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A Review on Machine Learning Techniques Used in Rice Crop Management

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Abstract: ***Rice is a major food crop for a significant population of the world and increase in its yield is a priority to ensure nutrition for many countries. Thus it is important to protect the crop from the various diseases that affect the crop. With the advent of machine learning, a number of methods have been proposed to identify diseases after the occurrence as well as at an early stage. Diagnose of these predators before occurrence can be much more beneficial. Journal papers that used rice as a major crop were considered eligible. In this review, an attempt is made to understand the preferred machine learning methods and algorithms that can be employed to detect various diseases and pest as well as predict crop yield of the rice crop. It is expected to be beneficial to all who wish to use machine learning in agriculture that can lead to constructive research in this area.***

Keywords: machine learning, rice blast, brown spot, ANN, SVM

I. INTRODUCTION

With increase in population, India has to increase the production of agriculture in order to achieve food security. Rice, which is a major food crop [1, 2] tends to be significantly affected by disease causing agents and pest and, thus has reduced yield. Control of pests can be achieved through application of the proper chemicals in the field. Monitoring and controlling environmental parameters like water irrigation, soil moisture and animal invasion in the field are being carried out by automated technology. Monitoring and implementing proper farming methods can alleviate many diseases. Inadequate access to expert knowledge in various areas such as fertilizer management, disease and pest control as well as difficulty in availing expert advice leads to a decreased rate of production in rice as well as lower crop quality.

Of the several challenges that affect the crop, such as pest, environmental conditions and natural diseases, disease is a significant concern in rice cultivation [3, 4]. In Asia 10 to 15% of production is destroyed because of rice diseases [5]. Some of the bacterial and fungal diseases that adversely affect the rice crop are *blast*, *bacterial leaf blight*, *tungro*, *sheath blight*, *sheath rot*, and *brown spots*. [6].

Of the diseases that affect the rice crop, Leaf blast, Sheath blight and Brown spot are the most common [7]. Caused by a fungus *magnaporthe oryzae*, the rice blast disease (RBD) may affect very small portion of the leaf during the nursery stage and then spread to entire crop resulting in significant reduction in crop yield. RBD, common in approximately 85 rice producing countries [8], results in loss of food that could feed millions of people per year. The quantity of grain loss in the rice crop due to the blast disease is expected to be 70 to 80% of the total damage according to a report of Tamil Nadu Agriculture University (TNAU), and 50% yield reduction in severe cases due to brown spot [9]. Even through the application of pesticides, it is a considerable challenge to control this infectious disease. A common pest, the Asian gall midge, Orseolia oryzae (Wood-Mason) (Cecidomyiidae: Diptera) is prevalent in South and Southeast Asia [10, 11]. After the stem borer and the plant hopper, the asian midge is the third most common rice pest in India [12], which affects 30–70% of the total rice area [13] impacting major rice producing regions in India such as Andhra Pradesh, Telangana, Tamil Nadu, Kerala, Goa, Karnataka, Maharashtra, Madhya Pradesh, Bihar, Odisha, Assam, Manipur, and in some parts of West Bengal, and Uttar Pradesh.

It has been observed that that there is a high correlation between plant diseases/pest and improper water management, insufficient soil nutrients. Appropriate decisions can be taken by making decision support systems which can help farmer to take appropriate measures and reduce the impact of diseases and, thus improve yields. Recently, researchers have utilized ML to examine the diseases of melon [14], tomato [15, 16], avocado [17], maize [18], citrus [19], and millet [20].

In order to reduce crop loss due to diseases it is very important that the diseases are identified at a very early stage. It is expected that the deployment of various ML and other computer aided algorithms would reduce the impact of diseased on rice production.

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II. LITERATURE REVIEW

Akula Manesha[21] developed a method that employed IOT and machine learning which predict disease in rice plant.Variable such as Ph, soil moisture, humidity and temperature were collected and stored in Thingspeak cloud. Machine learning algorithm viz. Naïve Bayes was employed in the study to predict rice plant disease such as sheath blight, brown spot, rice blast, Bakanae, stalk burn, rice tungro. It was observed that an accuracy of 92% was achieved in predicting diseases.

Hament Kumar Wani[22] proposed a method to predict pest and disease in crop using a machine learning algorithm. Naive Bayes Kernel method was applied to data collected using grove sensor, MICS -2714, VG 400, Therm200 sensor. Temperature and humidity data were employed in predicting pest occurrence while soil nutrients content, ph value in addition to temperature and humidity data were used to predict disease occurrence.

