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# Detection of Covid-19 in Chest X-Ray Images using Deep Convolutional Neural Network

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***Abstract:*** ***The pandemic COVID -19 has created an urgent need to do our part in the fight against the great threat to humanity. Studies diagnosing COVID -19 on chest x-rays have a binary or multiclass classification. VGG-16 (Visual Geometry Group), The software, which uses a deep convolutional neural network to detect COVID -19 cases on chest x-ray images, is open source and available to download. This research makes a significant contribution to the healthcare industry and research community by proposing a synthetic data augmentation in chest X-ray images using a deep convolutional neural network (CNN) architecture for the detection of normal pneumonia and covid-19. The model used is VGG-16, and after training and validation, an average validation accuracy and loss of 0.97 and 0.026 were obtained, with specificity and sensitivity of 0.96 and 0.95, respectively, compared with previous models trained for binary classification to detect abnormalities such as pneumonia and covid-19 in radiographs.***

***Index Terms: COVID-19, Convolutional Neural Network (CNN), VGG-16 (Visual Geometry Group), chest X-ray (CXR), Binary classification, Pneumonia***

## I. INTRODUCTION

The COVID -19 virus can cause fever, cough, headache, fatigue, difficulty breathing, and loss of smell and taste. Routine CT scans for all individuals living in or visiting at- risk areas may be cost prohibitive. Other preventive measures include physical or social distancing, indoor quarantine, and ventilation. A review of studies on the use of DL techniques for COVID -19 diagnosis and segmentation of lungs is discussed, focusing on work using radiographic and CT images. Review also includes a review of work predicting the prevalence of coronavirus in different parts of the world using DL.

Routine CT scans for all individuals living in or visiting at-risk areas may be cost prohibitive due to the global spread of COVID -19 viruses. Other preventive measures include physical or social distancing, indoor quarantine, and ventilation, covering coughs and sneezes, hand washing, and keeping unwashed hands away from the face. COVID-19 is the disease caused by the corona virus called SARS- CoV-2. COVID -19 is the designation given by the World

Health Organization (WHO) on February 11, 2020. Since the discovery of the first case, the disease has spread to nearly every country and has claimed the lives of more than 4.9 million people in nearly 244 million confirmed cases, according to World Health Organization statistics through October 2021. Since 2020, there have been more than 86 million cases of COVID -19 and more than 1 million deaths in the United States. It can be difficult to determine an accurate number of cases in the United States because many people with mild symptoms do not get tested or treated.

In addition, data are constantly changing, especially as waves of variants emerge. Between August 1, 2020, and July 31, 2022, more than 5 million people in the United States were hospitalized with COVID -19. The number of hospitalizations rises and falls with waves of variants. The number of new hospitalizations increased at the end of July 2022, with about 6,500 new hospitalizations per day. Most cases and deaths from COVID -19 have occurred in large metropolitan areas such as Los Angeles and New York.7 However, no U.S. state is unaffected by COVID -19. In addition, Phoenix and Miami are particularly hard hit, with over 1.3 million cases each.

The dataset is organized into 3 folders (train, test, validate) and contains subfolders for each image category (pneumo- nia/normal). There are 5,863 radiographs (JPEG) and 2 cat- egories (pneumonia/normal). The radiographs were selected from retrospective cohorts of pediatric patients aged one to five years from Guangzhou Women and Children's Medical Center, Guangzhou. All chest radiographs were performed as part of the patients' routine clinical care. For the analysis of the radiographs, all radiographs were first subjected to quality control by removing any poor-quality or illegible images. Diagnoses for the images were then graded by two medical specialists before being released for training by the AI system. To eliminate any errors in grading, the grading set was also reviewed by a third expert.

