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Convolutional Neural Network Based COVID-19 Detection Using Chest X-ray Images

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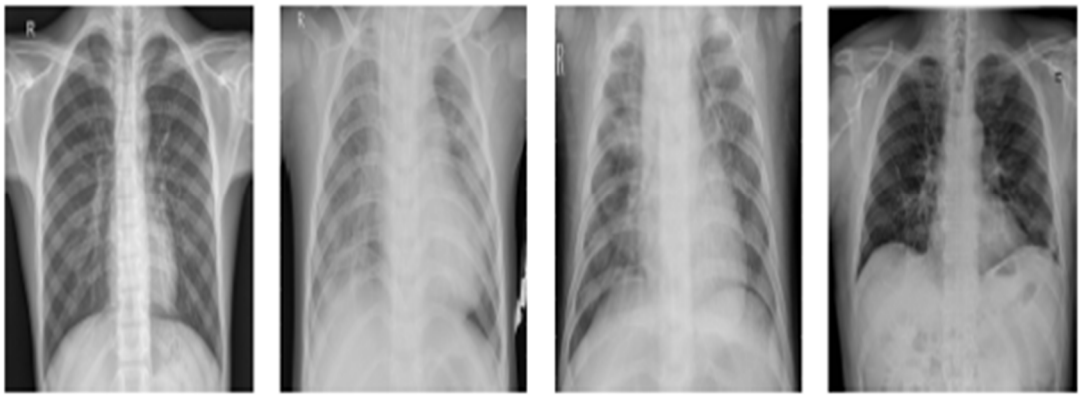
Abstract: Coronavirus disease 2019 (COVID-19) is a communicable disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). It was first identified in December 2019 in Wuhan province, China and has resulted in an ongoing pandemic. Most people infected with the Covid-19 virus will experience mild to moderate respiratory illness and recover without requiring any special treatment or medicines. But elder people, who has some past medical history problems like cardiovascular disease, diabetes, cancer etc. are more likely to develop serious illness and want some medical treatment to cure the disease. In this paper, we experimented with applying a Convolutional Neural Network (CNN) algorithm by using a dataset of 760 Chest X-ray images , some of them are covid positive images and remaining are covid negative images. Among 760 images, we have used 80% of Chest X-ray images for training purposes and 20% for testing purposes. After completing the process, we got the accuracy of 92.84%.

Keywords: Covid-19, Chest x-ray images, CNN, Pandemic, Deep learning

I. INTRODUCTION

A novel coronavirus (CoV) named '2019-nCoV' or '2019 novel coronavirus' or 'COVID-19' by the World Health Organization (WHO) is began at the beginning of December 2019 near in Wuhan City, China. In January 2020, a previously unknown new virus was identified this novel coronavirus was named Coronavirus Disease 2019 (COVID-19) by WHO in February 2020. Coronaviruses are a family of viruses that causes illness such as respiratory and gastrointestinal diseases. The most common symptoms of COVID-19 are Fever, Dry cough, Fatigueness. Other symptoms which are less common are loss of taste or smell, Nasal congestion, Conjunctivitis, Headache, Sore Throat, Muscle or joint pain, Nausea or Vomiting, Diarrhea etc. while symptoms of severe COVID-19 disease includes Loss of Appetite, Confusion, Shortness of breath, Pressure in the chest, High fever. Among those peoples who had common symptoms recover from the disease and does not need any medical treatment but a person with severe symptoms needs medical treatment to recover from this virus. Complications leading to death may include respiratory failure, acute respiratory distress syndrome (ARDS), thromboembolism (obstruction of blood vessel by a blood). Till today (28th June 2021), total 18.1 Cr cases are registered for COVID-19 from which 39.2 lacs deaths are registered. Below figure shows the chest x-ray images of Normal patients, pneumonia and Covid-19 positive patients. In this time of emergency, researchers and scientists are helping the world by identifying the virus inside the human body through the technology of Machine Learning (ML) and Deep Learning (DL) algorithms. Fast Covid-19 recognition through Chest X-ray can save the time and also minimizes the transmission of virus.



Normal Lung Bacterial Lung Viral Pneumonia COVID-19

Fig 1. Chest X-ray images of Normal Lung, Bacterial pneumonia, Viral pneumonia and Covid-19 affected.

