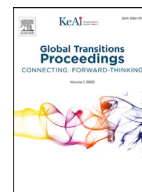




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Comparative analysis of deep learning models for COVID-19 detection

Santoshi Kumari*, Ediga Ranjith, Abhishek Gujjar, Siranjeevi Narasimman, H S Aadil Sha Zeelani

Department of CSE, MSRUAAS, Bangalore, India

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ABSTRACT

Corona virus disease also acknowledged as COVID-19 outbreak, a worldwide pandemic is one of the most acute and severe viruses in recent time. The rate of COVID cases rise rapidly around the world. Although vaccines have been developed, deep learning (DL) techniques shown as a useful method for clinical diagnosis and other fields. Deep structured learning also known as Deep learning is method based on artificial neural network with interpretation learning. This paper aims to do a comparative analysis on medical images like computer tomography scans (CT scan) and X-ray by means of different deep learning systems. This analysis discusses about structures developed for COVID-19 analysis via deep learning performances on Inception, VGG, Xception, Resnet models and provide insights and on data sets to train these neural networks. A comparative analysis is done for considering the better deep learning model for detection. The main aim of this paper is to ease medical experts and help them to understand the ways of deep learning techniques and how they can be prospective used to combat COVID-19.

1. Introduction

World health organization (WHO) declared Novel Corona Virus (COVID-19) as a global epidemic by on March 2020 caused by severe acute respiratory syndrome (SARS-CoV-2 virus) corona virus the first case was reported on Nov 2019 in Wuhan a city in China. Globally 119 million cases and 2.6 million deaths are reported till date and new cases are increasing rapidly [1]. This dangerous virus can transmit easily from person to person in close contact through respiratory droplets recently it is termed as airborne. The showcase of symptoms starts from day 2 to in between 14 days period after close contact to infected person. Most of the people will explore to mild to moderate symptoms and able recover without hospitalization and for aged people and patient with some other disease may require hospitalization. Initial symptoms include Cough, Chills, Headache, Body Pains, Fever, weakness, loss of appetite and serious symptoms includes respiratory problems like chest heaviness, dry sputum segregation results in difficulty in breathing and finally fatal may occur. Covid-19 is detected by conducting RT-PCR test (reverse transcript polymerase chain reaction) by collecting throat and nasal samples from the patients, which takes 2,3 days to for the results to get due to lack of resources availability and tests should be carried out in the restricted and isolated environment which is a major issue [1]. However, the RT-PCR also resulted in False COVID positive in few cases. Solution is to discover of vaccine many pharmaceutical companies are carrying out research on the discovery and some companies have already discovered the vaccines and the clinical trials have been

started all over the world but even though the results are not up to the mark many side effects are showcasing. However, this issue is an ongoing pandemic till the discovery of flawless vaccine. As humans evolved technologies are also evolved. The present era where the modern technologies are high on demand in various sectors. Advancement in modern innovations and technologies has played a vital role in the healthcare sectors basically in disease diagnosis, controlling as well as influencing intelligent healthcare facilities and tools. Especially in COVID-19 diagnosis an evolving technology called Artificial Intelligence played as vital role in the disease diagnosis, previously it was used in medical image analysis and where the results obtained are more accurate and indirectly helped in reducing time consumption and manpower which are the major factors in detection of COVID-19. In the recent development's artificial intelligence techniques like machine learning and deep learning played major roles in the healthcare applications [2]. Recently Deep learning techniques have proved as powerful technique for automatic inspection of COVID-19 showed by X-ray images and CT Scans [4]. These are the two imaging techniques carried out for COVID-19 diagnosis. Few systems which are improved considering Pre-trained models and some using Customized neural networks using deep learning approach with CT and X-RAY specimens as input images. The main purpose is to make a report on reviewing recent developments on COVID-19 diagnosis systems using deep learning based upon collected data.

* Corresponding author.

E-mail address: santoshik29@gmail.com (S. Kumari).

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2. Related works

In this section literature summary is discussed based on model selected for implementing this work.

Islam et al. [1] Comparison of different deep learning technique for diagnosis of novel corona virus (COVID-19). Its main aim is to review recently developed deep learning techniques for detecting COVID-19 with help of medical images like CT scan and X-ray. It is distinguished for insightful data information and addressing the challenges associated with deep learning techniques. In future they state that deep learning techniques and experts provide suitable support system for detecting COVID-19 specially in early stages or at the start when the individual is infected.

Sevi and Aydin [2] With help of deep learning methods on X-ray images and classify them as COVID-19 positive or negative cases. The dataset consists of COVID-19 viral pneumonia, X-ray images and healthy patients. Before pre-processing the data is augmented methods are applied to the dataset. Through multi class Classification deep learning model. 657 images of X Ray are classified and have been observed for analysis of COVID-19. Authors have used vgg19, and it is the most successful model, and it has 95% accuracy rate in upcoming time the success ratio can be increased by consolidation of the data dataset and developing different deep learning models.

