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An Efficient Deep Learning Approach for Detection of COVID-19 from Chest CT Scan Images

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Abstract: **-** The virus is responsible for A person infected with the coronavirus may transmit the disease to others by the droplets released when they cough, sneeze, or breath. The two most common ways for a person to get the virus are via direct contact with an infected surface or by breathing in droplets that an infected person nearby releases into the air. When infected, the majority of people only have mild to moderate symptoms. The rapid onset of lung inflammation characterizes acute respiratory distress syndrome (ARSD), which is experienced by individuals with severe symptoms. Serious complications, including blood clots, multiple organ failures, and other life-threatening issues, may arise out of nowhere, and in extreme cases, the patient may not survive.Put another way, COVID-19 causes an unfavourable infection in our lungs, making it impossible for a person to breathe properly.. This paper's overarching goal is to examine and contrast CT scan pictures of individuals with coronavirus infections with those of people who may not have the virus or who may be suffering from other types of pneumonia. Also we have compared our present research VGG19 model with optimizer Adamax with our previous VGG19 model in this research work. The VGG19 model with optimizer Adamax give more accuracy and precision i.e. 85% and 89% respectively than our previous VGG19 model.

Keywords: *COVID-19 , CT Scan , Deep Learning , Machine Learning , Respiratory*

I. Introduction

A new strain of the potentially deadly coronavirus family of viruses is sometimes referred to as a "novel" virus [1]. World Health Organization (www.who.int) reports that coronavirus is one of several viruses in a broad family that includes anything from the common cold to dangerous illnesses. Humans and animals alike are susceptible to these illnesses. Since its first appearance in Wuhan, China, in December 2019, a novel coronavirus strain known as COVID-19 has become a worldwide health emergency. Different coronaviruses, MERS and SARS, are related to the COVID-19 coronavirus strain. The global public health community is understandably worried about the COVID-19 pandemic. [2] [3]. Every day, labs throughout the globe are overwhelmed by the screening of large samples [4]. Most often, COVID-19 is identified by RT-PCR, which may detect SARS-CoV-2 from a nasopharyngeal swab sample. However, RT-PCR's sensitivity and specificity are not particularly strong[5]. Additionally, it takes roughly six hours for sample and subsequent testing to separate false positives from false negatives.[6]. Numerous individuals exhibit COVID-19-related clinical, laboratory, and radiological characteristics; yet, the results of their RT-PCR tests are negative.[7]

According to a plethora of research, chest computer tomography (CT) is a reliable and efficient way to diagnose COVID-19 [8]. An useful complement to RT-PCR, it offers exceptional sensitivity and a low misunderstanding rate [9]. Expert thoracic radiologists may not always diagnose positive cases of COVID-19 using CT images, which can delay treatment and even promote further transmission of the virus because infected patients are not immediately isolated, even though rapid detection of the infection using CT images is critical [10] [11] [12]. Here, assisting doctors and other medical personnel in using AI methods to differentiate between CT scans pertaining to COVID-19 and those unrelated to the virus is of the utmost importance.

Numerous research have indicated that machine learning and other artificial intelligence (AI) approaches have been extremely successful in the fields of bioinformatics and medical image analysis [13]. In the past ten years, deep learning methods have proven to be exceptionally effective at learning in several domains, such as image identification, surpassing multiple cutting-edge machine learning algorithms [14].

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In the lack of standards, artificial intelligence technologies, especially deep learning, have been extensively used for evaluating and collecting data on COVID-19 performance [15]. A new convolutional neural network (CNN) model called DeTraC was suggested by Abbas et al. (2021) [16] for the purpose of classifying chest X-ray pictures linked to COVID-19. The feature extraction, deconstruction, and class composition methods are the backbone of this model. Using deep transfer learning and several pre-trained convolutional neural network (CNN) architectures to identify CT images, Shalbaf and Vafaeezadeh (2021) [17] created an ensemble model for distinct COVID-19 diagnosis. A deep learning-based approach for anomaly detection in chest x-ray images was created by Zhang et al. (2020) [18] to screen out COVID-19