Some methods are developed to know whether a person is covid positive or not like Rapid Antigen test, RT-PCR (Reverse Transcription Polymerase Chain Reaction). The reverse transcription polymerase chain reaction (RT-PCR) is considered as a gold standard for COVID-19 diagnosis. This test detects RNA that is specific to the virus and can detect the virus within a days of infection, even those who has no symptoms. Since this tests accuracy is higher than normal Antigen test but time required to know the result is more. Specifically, for COVID-19 diagnosis, different imaging modalities like CT and X-ray are considered among the most effective techniques. Since, Computer Tomography (CT) and X-rays gives more accuracy as compared to Antigen test and RT-PCR. Furthermore, RT-PCR inspection also experiences false negative rates in some cases and the time required to obtain the result is also more. Hence, the only solution to effectively combat this transmissible disease, is through clinical vaccines as well as maintaining the protocols like use of mask, maintain the social distance formula, washing of hands at regular interval of time and so more.

II. LITERATURE SURVEY

To get prior knowledge about detection of covid-19 by using chest x-ray images, a search via online databases such as IEEE explore, Research gate, data science was carried out.

A.waheb Ahmed Musleh & Ashraf Yunis Maghari introduced a Convolutional Neural Network (CNN) in a similar way to the mechanism of work in CheXNet algorithm, which was developed by Stanford University to diagnose and detect the pneumonia from chest X-rays. In this experiment, to achieve better performance than existing technique, some changes are made to the algorithm by using a dataset of 550 chest x-rays images collected from kaggle website, some of them are covid infected and some of them are normal chest x-ray images. In this scheme, the dataset is divided into 446 images for training and 110 for testing, which is almost 80% of data for training model and 20% for testing. In the first experiment, the complete dataset must pass multiple times to the same Neural network to improve the learning process. The results shows accuracy of 84% with a loss of 45%. However, in second experiment, a group of 280 images are collected and passes to the previous data set to be 556 images and pass to the model again which shows 89.7% accuracy with 24.8% loss.

In another research work, Apostolopoulos & Bessiana developed a system for the automatic diagnosis of Covid-19 cases using transfer learning with five variants of Convolutional neural Network. The pre-trained model which are used in this study are VGG19, Inception, Exception, MobileNetv2 and Inception-ResNetV2. This system uses the dataset of 1427 images including 224 Covid-19 images, 700 pneumonia images and 504 healthy cases images. The dataset is divided into 10-fold CV (k-fold cross validation) method. In second setup, 224 Covid-19 images, 714 bacterial and viral pneumonia images and 504 healthy images are taken. The highest accuracy of 92.78%, sensitivity of 95.66% specificity of 91.46% are obtained.

Recently, J.C.Sangidong, H.D.Purnomo & F.Y.Santoso proposed a new learning model known as FJCovNet which is based on DenseNet121. The datasets are obtained from GitHub repository consists of 349 images of Covid infected persons and 397 images from non-infected persons. The datasets are divided in two categories viz. the training dataset and the testing dataset. Afterwards, the images from training datasets are resized to 1:1 ratio and image augmentation process is done to expand the data size. The full architecture of FJCovNet includes Pre-trained model DenseNet121, Batch Normalization, Global Average Pooling, Dense, Dropout, Dense. FCCovNet managed to get an accuracy of 94.14% surpassing Exception which has accuracy of 84.24%, and ResNet50 with accuracy of 91.53%. FJCovNet also managed to get less training time of 612 seconds which is lesser than VGG19 with 808 seconds and ResNet with 809 seconds.

Horry et.al. described a covid-19 detection framework using the concept of pre-trained model like VGG, Inception, Exception and ResNet with transfer learning. The datasets consists of 100 Covid-19 positive cases, 100 pneumonia and 200 healthy cases for the experiment. In this system, data partition is done in the ratio of 80:20 for training and testing of the datasets. The experimental results obtained precision of 83%, sensitivity of 80% and F-1 score of 80%. In another recently study by Rahimzadeh and Attar proposed a modified Convolutional Neural Network for the detection of covid-19 using chest x-ray images. The system chains the two well known architecture of CNN named Xception and ResNet50v2 which makes the system vigorous. Among the 15085 images, 180 are confirmed covid-19 images, 6054 images are of pneumonia cases and 8851 images are of normal cases. For data partitioning, the scheme used 5-fold cross validation. The network obtained accuracy of 99.50% and precision of 35.27% for the detection of Covid-19. Furthermore, Sanhita Basu et.al proposed a new concept called Domain Extension transfer learning (DETL). Used DETL, with pre-trained deep convolutional neural network, on large number of data set (1277) that is tuned for classifying between four classes viz. normal(350), pneumonia(322), other diseases(300) and covid-19(305). A 5-fold cross validation was performed to get an estimate of the feasibility of using chest X-rays to diagnose Covid-19. The overall accuracy was measured as 90.13%.