Huang et al. [3] Convolutional neural networks have become the dominant machine learning approach for visual object recognition. Recent works on the networks can be significantly deeper more precise and efficient to train. In this paper dense net dense convolutional neural networks are introduced which connects each layer to every layer in a feedforward fashion. Dense net has amassing advantage as they reduced the disappearing gradient problem and boost feature reuse. This paper is evaluated our proposed architecture for 4 highly benchmark task i.e. CIFAR-10, CIFAR100, SVHN, Image Net.

Anwar and Zakir [4] COVID-19 mostly infects lungs. they have taken a CT scan images for testing COVID-19. Methods like deep learning are used for diagnosis c subjected by CT scan. Efficient Net deep learning model is used for precise recognition of COVID-19 with accuracy of 89.7%, F1 score 89.6 and AUC at 89.5%. Three different strategy strategies rate are used such as cyclic learning rate, constant rate and reduce on plateau.

Yousefzadeh et al. [5] Convolution neural networks used to detect COVID-19 using CT scan. They present an Artificial intelligence Corona and assist radiologist by means of deep learning outline in CT scan. Data to be 2121 axial spiral CT scans in three classes. Normal, COVID positive, COVID negative. The data set is separated into 1764 training and 357 images for validation.

Jamshidi et al. [6] COVID Outburst has placed the world in an unprecedented condition. This paper concentrates on response of the virus using Artificial Intelligence. Deep Learning approaches such as Generative Adversarial Networks (GANs), LSTM (Long Short-Term Memory) and Extreme Machine Learning is used for diagnosing and treatment.

Hall et al. [7] X-Ray images dataset for diagnosis using the DL methods. Here it shows how advantageous chest X-Ray images are in analysis COVID-19 disease. Here dataset of COVID-19 chest X-Rays 135 images and chest X-Rays of pneumonia 320 images are used and analyzed.

Brunese et al. [8] Adoption of X-Rays and using Deep Learning Methods. Here three phases of approach are used in which detection of chest X-Ray pneumonia in phase-I, distinguish between COVID-19 and pneumonia in phase-II. Phase-III is to localize the area of COVID-19 presence.

Alazab et al. [9] Method for detection is done with deep learning methods and 1000 images is used as dataset. Here three forecasting methods are used i.e., ARIMA model, the Prophet algorithm (PA) and LSTM.

Haghanifar et al. [10] Detection of COVID-19 using X-Ray images. A dataset of 780 images is used. Here CheXNet model is applied to develop COVID-CXNet. This model can perceive corona virus pneumonia based on features and location.

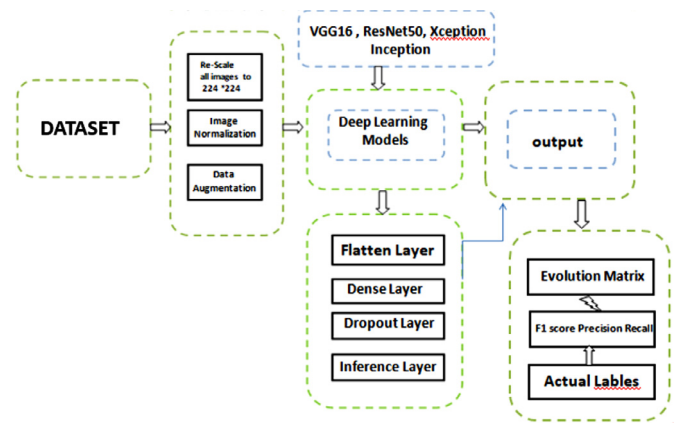


Fig. 1. Block diagram.

Irmak et al. [11] In this method of COVID-19 detection Convolution Neural Network model is used by using publicly available datasets. Here authors have achieved an accuracy of 99.72%. Stochastic Gradient Descent Momentum (SGDM) is used as the optimization method.

Zhang et al. [12] The viral pneumonia is differentiated from non-viral pneumonia. Here the confidence aware Anomaly detection (CAAD) model is used. Here accuracy of 83.61% and sensitivity of 71.7 is achieved.

Karhan and Fuat [13] ResNet-50 model, which is a type of Convolutional Neural network is used. The image dataset consists of X-Ray images.

Khan et al. [16] A 3D-Deep Learning model is used i.e., a reliable method known as Computed Tomography (CT) imaging to detect corona virus precisely. In this method it automatically screening of coronavirus patients using 3D volumetric data.

Shoeibi, et al. [19] X-Ray and CT imaging modes are used to attain a quick and accurate result. Here literature survey is done and methods from Artificial Intelligence, Machine learning, Deep Learning are taken in consideration.

3. Methods and methodologies

Novel Corona Virus is a present global pandemic where entire world is suffering. Deep learning techniques can solve the complex problems by learning from the simple representations. As deep learning techniques have the capable of learning exact representation and the learning the data in a process where the multiple layers are used consecutively made the deep learning so popular. Implementation of existing deep learning models as ResNet50, VGG16, InceptionV3, Xception and compare their performance and analyze as shown in Fig 1.

