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An Approach for Detecting Fruit Quality with RBF-SVM Classification Model

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Abstract: For the regular development of rural area especially for the agriculture domain, automation is very important. Currently fruit's quality plays an important factor in their sales and production. Detecting the quality of fruits by using manual methods are not recommended because of the reasons that it cause delay and the results are also not upto the mark. Therefore, machine learning and computer vision is gaining much interest from current researchers to develop fruit quality detection systems. This paper contributes to provide an effective and advanced Orange fruit quality detection system. the proposed scheme is focused on giving an Fuzzy C-Mean based region of interest extracting scheme along with RBF-SVM classification model to improve the classification rate in comparison to existing approaches. The proposed scheme is simulated in MATLAB software and results are evaluated in terms of various performance factors such as Accuracy, Sensitivity, Specificity, Precision, Recall and F-Score. Finally a comparison of the proposed scheme is given that show an improvement of approximately 18% with respect to various state of art techniques. this strengthen the recommendation of proposed scheme for future fruit quality analysis system.
Keywords: Fruit quality detection, Fuzzy C-Mean clustering, Radial basis function, computer vision application, agriculture applications, machine learning, etc.

I. INTRODUCTION

Fruit rotting has substantial economic consequences; it is predicted that roughly a third of the price of fruit is spent on rotting materials. Furthermore, the purchase of fruits will be affected because buyers believe that rotten fruits are harmful to their health [1], as lowered percentages of carbohydrate, amino acids, vitamins and other nutrients invariably enhance public suspicions about health problems, prompting debates on how to avoid or stop the rotting operation. Fruit freshness rating is significant because of the importance of food quality in people's daily lives and participation to the economy yet the manual process is time demanding. Computerization of sorting through the use of automation methods is thought to be the ultimate answer. The categories in autonomous vegetable/fruit grading are seen using state-of-the-art computer vision techniques: Vegetable/Fruit defect identification and problems induced by foreign biological invasion, fruit categorization for a variety of horticulture goods, calculation of vegetable/fruit nitrogen content, real-time monitoring of fruit objects, and so on.

Image processing method for fruit quality check entails five processes, as shown in Fig. 1, namely picture capturing, pre-processing, picture segmentation, characteristics extraction, and categorization [2]:

