How to Cite:
Chimote, G., & Karandikar, A. M. (2022). COVID-19 pneumonia detection using chest X-ray processing. *International Journal of Health Sciences*, *6*(S1), 10546–10560.
https://doi.org/10.53730/ijhs.v6nS1.7541

COVID-19 pneumonia detection using chest X-ray processing

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***Abstract*---**COVID-19 is one of the most fatal diseases and get increases rapidly through close contact with somebody infected or holding virus-contaminated objects. Another infectious illness referred to as Pneumonia is usually caused by infection because of a bacterium within the alveoli of the lungs. When contaminated tissue of the lungs has inflammation. To see if the patient has these diseases, experts conduct physical exams and identify their valetudinarian through Chest X-ray, ultrasound, or biopsy of the lungs. Misdiagnosis, inaccurate treatment, and ignored disease will cause the patient's loss of life. Due to increasingly frequent cases, the number of COVID-19 test kits available in hospitals is decreasing. To prevent COVID-19 from spreading among humans, an autonomous detection method should be established as a quick, alternative diagnostic. For this purpose, three different deep learning models: Xception, VGG16, and Basic CNN have been proposed in this analysis for the diagnosis of patients infected with coronavirus, and pneumonia using an X-rays dataset of 6432 images is applied to prove the execution of the model. Xception model has the best efficiencyamong the two other models (VGG16 and Basic CNN). In terms of predicting cases, however, the Xception network outperformed the other models. As a result, we noticed that on the same dataset, each network has unique capabilities.

***Keywords*---**COVID-19, Pneumonia, Chest X-ray, Deep Learning, Xception, VGG16, CNN.

Manuscript submitted: 27 March 2022, Manuscript revised: 18 April 2022, Accepted for publication: 9 May 2022

Introduction

COVID-19 has been identified by the World Health Organization (WHO) as a virus that has had a major impact on people's daily lives [1]. COVID-19 is a rapidly spreading virus that affects both humans and animals So far, a large number of people have died as a result of coronavirus complications [2]. This was mostly transmitted from person to person. The only means to keep the disease from spreading are social seclusion and self-isolation. Early detection is critical for controlling its spread. Fever, sore throat, headache, cough, and moderate respiratory symptoms, including pneumonia, are all indications of the condition. It's currently a global pandemic that's affecting several countries.Every day, thousands of people are diagnosed with corona positivity, and the number of deaths [3].

Pneumonia can be a life-threatening illness if not diagnosed properly and can result in the death of a person. It is in a form of severe respiratory illness caused by transmittable agents like viruses, or bacteria that affect the lungs [5]. It can be spread through the nose or throat and affect the lungs if they are inhaled or communicated through air-borne droplets from a person coughing or sneezing [6]. The lungs of a person are made up of small sacs or alveoli that supply the air passage whenever a well-fit person breathes. When a person is infected with pneumonia, tissue discomfort produced by alveoli coated in fluids or pus inhibits oxygen intake and makes breathing difficult and painful [6]. Pneumonia is a disease that affects people over the age of fifty and children under the age of five because they have a weakened immune system, and it has claimed the being of over a lakh people worldwide [5].

Polymerase Chain Reaction (PCR) detects a certain coronavirus gene sequence and replicates it numerous times, making it easy to identify. In addition to this PCR test, we can conduct a reverse transcription PCR test. This is done by collecting nasal secretion samples. In addition to these medical checks, it is beneficial to support computer technology such as Artificial Intelligence, since it has the potential to play a crucial role. Artificial Intelligence (AI) is used in cameras to infect patients with travel histories using facial recognition so that we can easily recognize other people who come into physical contact with a corona-affected person, drones to sanitize public spaces, robots to transport meals and medicines to patients, and so on. AI has been used extensively to find novel chemicals in the same way that it was used to locate COVID-19[4].

COVID-19 signs and indications are almost identical to pneumonia, if not properly diagnosed will lead to incorrect diagnosis now that many hospitals around the world are congested. Many of these hospitals are working 24/7 due to the massive increase in infections and most of their medical personnel are also infected with the virus [4]. Imprecise findings of pneumonia or non-COVID-19 may be labeled incorrectly as COVID-19 infected and setbacks in proper treatment are costly, the struggle and risk of being exposed to other positive patients of COVID-19.