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COVID -19 has spread rapidly throughout the world. The greater impact on health departments is primarily due to the number of people affected day after day by having to mechanically ventilate critically ill patients admitted to the intensive care unit. As a result, the number of ICU beds must be significantly increased. In this scenario, early diagnosis is critical to ensure that patients receive appropriate treatment and to reduce the burden on the healthcare system. COVID-19 remains a deadly disease due to the lack of early di- agnostic techniques worldwide and the presence of medical preconditions such as cancer, chronic liver, lung and kidney disease, and diabetes. RT-PCR has a low success rate of 70 percent and a sensitivity of 60-70 percent. False-negative RT-PCR cases also show positive chest x-ray results. Due to its wide availability, X-ray imaging plays an important role in many medical and epidemiological situations. Because of its speed, low cost, and ease of use by radiologists, chest X-rays appear promising for emergency and treatment use. However, previous studies have found significant differences in chest radiographs of patients with COVID-19.

Development of a (DL) model to segment and quantify in- fection from chest X-ray images for the detection of Covid patients and patients with common pneumonia. To overcome the need for a computerized tool to accurately quantify the severity of Covid19. Provides quantitative capabilities to seg- ment COVID19-infected regions in CT images and accelerates manual CT image delineation for training. To accommodate fine-tuned Chest X-Ray CT scans available in 2D.

## II. METHODOLOGY

### A. *Deep Convolutional Neural Network Model Establishment*

1) *Visual Geometry Group (VGG-16):* Our proposed method is based on the well-established pre-trained DL model (VGG-16). We prefer to use the VGG-16 model for two reasons. Firstly, it extracts the features at low-level by using its smaller kernel size, which is appropriate for CXR images with a lower number of layers compared to its another counterpart VGG-19 model. Secondly, it has a better feature extraction ability for the classification of COVID-19. We use a fine- tuning approach, which is one of the transfer learning techniques. To work with the VGG-16 model for the fine-tuning process, we use the pre-trained weights of ImageNet. It helps to overcome the over-fitting problem as we have limited amount of COVID-19 CXR images for training purposes.Our proposed method (VGG-16) consists of three main blocks, Convolution module, FC-layers, and Soft-max classifier.

   In this proposed work we are going to build two Covid19 Image classification models. Both models use Lung CT scan images to classify the covid-19. We build the first classification model using VGG16 Transfer leaning framework and second model using Deep Learning Tech- nique Convolutional Neural Network-CNN to classify and diagnose the disease and we were able to achieve the best accuracy in both the model. Convolutional neural network models need a massive amount of data to train and achieve state-of-the-art performance. In addition to the massive amount of data, hyper-parameters such as learning rate, drop-out, batch normalization, optimizers, loss function, number of output layers, and activation functions play an important role in achieving the best results in a shorter time. It would not be easy to build these models from scratch to predict covid-19 cases due to the long training period. So, in this situation, the concept of the Transfer Learning method can be helpful because it is trained on millions of data and is used to solve a similar task with relatively fewer data.

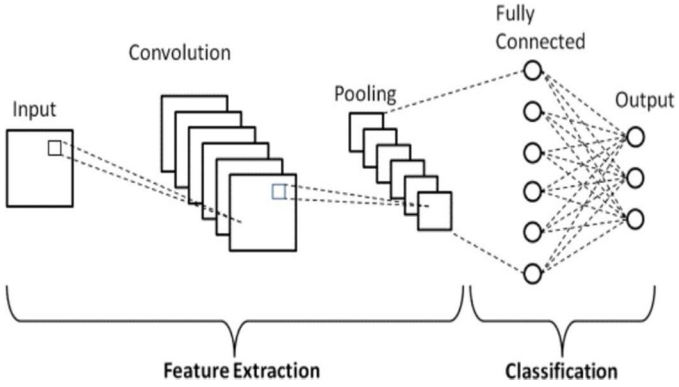



Fig. 1. Basic Convolutional Neural Network

2) *DL model (VGG-16):* Today VGG-16 is to be con- sidered an excellent machine-learning network. The in- novative features of VGG16 are that it focuses on the 3x3 convolutional filter layer with a stride of 1 instead of many hyper-parameters, which uses padding and a maximum pool layer of a stride of 2.