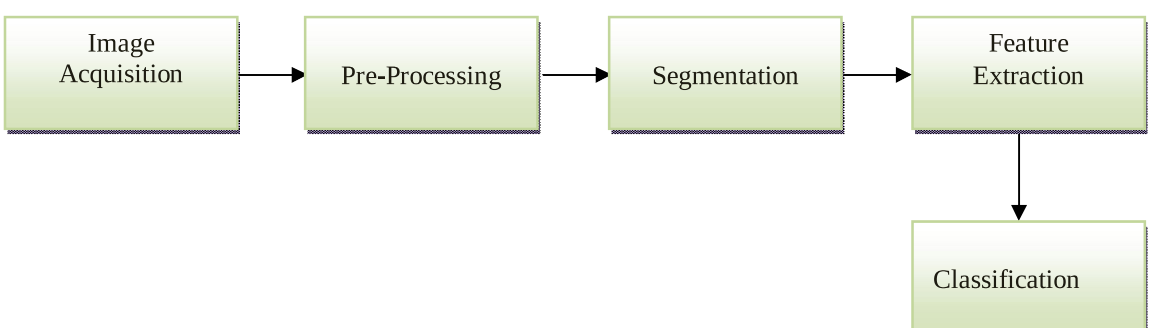

Fig 1 Block diagram for fruit quality inspection

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1) *Image acquisition:* Image acquisition technologies utilized in food applications include CT "computed tomography", electrical tomography, MRI "magnetic resonance imaging", ultrasound, and cameras. CMOS "complementary metal oxide semiconductor" and CCD "Charged coupled device" image sensors are utilized to create the digital image. The five basic elements of a conventional computer vision system are computer hardware, a camera, an image capturing board (digitizer or frame grabber), and lightning. The light systems in the study of vegetation and fruits are designed as back and front illumination. Front lighting is used to assess surface quality parameters such as color, texture, and skin flaws [3]. Back lighting is designed to check the border quality aspects such as shape and size. For the quality assessment of agriculture and food goods, classical, hyper spectral and multispectral computer vision systems have been widely developed.
2) *Preprocessing:* This refers to the raw image's preliminary processing. Pictures are recorded or acquired and then sent to a computer where they are transformed to digital pictures. Pre-processing is sometimes used to enhance image quality by reducing unwanted distortions known as "noise" or by enhancing significant characteristics of interest [4].
3) *Segmentation:* Segmentation is a method of cutting, adding, and feature analysis of pictures intended at splitting a picture into sections that have a powerful link with objects or regions of concern, utilizing the concept of matrix analysis. The following approaches can be used to segment data: region-based segmentation, edge-based segmentation, and thresholding [5]. Thresholding is a technique for classifying picture sections depending on their surface's continuous reflectivity or light absorption.
4) *Feature Extraction:* Characteristics are determined after picture segmentation for subsequent analysis. These characteristics are essential in a computer vision technology because they provide valuable information for visual perception, interpretation, and classification algorithms [5]. During this step, retrieved characteristics are converted into feature vectors, which are then classified to recognize the input.

The process of fruit categorization necessitates human perceptual or cognitive skills. The categorization process is usually conducted in two stages: Phases of testing and training. For the formation of the training set, the distinctive qualities of pictures belonging to various categories are split into various categories throughout the training process. On the basis of the training dataset, a picture is categorized into a category in the subsequent testing stage. ANFIS, SVM, ANN, and FL are some of the most common classifier systems. Other than this there a number of algorithm and strategies those are proposed by different researcher in area of fruit quality detection or disease detection. Few of such studies are discussed in the next section of this paper.

II. LITERATURE SURVEY

This section presents the strategies presented in the recent years for the classification of fruit quality or detection of grades. Hardik Patel et al. [6]: This research shows an Orange size and Bacteria Spot Defect distinguishing and reviewing framework which is dependent on the picture preparing. The early appraisal of Orange quality requires new apparatus for size, color and texture estimation. Subsequent to catching the Orange side view picture, some fruits characters are removed by utilizing and identifying the calculations. In this paper author elaborated the different features and classification methods by considering their advantages and disadvantages. Bhavini J. Samajpati et al. [7]: Two extraction method are used in this paper color feature and texture feature. CCV (Color Coherence Vector) and GCH (Global Color Histogram) method are used for an extract color feature. GF (Gabor features), LTP (Local Ternary Pattern) CLBP (Complete Local Binary Pattern), and local binary pattern (LBP) method are used for an extract texture feature. Feature fusion are done after extract all feature like GCH + GF, GCH + LTP, GF + GCH + LBP, GF + CLBP + LTP etc. In second step is classify the fruit using RF (Random Forest) Classifier. In last step use Segmentation for identify the defect. Manali R. Satpute et al. [8]: Built a system for Defect detection in tomato based on the automatic fruit quality inspection system for detection of defected tomato and sorting and grading of tomato. In First step they have segment the tomato, segmentation based on OTSU algorithm. After segment the tomato, next step is extract the feature. Author use two feature extraction algorithms size detection and color detection. Dilation and Erosion (Morphological operation), use for size detection. After that shape feature are used for size detection like small, medium and large. Color detection based on Red, green and yellow tomato use for sorting the tomato. Tasneem Abass Najeeb et al.[9]: build model for Image processing based on Dates Maturity Status and classification. First step is Resize the image (Preprocessing). Then second step is threshold the image (segmentation). After segmentation they have done object measurement image labeling. Last step is extract the feature of the fruit based on Size Detection and Color Detection. Nashat M. Hussain Hassan et al.[10]: built model for automatic olive fruits defects detection. In first step they have apply RGB to GRAY (Pre-processing) on the olive fruit. Next step is segmentation based on thresholding. Last step is extract the feature of olive fruit. Two feature extraction technique are used in this paper, Special Image Convolution Algorithm (S.I.C.A) and Texture Homogeneity Measuring Technique (T.H.M.T). Sheikh Ziauddin, et al. [11]: build system for Orange fruit defect detection. In first