Maya Gopal[23] evaluated the performance of different machine learning algorithm in predicting the yield of paddy crop. In addition to multiple machine learning algorithm viz. ANN, SVR, KNN and RF the study also attempted to examine the impact of various feature selection algorithm viz. FFS, CBFS, VIF, RFVarImp on the final performance. With the data collected from Meteorological Department of India as well as Agricultural Department of Tamil Nadu, it was found that RF in the combination with FFS was the most accurate in predicting crop yield.

Sushila Shindal[24] attempts to design two separate but independent algorithms for analysis and to predict yield of paddy crop. The first algorithm uses images to identify the deficiency of different nutrients viz. nitrogen phosphorus and potassium through the use of tensor flow. In the second algorithm, an estimation of the quantum of deficiency of the nutrients identified by the first algorithm is attempted through the means of k means clustering algorithm. An accuracy of 76-77% was achieved through this method which is considered to be fair.

T. Gayatri Devi [25] applied multiple classification methods to predict rice plant leaves diseases in Thanjavur, Tamil Nadu using images collected from Indian Rice Research Institute as the input. She classified the leaves into three categories viz. healthy, brown spot, and blast. Classifiers such as k-nearest neighbor, Neural Network, ANN, Bayesian and Multi Class SVM were used to predict common diseases of rice plant such as leaf blast, brown spot, false smut and leaf streak. It was observed that multi class SVM classifier provided the best accuracy into prediction at 98.63%.

Libo Lui[26] examined the feasibility of using BP neural network classifier on images to classify healthy and diseased part of rice leaves .The data was collected from leave samples in the northern part of Ningxia Hui Autonomous Region in order to detect rice brown spot disease .Using R, G and L components of the colour space and subsequent application of BPNN, an accuracy level of above 90% was achieved.

John William Orillo[27] developed a method to identify three common diseases in rice plant viz. bacterial leaf blight, brown spot and rice blast using digital image processing. Using back propagation neural network on Matlab, preceded by image acquisition, image enhancement, image segmentation and feature extraction, the method achieved a 100% accuracy in predicting the three diseases. The data for the study was obtained from the greenhouse of the international rice research institute located at Los Banos, Laguna, Philippines.

Amrita A. Joshi [28] developed a automated system for identifying and classifying different diseases in rice plant. The proposed method employed image processing techniques like segmentation, future extraction and two classifier viz. Minimum Distance Classifier (MDC) and K –nearest neighbor Classifier (K-NN) in order to identify rice bacterial blight, rice blast, rice brown spot and rice sheath rot. The overall accuracy achieved with the two classifiers, K-NN and MDC showed 87.02 and 89.23 percent accuracy respectively.

Rakesh Kaundal[29] compared multiple modeling approaches to predict occurrence of rice blast disease using weather condition data. Analyzing data collected from five different locations in Himachal Pradesh of India, the study used four approaches namely REG, BPNN, GRNN and SMV. Of the four approaches, it was found that the SVM model performed the best. It was also observed that the rainfall was the most influential variable out of the weather variable considered. An SVM based web server for rice blast prediction was developed as a subsequent step of the study in order to help farmers in improving their decision making capability.

Santosha Rathod[30] analyzed the accuracy of count time series and machine learning models in predicting the incidence of the Asian Rice Gall Midge (Orseolia Oryzae) in rice plant. For the study, gall midge population at multiple rice cultivating reason and climatological parameters such as air temperature and air relative humidity and insulation in these reasons were collected. The models that were used for the study were ANN, INGARCH (Inter –Valued Generalized Autoregressive Condition Heteroscedastic) and SVR (Support Vector Regression), and it was found that the ANN with exogenous variable (ANNX) variable performed the best. Overall it was seen that the performance was in given order ANXX > INGARCH > SVR.

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Yongseon Kim [31] studied the impact of varying the input variables in an LSTM model in order to predict the incidence of the rice blast disease in the different regions: Cheolwon, Icheon and Milyang in South Korea. The variables that were used in the model were Rice Blast Disease score, air temperature relative humidity, and sunshine hours of the previous three years. It was found that the LSTM model with all four variables included provided the highest accuracies among all variation .accuracies of 79.4%, 64.7% and 55.6% were obtained from the Cheolwon, Icheon and Milyang respectively.

Li Wei Liu [32] conducted a study to evaluate the performance of various machine learning algorithm in predicting rice blast occurrence in rice plant using short time environmental data. The data include average, highest and lowest air temperature, average relative humidity, soil temperature and solar energy and four different models viz. Multilayer Perceptron (MLP), Support Vector Machine (SVM), Elman Recurrent Neural Network (Elman RNN) and probabilistic Neural Network (PNN) were used to predict the occurrence of rice blast. It was found that the PNN model performed the best with F-measures of 96.8%. Through the study's result it was observed that the rice blast warning can be can be issued 10 days in advance.

