Automatic Detection of COVID-19 based in Artificial Intelligence Tools

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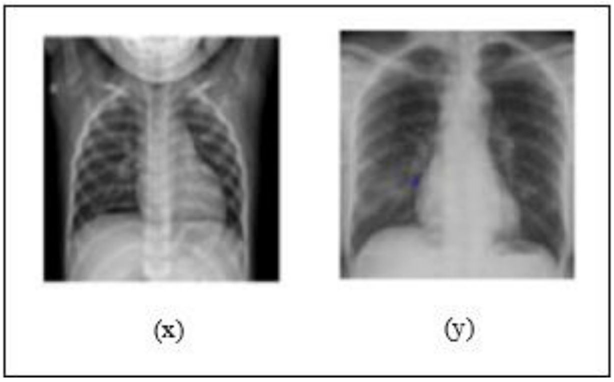
Abstract: The corona virus (COVID-19) spread speedily over the world and eventually became a pandemic. It has had a terrible impact on people's lives, public health, and the global economy. It is vital to find positive cases as soon as workable to prevent the pandemic from spreading further and to treat patients as hurrying as possible. A chest X-ray exam can detect this condition, which should be treated appropriately. Using a multilayer Perceptron (MLP) Neurons Network and a Convolutional Neural Network (CNN). in this study we present an automatic detection approach for COVID-19 infection based on chest X-ray images. The two models are evaluated in two classes, COVID-19 and normal X-ray images, with 95,7% accuracy for MLP model and, 90% accuracy for the CNN model.

Keywords: Artificial Intelligence, COVID-19(Coronavirus), Detection Approach, MLP Neural Network, X-rays images (CXR), Machine learning, CNN.

1. Introduction

In 2019, the tale coronavirus (COVID-19) began to spread in China as the starting point, and also in many other countries across the world [1 & 2]. Early automatic diagnosis of this disease could be very helpful in limiting its spread. Machine Learning is one artificial intelligence method that can help in the detection of COVID-19 infections in medical images like chest X-rays. An X-ray is an imaging technique used to investigate fractures, bone displacement, pneumonia, and tumors. X-rays have been used for many decades and provide an impressively fast way of seeing the lungs, making them a useful tool in the detection of COVID-19 infections[3-4]. They are capable of producing images that depict lung damage, such as that caused by Coronavirus (COVID-19) pneumonia [5]. CT scans make use of the principles of X-ray in an advanced manner to examine the soft structures of the body. It is also used to get clearer images of organs and soft tissues [6-7]. However, X-rays use less radiation [8], so using an X-ray is faster, less harmful, and less expensive than a CT scan [9]. Changes in chest radiography pictures such as X-ray and CT scan were detected even before clinical signs of COVID-19 appeared in several studies [20]. We need an expert radiotherapist to examine the x-rays because they contain very small details. Even if some cases are a failure due to poor vision.

Figure 1 :((x) Normal chest image and (y) COVID affected chest image.



From Figure1 it is very difficult to detect Covid1-9 infection. But artificial intelligence techniques can classify them by training with labeled data. Thus, we use machine learning [10-11].

In this work, we present an automatic detection system to classify chest X-ray images as from COVID-19 patients or normal patients using perceptron neural network (MLP) compared with Convolutional Neural Network

(CNN). The results show that MLP neural network achieved the highest accuracy (95.7%) and the CNN achieved 90% in the same dataset, showing the effectiveness of the proposed model.

This study is structured as follows: the related works are presented in Section II. Section III describes the technique's suggested methodology (Multi-layer Perceptron MLP) and Convolutional neural network (CNN), including the dataset, classification processes, and metrics used to evaluate the approach. The results are discussed in Section IV. The conclusion and future prospects are presented in Section V.

2.Review Of Related Studies

Many uses of image analysis and machine learning techniques can already be seen in the field of precision medicine. Several investigations on COVID-19 are now being conducted in order to emphasize proofs of concepts and scientific realities regarding this little-known disease.

According to current approaches, Table 1 lists the most notable works. in terms of publication year (Year), Data type Name (DT), DataSet (DT), and the metric of every study (where Acc. is Accuracy,) and methods.