Convolutional neural network (CNN): CNN is a type of Deep Neural Network, normally pragmatic to analyze visual imagery. CNN are very alike to normal Neural Networks. It consists of neurons that are pre trained about the data. Every neuron takes nearly inputs, dot product function is shown and achieves it non-linearly. A single differentiable function is shown by the entire network. Raw image pixels on one point to scores of the class at the other. Loss function like SVM/SoftMax are utilized and at the last fully connected dense layer is applied.

4. Dataset description

The Dataset was gathered from various open-source web applications such as Kaggle and GitHub 4000 image Dataset were collected. Positive for COVID and negative for COVID. 2000 Chest X-Ray images were collected which contained positive and negative COVID cases. 2000 CT Scan images were collected which contained both positive and negative COVID cases.

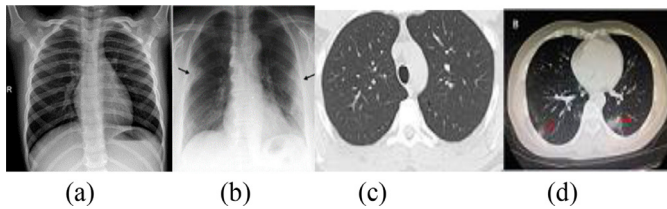


Fig. 2. (a) Negative, (b) Positive for X-Ray data, (c) Negative (d) Positive for CT-scan dataset.

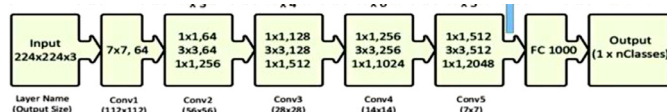


Fig. 3. Resnet50 architecture.

Implementation of four types of Deep Learning Models for Comparative Analysis for dataset sample shown in Fig 2. Added 3 custom layers to the pretrained models so that they can be trained on our dataset [14–16]

4.1. Resnet-50

Resnet-50 is a kind of Convolution Neural Network which was introduced by Kaiming He in 2015 and stands for Residual Neural Network which has 50 Deep Layers. In this Model there are blocks which are known as Convolution Block and Identity Block. Skip Connection is the concept used in Resnet-50. Out of the 50 Layers, 48 are the Convolution Layers, 1 Max pool layer and 1 average pool layer. ImageNet Database containing a more than a million cases can be loaded and pre trained [17–19].

This Architecture or this Algorithm is used mostly in image classification, object localization and object detection as shown in Fig 3. It consists following elements.

A kernel size 7×7 and different 64 kernels giving us 1 layer.

In the second convolution, 1×1 , 64 kernel following 3×3 , 64 kernel and at last 1×1 , 256 kernels giving 9 layers.

In the third convolution, 1×1 , 128 kernel following 3×3 , 128 kernel and at last 1×1 , 512 kernels giving 12 layers.

In the fourth convolution, 1×1 , 256 kernel following 3×3 , 256 kernel and at last 1×1 , 1024 kernels giving 18 layers.

The fifth and sixth convolutions giving 9 layer and 1 layer total comprising of 50 layers.

4.2. VGG 16

VGG-Visual Geometry Group developed at Oxford university by Karen Simonyan and Andrew Zisserman 2014. They have also published a research titled “Very deep convolutional networks for large scale image recognition”. This paper won the challenge in 2014 named ImageNet Large-Scale Visual Recognition Challenge (ILSVRC). The block model accomplishes 92.7% accuracy the top-5 tested in a database over a million images fitting 1000 classes called ImageNet. This network is categorized by its simplicity and uniform architecture. This model uses 3×3 convolutional layers weighted on top of each other in growing depth. It makes an improvement against Alex Net by replacing the large kernel size filter [20–22].

This network consists of 16 convolutional layers stacked one after the other with a kernel size of 3×3 . This model increases the number of feature map or convolutions as the network depth increases as shown in Fig 4. This network has 138 million parameters. The input layer is of 224×224 RGB (Red, Green, Blue) image. The input image passes by a layer of convolutional network layers. The 1st and 2nd stack of convolutional layer contains 2 convolutional stacks followed by maximum

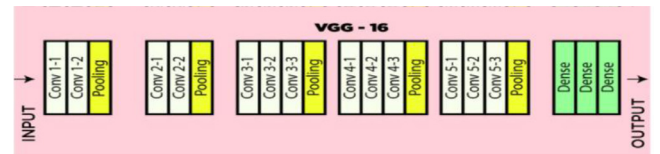


Fig. 4. VGG16 architecture (For interpretation of the references to color in this figure, the reader is referred to the web version of this article.).