The most effective method available to medical research is deep learning [13]. It is a quick, effective procedure with a high accuracy rate for diagnosing and prognosticating a variety of ailments. To categorise the inputs into the many groups that the programmers want, there are models that have been specially trained. They have several uses in the medical profession, including the diagnosis of cancer, the use of image processing to detect tumours, and the detection of cardiac issues [14].It is also used for the purpose of distinguishing between positive and negative results in CT scans of COVID-19 infected individuals. In the end, an 82.1% accurate VGG19 model was produced. Additionally, we have run the CT scan picture through a battery of pre-existing models to hone the accuracy. In order to determine whether a picture is positive or negative for COVID-19, we discovered that the VGG-19 model with optimizer Adamax produced the best results, with an accuracy around 94.52%. Here, you can see our suggested model illustrated with figures and tables. A VGG-19 model checks the CT scan for the presence or absence of COVID-19 and assigns a rating accordingly.

The structure of the present research work are as follows: Section 1 include history of COVID-19, and about our model and results, Section 2 include previous research work related to COVID-19 finding. Section 3 include dataset used for present research work. Section 4 includes the details performance analysis of research work and compare the present research work VGG19 model with optimizer Adamax with previously used VGG19 model. Section 5 describe the finding of the research work such as evaluation of results like precision, recall, F1Score and Support, and then we compared the accuracy and loss of model by graphical representation. Section 6 include discussion about research work and result obtained from the present research work. Last 2 sections i.e. 7 and 8 describe the conclusion made from the research work and future scope of research work.

II. Literature Survey

Some deep learning research have suggested analysing chest X-ray and CT images of the lungs to detect the illness, because the COVID-19 virus destroys people's lungs [19]. Stephen et al. (2019) [20] suggested a deep learning model that may identify pneumonia. They suggested a model with flatten layers, dense blocks, and convolution layers. They have a 200 × 200 pixel input image. The final success rate is 93.73 percent. A variety of medical diagnoses have been used to identify persons infected with coronavirus. It seems that the best ways to identify COVID-19 are using a CT scan and X-ray images. What follows is a summary of the studies conducted in this area

The authors Chouhan et al. (2020) [21] introduced a deep learning model that could distinguish between bacterial, viral, and normal pneumonia in pictures. Phase one included the provision of specific preprocessing methods for the elimination of noise in images. The images were further enhanced before being used to train the model. Whopping 96.39% of the time, they get the categories right.

In their 2020 study, Toğaçar, Ergen, and Cömert proposed a deep learning method that might be used to identify people infected with the coronavirus by analysing chest X-ray images. Pictures of normal, pneumonia, and coronavirus infections made up their dataset. A classification rate of 99.27% was achieved by them.

A study conducted by Wang et al. (2020b) [22] examined 325 photos of COVID-19 patients verified by pathogens and 740 images of typical viral pneumonia. A total of 89.5% accuracy in categorization was produced by their internal validation. A total of 79.3% of the time, their external testing dataset was accurate. For this purpose, Zahangir et al. (2020) [24] proposed a deep learning system that can handle many tasks. Their approach included comparisons between CT scans and X-ray images. The results showed that CT scan images are more accurate than X-ray photos, with an accuracy of 98.78% compared to 84.67% with the former. Along with that, they tried to figure out what percentage of areas in CT and X-ray pictures were contaminated.

According to Zheng et al. (2020) [25], a 3D deep neural network might be used to forecast the probability of contracting COVID-19. They trained with 499 CT volumes and evaluated with 131. There was a total accuracy rate of 90.1% for their method. In their 2020 paper, Gifani, Shalbaf, and Vafaeezadeh [26] suggested an ensemble method for choosing the best deep transfer learning combination among many pre-trained convolutional neural networks. This method relies on majority voting. With their approach, they were able to get an accuracy rate of 85% on a CT dataset that included 349 positive and 397 negative occurrences.

A deep neural network architecture was proposed by Mukherjee et al. (2020) [27] for the purpose of analysing chest X-rays and CT images. Their overall accuracy was 96.28% when they used their own dataset

III. MATERIAL AND DATASET

The COVID-19 CT dataset included pictures from individuals who had tried positive for the infection and the RT-PCR technique had verified this result. An analysis of 738 CT scan pictures revealed that 349 photos from 216 individuals tested positive for COVID-19, whereas 397 images were from patients who did not test positive for the virus [21]. In order to train and test the models, the initial 40 COVID-19 positive CT pictures and the 40 COVID-19 negative CT images were visually separated into two sets, with half of the pictures utilized for preparing and half for testing(see Figures 1 and 2, respectively).

