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A Review on Automated Diabetic Retinopathy Detection using Pretrained Deep Neural Network

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Abstract: Diabetic retinopathy damages the retina of then patient. It is most frequent in the patients who have had diabetes for longer than 10 years. This problem is occurring in millions of people worldwide but medical practitioners and the tools required for detection of diabetic retinopathy is scare for serving the mass population. The work already was to serve this problem using the application of machine learning but the efficiency of machine learning algorithm depends on the quality of feature extraction which requires domain knowledge. The work presented in this paper overcome the problem by using deep learning algorithm which automatically identifies the pattern and classifies the retina images into one of the five class based.
Keywords: Deep Learning, Diabetic, Diabetic Retinopathy, Convolutional Neural Network

I. INTRODUCTION

According to International Diabetes Federation (IDF) Diabetes Atlas 2017 [HYPERLINK \l "IDF17" 1], more than 425 million people are affected from diabetes. The statistics shows increase of 10 million cases in past two years. As in 2015 it was reported 415 million. The people lived in low and middle income countries are more prone to effect by this disease. The report shows that there will be 629 million people with diabetes in the World in 20452]. The Diabetic Retinopathy (DR) is a medical condition that damage the retina of eye which cause the blindness. With the proper treatment and monitoring of the eyes the new cases of diabetic retinopathy can be reduced up to 90%. The longer a person has diabetic , higher are chances of developing the diabetic retinopathy. The people with diabetic of 20 years or more at 80% of risk of diabetic retinopathy[2]. As of now, recognizing DR is a tiresome and manual process which requires a clinician to inspect and assess fundus photos of the retina [HYPERLINK \l "RJW09" 3]. These images are then analyzed by clinicians and reported in day or two, which cause the deferred outcomes prompt lost development, miss communication, and postponed treatment4].. While this methodology is viable, its resources requirement are high. The expertise and tools required to examine the mass population are lacking.

A. Diabetic Retinopathy Texonomy

Diabetes causes from the high sugar present in the blood. The diabetic can cause diabetic retinopathy if not treated earlier. The diabetic patients with 10 years or more diabetes are at greater risk of diabetic retinopathy. The high blood sugar damages the tiny blood vessels that supplies blood to retina which cause diabetic retinopathy. The light detected by retina converted to signal which passes to brain through the optic nerve. In later stages it leads to scarring and cell loss due to abnormal increase in blood vessels. Diabetic retinopathy clinically validated into four stages [HYPERLINK \l "Eli17" 5] that includes mild nonproliferative retinopathy, moderate nonproliferative retinopathy , severe nonproliferative retinopathy, and proliferative diabetic retinopathy (PDR). The details cause and effects of these four stages are explained in the table I.

Mild nonproliferative retinopathy	This is the initial stage of DR. It causes micro aneurysms in the blood vessels that may cause leak of fluid into the retina. Very small swelling in the retina's blood vessels, called micro aneurysms
Moderate nonproliferative retinopathy	This is progressive stage that causing the swell and distortion of the blood vessels that are connected to retina for transporting blood for retina's nourishment. This may sometimes loss their ability to transport
Severe nonproliferative retinopathy	This is severe condition where many blood vessels blocked thus causing less supply of blood to retina compared to the minimum requirement. These areas exude growth factors that signal retina for growing new blood vessels.
Proliferative diabetic retinopathy (PDR)	This is the advanced stage of diabetic retinopathy .Due to blockage of tiny blood vessels retina form new vessels which grow inside.

The sample images of eye with no diabetic retinopathy are shown in figure 1(a) and sample images of eye with proliferative retinopathy are shown figure 1(b). These sample images are taken from Kaggle6].

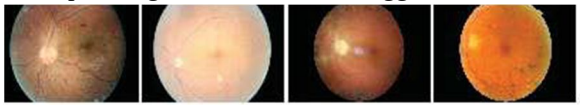


Figure 1(a): No Diabetic Retinopathy

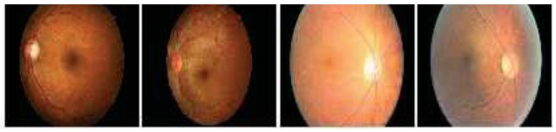


Figure 1(b):Proliferative Retinopathy

The comprehensive detailed eye exams used for detecting on, Pupil dilation and Optical coherence tomography (OCT) [HYPERLINK \l "Hel06" 7] as shown in the figure

