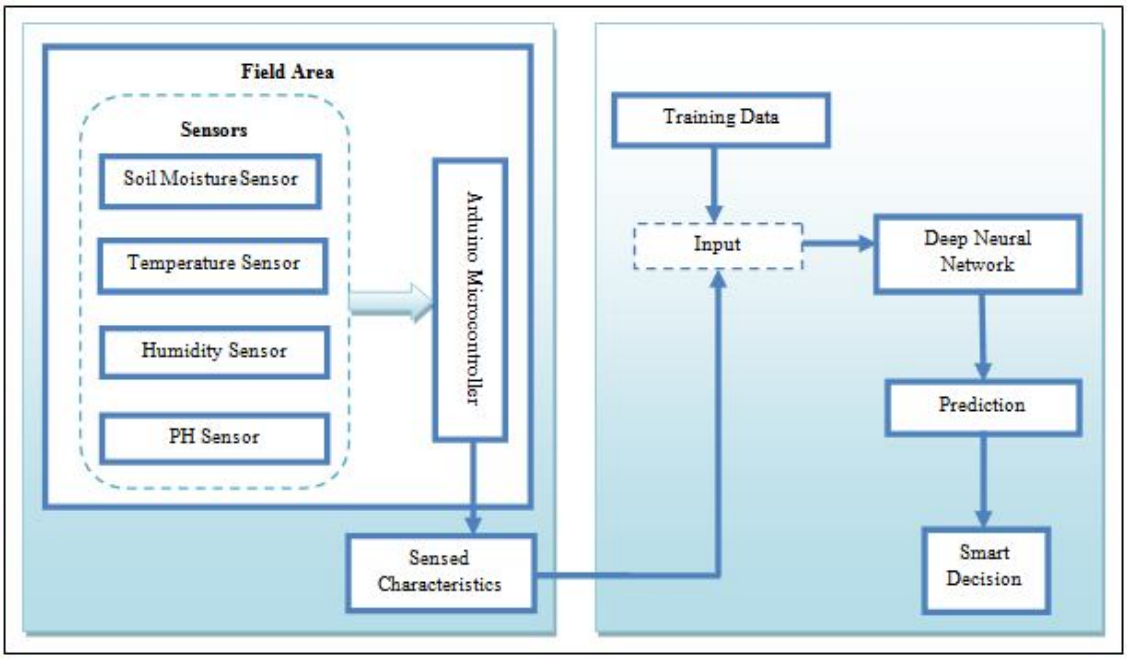

Fig. 2 The proposed system for precision crop suggestion

V. CONCLUSION

In the future, the agriculture sector in our country needs to be given more importance. Hence to overcome the issues in agriculture sector greater efforts have been carried out for predicting right crop. The solution to overcoming these issues can be given using IoT with this efficient analysis can be made to improve the quality of crops in agriculture. The precise crop can be suggested only when the developed model gives accurate results. The proposed model aims at overcoming the issues in the agricultural sector by integrating IoT and Data Analysis. Then, by analyzing the collected data, the analysis result will greatly support the farmers for cultivating the crops at right time to acquire profit and to increase productivity. As technology is increasing dramatically, on the other side the electronic hardware component's quality is improving but the costs are decreasing. The components used in our proposed system for precision agriculture is an affordable one which makes the system cost-effective. The result generated by the prediction model will greatly help the farmers in acquiring high profit and yield irrespective of the seasonal variations with the best selection for crop cultivation. Further implementation work deals with taking immediate actions whenever climatic condition gets changed. The quality of the agricultural sector can be achieved with the help of low-cost sensors and a reliable communication mechanism with the help of this prediction model can be developed efficiently to improve crop cultivation. The result generated by the prediction model will greatly help the farmers in acquiring high profit and yield irrespective of the seasonal variations with the best selection for crop cultivation.

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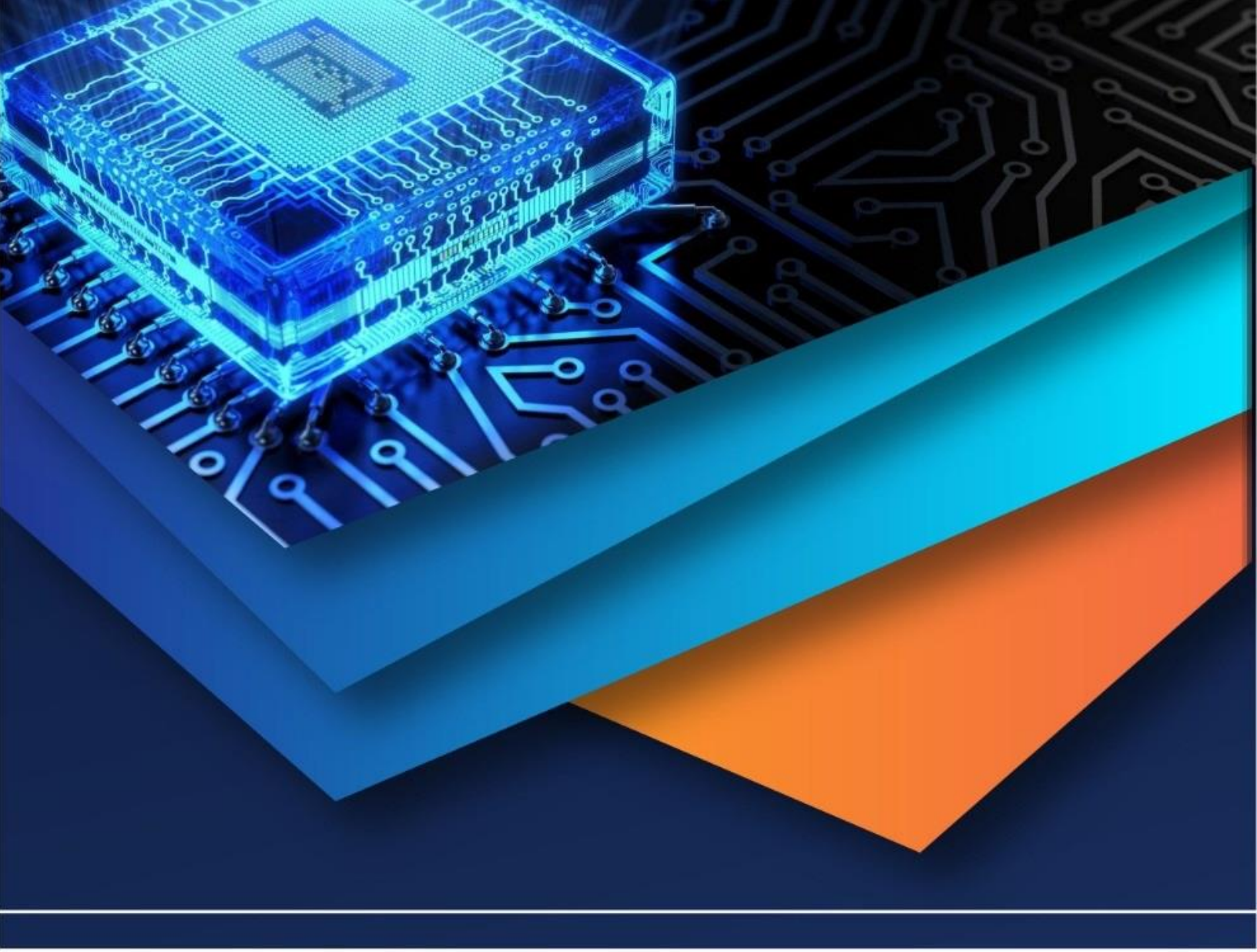

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