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step, RGB image convert in to a GRAY scale image (Pre-processing). Second step is segment the orange fruit image based on OTSU technique. After segmentation last step is, Author algorithm use for find the defect. Last step is find size of fruit based on Shape feature. Sangita B. Nemade [12]: This paper proposes fruit annotation in a broad sense along with its hierarchical features that can be narrowed down to inherit, further achieving fruit classification into binary or multiple classes indicating subcategories of that fruit. The fruit objects within images are measured to its actual size in the required units. The classification is also used for identifying true color, texture, size, deep features and shape based on the ratio of major to minor axis helpful for fruit gradations. Hongjun Wang et al. [13]: This paper proposes a YOLOv3-Litchi model based on YOLOv3 to detect densely distributed litchi fruits in large visual scenes. We adjusted the prediction scale and reduced the network layer to improve the detection ability of small and dense litchi fruits and ensure the detection speed. From flowering to 50 days after maturity, we collected a total of 266 images, including 16,000 fruits, and then used them to construct the litchi dataset. Then, the k-means++ algorithm is used to cluster the bounding boxes in the labeled data to determine the priori box size suitable for litchi detection. W. N. S. W. Nazulan et al. [14]: the objective of this work is to investigate the sweetness parameter for the fruit's detection and classification algorithm in machine learning. This study applies image processing techniques to detect the color and shape of watermelon's skin for grading based on the sweetness level using K-means clustering method via the Python platform. 13 samples of watermelon images are used to test the functionality of the proposed detection system in this study. Then, each watermelon is grouped into Grade A (high level of sweetness), Grade B (medium level of sweetness), and Grade C (low level of sweetness) based on its color and shape detection results. F. Zidane et al. [15]: have recently proposed to combine W-band imaging with nonlinear support vector machine (SVM) classifiers to sort out healthy from damaged fruits for a single variety of fruit. S. Abasi et al. [16]: In this study, a portable optical instrument was designed and developed for real-time nondestructive determination of fruit ripeness. A prototype of the instrument using inexpensive parts was developed and calibrated for apple ripeness detection based on moisture content, soluble solids content, pH, and firmness. From the literature study it is analysed that there are number of algorithms available for the fruit quality analysis. Most of the work is done on the basis of feature extraction and classifiers. The commonly used features for the fruit quality analysis are color, histogram and texture based. The current system need to separate region of interest from the captured images of fruits. For that Kmean clustering is focused in few of the studies. But as the Kmean clustering algorithm faces many drawbacks such as defining initial cluster points etc. The proposed scheme focused on adapting alternate to extract effective region of interest. Other than SVM classification techniques are effective till nor in most of researches, but as due to variation in dataset, different kernal based SVM may improve the classification rate for fruit quality detection. Inspired from it, this paper given an improved and advanced fruit quality detection system discussed in next section.

III.PROPOSED WORK

The proposed model is focused on designing the fruit quality detection model in order to overcome the issue faced by traditional methods as stated in the previous part of this article. The proposed scheme is using Fuzzy CMean clustering (FCM) for extracting the region of interest from the captured image of fruit. In addition to this RBF Kernal based SVM classifier is used for improving the classification rate. The flow diagram of the proposed scheme is as follow:

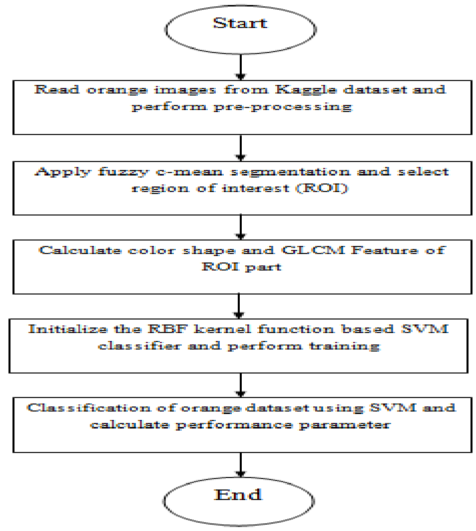

Fig. 2 Flow diagram of proposed fruit quality detection model

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A. Methodology

The methodology that is used in the proposed scheme to achieve high detection rate for fruit quality is given below:

1) Initial step is to collect the dataset, for that we have used Kaggle.com having the dataset of orange fruit with normal and defective images in it.
2) Once the data is collected next step is to process it before passing to the segmentation phase, for that the image is converted to gray scale image and then passed to FCM algorithm to extract the region of interest.
3) Once the region of interest is segmented using FCM, after that, specific part is separated from original sample image.
4) The separated part of the sample having the fruit region is passed to feature extraction phase where we have extracted below written features
a) Color content
b) Shape of the fruit in terms of roundness
c) Gray Level Co-occurance Matrix (GLCM) in terms of

- Contrast
- Energy
- Homogeneity
- Correlation

5) Once the features of the samples are extracted a dataset of features is constructed in terms of matrix with the labels as normal and defective samples.
6) Next step is to initialize the classification model, that is RBF Kernal based SVM.
7) The dataset is divided into training and testing, The training dataset with the labels are passed to the SVM classifier and once training is done it get ready for the classification phase.
8) After the training the testing dataset is classified, and evaluated in terms of various performance factors such as Accuracy, Precision, Sensitivity, Specificity, Recall and Fscore.

The next section of this paper shows the performance evaluation and results obtained after the simulation.

IV. RESULTS AND DISCUSSION

The simulation of the proposed scheme is carried out in the MATLAB software, the performance is evaluated and compared with the exiting techniques in order to prove the effectiveness of the proposed scheme.

A. Performance Evaluation

The proposed scheme is evaluated firstly by using the confusion matrix, the phases those are covered during the process are shown in fig 3, that represents the original sample of fruit that is taken for the simulation.

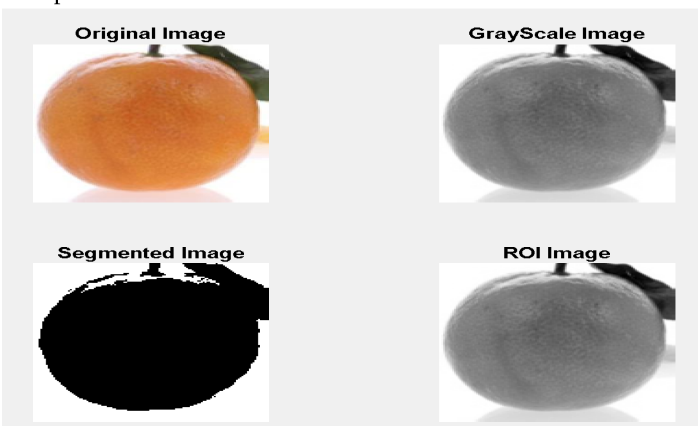

Fig. 3 Phases of proposed scheme

Fig. 3 represents the phases those are involved in proposed scheme as defined in methodology. It includes conversion of original sample into gray scale, segmentation of the proposed scheme using FCM algorithm and finally separating the region of interest from the sample fruit image.

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Next to it the confusion matrix obtained after the testing of test sample with the trained RBF kernal based SVM system. the confusion matrix of the proposed scheme is shown in fig 4.