Table.1. Literature review summary

Methods	Year	Author	DS/DT	Acc
SVM	2020	Togacar et al.	Joseph Paul Cohen/ CT images	99.2%
CNN	2020	Pereira et al.	RYDLS-20 / CXR images	65% 89%
(K-NN), Decision Tree SVM Na¨ive Bayes,Logistic Regression Random Forest	2022	Muhammad Imran et al	Kaggle	97.4% 97.5% 98.0% 98.8% 99.6% 99.8%
InceptionV3-Inception-ResNetV2	2020	Narin A et al	X-ray	97% 87%
VGG 16	2020	Hemdan E. E. D et al	X-ray	90%
CNN	2020	Wang L and Wong A	NET/ X-ray	83.5%

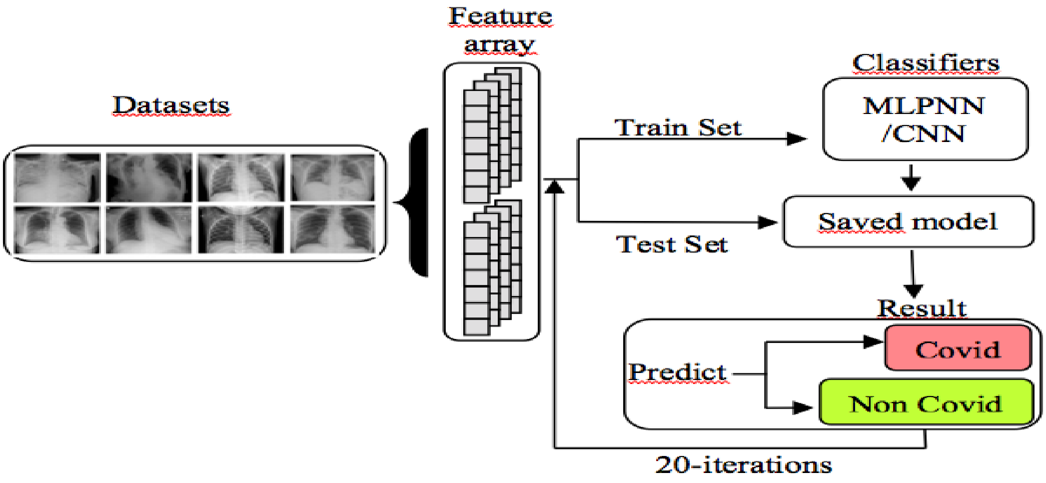
3. Methodology:

In most cases, we always require a medical diagnosis based on multiple expert medical opinions. several medical opinions help to reach a more reliable conclusion. Following the same principle, two models MLP and CNN have been adopted in our proposed work

3.1 Model architecture:

Three main modules are distinguished in this architecture (Figure 2). Each one has a distinct role and task that will act and interconnect in the order listed below:

Figure.2 : A description of the COVID 19 detecting system.

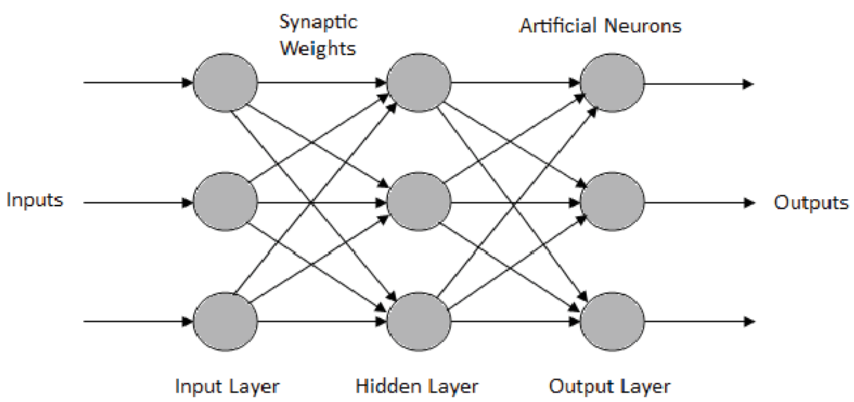


3.2 Perceptron Neural Network:

A multi-layer perceptron (MLP) is a feed forward neural network that has been supplemented. The three types of layers depicted in Figure. 3 are input, output, and hidden layers.

The first layer receives the information that is going to be processed. Tasks like prediction and classification are under the output layer's purview. The multilayer perceptron has between the input layer and the output layer one or more so-called "hidden" layers. The number of layers correlates to the network's weight matrices. A multilayer perceptron is therefore better suited to deal with nonlinear types of functions. Similar to a feed forward network, data flows forward from the input to the output layer to train the neurons, the back propagation learning technique is utilized. MLPs are meant to approximate any continuous function and can handle issues that aren't linearly separable [18]

Figure.3 : Basic architecture of Artificial Neural Network.