Radiological imaging which is easily available in most hospitals is one significant diagnostic instrument for COVID-19. The radiologist captures a chest image of the patient through a radiograph instrument.Radiation is used to create a radiograph image on a thin-skinned film to confirm whether or not a patient is infected with the disease. Even though usual CXR images could assist early signs of suspected cases, the images of various related pneumonia are similar, and they interrelate with other contagious lung illnesses.

Convolutional Neural Networks (CNNs) have shown to be tremendously valuable in feature extraction and learning through training and for that reason, it is commonly implemented in medical research. The application of CNN has improved the image attributes in the environment with low-light conditions, efficient endoscopy video, lung nodule detection, and identification through computed tomography images, and analysis of pediatric pneumonia through X-ray images of the chest. Methods of Deep learning covering the deep CNNs techniques on X-Ray images of the chest are receiving recognition and encouraging outcomes have made it known in diverse applications.

Chest X-rays are famous imaging techniques to diagnose lung-related problems. And considering throat infection and experiencing difficulty while breathing are usually the first major symptoms of COVID-19. Moreover, the cost of diagnosing COVID-19 is costly in some countries and thus, a low-cost method for detecting COVID-19 complications is needed.

Literature Review

CNN, VGG16, VGG19, and InceptionV3. A dataset of 2992 pneumonia and 2972 normal chest x-rays from children with pneumonia was used to train the model. The results were then double-checked using 854 pneumonia and 849 normal photographs. The realm of medicine will directly profit from this paper's automated diagnostic.

Fig.1: Graph of India'sSpread of COVIDdisease cases (23 January 2020 to 5th March 2022)

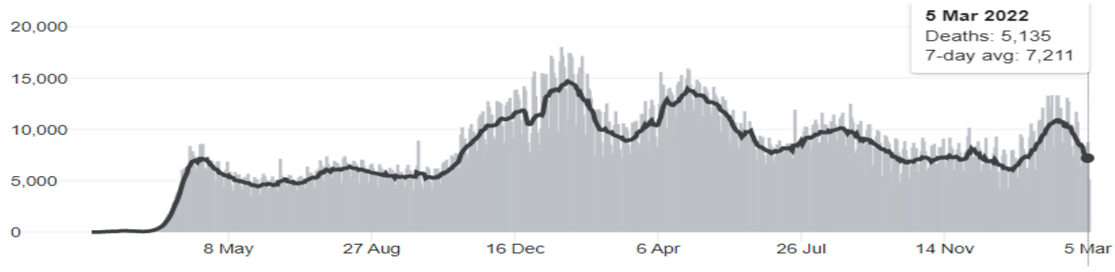


Fig. 2: Graph of India'sSpread of COVID-19 Deaths (23 January 2020 to 5th March 2022)

The paper [4] suggested that the Deep Learning models trained with X-ray images of COVID infected and the non-infected patient are a new promising strategy for early detection and prediction of infection. Persons who have been infected with COVID. They have made use of Transfer Learning as a Concept for Its Benefit reducing the training time for a neural network model of a network Making use of the VGG model According to a study on transfer learning, there is a 95% accuracy rate. The suspected patient's X-ray.

The Writer of the paper [5] shows two definite algorithms: neural networks and logistic regression. To train the model, the author utilized the neural network method and logistic regression as the second algorithm. Which is greater than Neural Networks working. For image analytics project on different chest X-Ray Images for the prediction of pneumonia.

The trained VGG-16 model proposed in paper [6] for the study of COVID-19 detection and pneumonia detection on chest x-ray images using the NN method. The developed CNN model effectively extracted features from an x-ray image and forecasted the occurrence or nonexistence of COVID-19, bacterial, and viral pneumonia. Correspondingly, data augmentation techniques were used to advance the testing data in the study. In addition to the improvement of computer-related applications in the medical division, COVID-19 and pneumonia can be efficiently found by employing chest radiographs with the support of CNN and deep learning technologies.

A picture resizing method based on the max pool function was proposed in the paper [7], which enhanced the classification of pulmonary illnesses in chest X-ray images. Eleven trials including COVID-19 pneumonia image classification were used to test the approach. Patients with lung illnesses, particularly COVID19, could be screened using deep learning classification approaches. First, because pneumonia caused by COVID-19 shares many characteristics with other types of pneumonia, X-ray image classification to identify pneumonia is a difficult and crucial task, especially in a COVID-19 pandemic scenario. Second, there are few photos of COVID-19 pneumonia, which makes it difficult to use a CAD system to support the COVID-19 diagnosis.