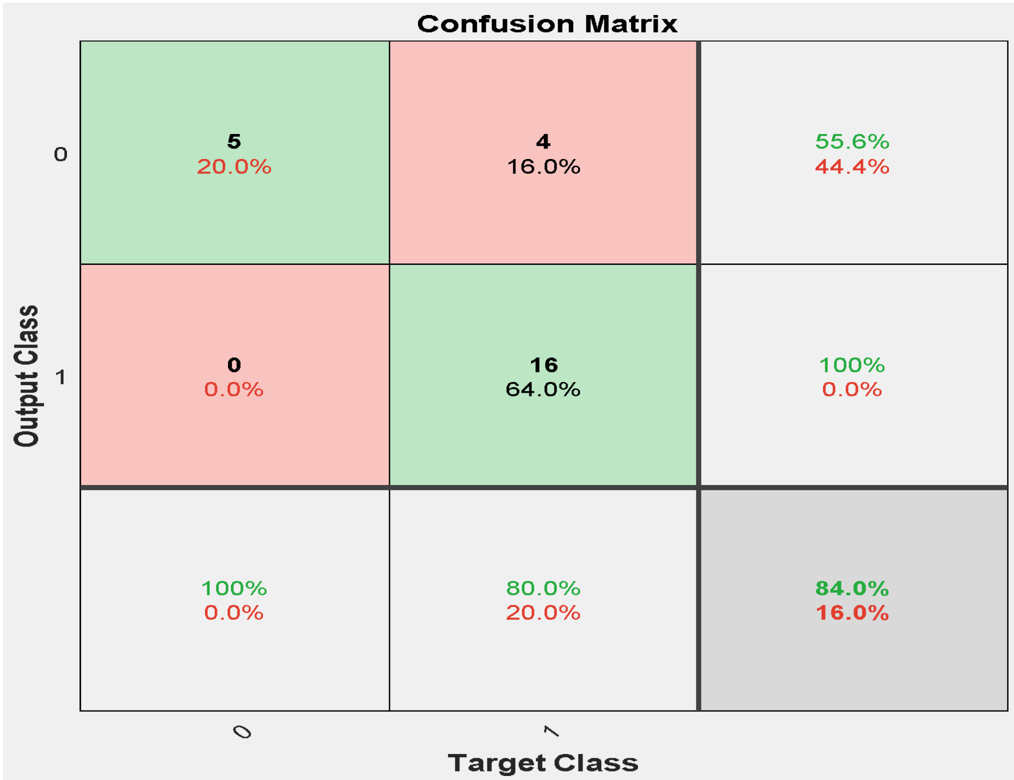

Fig 4. Confusion matrix of proposed RBF-SVM model

In Fig. 4, the confusion matrix is given that is giving the information of the total sample came under individual class that is normal or defective. It also gives us the information , that how many sample is correctly classified and hoe many are classified to other class. Finally the evaluation of the proposed model is done by calculating the performance factors such as accuracy, Sensitivity, Specificity, Recall, Precision and Fscore.

The values of the individual parameter calculated are given in table 1. that represents that the proposed scheme has achieved an accuracy of 84% and Fscore of 90.4762 %. Where as in terms of Sensitivity, Specificity, Precision and Recall the proposed model is giving an effective results that is 100%. this score strengthen the outcome to be effective with respect to various state of art existing models.

TABLE I
Performance factors of proposed fruit quality detection model

Sr. No.	Performance Parameters	Values (%age)
1	Accuracy	84.0000
2	Sensitivity	100.0000
3	Specificity	100.0000
4	Precision	100.0000
5	Recall	100.0000
6	Fscore	90.4762

To represents the effectiveness of the proposed scheme the comparison is done with the existing techniques as Gabor+LBP+GCH, Gabor+CLBP+LTP and ColorMoment+GLCM+Shape. the comparison is performed in terms of accuracy as shown in fig 5.