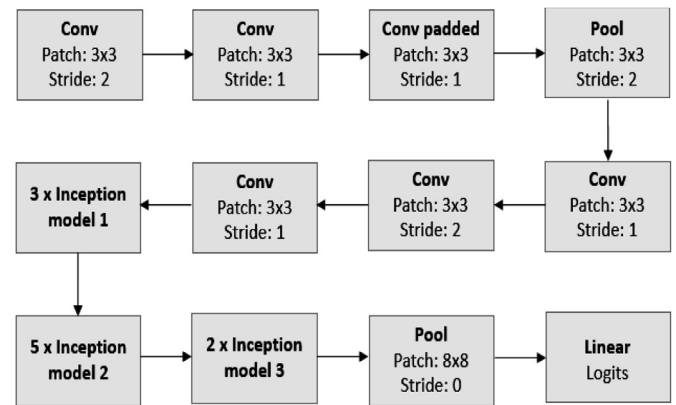


Fig. 5. Inception v3 architecture.

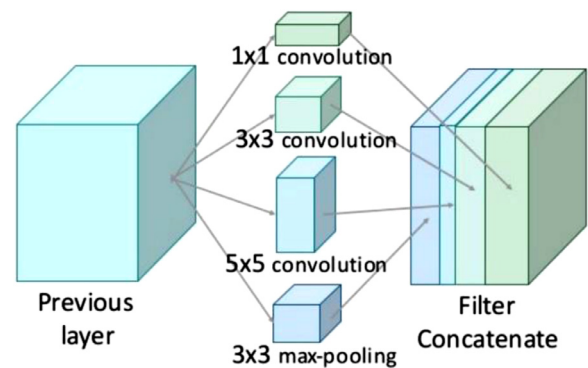


Fig. 6. Xception architecture.

pooling layer. 3rd, 4th, and 5th stack of convolutional layers contains 3 convolutional layers followed by max pooling layer. The last layers are completely connected dense layers as to obtain the output. As in above, the architecture can be seen in a uniformity.

4.3. Inception V3

It is also a type of CNN which is heavily engineered. Its constant development led to discovery of other models which are inception V2, V3, V4 and inception Resnet where the new model is the development of the previous model. Both inception v1 and v2 consists of 27 layers including the pooling layers. In V1 model there was auxiliary loss which is completed in inception V2. Inception V3 is of 48 layers deep including the pooling layers.

This architecture is a Convolutional Neural Network type of architecture as shown in above Fig 5.

It is 48 layers deep including pooling layers. This model is most widely used model for image data recognition model as it shows greater than 78.1 accuracy on Image Net dataset. Consisting of asymmetric and symmetric building blocks which includes fully connected layers, average pooling, and convolutions. It consists of three sizes of filters i.e., 1×1 , 3×3 and 5×5 .