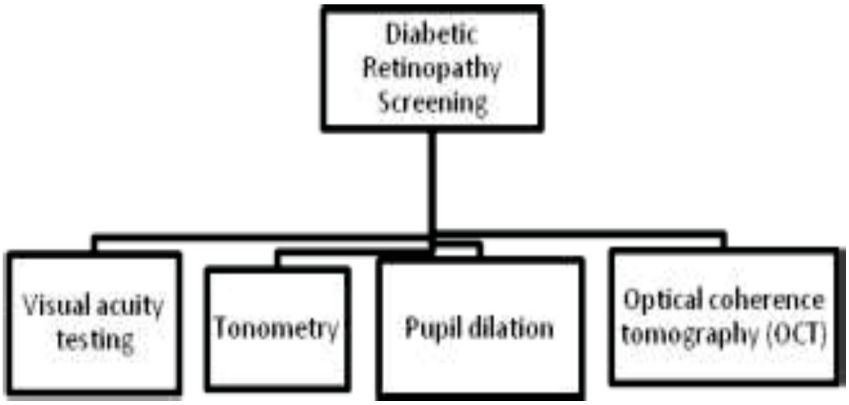


Figure 2.

Figure SEQ Figure * ARABIC 2: Diabetic Retinopathy Screening
Methods CITATION Jan15 \l 1033 [HYPERLINK \l "Jan15"8]
The visual acuity done is used to measure the ability of person to see objects at various distances. Tonometry CITATION Tom17 \l 1033 [HYPERLINK \l "Tom17"9] test performed to measure the pressure inside the eye. In Pupil dilation test , drop in the eyes is placed that widen (dilate) the pupil and then clinician examine the retina and optic nerve. OCT works like ultra sound image. In OCT, the light is penetrated inside the eye which captures the detailed images of the tissues inside the eye. The work demonstrate the development of convolutional neural network that takes color fundus images as input and predicts the stage of diabetic retinopathy on them as shown in the figure3. The proposed model is built around the Convolutional neural network architecture. The architecture consists of convolutional layer that convolve the input and then passed to pooling layer . The features are extracted byrepeating this process hundreds to thousands times. Thus enables the model to extract multiple features from each input. Architecture of the proposed model described in detail as follow.

B. Proposed Method

The entire process proposed methodology “Automated Diabetic Retinopathy Detection Using Pretrained Deep Neural Network For Classification & Texture & Color Features For Feature Extraction**”** is the working strategy of our system. is shown in Fig 2.The proposed method can be divided into six main stages:

1) Preprocessing
2) Feature Calculation
3) Feature Dataset
4) Feature Matching
5) Deep Neural Network
6) Diabetic Retinopathy Classification output

The block diagram of Proposed System is shown below.

a) *Preprocessing:* The images present in the set are of very high resolution and different in size. Thus before forwarding them to the training phase, all images are cropped into size of 128x128 for uniformity. It also increase the computational speed of the network.

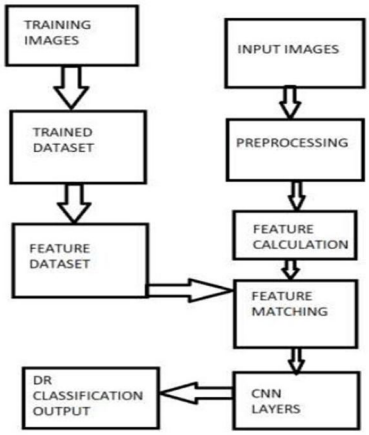


Figure3. Block Diagram of Proposed Methodology

b) *Feature Calculation:* A feature is a piece of information which is relevant for solving the computational task related to a certain application. Features may be specific structures in the image such as points, edges or objects. Features may also be the result of a general neighborhood operation or feature detection applied to the image. The features can be classified into two main categories: Feature extraction is a process of dimensionality reduction by which an initial set of raw data is reduced to more manageable groups for processing. A characteristic of these large data sets is a large number of variables that require a lot of computing resources to process. Feature extraction is the name for methods that select and /or combine variables into features, effectively reducing the amount of data that must be processed, while still accurately and completely describing the original data set.

c) *Feature Matching:* Feature matching means finding corresponding features from two similar datasets based on a search distance. One of the datasets is named source and the other target, especially when the feature matching is used to derive rubbersheet links or to transfer attributes from source to target data. Feature detection is a process by which the nervous system sorts or filters complex natural stimuli in order to extract behaviorally relevant cues that have a high probability of being associated with important objects or organisms in their environment, as opposed to irrelevant background or noise.

d) *Feature Dataset:* A feature dataset is a collection of related feature classes that share a common coordinate system. Feature datasets are used to spatially or thematically integrate related feature classes.