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III. PROPOSED SOLUTION

This section describes the Convolutional Neural Network (CNN) model which includes the phases used for the detection of Covid-19. The phases are shown in the figure 2 below.

A. Data Collection

The data consist of 760 images of Chest X-rays from which 400 images are affected with Covid-19 i.e. Covid-19 positive and 360 images are healthy images i.e. Covid-19 negative. The images are divided for training and testing purposes into the ratio of 4:1 i.e. 80% for training purposes and 20% for testing purposes. The datasets are collected from the kaggle website.

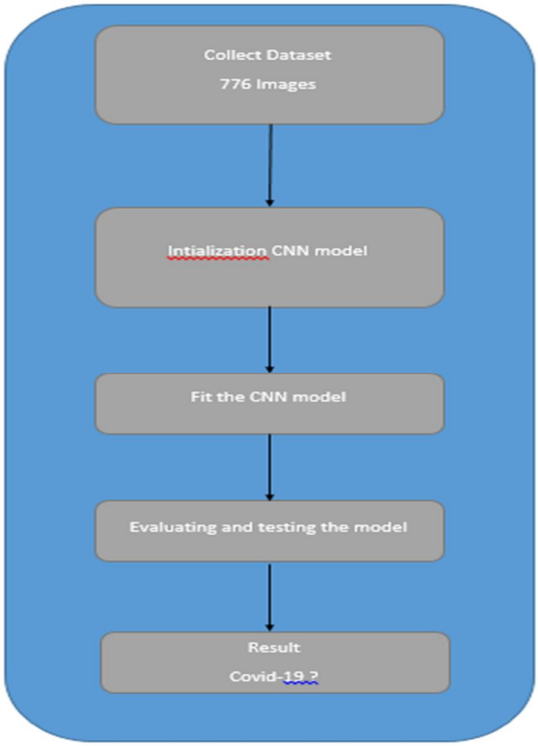

Fig 2 The proposed CNN model for Covid-19 Prediction

B. Data Pre-processing

Covid-19 findings can be identified easily by using a grey scale image and hence first of all, we converted all input X-ray images to grey scale images. Now, all the grey scale chest X-ray images are of different size, since different size of input images to the model are risky hence we reduce this input image size's to 400x400. Thus the problem is terminated and our model is also accelerated.

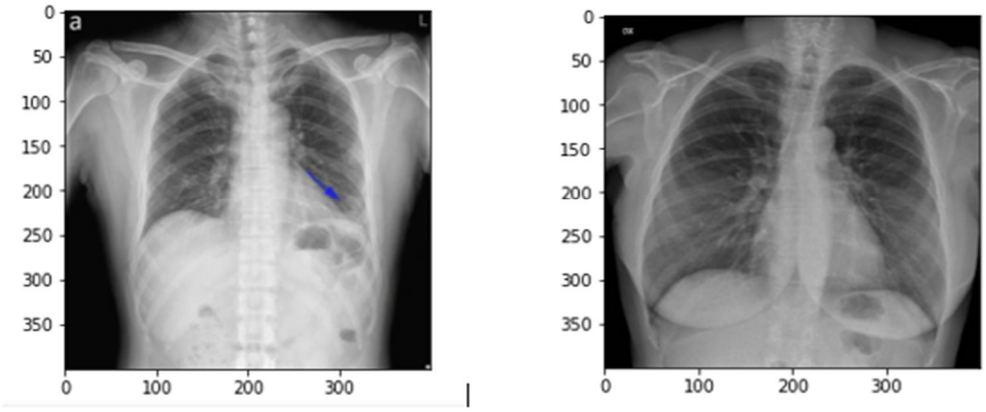

Fig.3 Grey scale images of chest X-ray reduced to size 400x400

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C. Initialization

1) Add Convolutional layer (Convolutional 2D) : We use 64 output filters in the convolution 3*3filter matrix that will multiply to input RGB size image and use Relu as a activation function.

2) Applying MaxPolling 2D layer pool size of 2*2, processing, hidden layer 1 to all the images. Same steps repeats again with conv2D of 32 output filters.

3) To convert the matrix in a single array: Add flatten is used.

4) Adding a dense layer where every neuron is connected to every other neuron for the output (64 final layers of output, Relu as activation function, Sigmoid as activation function).