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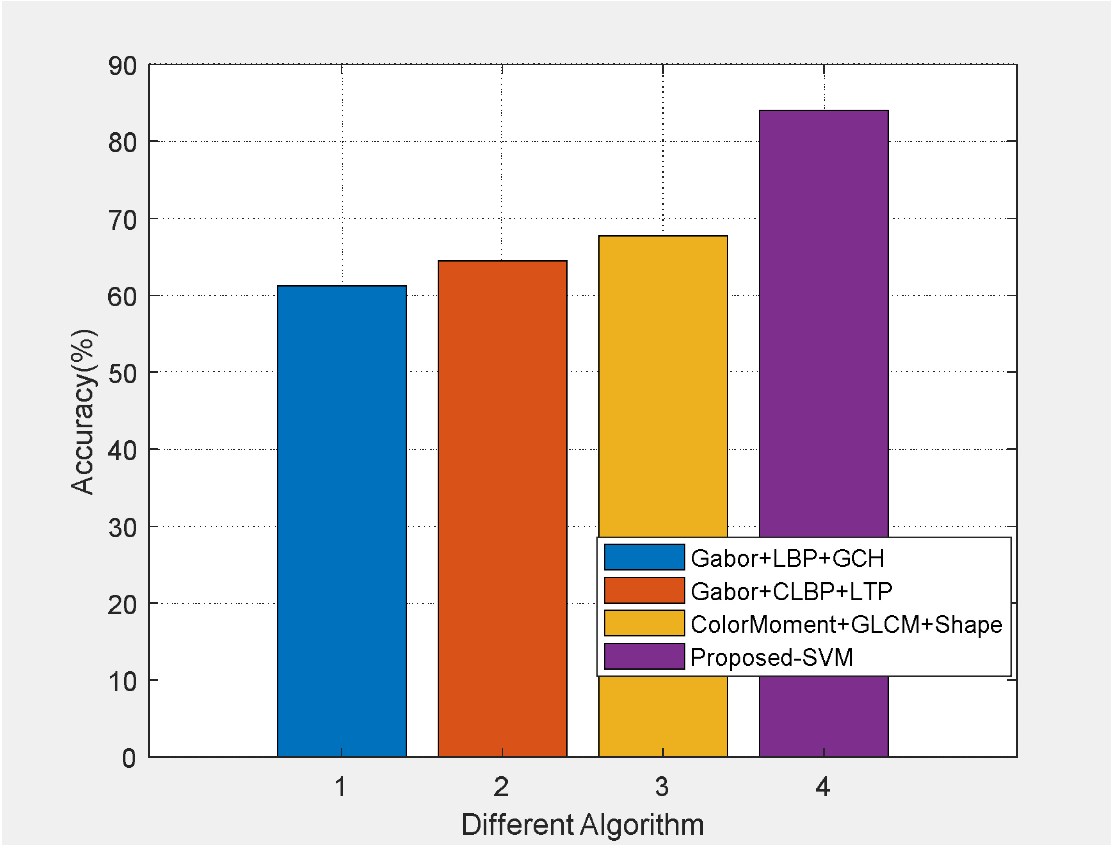

Fig 5. Comparison graph of proposed scheme in terms of accuracy

Fig 5. represents the comparison of accuracy for proposed scheme and existing techniques. The accuracy percentage of the traditional schemes Gabor+LBP+GCH, Gabor+CLBP+LTP and ColorMoment+GLCM+Shape are 61.29, 64.5, and 67.74. Whereas, in proposed scheme the accuracy achieved is 84% which is much improved with respect to traditional approaches. the values of achieved results are shown below in table 2.

TABLE 2

Comparison of accuracy of proposed and traditional schemes

Sr. No.	Techniques	Accuracy Values (%age)
1	Gabor+LBP+GCH	61.2900
2	Gabor+CLBP+LTP	64.5200
3	ColorMoment+GLCM+Shape	67.7400
4	Proposed-SVM	84.0000

V. CONCLUSIONS

Fruit quality detection is very important for the current agricultural advancement. Traditionally manual methods were used by farmers and production units, but those schemes were time consuming and less effective. Currently computer vision and artificial intelligence gives much effective strength to develop automated systems. The proposed scheme in this article is inspired from such technologies. The scheme is using FCM based region extraction and RBF-SVM classification approach. the results are calculated in terms of various factors such as Accuracy, Sensitivity, Specificity, Precision, Recall and Fscore. The proposed scheme is giving effective results in terms of all the factors. For proving its effectiveness the proposed scheme is compared to existing techniques those are achieving approximately 18% improved results in terms of accuracy. this proves the proposed scheme is effective and reliable for future fruit quality detection systems. For future, the work can be done on considering different fruits in a single system. Other than this extending the features can be one of the scope of improvement.