Each neuron in the output and hidden layers computes the following:

$$A(x) = F\big(n(2) + E(2)j(x)\big) \qquad (1)$$

$$\boldsymbol{Z(x) = \Phi(x) = d(n(1) + E(1)x)} \qquad \mathbf{(2)}$$

With the parameters as shown in Table 2 [18].

Table.2. Summarize network parameters tirunelveli district**.**

Parameters	**Description**
$n(1)$, $n(2)$	Bias vectors
E(1) , E(2)	Weight matrices
F , d	Activation functions
$\vartheta = \{E(1), n(1), E(2), n(2)\}$	is the set of parameters to be learned.
$\tanh(a) = \frac{(e^{a} - e^{-a})}{(e^{a} + e^{-a})}$ $\text{sigmoid(a)} = \frac{1}{(1 + e^{-a})}$	are two common choices ford

Our model consists of four Multilayer Perceptron layers in a Dense layer, followed by a Rectified Linear Unit (ReLU) and sigmoid activation function:

- (ReLU): a deep neural network's classification function that is utilized as an activation function for a multi-layer perceptron MLP learning network [21]. We accomplish this by taking the activation of the penultimate layer ***hn1*** in a neural network, then multiply it by weight parameters $\boldsymbol{\theta}$ to get the raw scores ***oi*** (2)

$T(O) = Max(O, oi)$ where

$T(O)$ is the ReLU function

- Sigmoid is an activation function that receives a real value as input and returns a probability between 0 and 1..It appears to be in the shape of a 'S'.

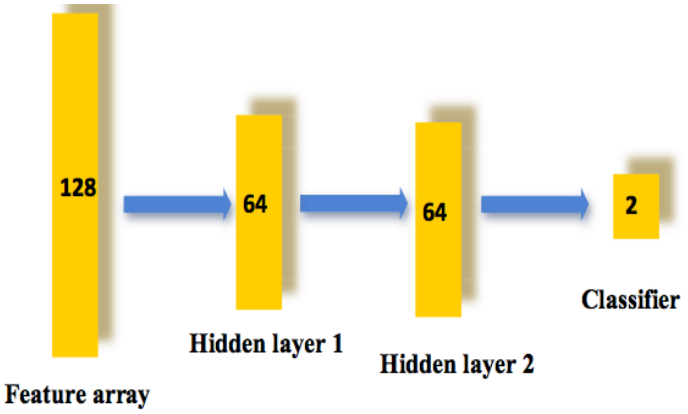
$$S(Z) = \frac{1}{1 + e^{-z}}$$

The data is moves from the input layer to the hidden layers. Each layer simply multiplies the inputs by the weights, adds a bias, and applies an activation function to the result before passing the output to the next layer. We keep going till we get to the last layer [19]. The activation functions ReLU and Sigmoid were used in our study.

- **Model training:**

  We divided our CXR images into two target classes for our classifier: COVID-19 and non-COVID-19. To classify CXR images into two groups, we used a multi-layer neural network with two hidden layers and one output classifier (Figure 4).

Figure.4: Multi-layer neural network designed for the classification task including the first layer with 128 neurons (the number of nodes depends on data size), two hidden layers with 64 neurons for each and a final layer to classify cases into two categories of COVID-19, no-COVID-19 , we used Binary classifier (0 and 1) : 0 for COVID -19 and 1 for Normal cases.



3.4 Convolutional Neural Network *(*CNN*):*

A CNN or ConvNet convolutional neural network is a type of acyclic (feed-forward) artificial neural network, in which the connection pattern between neurons is inspired by the visual cortex of animals.

CNN is a mathematical construction generally composed of three types of layers: (Convolutional layer), the pooling layer (Pooling layer) and the fully connected layer (Fully-connected layer)

The role of the convolutional layer consists in extracting the relevant information from the image (characteristics) thanks to a convolution operation the rectified linear unit layer (ReLU) is an activation function that is used on all elements of the volume to eliminate all negative values and keep positive values. It aims to introduce non-linear complexities to the network.