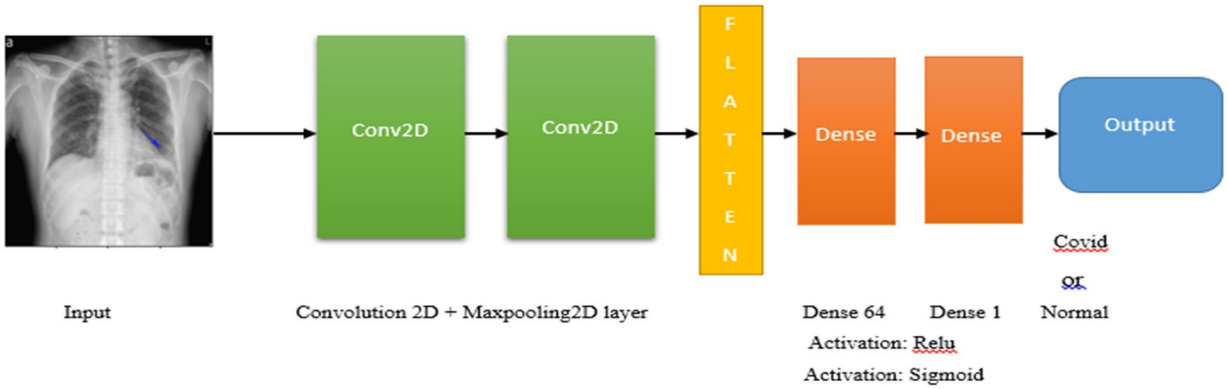

Fig.4 The layers of CNN Architecture

```
Epoch 41/50
37/37 [==============================] - 2s 68ms/step - loss: 0.1294 - accuracy: 0.9193
Epoch 42/50
37/37 [==============================] - 2s 67ms/step - loss: 0.1333 - accuracy: 0.9156
Epoch 43/50
37/37 [==============================] - 3s 68ms/step - loss: 0.1301 - accuracy: 0.9156
Epoch 44/50
37/37 [==============================] - 3s 68ms/step - loss: 0.1305 - accuracy: 0.9119
Epoch 45/50
37/37 [==============================] - 2s 68ms/step - loss: 0.1253 - accuracy: 0.9193
Epoch 46/50
37/37 [==============================] - 2s 68ms/step - loss: 0.1269 - accuracy: 0.9193
Epoch 47/50
37/37 [==============================] - 3s 68ms/step - loss: 0.1239 - accuracy: 0.9101
Epoch 48/50
37/37 [==============================] - 3s 68ms/step - loss: 0.1235 - accuracy: 0.9156
Epoch 49/50
37/37 [==============================] - 3s 68ms/step - loss: 0.1222 - accuracy: 0.9211
Epoch 50/50
37/37 [==============================] - 3s 68ms/step - loss: 0.2677 - accuracy: 0.9284
```

Fig.5 Result of model training in 50 epochs

The adam optimizer is an algorithm for optimization technique for gradient descent. The method is really effective when working with large problem involved a lot of data or parameters. Also it requires less memory and it is efficient. After fitting the training set (steps_per-epochs: 15, no. of epochs: 50), figure 5 shows the result of model training in 50 epochs.

D. Testing the Model

For evaluation the CNN model, loss and accuracy matrices are used. Compiling the model with binary Crossentropy which is related to inverse of information gain and optimizing it with adam optimizer. In order to test our model, some sample of images are given to detect Covid-19. The pictures were loaded and converted it into arrays, then the model predicts whether the image is covid infected or normal.

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IV. RESULT AND DISCUSSION

The Convolutional Neural Network (CNN) model were developed using tensorflow, with wrapping library Keras in python. The experiment is performed in Python as well as in Google Colaboratory. Adam optimization algorithm is used for hyperparameter optimization for training the CNNs. The model was trained for 50 epochs with a batch size of 15. As a result of the experiment, we get an accuracy of 92.84%, validation loss of 0.2677, batch size of 15 and an epoch of 50. The confusion matrix after classification is given in figure below. From the following confusion matrix Recall, precision values are calculated which are found as 0.5769 and 0.7894 respectively.

Recall and Precision is calculated using following formulae's.

Recall = TP/ (TP+FN)

Precision = TP/ (TP+FP)

```
array([[ 15,   4],
       [ 11, 107]])
```

Fig.6 Confusion matrix of Covid-19 and normal.