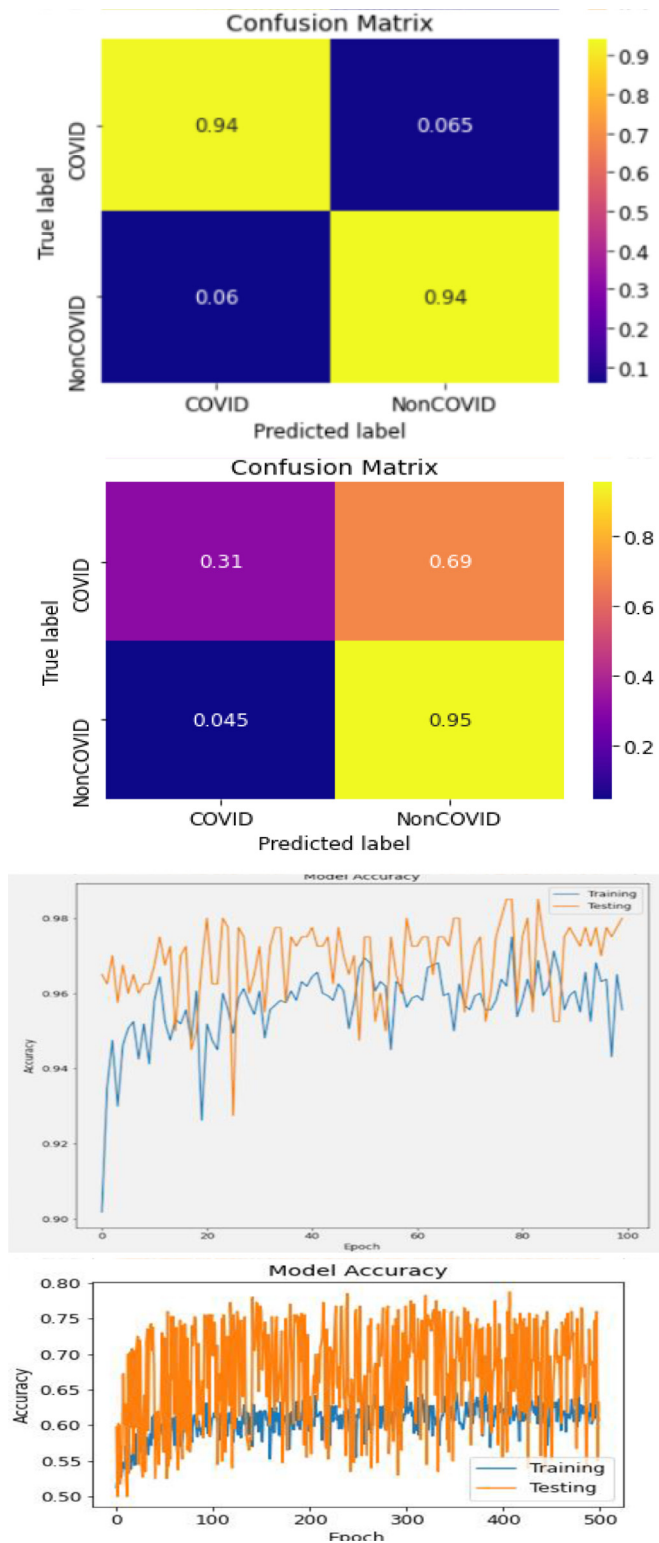


Fig. 7. Confusion matrix and model accuracy for X-Ray and CT-Scan dataset respectively for Resnet50 model.

4.4. Xception

Xception Model is proposed by Francois Chollet. Xception is an augmentation of the initiation Architecture which replaces the standard Inception modules with profoundity astute Separable Convolutions. This is the Pre-prepared Xception Model for Image Classification. For Image

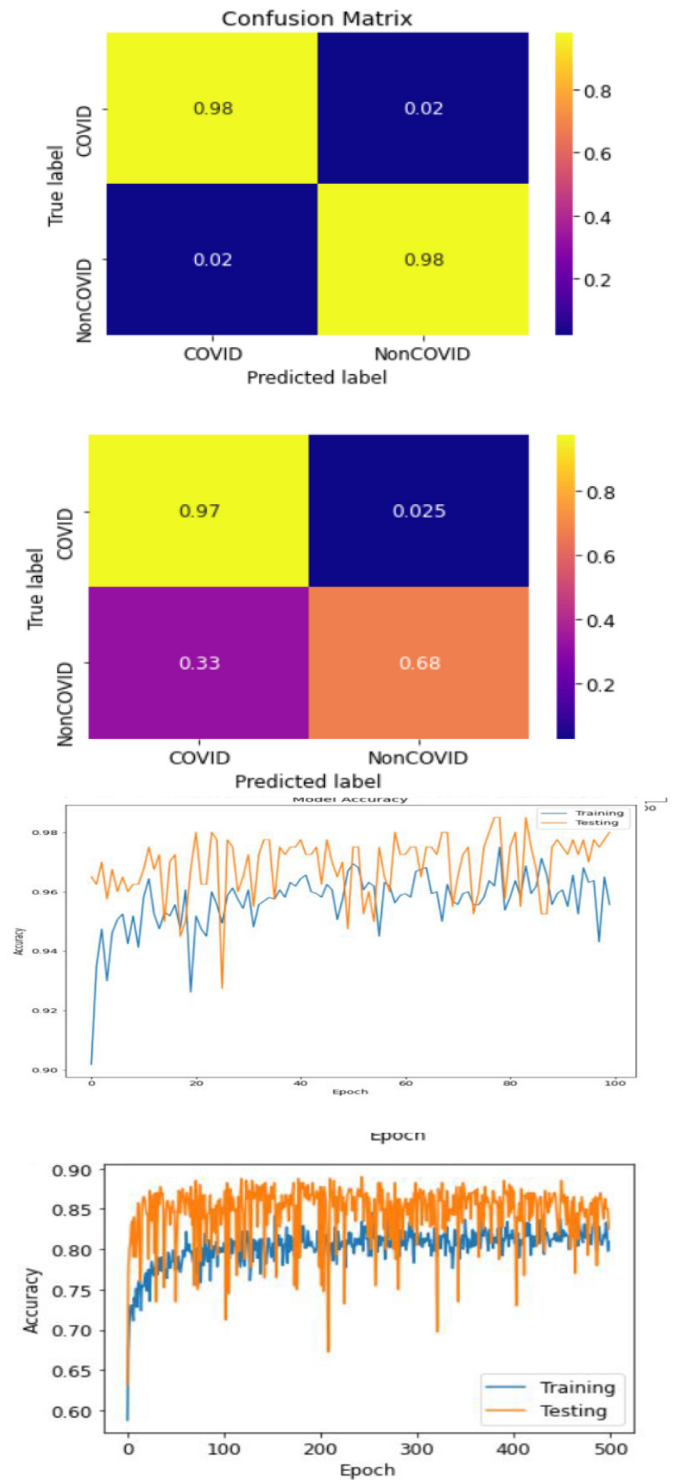


Fig. 8. Confusion matrix and model accuracy for X-Ray and CT-Scan dataset respectively for VGG16 model.