3) *Core Layers:* Uses fully connected core layers for the representation of combined features derived as single- dimension features. As shown in the figure, it consists of three layers: flat, drop-down, and dense. In this technique, the dropout is to considered as 0.6 and the dense layer as 128. Fully connected layers—VGGNet includes three fully connected layers. The first two layers each have 4096 channels, and the third layer has 1000 channels, one for every class.
4) *Input Layer:* Input—VGGNet receives a 224×224 image input. In the ImageNet competition, the model's creators kept the image input size constant by cropping a 224×224 section from the center of each image.
5) *Convolutional Layers:* Convolutional layers—the convo- lutional filters of VGG use the smallest possible receptive field of 3×3. VGG also uses a 1×1 convolution filter as the input's linear transformation.
6) *Hidden Layers:* Hidden layers—all the VGG network's hidden layers use ReLU instead of Local Response Normalization like AlexNet. The latter increases training time and memory consumption with little improvement to overall accuracy.
7) *Max-Pooling Layers:* Pooling layers–A pooling layer follows several convolutional layers—this helps reduce the dimensionality and the number of parameters of the feature maps created by each convolution step. Pooling is crucial given the rapid growth of the number of available filters from 64 to 128, 256, and eventually 512 in the final layers.

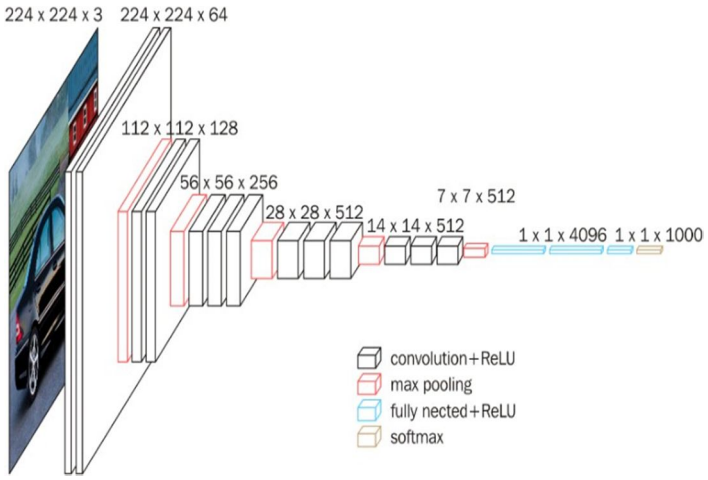



Fig. 2. Architecture of VGG-16

8) *Soft-max Classifier:* In the soft-max layer, number of units depends on different number of categories. A soft- max layer outputs a polynomial distribution of probability estimates based on the classifications performed.
9) *ReLu Activation:* ReLu activation—next is the Recti- fied Linear Unit Activation Function (ReLU) component, ReLU is a linear function that provides a matching output for positive inputs and outputs zero for negative inputs. VGG has a set convolution stride of 1 pixel to preserve the spatial resolution after convolution).

### *B. Data Pre-processing*

The pre-processing of data is an essential stage in models is to create networks that require the correct input data format. This model requires huge dataset to obtain high accuracy and performance. Machine learning researchers used data augmentation which helps in increasing images. This is done to increase the data set and give the neural network different image options. This makes the model more likely to recognize an object when it appears in some shape or form. There are very few chest x-rays of Covid-19 available in the data set. In addition to the massive amount of data, hyper-parameters such as learning rate, drop-out, batch normalization, optimizers, loss function, number of output layers, and activation functions play an important role in achieving the best results in a shorter time. It would not be easy to build these models from scratch to predict covid-19 cases due to the long training period.

## III. MODELLING AND ANALYSIS

### *A. Batch Normalization*

Normalization is the process of transforming the data to have a mean zero and standard deviation one. In this step we have our batch input from layer h, first, we need to calculate