Jia-You Hsieh [33] attempted to develop a prediction model to provide an early warning mechanism through the application of machine learning and neural network, the study focuses on detecting rice blast disease (RBD), a particularly damaging crop disease for rice in Taiwan. In the study, climate data such as max temperature, min temperature, temperature difference, maximum humidity, minimum humidity, humidity difference were used and neural network as well as Auto-Sklearn were used to establish the classification model. It was found that the proposed model could classify the RBD condition with an accuracy of 72% on average. In particular, the model could achieve an accuracy of 89% in the exacerbation case. In addition, it was also observed that high humidity environment and high temperature are the primary causes of RBD.

Skawasnag[34] employed weather and host plant phenology factors in order to forecast *brown plant hopper* (BPH) population density in rice crop in the central plain of Thailand. MLR (Multiple Linear Regression), ANN (Artificial Neural Network) and RF (Random Forest) models were used to predict BPH population and ANN was found to provide the highest accuracy while the accuracy of the prediction provided by the MLR model was lowest of the three.

Rajni Jain[35] compared the performance of the three machine learning techniques viz. RS, CJP and RJP with the prediction model developed using LR techniques in predicting the occurrence of the Powdery Mildew Mango(PWM). Using relative humidity and maximum temperature data from the project "Epidemiology and forecasting of PWM" undertaken at Central Institute for Subtropical Horticulture, Uttar Pradesh, it was observed that CJP and RJP performed better than LR and RS.

S Ramesh[36] studied the application of machine learning in the detection of blast disease in rice. Using image data of healthy and infected leaves, two machine learning methods were used (KNN and ANN) to predict the occurrence of blast disease. It was observed that ANN algorithm shows an accuracy of 90% for blast infected image and 88% accuracy for normal image while KNN showed an accuracy of 79% for blast infected images and 63% for normal images.

Dubey[37] evaluated the accuracy of different machine learning techniques in predicting occurrence of pests and diseases associated with rice using weather data. The weather and pest data was taken from the Crop Pest DSS database. Three pests namely *yellow stem borer*, *green leaf hopper* and *gall midge*. KNN, Logistic Regression, Decision Tree, Random Forest and Support Vector Machine (SVM) were applied for the study; and random Forest provided the best accuracy, F1 score and AUC (area under curve) while logistic regression had the lowest accuracy.

Rini Pal and Dipankar Mandal[38] studied the impact of weather condition on the incidence of leaf blast disease in the rice variety SWARNA (MTU-7029). The five selected variable studied were max temperature, min temperature, max relative humidity, min relative humidity and total rain fall. It was found that max relative humidity and rainfall exhibited significant positive effect on disease severity, but maximum temperature increment cause negative contribution to disease incidence.

Harshad Kumar[39] developed a method for identifying three rice diseases based on images of infected rice plants. The images of the rice plant were collected with a digital camera, and then four background removal methods and three segmentation techniques were evaluated. Centroid feeding centric KMC was found to be a suitable candidate for segmenting the disease portion and then, SVM was utilized for multi-class classification. Using this method, an accuracy of 73.33% was achieved on the test dataset.

Mukharjee[40] proposed a method to spot disease at an early stage in rice plant. The method used images of paddy leaves which were then transmuted as of RGB to gray images and then exported to a histogram with the use of Matlab. The resulting images were then used as input for categorizing and identifying diseases.

M.N Abu Baker [41] explored the development of an integrated framework to identify RLB which is a disease of the leaf in the rice plant. The method has three stages viz. preprocessing, image segmentation and image analysis, where hue situation value (HSV) color space is utilized.

Image segmentation was carried out to extort the disease region and pattern recognition based on multilevel thresholding was employed. It was found that the severity of RLB disease could be categorized into three stages namely infection stage, spreading stage and worst stage.