Recognition, we can utilize pre-prepared Xception models accessible in the Keras center library. This will take you to foresee pictures utilizing Xception Model Which is pre-prepared on the ImageNet information base with profound learning library.

Xception is a convolutional neural organization that is 71 layers profound. You can stack a pretrained adaptation of the organization prepared on more than 1,000,000 pictures from the ImageNet data set. The architecture is shown in above Fig 6.

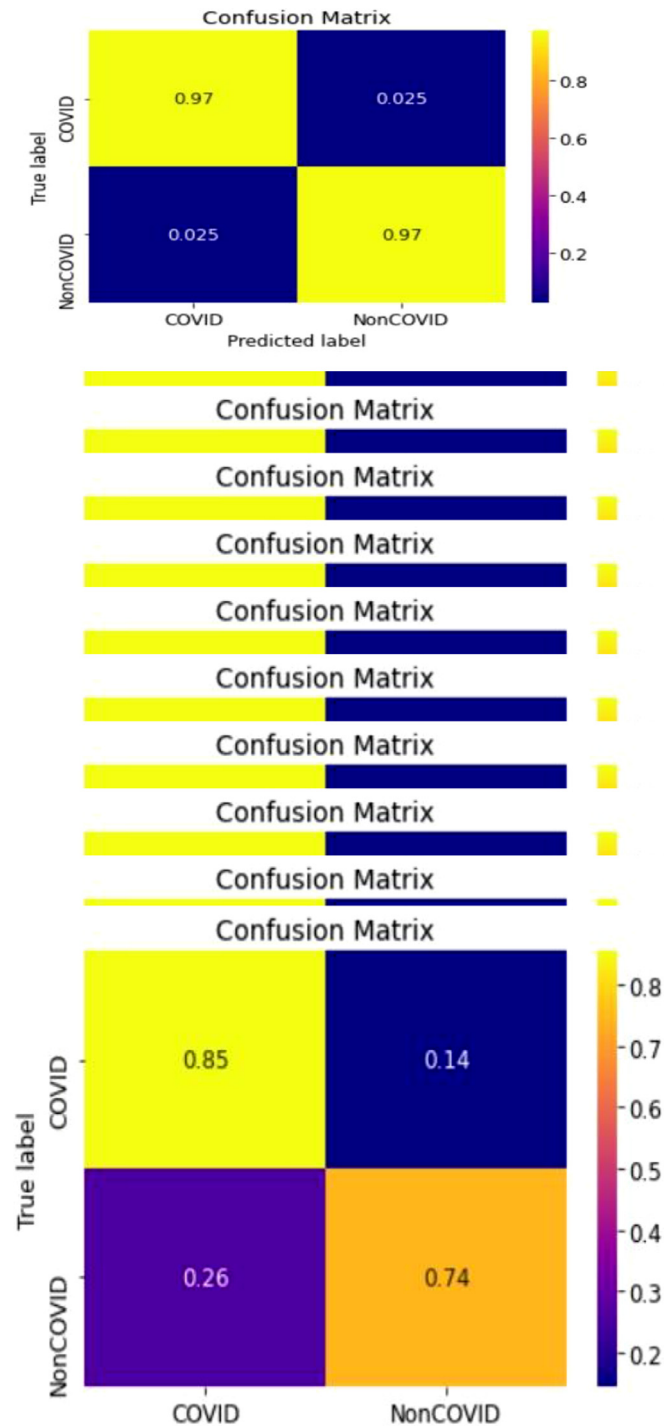


Fig. 9. Confusion matrix and model accuracy for X-Ray and CT-Scan dataset respectively for Inception model.

5. Results and analysis

The Comparative analysis for COVID-19 recognition by means of Deep Learning models is executed and the results are as shown individually. Dataset of 4000 images containing 1000 positive and 1000 negative in each X-Ray images and CT scan images. The accuracy of a dataset model is defined and measured using certain parameters which are as follows.

Precision: It is the fraction of the relevant instances among retrieved instances. It is calculated by true positives divided by total number of