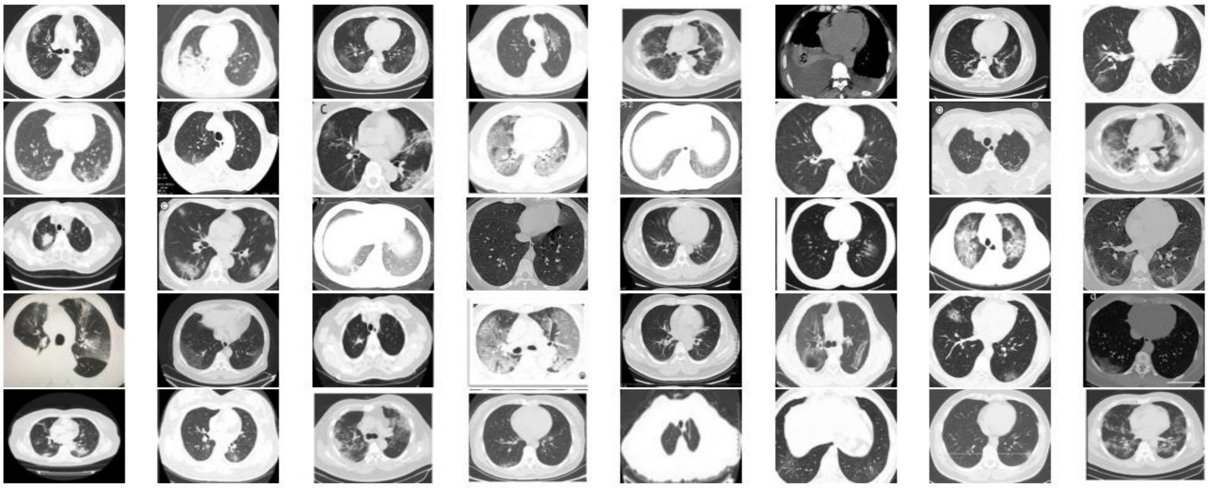


Figure 1: Dataset of Positive Photos for COVID-19

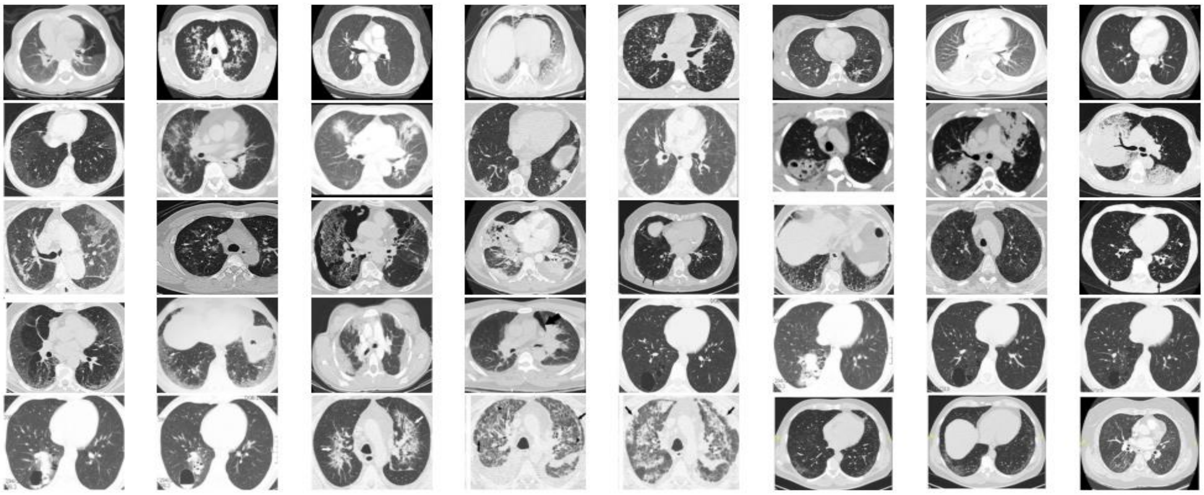


Figure 2: Dataset of Negative Photos Representing COVID-19

IV. PERFORMANCE ANALYSIS

4.1 Performance analysis

Following figure 3 shows that the Process of performance analysis used in this present research work. It include normalization, train and test split of data set, then we have visualized few images (10 CT Scan images) from the split dataset. Then build and visualize the model and train the model after image augmentation, it takes long time to train the present model. Then compared present research work model results with previous research work model. Process explained as follows:

A. Normalization

The CT scan pictures must be converted into an array of pixels before the model can use them, and then they must be normalised.

B. Train Test Split

Dissect the dataset into two parts: one containing photos that are positive for COVID-19 and the other including images that are negative. There was a 50% split in the dataset for testing, and a 50% split for training.

C. Visualize a few CT Scan Images

Visualize few CT Scan Images train and test from dataset for Building and visualization of model.

D. Building and Visualizing model

In previous model we load VGG19 Model, in this present research work we load VGG19 Model in addition to optimizers import Adamax. This is a default optimizer used by system for obtaining better result from the dataset and detection COVID-19 accurately. The model code are as follows:

```
# Extend the architecture

outputs = vggModel.output

outputs = Flatten(name="flatten")(outputs)

outputs = Dropout(0.5)(outputs)

outputs = Dense(256, activation="relu")(outputs)  # Add a Dense layer with 256 units and ReLU activation

outputs = Dropout(0.5)(outputs)

outputs = Dense(128, activation="relu")(outputs)  # Add another Dense layer with 128 units and ReLU activation

outputs = Dense(2, activation="softmax")(outputs)
```

E. Image Augmentation

To train the CT scan image dataset at different positions, angles and flips.

F. Training the Model

Train the VGG19 Model with Adamax optimizer for obtaining loss and accuracy of the model and compare them with previous model.

G. Making Predicions

In this step prediction the patient is COVID-19 Positive or negative by optimizing CT scan image of patients. COVID-19 Positive prediction is 96.28 % after visualization of first image from the selected datasets