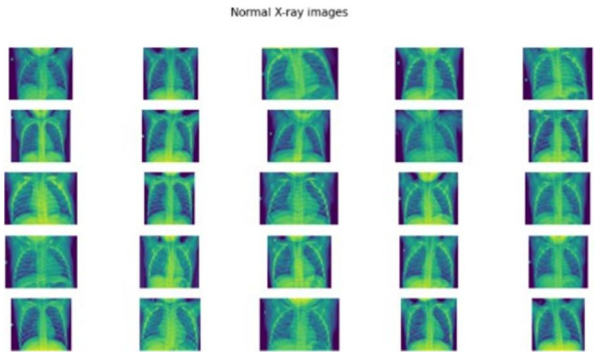



Fig. 3. Normal X-ray Images

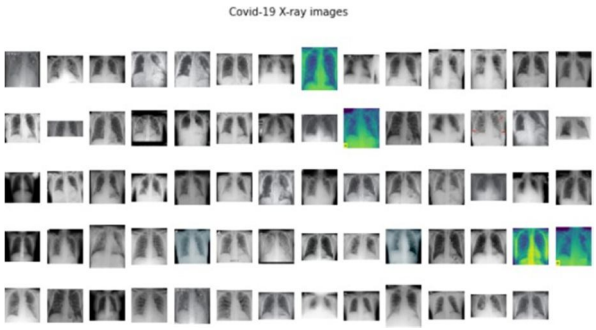



Fig. 4. Covid-19 X-ray Images

the mean of this hidden activation.

$$\mu = \frac{1}{m} \sum (h_i) \qquad (1)$$

Here, m is the number of neurons at layer h. Once we have meant at our end, the next step is to calculate the standard deviation of the hidden activations.

$$\sigma = \left[\frac{1}{m} \sum (h_i - \mu)\right]^{\frac{1}{2}} \qquad (2)$$

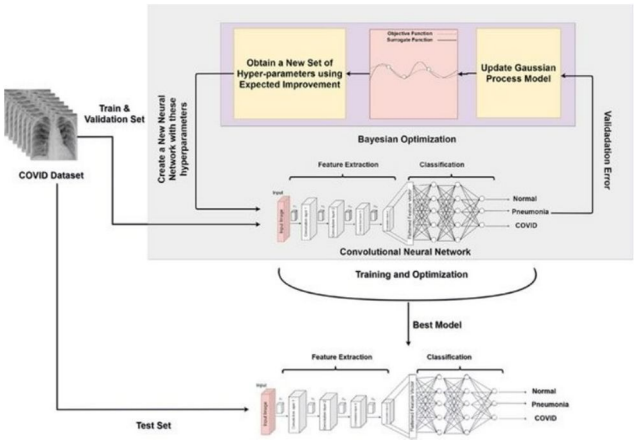



Fig. 5. Sequence Chart for Deep Convolutional model

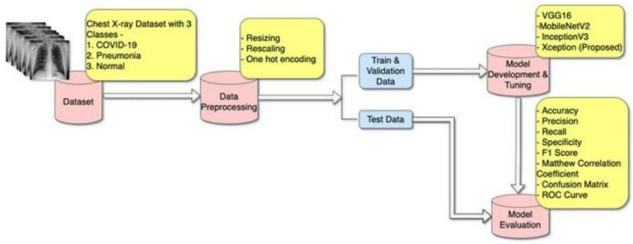



Fig. 6. Flowchart of Deep Learning Model Established

### *B. Scaling Features*

Further, as we have the mean and the standard deviation ready. We will normalize the hidden activations using these values. For this, we will subtract the mean from each input and divide the whole value with the sum of standard deviation and the smoothing term.

The smoothing term assures numerical stability within the operation by stopping a division by a zero value.

$$h_i(norm) = \frac{(h_i - \mu)}{\sigma + \epsilon}$$

### *C. Feature Extraction*

In the final operation, the re-scaling and offsetting of the input take place. Here two components of the BN algorithm come into the picture, gamma and beta . These parameters are used for re-scaling gamma and shifting beta of the vector containing values from the previous operations.

$$h_i = \gamma * h_i(norm) + \beta \qquad (4)$$

These two are learnable parameters, during the training neural network ensures the optimal values of gamma and beta are used. That will enable the accurate normalization of each batch.