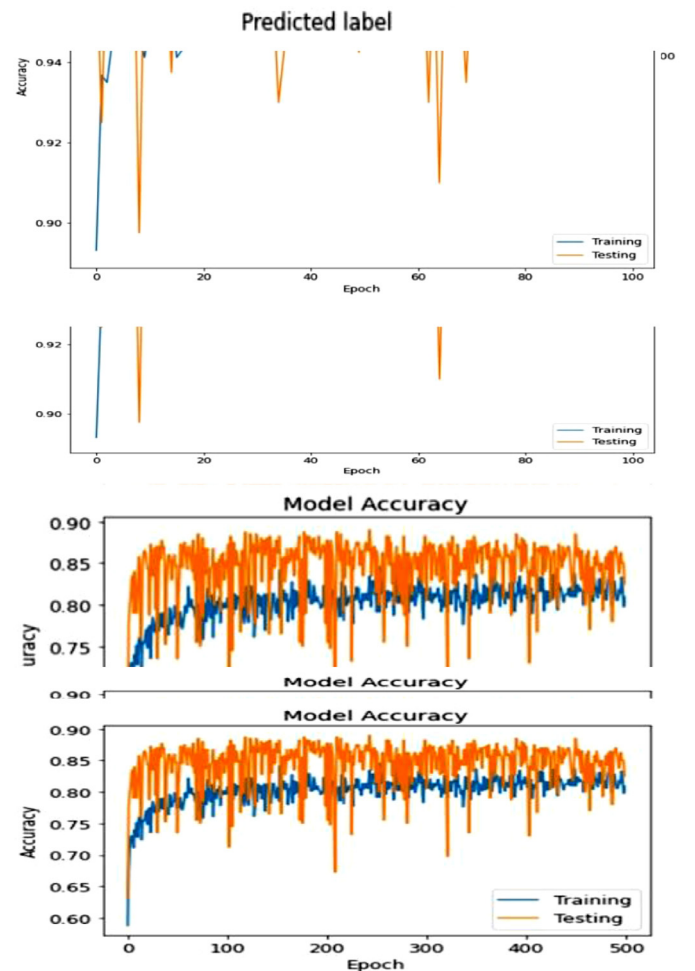


Fig. 9. Continued

true positives and false positives.

$$\text{Precision} = TP / (TP + FP) \quad (1)$$

Recall: Recall is formulated by number of true positives divided by sum of number of true positives and false negatives.

$$\text{Recall} = TP / (TP + FN) \quad (2)$$

F1score: F1 score is well-defined as the harmonic mean of recall and precision. F1 score is 1 only when both precision and recall are 1.

$$F1score = 2 * P * R / (P + R) \quad (3)$$

$$P = \text{Precision}, R = \text{Recall}$$

5.1. Resnet-50

The confusion matrix and accuracy model for X-ray and CT scan dataset, RESNET-50 model is shown above Fig 7 respectively. For X-ray dataset 100 epochs and for CT-scan dataset 500 epochs are applied and achieved an accuracy of 94% for X-Rays and 63% for CT Scan.

The confusion matrix and accuracy model for X-ray and CT scan dataset, VGG 16 model is shown above Fig 8 respectively.

For X-ray dataset 100 epochs and for CT-scan dataset 500 epochs are applied and achieved an accuracy of 98% for X-Rays and 82% for CT Scan.