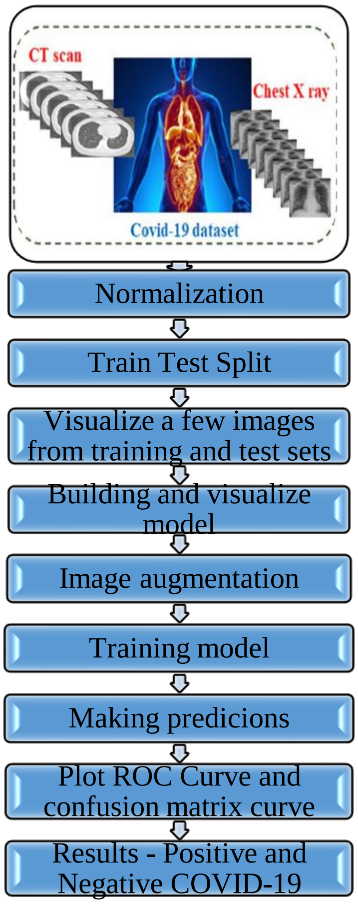


Figure 3: Process of Performance Analysis

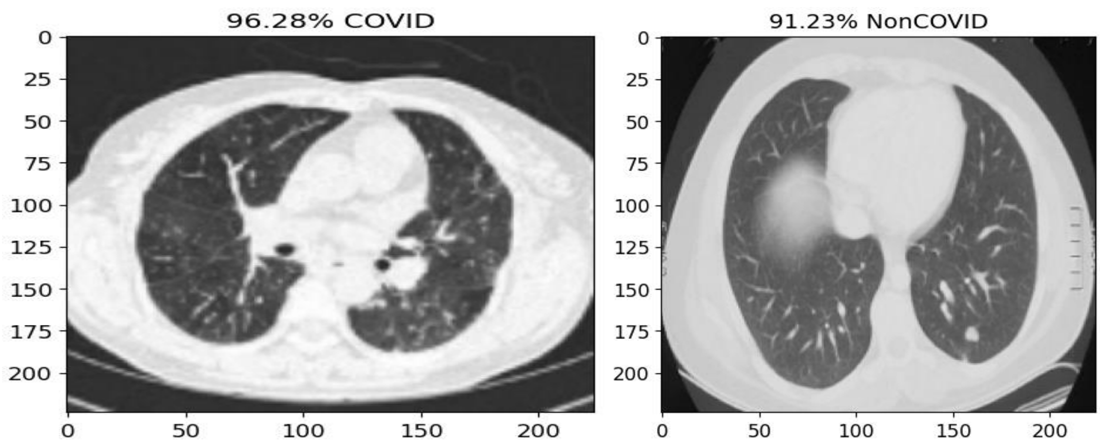
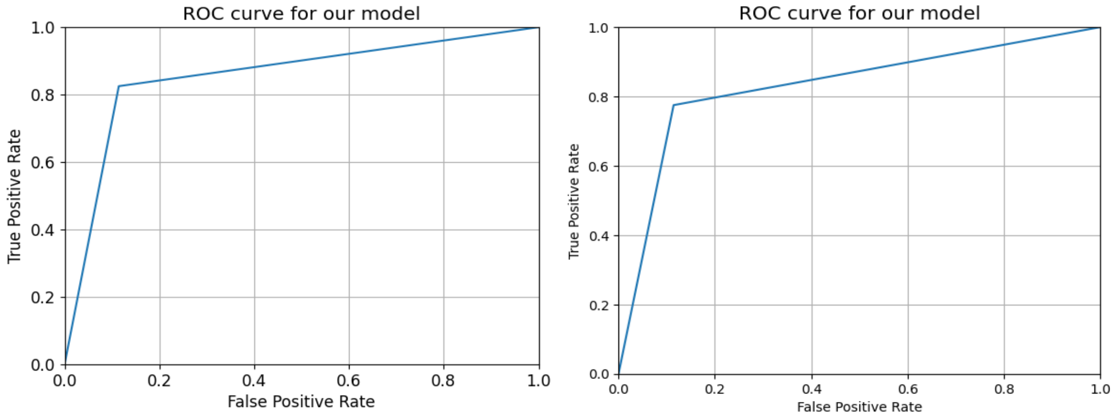


Figure 4: COVID-19 and Nov COVID-19 predicted by VGG19 model

H. ROC Curve of VGG19 Model with Adamax Optimizer and Previous Model VGG19

Figure 5 displays the ROC Curve of the VGG19 Model with the Adamax optimizer and the VGG19 model that was previously employed. The model's True Positive and False Negative rates are shown via the ROC Curve. The VGG19 model with the Adamax optimizer achieves a true positive rate of 85.2% and a false positive rate of 78.4%, compared to the prior model.