### *D. Adam Optimizer*

Adam (Adaptive Moment Estimation) is an adaptive op- timization algorithm that was created specifically for deep neural network training. It can be viewed as a fusion of momentum-based stochastic gradient descent and RMSprop. It scales the learning rate using squared gradients, similar to RMSprop, and leverages momentum by using the gradient's moving average rather than the gradient itself, similar to SGD with momentum.

## IV. RESULTS AND EVALUATION

### *A. Training Performance*

After building a model, it is very important to know the predictive ability of the model for new instances. You might want to try different types of models for the same prediction problem, and then simply compare them in terms of predictive performance. Predictor performance is usually measured using precision and recall. We discussed performance metrics used

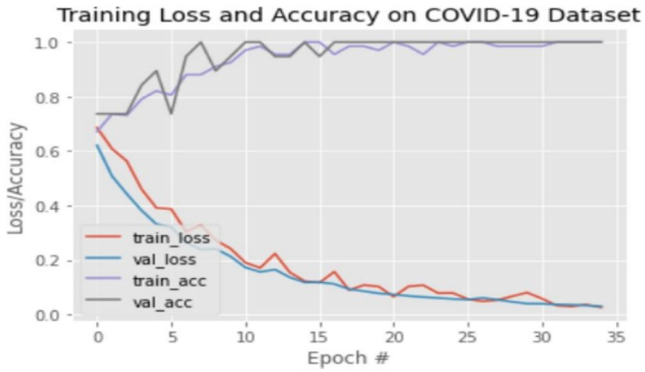



Fig. 7. Accuracy and Loss Curve Graph

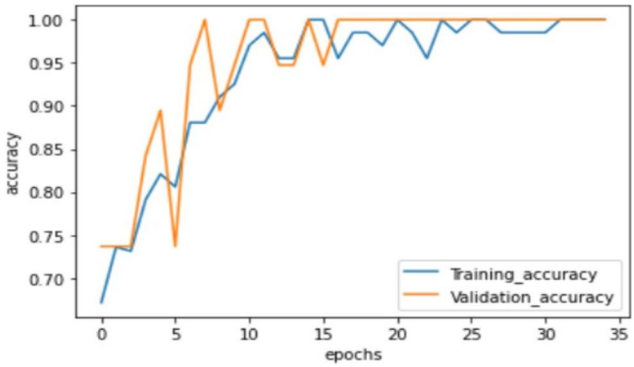



Fig. 8. Accuracy Convergence plot graph

in daily basis. A detailed analysis of COVID-19 predictions based on X-ray datasets was performed using VGG-16, convo- lutional model. We tested various hyper-parameters associated with the model, such as the learning rate, optimizer, and loss function. Fig. 7 shows the training accuracy and training loss as well as validation loss and accuracy.

The next part, the pre-trained VGG-16 CNN architecture, Figure 7,8 displays the loss convergence plot and the accuracy convergence plot for the training accuracy, loss, and validation accuracy, loss.

Overall classifier accuracy is assessed through the division of total number of positive, negative results by the sample size. The newly developed architecture of deep neural convolutional networks can be similar to neuron connections in human brain, where individual neurons in the visual cortex are located in a confined visual field known as the receptive field. figure 12 shows a confusion matrix for binary classification. The deep convolutional neural network model examines the determining values like Support, Precision, Recall, and F-measure. The Evaluation metrics and Confusion matrix is obtained by our built model shown in Fig. 9, 10.