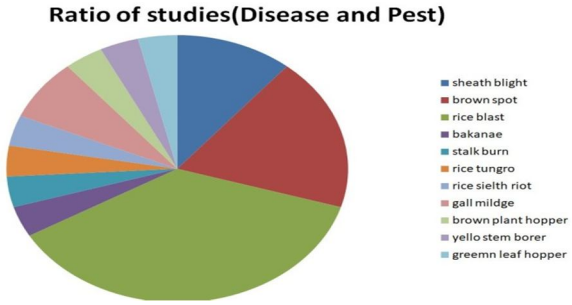

Fig. 1

Common Models /Algorithm in Rice Crop Management

Information	Function	Models/Algorithm
pH, soil moisture, humidity and temperature	Prediction of sheath blight, brown spot, rice blast Bakanae, stalk burn, rice tungro.	Naïve Bayes
Temperature and humidity data using sensors	Predict pest and disease in crop	Naive Bayes Kernel
Weather data	Predicting the yield of paddy crop	ANN, SVR, KNN and RF
Images	Identify the deficiency of different nutrients and estimation of the quantum of deficiency	K-means
Images of leaves	Predict common diseases of rice plant such as leaf blast, brown spot, false smut and leaf streak.	KNN, NN, ANN, Bayesian and Multi Class SVM
Images of leaves	Classify healthy and diseased part of rice leaves	BPNN
Image	Identify three common diseases in rice plant viz. bacterial leaf blight, brown spot and rice blast using digital image processing.	BPNN
Image Processing	Rice bacterial blight, rice blast, rice brown spot and rice sheath rot.	MDC and K-NN
Weather condition data	Predict occurrence of rice blast disease	REG, BPNN, GRNN and SVM
Air temperature and air relative humidity	Asian Rice Gall Midge (Orseolia Oryzae)	ANN, INGARCH and SVR
Rice Blast Disease score, air temperature relative humidity, and sunshine hours	Predict the incidence of the rice blast disease	LSTM model
Average, highest and lowest air temperature, average relative humidity, soil temperature and solar energy	Rice blast occurrence in rice plant	MLP, SVM, Elman RNN and PNN
Max temperature, min temperature, temperature difference, maximum humidity, minimum humidity, humidity	Detecting rice blast disease	NN and Auto-Sklearn
Weather and host plant phenology factors	Forecast *brown plant hopper*	MLR, ANN and RF
Relative humidity and maximum temperature	Predict occurrence of the Powdery Mildew Mango	RS, CJP and RJP
Image data of healthy and infected leaves	Detection of blast disease	KNN and ANN
Weather data	yellow stem borer, green leaf hopper and gall midge	KNN, LR, Decision Tree, RF and (SVM)
Max temperature, min temperature, max relative humidity, min relative humidity and total rain fall	Leaf blast disease	Multiple regression
Images of infected rice plants	BLB, leaf smut, brown spot	KMC, SVM

Table 1.0

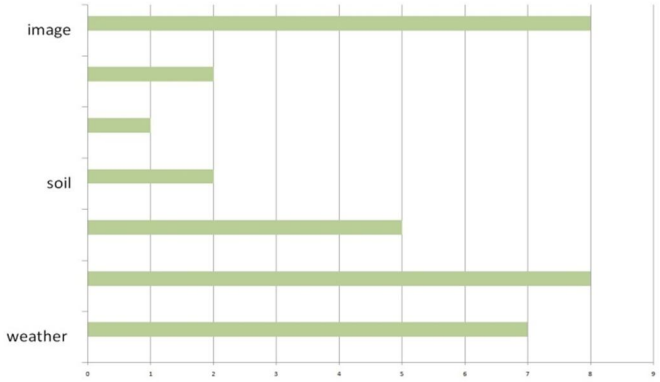

Fig. 2

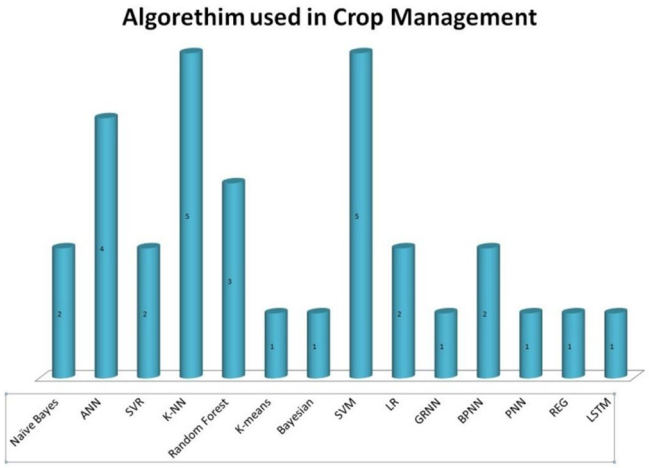

Fig. 3

III. DISCUSSIONS

Early disease and pest detection is an important aspect to shape the agricultural productivity of a country .the aim of this paper is to do a review on various machine learning techniques used to diagnose various diseases and pest that occur in rice plant which influences the yield capacity. Many algorithms were used to achieve the goal which is mentioned in Fig.3. Fig.2 depicts the data sets that were used to analyse the desired task in which it was found that images of the plant was common. Rice Blast, Brown Spot and Sheath Blight were the most common diseases of all. Fig. 1 shows the ratio of studies that is being performed in a disease .from the studies it can be determined that forewarning of disease and pest using machine learning algorithm can play an vital role in moulding a countries agriculture .models need to be developed using various factors from different natural perspective like soil and weather which seem to be in demand in the near future