a) Present research VGG19 model with Adamax b) Previous research VGG19 model

Figure 5: ROC Curve for model

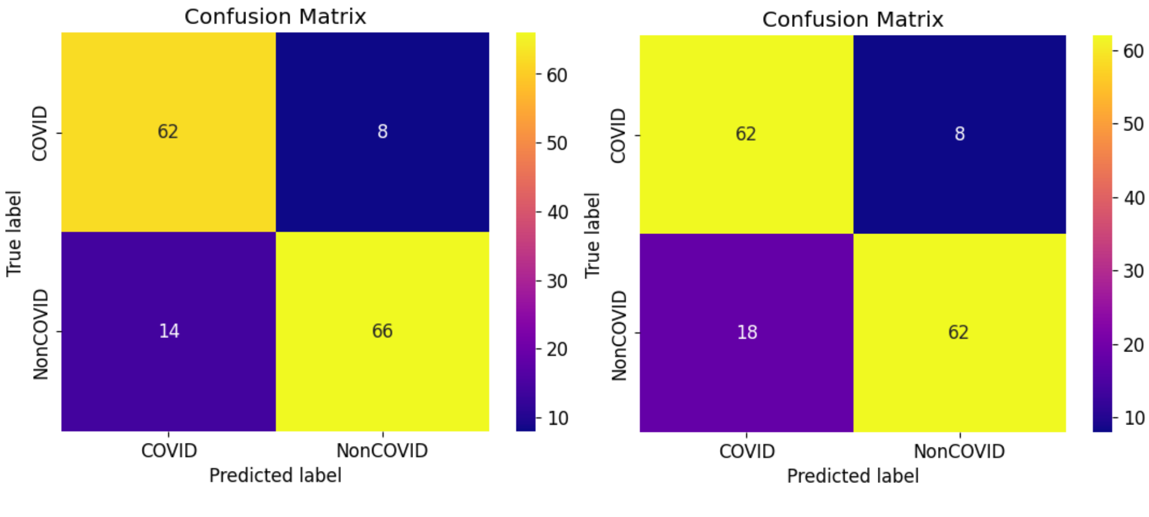
I. Plot Confusion Matrix

a. Confusion Matrix without Normalization

Figure 6 shows that the confusion matrix without CT scan image normalization of present research VGG19 model and previous VGG19 model. VGG19 model with optimizer Adamax obtain better result than previous model. Matric shows that the True label and Predicted label of COVID-19 rate

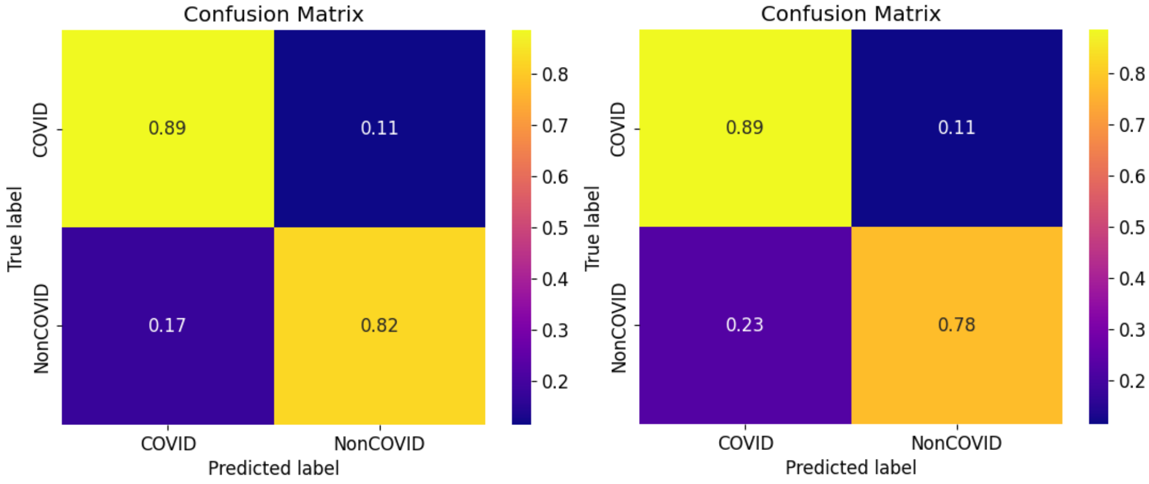
b. Confusion Matrix with Normalization

below figure 7 a) and 7 b) shows that the present research VGG19 model with Adamax optimizer and previous research VGG19 model. Present VGG19 model obtain better true label than previous model.



a) Present Research Model b) Previous Research Model

Figure 6: Confusion matrix without normalization



a) Present research Model b) Previous research model

Figure 7: Confusion matrix with normalization

V. RESULTS AND DISCUSSION

5.1 Classification of Precision, Recall, F-1 Score and Support of the Models

For this purpose, we assess the suggested model using some of the most widely used performance metrics, including precision, accuracy, recall, F1 Score, and Support. They are described from Equation (1) to (2)

$$\text{Accuracy} = \frac{\text{TP+TN}}{(\text{TP+FP+TN+FN})} \qquad \ldots (1)$$

$$\text{Precision} = \frac{\text{TP}}{(\text{TP+FP})} \qquad \ldots (2)$$

Here, TP, TN, FN, and FP represent the following: properly categorised COVID-19 samples; correctly classified non-COVID-19 samples; COVID-19 samples classified as non-COVID-19; and non-COVID-19 samples classified as COVID-19. True Positives (TP), True Negatives (TN), False Positives (FP), and False Negatives (FN) are represented in the confusion matrix by the previous equation

$$\text{F1 Score} = \frac{\text{Precision}*\text{Sensitivity}}{\text{Precision+Sensitivity}}\ldots \qquad (3)$$