This study in paper [8] provides insight into how deep transfer learning approaches can be used to detect COVID-19 at an early stage. The classification efficiency of various BiT models can be evaluated in subsequent experiments by the number of images in the dataset.

The paper [9] has used CNNs to extract features, applying the transfer learning concept, and then classifying these features with Concentered machine learning methods is afruitful way to classify X-ray images as in normal state or positive for COVID-19. The idea shows potency in the identificationof COVID19 in X-ray data.

The study paper [10] indicates that the deep learning convolutional neural network model has the ability to grade the severity of lung infection secondary to COVID-19 accurately, which may have an impact on triaging patients with early exposure and mild symptoms to early care and treatment, and decision making of nature of care as well as evaluating the efficacy of medications.

The approach of recognizing and localizing pneumonia in chest X-rays using DeepConv-DilatedNet was given in the study [11]. (CXR) images. Faster R-CNN is a two-stage detector. As a network structure, this was implemented. Feature The Pyramid Network (FPN) is a part of the A dilated bottleneck's residual neural network as a result of the deep features being stretched to keep the deep feature and its location in the object's information When it comes to DeepConv-DilatedNet is a deconvolution algorithm. To renew high-level features, the network is used. resizes the maps to their original dimensions, and the target Information is saved indefinitely. So, in this case, paper is a more advanced method capable of providing doctors with information.

The concept of pneumonia lesions has been proposed. The study proposed in the paper [12] indicates that it is possible to construct an accurate Using both transfer learning with VGG16 and a variety of data augmentation methods, a CNN model was created.The results show that diagnostic accuracy of the 3-category classification between COVID-19 pneumonia, non-COVID-19 pneumonia, and the healthy was more than 80% in the proposed method. Additionally, COVID-19 has a sensitivity of more than 90%.

The efficiency of this end-to-end classification model and chest X-ray is demonstrated in the paper [13]. images are the best tool for the detection of COVID-19 and the proposed model classifies between COVID-19, Healthy, and Pneumonia patients.

This model has been deployed as an application. The study publication [14] proposes a two-stage deep residual learning approach for detecting COVID-19-induced pneumonia using lung X-ray images. Using the VGG16 model, the researchers were able to distinguish between COVID-19 patients and COVID-19-induced pneumonia patients.

The following is a summary of the proposed work's innovation:

1) Our model can conduct operations without the need for manual intervention, reducing the number of time radiologists spend on detection.

2) We have shown that Xception is a more powerful model than the standard VGG-16 model.
3) To detect COVID-19, X-ray scans of the chest can be utilized as an identification technique.

Proposed Work

Fig. 3: Illustrates the proposed approach for this research. This method is decomposed into different stages: Input X-ray image, pre-processing of chest X-ray images, pre-trained models, Deep Transfer Learning (Training phase), feature extraction, and accurate model prediction.