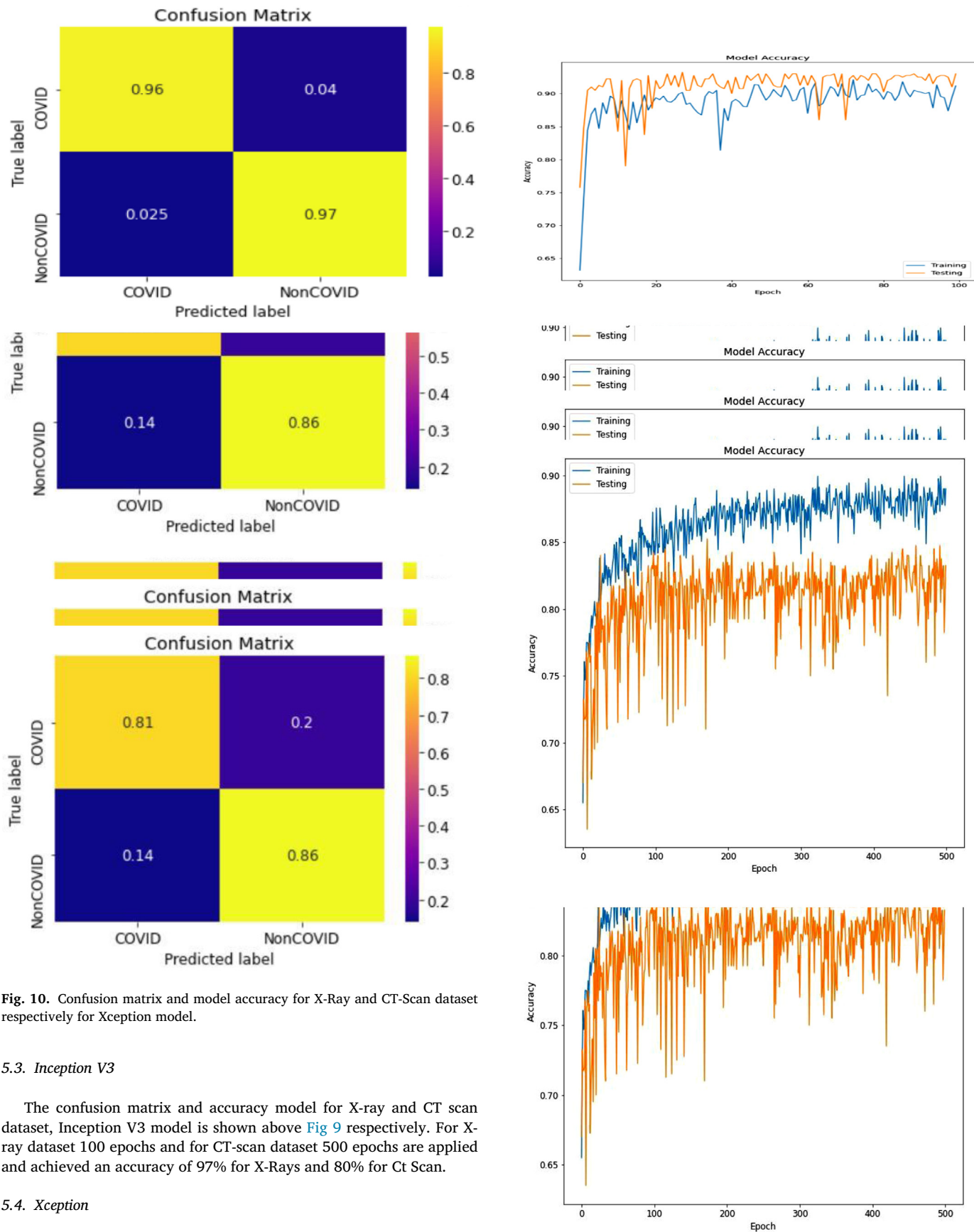


Fig. 10. Confusion matrix and model accuracy for X-Ray and CT-Scan dataset respectively for Xception model.

5.3. Inception V3

The confusion matrix and accuracy model for X-ray and CT scan dataset, Inception V3 model is shown above Fig 9 respectively. For X-ray dataset 100 epochs and for CT-scan dataset 500 epochs are applied and achieved an accuracy of 97% for X-Rays and 80% for Ct Scan.

5.4. Xception

The confusion matrix and accuracy model for X-ray and CT scan dataset, Xception model is shown above Fig 10 respectively. For X-ray dataset 100 epochs and for CT-scan dataset 500 epochs are applied and achieved an accuracy of 95% for X-Rays and 95% for Ct Scan.

Fig. 10. Continued

Table 1
Comparative analysis.

DL MODELS	X-Ray	CT Scan
RESNET-50	94 %	63 %
VGG-16	98 %	82 %
INCEPTIONV3	97 %	80 %
XCEPTION	97 %	83 %

5.5. Comparative analysis

The execution for recognition of COVID-19 using various deep models is as shown in the above Table 1. Comparing the above table VGG16 is accurate on X-Ray image dataset and Xception model is accurate on CT-Scan dataset.

6. Conclusion

Novel corona virus is a current emerging pandemic disease that, with in brief span of time, it can seriously endanger the health of many humans during the world pandemic. It has direct effect on lung cells, that may harm extremely, and if no longer identified early. It will result in irreversible harm, which includes death. The virus is diagnosed using X-ray or CT pictures collectively with PCR effects. The PCR effects imply the form of lung disease which include pulmonary tuberculosis, as opposed to COVID-19. In this examine, a complete evaluation of the performed research of COVID-19 diagnosis is carried out deep learning networks. The public databases are available for diagnose and are expecting COVID-19 are presented. One of the demanding situations to increase a sturdy and accurate COVID-19 diagnosis system is the availability of an extensive public database. We strongly sense that, with extra public databases, higher deep learning modes may be evolved via way of means of researchers to stumble on and are expected to detect COVID-19 acceptably. Hence, this could assist to increase the excellent acting version. We sense that records fusion fashions can assist to enhance the overall performance of prognosis and prediction. The capabilities extracted from the ml and dl ways may be fused to increase a correct version. In this examine, we brought 4 powerful deep learning models for COVID-19 detection the usage of CT and chest X-ray images. Comparative analysis has been carried out for each CT and chest X-ray the usage of 4 different deep learning models. On evaluating we concluded that the usage of chest X-ray as enter the fashions performed extra accuracy than CT pictures. Vgg16 performed as an alternative excessive COVID-19 detection accuracy of 98% for X-ray image dataset and xception performed 83% accuracy for CT-scan dataset. The purpose of this study is to provide radiologists, data scientists and research community with a simple deep learning model which can be adopted for early diagnosis of COVID-19. The collected dataset is good enough furthermore images can be collected in future and further investigation also need to build a more accurate models which can achieve better results. Also, in future one can develop a system to deploy and run the models which are proposed on current amazing advancements, like smart phones and tablets. Hope that the outcomes introduced in this examination will be the little advancement towards building a complex COVID-19 illness identification from X-ray or CT images sooner than later to save however many live as could be expected under the circumstances (Eqs. (1)–(3)).

Declaration of Competing Interest

None.

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