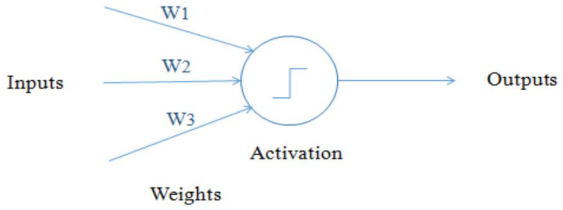
e) *Deep Neural Network:* Deep Neural Networks (DNNs), also called convolutional networks, are composed of multiple levels of nonlinear operations, such as neural nets with many hidden layers (Bengio et al., 2007; Krizhevsky et al., 2012). Deep learning methods aim at learning feature hierarchies, where features at higher levels of the hierarchy are formed using the features at lower levels (Dean et al., 2012). In 2006, Hinton et al. (2006) proved that much better results could be achieved in deeper architectures when each layer is pretrained with an unsupervised learning algorithm. Then the network is trained in a supervised mode using back-propagation algorithm to adjust weights. Current studies show that DNNs outperforms GMM and HMM on a variety of speech processing tasks by a large margin (Hinton et al., 2006).

C. *Overview Of Neural Network*

Deep learning is based on neuron like structure which is present in human brain. To understand the deep learning, the study of neuron structure is important.

1) *Neurons:* The artificial neurons are building blocks for neural networks. A specialise computational units along with weighted incoming signals and generate resulting output by activation function (sum of all input signals).A simple neuron structure show in fig.1.

2) *Weight of Neutrons:* The bias value possesses by each layer can be significance of a resaved entity which equivalent to 1 and weighted. In linear regression, larger weights indicate increased difficulty and flaws of the model. So it advantageous for weight's value small in the net-work and also use for identifies existing ideology.



3) *Activation Function:* The summation of weighted inputs is vent by means of function called activation. Activation function also known as transfer-function, which is a complex assigning of calculated weighted incomings of the neuron into the final resultant. Function of AF lead to govern threshold requirement, neuron triggered and give the output signal. If the summed input is above a threshold, then a simple step activation function is used.

4) *Network of Neurons:* Deep Learning involves very huge and deep (i.e. many layers of neurons) neural networks for solving specific problems, as shown in Fig.2. Thus, shows how neurons are prearranged in layers like in the brain of human cells, neurons in neural networks are often organized in layers as well. So, an algorithm of problem is deep, if the weighted input is gone through several non-linearities before converted into output.

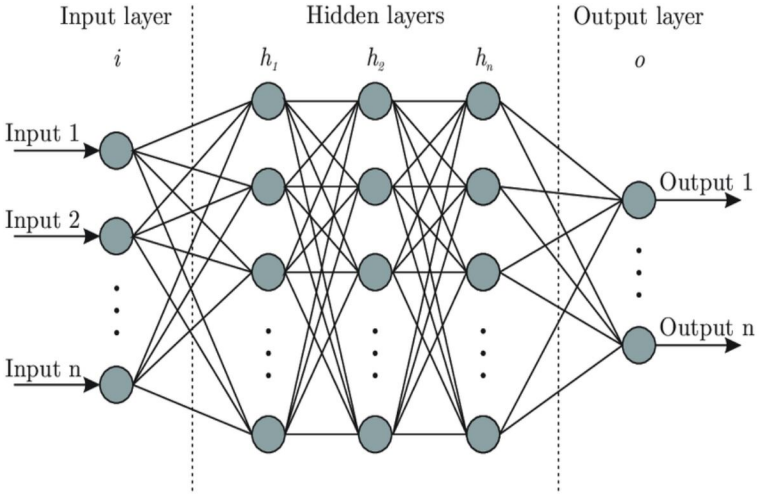


Fig.2: Deep Neural Network

a) *Input Layer:* The first layer of neural network that receives input from dataset this layer called the input or visible layer of neural network. Adaptation of neural analogues to network considered inputlayer neuron. One neuron is taken for each input value in the dataset.

b) *Hidden Layer:* Hidden layers are noting but layers between input and output layers, they considered as hidden as they not directly out in or open to the input. Example of a neural network represented in fig.3 , it have a single hidden layer which is directly connected to the outputs layer. The deep neural networks can be built by increase in computing power and very well-organized libraries. Neural network can have several hidden layers in it as show in fig.2.

c) *Output Layer:* The last layer of network identifies as output layer, because of the individual value of vector which match to systems considerable problem solving requirement.

d) *Diabetic Retinopathy Classification Output:* Further diabetic retinopathy are graded as normal, mild and serve. When red lesion count is less than 5 DR is mild, between minimum value and maximum value the DR is moderate and more than maximum value then DR is severe