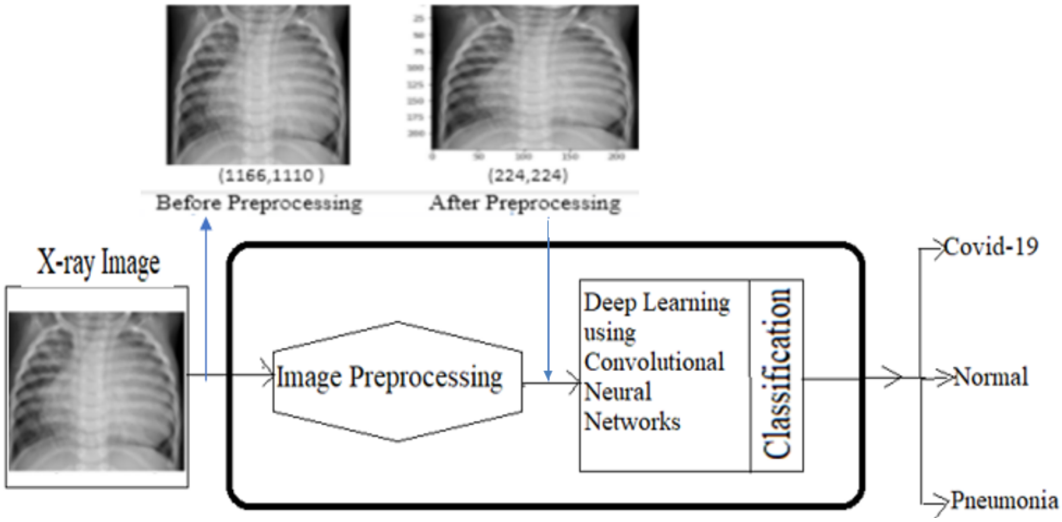


Fig. 3: Methodology of Work

It is a sub-field that takes data and processes it through neural networks in a manner comparable to the biology of human brains. Many biomedical health challenges, such as Pneumonia identification, rely on AI-based computer-aided diagnostics. Models can detect hidden characteristics in photographs that aren't evident or that medical specialists can't find with its capacity to extract features making it useful in several sub-fields of the healthcare system to learn to distinguish between different classes such as the person is affected by Covid-19, Pneumonia, Normal.The data used to carryout the discoveries of this study can be found at https://www.kaggle.com/prashant268/chest-xray-covid19-pneumonia.

Table. I
Distribution of Dataset

Description	COVID-19	Pneumonia	Normal
Train Set	460	855	1266
Test Set	116	3418	317

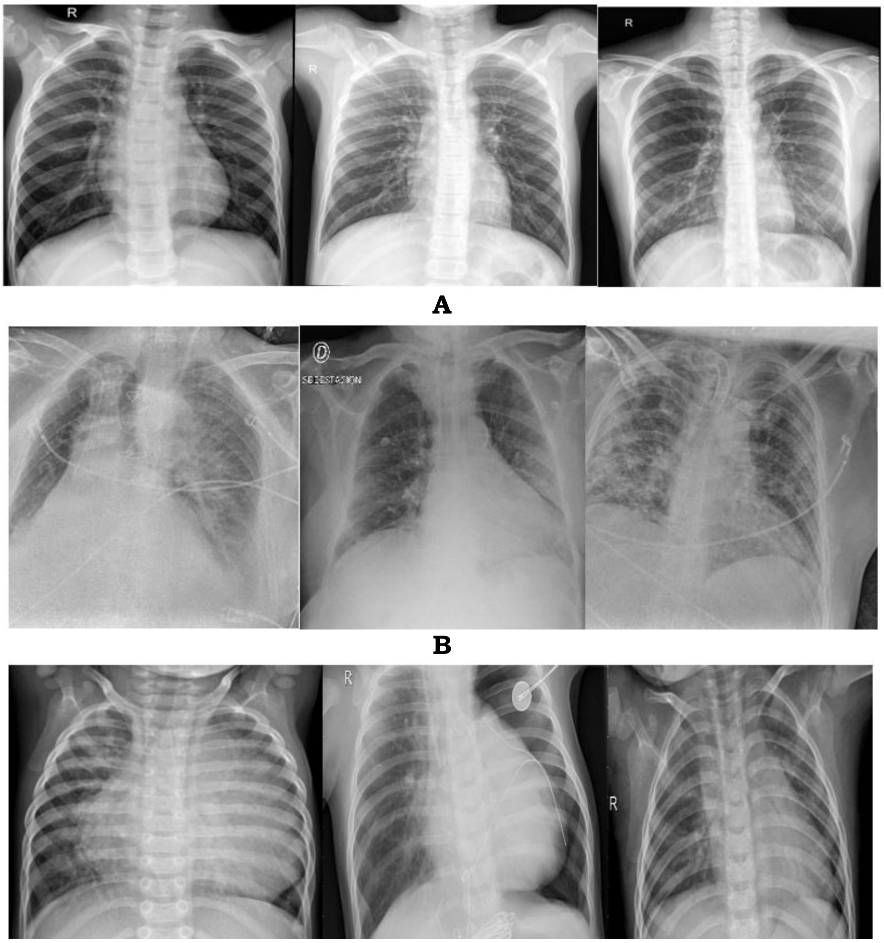


Fig. 4: Sample chest X-ray images from the datasets. A -Shows Normal; B – Shows COVID-19; C - Shows Pneumonia

Convolutional Neural Networks

Convolution was first described by LeCun et al. [15] in 1989. Convolution is simply a mathematical operation in which two matrices are multiplied on an element-by-element basis and then summed [16].