IV. CONCLUSION

From the papers that have been reviewed in this study, it is observed that there are two types of strategies when applying machine learning in order to predict diseases in rice plant. The first method uses images as the input data and the second method uses weather data as the input. In the first method, KNN, ANN and SVM have been found to be the preferred algorithms to predict diseases, while RF, SVM and KNN were observed to be adopted when using weather data for prediction.

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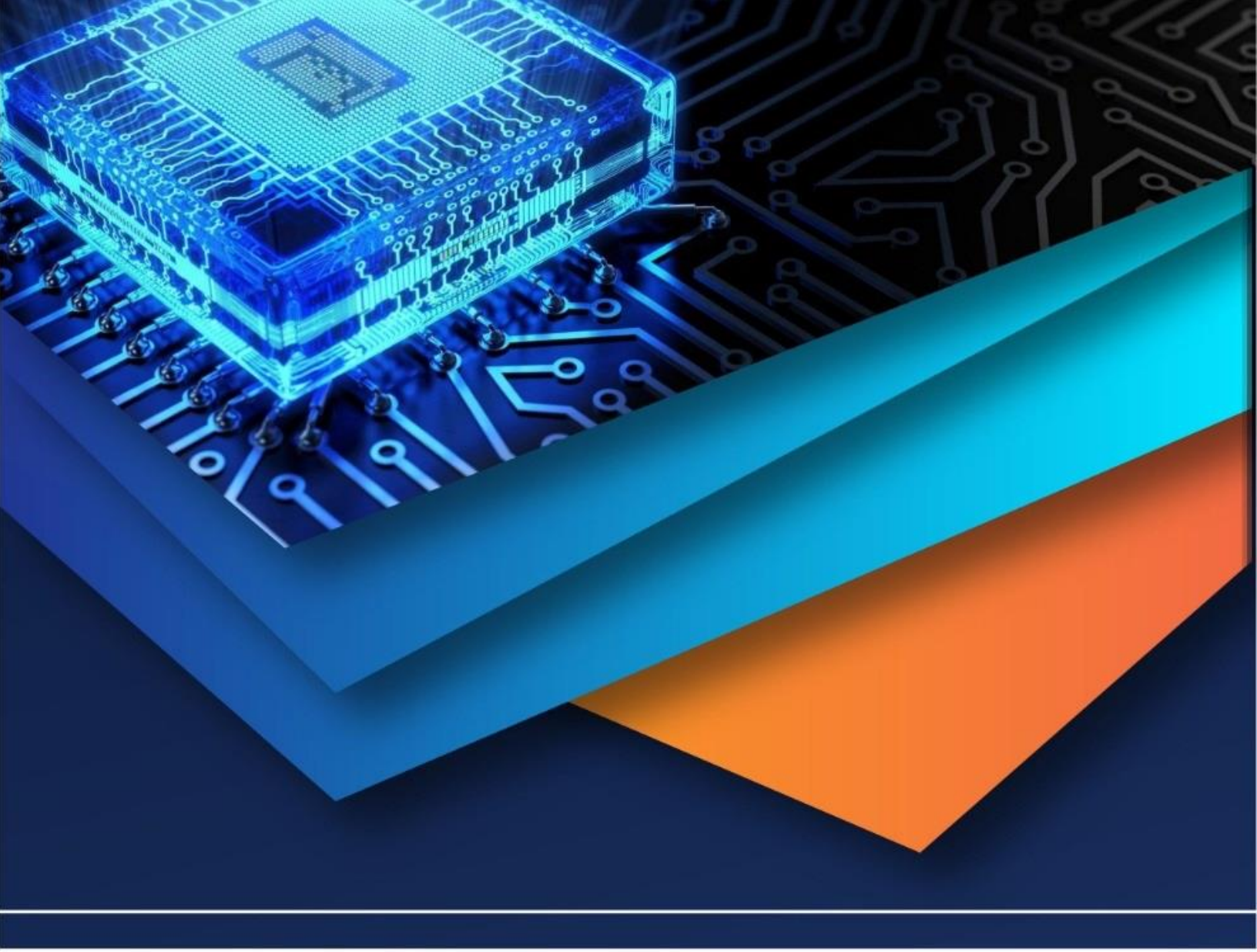

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