II. LITERATURE REVIEW

Multiple automated diagnosis systems have been developed over the last decade. Since human experts usually focus on some typical lesions associated with DR such as microaneurysms, hemorrhages and hard exudates (see Fig.1) when evaluating fundus photographs, many works paid attention to automatedly detect and segment these lesions or calculate some numerical indexes [3]. Shahin *et al.* [4] developed a system to automatedly classify retinal fundus images into those with or without proliferate diabetes retinopathy. They adopted morphological processing to extract pathological features such as blood vessels area and exudates area as well as two indexes including entropy and homogeneity. These features are fed into a shallow neural network and a sensitivity of 88% and a speci_city of 100% are obtained.

Jaafar *et al.* [5] proposed an automated algorithm, which mainly consist of two part: the top-down segmentation to segment the exudates legion and a polar coordinate system centered at the fovea to grade the severity of hard exudates. Based on a small dataset of 236 fundus images, it reaches a sensitivity of 93.2%. Casanova *et al.* [6] introduce an algorithm of random forest to discriminate people with or without DR with the accuracy of more than 90% and assess the DR risk based on graded fundus photographs and systemic dataThus, the deep learning method with the ability to learn signi_cant features directly from the fundus photography has aroused the attention of researchers in recent years. Quellec *et al.* [7] proposed a system to detect referable DR by employing a deep convolutional neural network (CNN) and automatedly segment DR lesions by creating heatmaps of the convolutional layer which shows the potential to discover new biomarkers in images. They adopted the CNN structure with an ensemble learning method from the solution ranked second in the Kaggle Diabetic Retinopathy competition [8] and obtained a good detection result with the area Az under the Freeresponse receiver operating curve (FROC) of 0.954 in the Kaggle dataset. Gulshan *et al.* [9] adopted a deep CNN model named Inception V3 to detect referable diabetic retinopathy (RDR) based on a development dataset which contains more than 128 thousand fundus images. Bene_ted from the large training data and well sifted expert grading to the fundus images, the work achieved an impressing performance with the area under the receiver operating curve (AUC) of 0.991/0.990 and sensitivity of 97.5%/96.1% on two different test sets respectively. Gargeya and Leng [10] proposed a method that combines deep CNN with traditional machine learning algorithm. In their work, fundus images are fed into a residual network after pre-processing, and then the characterization of images obtained from the last pooling layer of network, appended with several metadata variables, is sent into an decision tree classifier to differentiate between healthy fundi and fundi with DR. As a result, the method achieves an AUC of 0.94 with sensitivity of 0.93 and specficity of 0.87 on a test set obtained from public.

In this paper, a deep learning based method which is inspired by the diagnostic process of human ophthalmologists is proposed to automatically classify the fundus photographs into 2 types _ with or without RDR.

Diabetic retinopathy damages the retina of the patient. It is most frequent in the patients who have had diabetes for longer than 10 years. This problem is occurring in millions of people worldwide but medical practitioners and the tools required for detection of diabetic retinopathy is scare for serving the mass population. The work already was done to serve this problem using the application of machine learning but the efficiency of machine learning algorithm depends on the quality of feature extraction which requires domain knowledge. The work presented in this paper overcome the problem by using deep learning algorithm which automatically identifies the pattern and classifies the retina images into one of the five class based. "Automated Diabetic Retinopathy Detection Using Pretrained Deep Neural Network For Classification & Texture & Color Features For Feature Extraction**"** is the working strategy of our system.

III. SUMMARIZED WORK DONE

Table 1: Summary Of Methods Used For Diabetic Retinopathy Detection

REF. NO.	METHODOLOGY	RESULT
1	Exudate Detection DR with Convolutional Neural Networks	An accuracy of 91.92%
2	Automated DR detection & Classification System	from 63.97% to 72.54% for sensitivity, 97.32% to 99.88% for specificity, 80.65% to 86.21% for accuracy.
3	Red Lesion Affected By Diabetic Retinopathy In Digital Fundus Image	Sensitivity = 88 % Specificity = 92 %
4	Automatic Diabetic Retinopathy Detection	Sensitivity = 87 %

	Using Digital Image Processing	
5	Symptom Analysis of Diabetic Retinopathy by Micro-Aneurysm Detection Using NPRTOOL	61.6% sensitivity 41.4% specificity.
6	Implementation of Diabetic Retinopathy Prediction System using Data Mining	The accuracy of NN algorithm which is more than Naïve bayes algorithm and time required for classification for NN is less than naïve bayes also memory required for naïve bayes is greater than the NN. Hence NN is better than naïve bayes in terms of accuracy and time.
7	Diabetic Retinopathy Grade Classification based on Fractal Analysis and Random Forest	An accuracy of 62.37%
8	Automated Diabetic Retinopathy Detection Based on Binocular Siamese-Like Convolutional Neural Network	Sensitivity = 77.4 % Specificity=63.5%