1) *Convolution layer*: In this layer, the filter matrix, which will automatically extract the features from the image with the image matrix is subjected to the convolution process. The filter is the first call on in the image's higher left corner. Here, pixels of the image matrix and filter matrix with the same index are multiplied by each other and all results are summed. This part is then recorded in the yield matrix called the feature map.The filter is then moved to the right, and multiplication operations are performed on a regular basis. At the end of the row, the filter is shifted downwards and the same functioningis repeated from left to right. After all, rows are scanned from left to right with these operations, anda yield matrix is created.

2) *Non-linearity layer*: This layer is used after the convolution layer, and transforms the linear output of the previous layer into a nonlinear structure using an activation function.At the end of a process, the activation function applies the inputs in a non-linear technique. In a CNN, sigmoid activation was utilized in the final layer with two nodes, whereas Rectified Linear Unit (ReLU) activation was applied at the peroration of each layer.

3) *Pooling layer*: Then these filters, average pooling, where the values in the input matrix are averaged, or maximum pooling, where the maximum is taken, is performed.

4) *Flattening layer*: This layer transforms the matrix into a vector by successively adding the rows of the output matrix obtained from One-dimensional data that can be typed into completely connected layers using the precursory layer.

5) *Fully connected layer*:All of these neurons are connected to neurons. By making use of the softmax activation feature. The items are tagged and the classes to which they belong are determined in the final layer. Dropout is a model overfitting reduction strategy. For classification, we employed a dropout of 0.5 in dense layers.

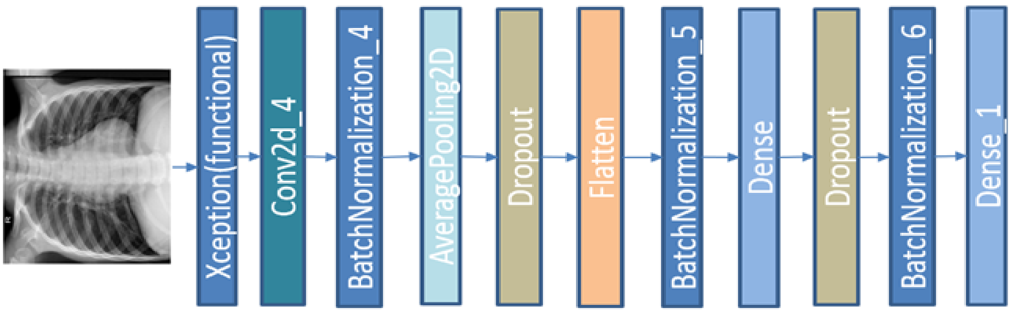


Fig. 5: Xception

*Xception*is a convolutional neural network with inception layers. They argued that the kernel of a convolution layer does not have to be applied to each channel of the input data and that the spatial and channel operations should be separated. As a result, the number of weights was reduced, and models with additional layers were developed. Features [19], Xception had the third-best rection. Xception accepts photos with a fixed size of 299* 299 pixels.The number of restriction in InceptionV3 and Xceptionispracticallyidentical.Our Xception impersonation for identifying COVID-19 and pneumonia is depicted in Fig.5.

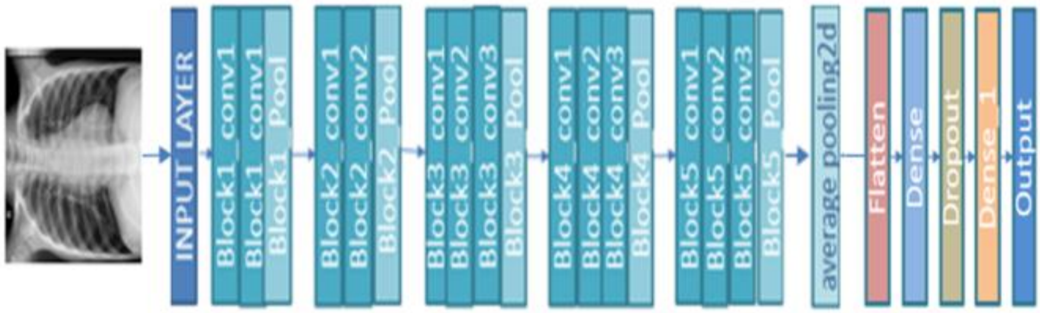


Fig. 6. VGG16

VGG-16 is a Convolution network architecture. Preprocessed using the ImageDataGenerator source Keraspreprocessing.Image size is set as 224*224,as it is the standard input size for a VGG-16 network.With a layer of max-poolingin between, each layer of the convolutionalgroup is partitioned into five groups.Despite fact that just 16 layers weightare present, there are 13-convolution layers, 2-nonlinear layers, 5-max-pooling layers.Average pooling layer with a pool size of (3,3)Flattening is a petition for transforming multidimensional data within one-dimensional data to input it into the next layer.In Dense Layer, the base neural networks have been frozen to preserve weights during the training phase.It is typically taken as about 0.2.Our VGG16 impersonation for identifying COVID-19 and pneumonia is depicted in Fig.6