Table 1: Comparison of Performance Evaluation Results from Both Models

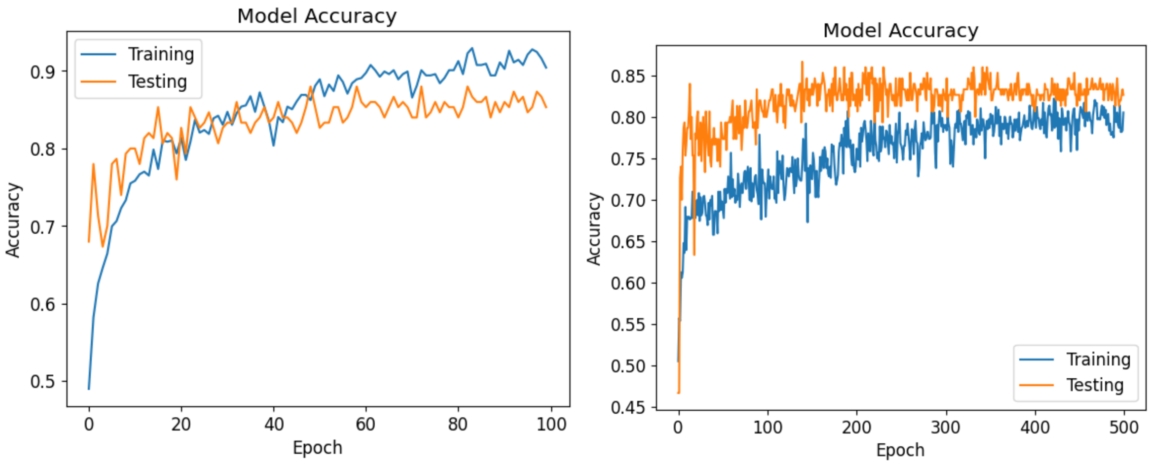
	Precision		Recall		F1-Score		Support	
	A	B	A	B	A	B	A	B
0	0.82	0.78	0.89	0.89	0.85	0.83	70	70
1	0.89	0.89	0.82	0.78	0.86	0.83	80	80
Accuracy					0.85	0.83	150	150
Macro avg	0.85	0.83	0.86	0.83	0.85	0.83	150	150
Weighted avg	0.86	0.83	0.85	0.83	0.85	0.83	150	150

0 – COVID19 Negative, 1- COVID-19 Positive

A – VGG19 Model with optimizer Adamax , B – Previous VGG19 Model

Above table1 shows that the Comparison of Performance evaluation results from both models. According to the table, there are zero situations where COVID-19 was not present and one example where it was. The precision level for COVID19 Negative patients in present model VGG19 with Adamax 0.82 and in previous model is 0.78 and for COVID019 Positive patient it is 0.89 same in old model as well. Recall of the present model VGG19 with

Adamax is more than previous model i.e. 0.82 for COVID-19 Positive patients. Accuracy of the VGG19 model with optimizer Adamax is 0.85 is more than previous VGG19 model (Also shown in Figure 8 a)).F1 score of VGG19 Model with optimizer Adamax is also more than previously used model. Large scale typical and weighted typical for exactness, survey and F1-Score ismore in VGG19 Model with optimizer Adamax than previously used model VGG19 as shown in table 1