IV. CONCLUSION & FUTURE WORK

In this paper, we have described the development and implementation of Convolution Net based algorithm for diabetic retinopathy classification from fundus color images. Our work shows the viability of deep learning approach to this problem. There remains a lot of experiment with to continue improving our model. We found that the model can be used on the top of pre trained model which can provide a substantial boost to our results, but there is many more experiment that we will do in future to improve results.

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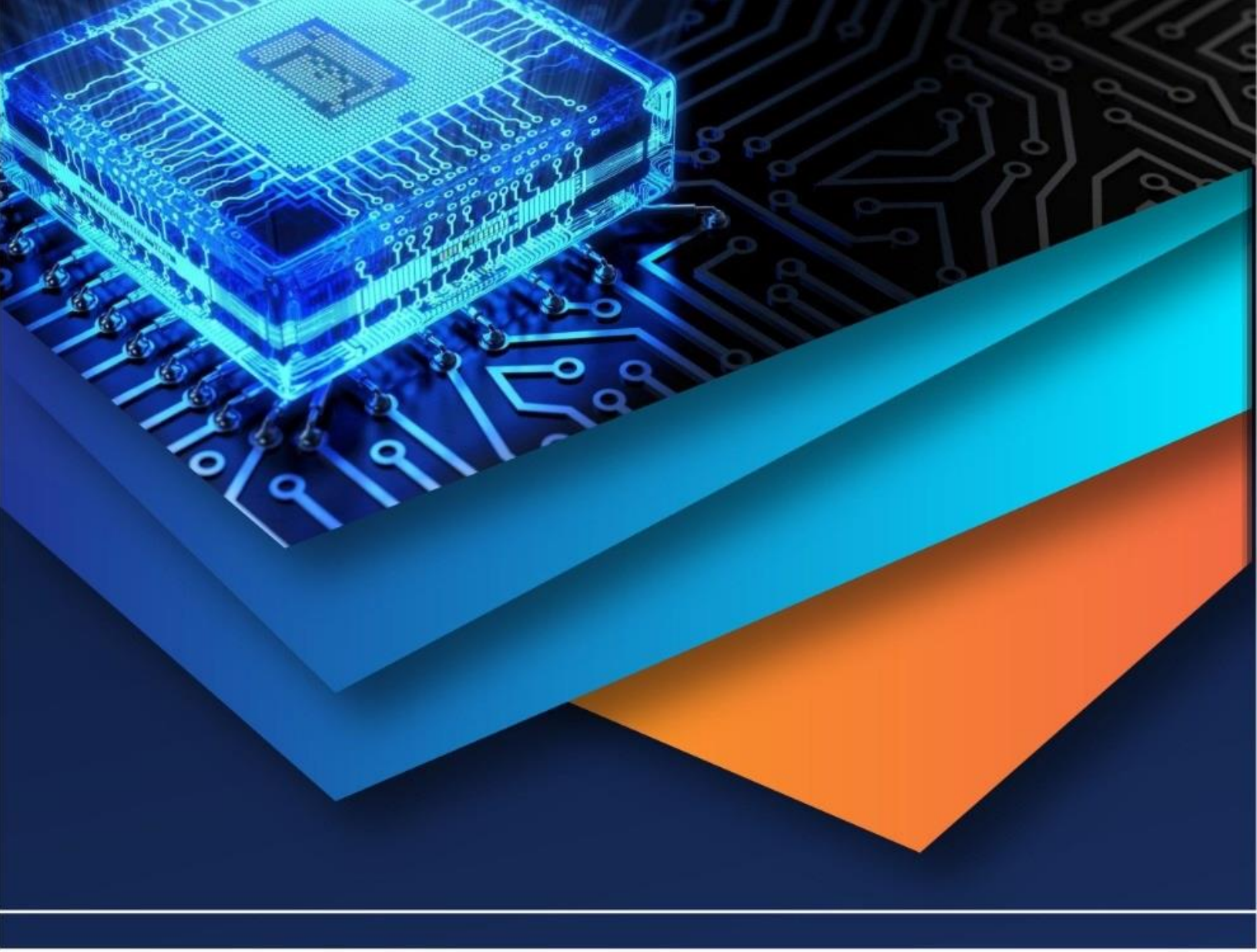

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