Result

In this part, you'll find training methods as well as test results.All Chest x-rays are modified for the target network model before the training phase. Because the Xception network permits photos with sizes of 299x299x3, whereas the Vgg16 network accepts images with dimensions of 224x224x3. After each convolutional layer, batch normalization was applied.Second, the dropout detain was activated when all layers were entirely connected. Fig. 7 and 8 show the Xception and Vgg16 networks' accuracy and loss graphs, respectively. The suggested networks are implemented by using Keras's deep learning framework using is carried out in the Python 3 programming language. A machine with an Intel® Core i5 1TB HDD and 16 GB of RAM running on an OS with no GPU is referred to as an environment.

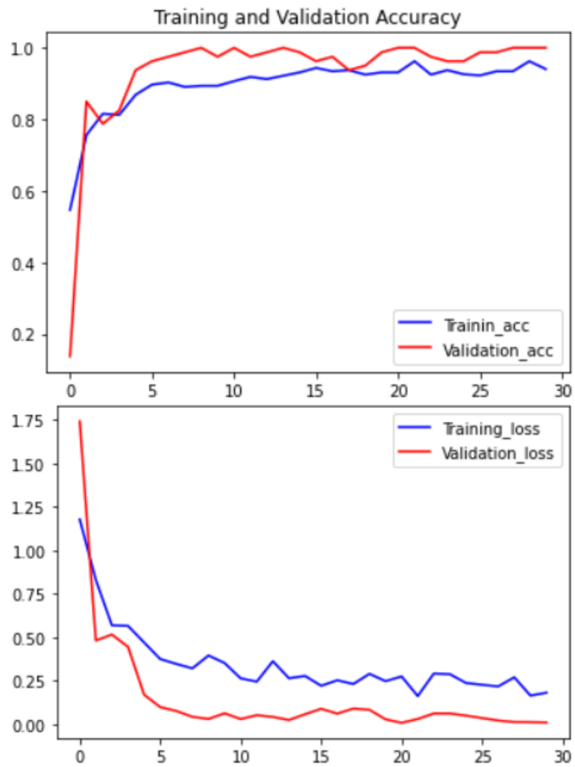


Fig. 7: Xception model's accuracy and loss of graphics

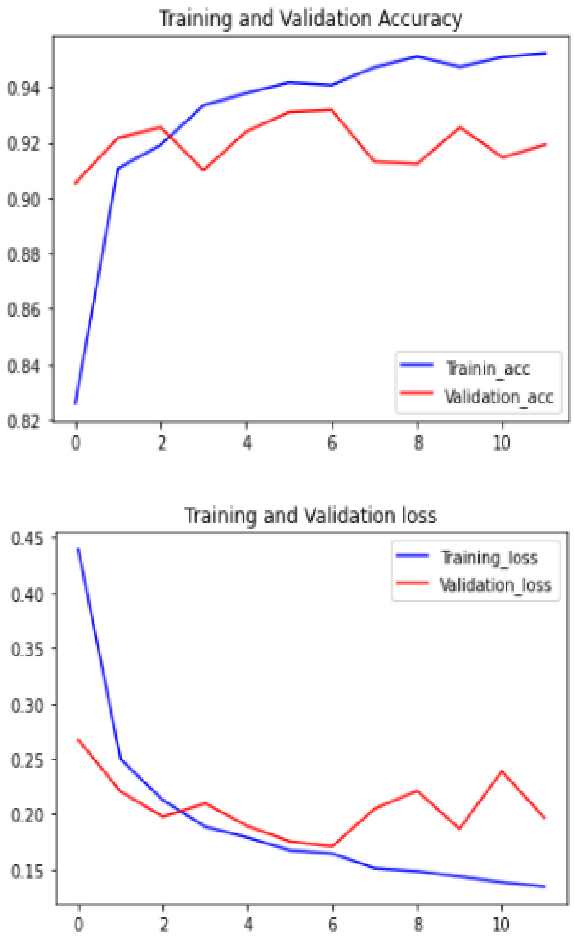


Fig. 8: Vgg16 model's accuracy and loss graphics

Evaluation metrics

The models were estimatedby utilizing stagings typically like f1 score, Precision, Accuracy, and Recall. The model's accuracy refers to how often it is classified properly. This metric can provide a rating that represents the technique's overall quality. True positives mention the count of times the model assort the X-rays rightly (TP).The number of measures the X-rays were misclassified as being from a healthy patient is referred to as false-negative (FN). False positives mention the count of times the model improperly finds a healthy patient (FP). True negatives (TN) are the count of times the model finds healthy patient X-rays that are perfectly identified.(1)–(4) are Formulas.