**Fig. 10** Accuracy Convergence plot graph

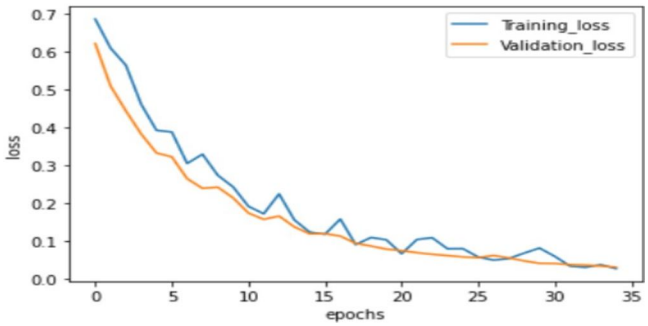



Fig. 9. Loss Convergence plot graph

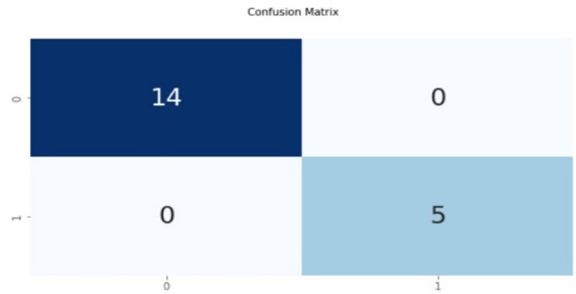



Fig. 10. Confusion Matrix

```
[INFO] evaluating network...
3/3 [==============================] - 9s 3s/step
              precision    recall  f1-score   support

       covid       1.00      1.00      1.00        14
      normal       1.00      1.00      1.00         5

    accuracy                           1.00        19
   macro avg       1.00      1.00      1.00        19
weighted avg       1.00      1.00      1.00        19
```

Fig. 11. Evaluation Metrics

```
1/1 [==============================] - 1s 834ms/step
[[9.97679174e-01 2.32086377e-03]
 [7.53423339e-03 9.92465734e-01]
 [6.88164255e-06 9.99993086e-01]
 [1.17923926e-04 9.99882102e-01]]
[0 1 1 1]
```

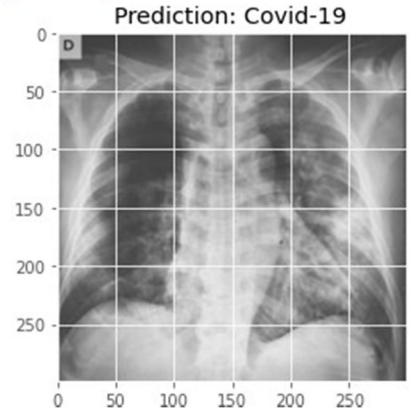



Fig. 12. DL Model predicted result as Covid-19 Patient

```
1/1 [==============================] - 1s 626ms/step
[[2.0234844e-18 1.0000000e+00]]
1
<matplotlib.image.AxesImage at 0x7f71aeca0a10>
```

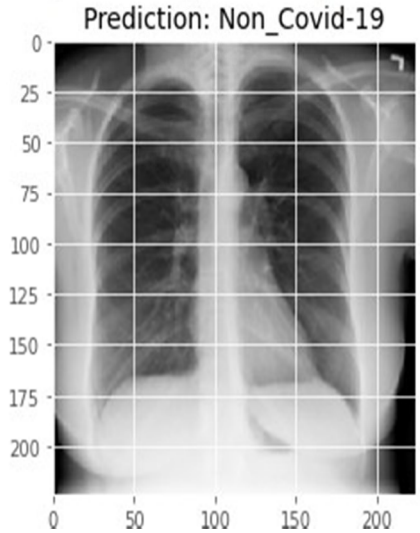



Fig. 13. DL Model predicted result as Non Covid-19 Patient

## V. CONCLUSIONS

The approach proposed a model as VGG-16 for classifying Covid-19 images. Methods were evaluated on two different Covid-19 datasets. The results when evaluated show that our method is effective in terms of learning parameters as well as classification accuracy. From these results, it can be concluded that the introduced model is suitable to classify Covid-19 X- ray images. This deep convolutional neural network approach provides a two-step deep residual learning method for the detection of normal patients. This model performed well in distinguishing images with Covid-19 and pneumonia from images with the use of the VGG-16 model.