a) Present research VGG19 model with Adamax   b) Previous research VGG19 model

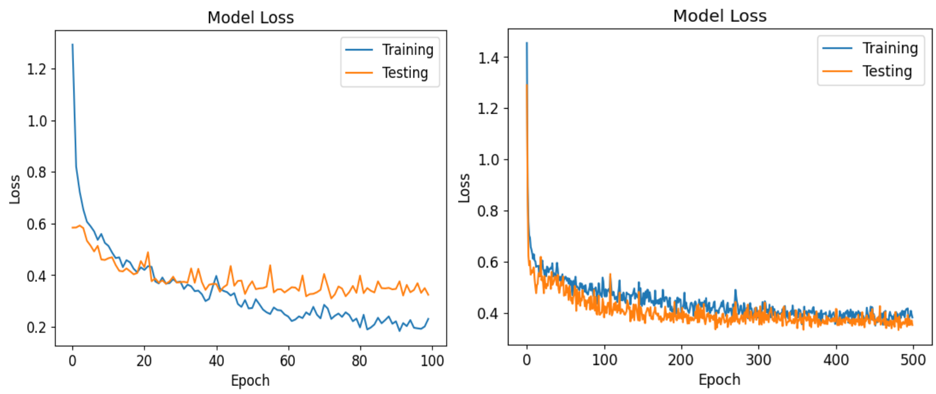
Figure 8: Accuracy plot of present research VGG19 model and previous VGG19 model

5.2 Accuracy and loss plots of models

Above figure 8 a) and 8 b) shows that the accuracy of level by training and testing of CT Images. Accuracy increases with increase in epoch. The accuracy level in Present research model for training is approximately ranges 0.88 to 0.95 and for testing it ranges 0.82 to 0.86 for 60 to 100 Epoch respectively. On the other hand in previous research VGG19 model, the accuracy level ranges 0.67 to 0.73 for training and 0.73 to 0. 83 for testing for 60 to 100 Epoch. The current study model outperformed its predecessor in terms of accuracy, as shown by the graphs

B. Loss plot of models

Following figure 9 a) and 9 b) shows that then loss plot of VGG19 model with optimizer Adamax and VGG19 model respectively for training and testing of dataset for different Epoch. As show in figure model loss in training is more in previous model than current VGG19 model and also same for testing dataset. The model loss decrease with increase in epochs. On the other than hand in previous model loss is constant while increases in number of epochs. In current model, the loss of model is more in testing than training datasets as shown in figure 9 a).



a) Present research VGG19 model with Adamax   b) Previous research VGG19 model

Figure 9: Loss plot of present research VGG19 model and previous VGG19

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5.3 *Discussion*

Utilising CT scan pictures, patients may be checked for the COVID-19 virus. It provides a detailed image of a specific location, allowing us to detect interior abnormalities, injuries, component size, tumours, and so on. CT scans are more reliable than the existing RT-PCR approach. It is an effective strategy for classifying pictures of COVID-19 patients. The VGG19 Model with Adamax optimizer provides accurate and speedy results. There are potential risks associated with CT scan screening, such as radiation exposure if many CT scans are performed. When a virus or illness is detected early on, it is often possible to treat it more effectively. Nevertheless, a misdiagnosis of a big or minor illness might occur from a few modest symptoms. A little virus or a major illness like cancer may both produce early and simple symptoms. It is possible to make a wrong prediction about the patient's prognosis with an early diagnosis of this illness.

Right now, we're using a method that sorts CT scans as either positive or negative for COVID-19. We may integrate many models to evaluate the CT filter for other infections that will support differentiating them from the coronavirus with the use of deep learning methods, such as the VGG19 model with optimizer Adamax. Additionally, our models may be enhanced to categorise COVID-19 positive CT scan pictures according to the extent of the virus's propagation in the lung region.

VI. CONCLUSION

The novel coronavirus (COVID-19) disease begins with a typical cold and progresses to a serious illness that can be fatal. The primary goal in critical COVID-19 situations is to reduce fatalities. Fewer deaths and greater recovery will occur as a consequence of using AI for early diagnosis of COVID-19.

Detecting COVID19 positive cases from CT scan pictures will allow doctors to diagnose patients without having to undergo time-consuming and expensive molecular tests. This paper proposes a machine learning strategy that utilizes deep learning to accomplish this objective.. We run the proposed model many times on a publicly accessible CT imaging dataset to see how it performs. The suggested model is trained using a randomly selected subset of the photos, and its performance is assessed using the remaining images. Other customizable parameters are also covered. The findings demonstrate the suggested model's capacity to classify photos.This suggested model VGG19 with optimizer Adamax is a powerful CAD tool for physicians to utilise since its overall accuracy can easily surpass 95% and its ROC can easily exceed 90%, respectively, when compared to prior models used for research work.

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