V. CONCLUSION AND FUTURE WORK

The accuracy given by Convolutional Neural Network (CNN) using chest x-ray images of the patients and classify this images in two types of classes i.e. COVID-19 positive and COVID-19 negative. The accuracy obtained in this experiment is 92.84% with a validation loss of 0.2677. Since we managed to get an accuracy of 92.84%, surpassing Xception with an accuracy of 84.24% and ResNet with an accuracy of 91.53%. This paper also addressed the current scenario of COVID-19 in worldwide as well as in India. In future, we focused on applying this technique in real time data and to improve the accuracy with minimum required time, as well as trying to explore different approaches to Convolutional neural Network (CNN).

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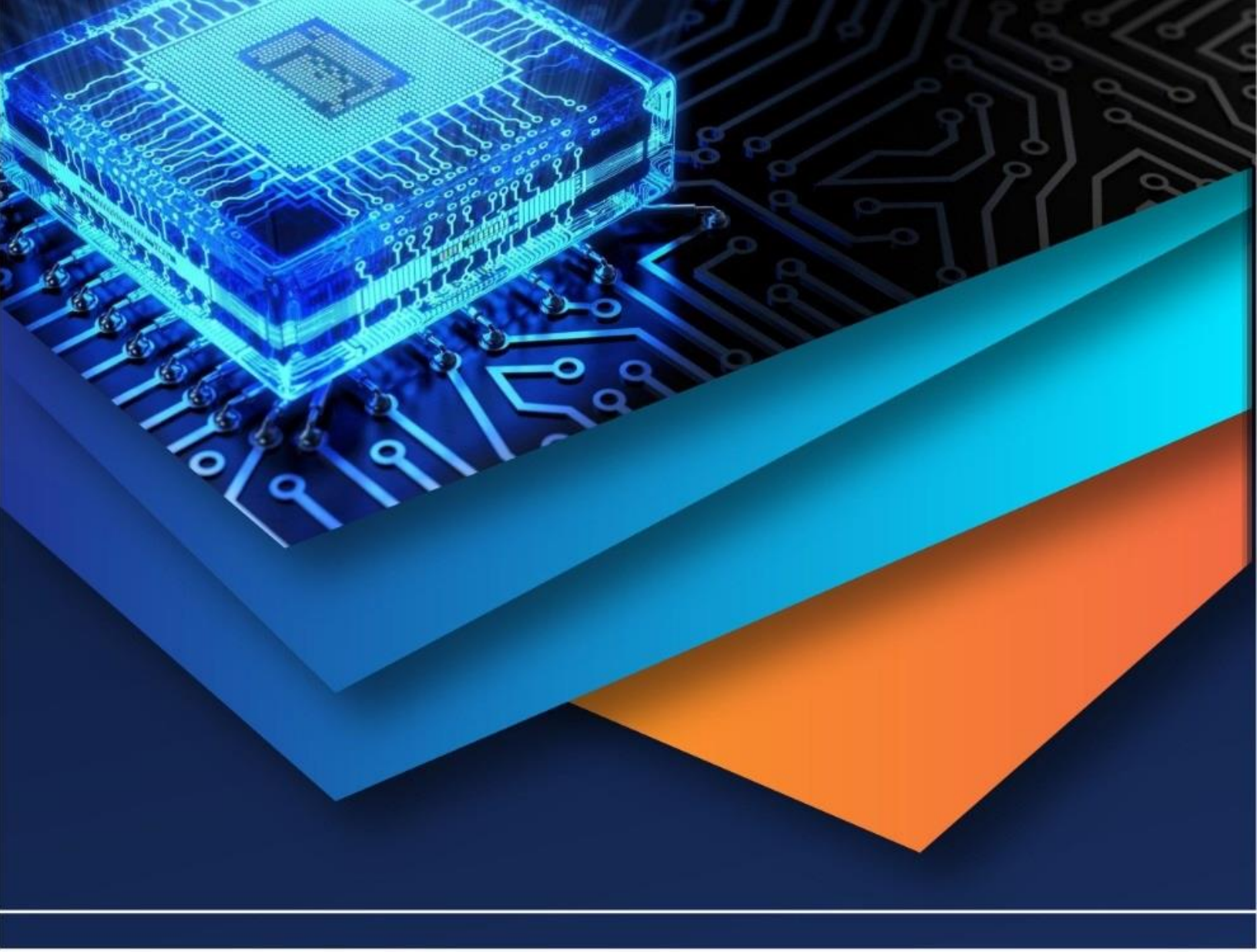

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