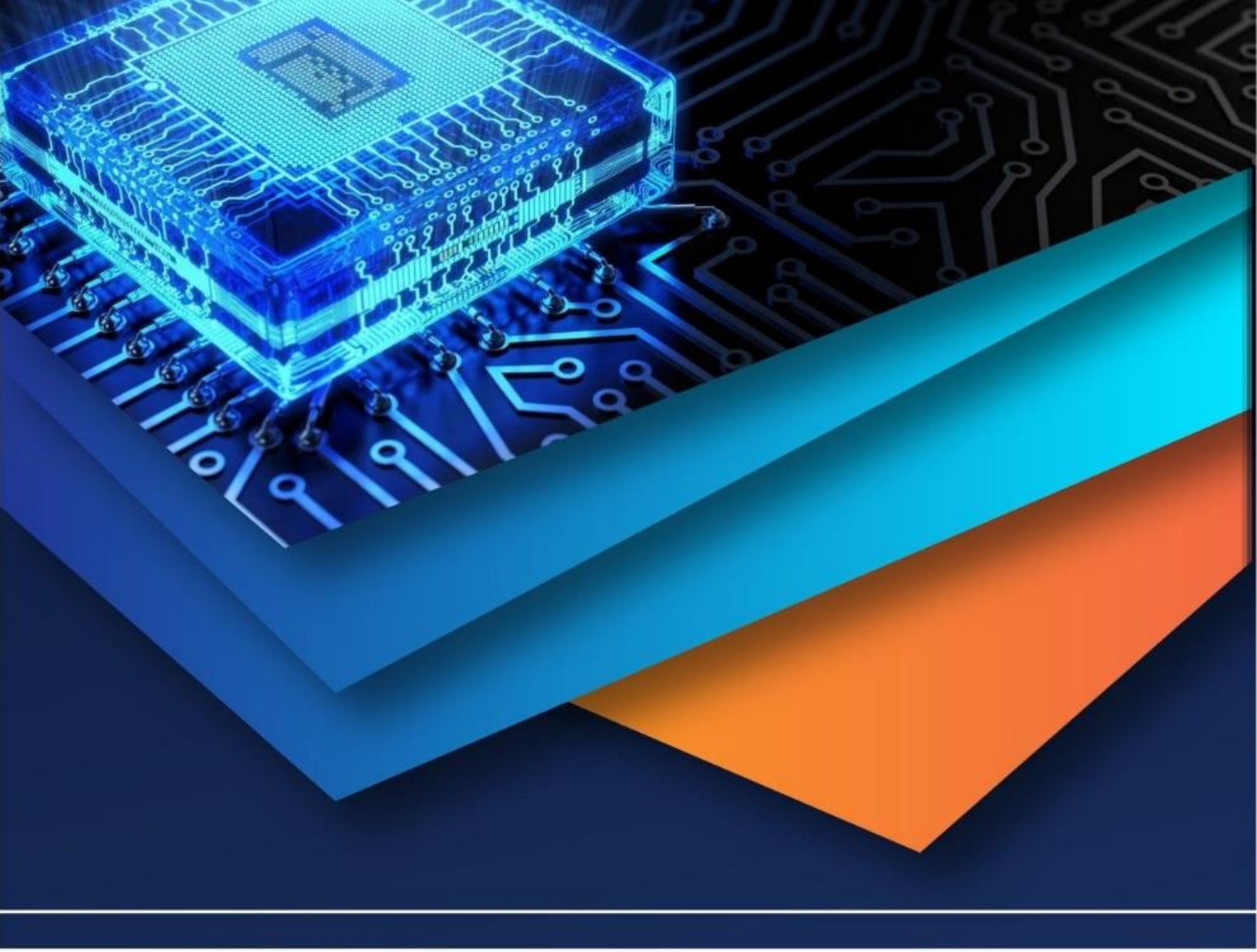
Evaluated results which we obtained using transfer learning models compared with a section of previously used methods and related work shows the newly established DL techniques for automatic diagnosis of Covid-19 which uses lungs image. According to observations, the method we propose in this study achieves superior performance compared to other newly established techniques. New deep-learning models are being established in the future that provides more accuracy. The model will be able to train with large datasets and provide different ways to detect covid-19. The performance of the model can be enhanced by several techniques. Reinforcement techniques like Generative Adversarial Networks or Auto- encoding the images before training can enhance the accuracy. It increases frames, which neutralizes overfitting at the training stage. using models with small-sized filters can enhance auto- tuning of images. Indeed, the smaller filter size makes it possible to extract a better discriminant ROI from images.

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