$$\text{Accuracy} = \frac{\text{TP} + \text{TN}}{\text{TP} + \text{FN} + \text{FP} + \text{TN}} * 100 \quad (1)$$

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

Recall $=\frac{TP}{TP+FN}$ (3)

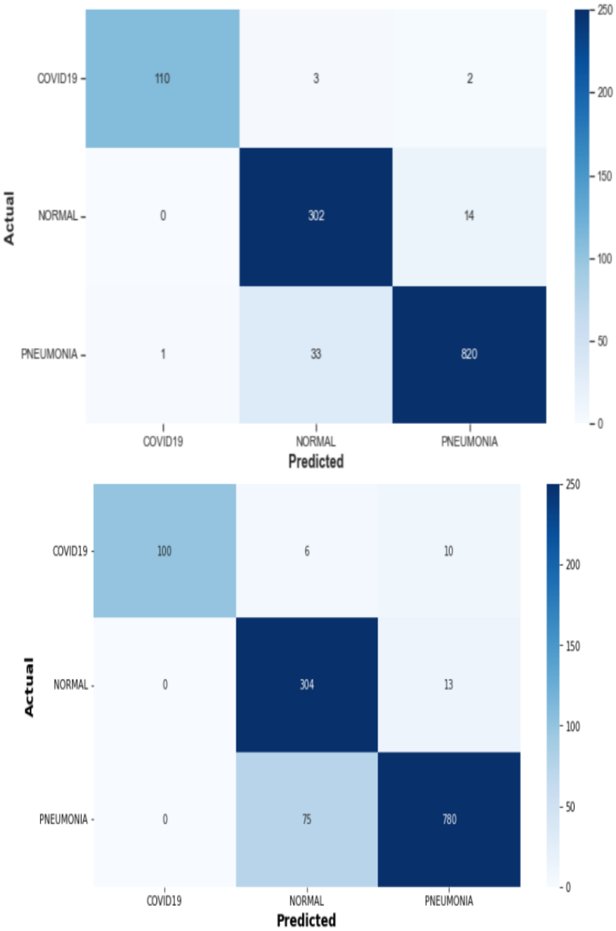
F1 score = 2 * $\frac{Precision * Recall}{Precision + Recall}$(4)

	precision	recall	f1-score	support
0	0.99	0.96	0.97	115
1	0.89	0.96	0.92	316
2	0.98	0.96	0.97	854

	precision	recall	f1-score	support
0	1.00	0.93	0.96	116
1	0.88	0.91	0.89	317
2	0.96	0.96	0.96	855

(a) (b)

Fig. 9: Precision, Recall, F1-score for (a)Xception (b)VGG16



(a) (b)

Fig. 10: Confusion matrix for (a)Xception (b)VGG16

Conclusion

COVID-19 individuals needto be diagnosed instantly to keep away from the diseasespreading to others. We suggested a deep learning strategy based on chest X-ray pictures from Kaggle in this work. The dataset is used to train and test our models.Xception pre-trained model exceeds the other two models' accuracy. In view of our findings, it is believed that the high results will assist doctors in making clinical practice judgments. This research shows how deep learning techniques can be utilized to detect COVID-19 at an early stage. The classification efficiency of models can be evaluated in subsequent experiments by the number of images in the dataset. In the future, we would like to expand the dataset by getting additional X-ray photos of patients with COVID-19, as well as X-ray scans of other lung-related disorders, therefore confirming the effectiveness of the proposed technique.

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