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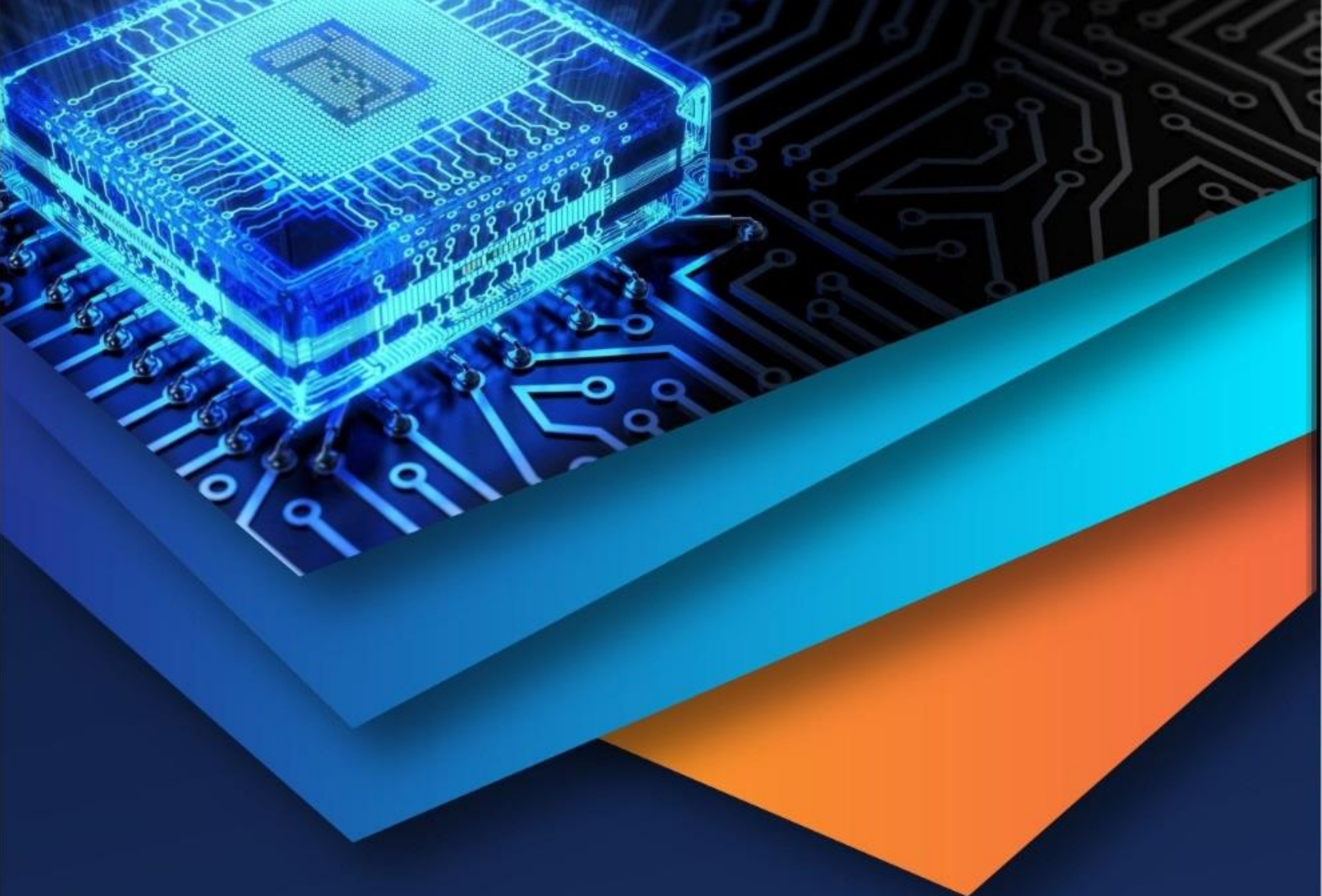

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