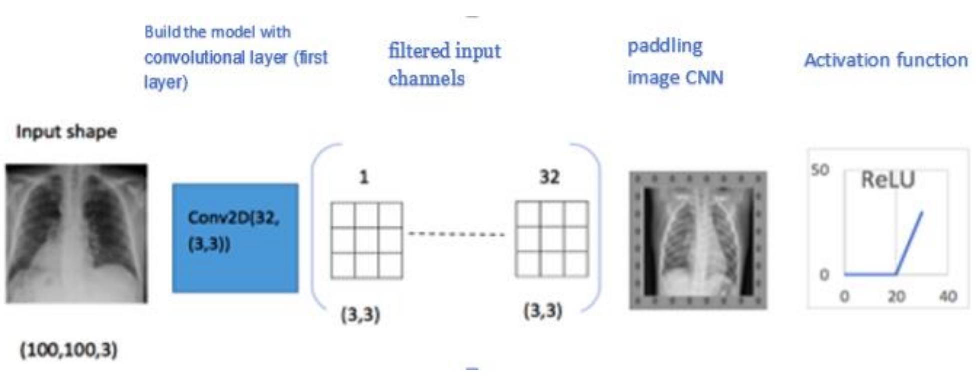
The pooling step is a down sampling technique. Generally, a pooling layer is inserted regularly between the correction and convolution layers. By reducing the size of the feature maps, and therefore the number of network parameters, this speeds up the computation time and reduces the risk of over-fitting.

Fully-connected layer FC Fully-connected layer This layer is at the end of the network. It allows the classification of the image from the characteristics extracted by the succession of processing blocks. It is entirely connected, because all the inputs of the layer are connected to the output neurons of this one.. [21].

A. Nonlinear activation function:

The rectified linear unit (ReLU) is presently which is used as a activation function, which simply computes the function: $g(x) = max(0, x)$ as seen in Figure 5, and then is forwarded through a nonlinear activation function sigmoid in the final layer (output layer).

Figure 5: Architecture of the first layer.



The planned CNN design will be presented in this part. As previously stated, this network is made up of an input layer, 8 layers of hidden blocks, and then a classification layer. The input images of this network are sized as (100, 100, 3), while the output can be one of two different classes: COVID-19, or normal.

The proposed model consists of eight convolutional layers and six pooling layers. Filters of (3 3) size with padding are applied to each convolutional layer, and each pooling layer implements a max-pooling window of (2 2) size. The terms "Conv2D," "MaxPool2D," and "FC" refer to the convolution, pooling, and fully connected layers, respectively, in the following. (The filter has dimensions of 3 height and 3 width, Convolution over volume (color image — 3 channels) with a filter of 3 x 3, and the table1 explains:

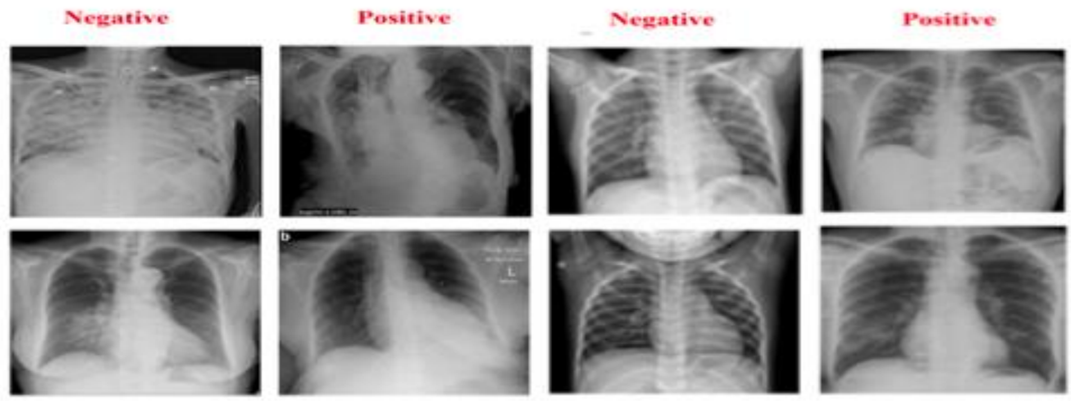
TABLE 3: The architecture of our suggested cnn .

Layers	Layers type	Output shape
Image-input	Input-layer	[(None, 100, 100, 3)]
Layer-1	Conv2D	(None, 100, 100, 32)
Layer-2	Conv2D	(None, 100, 100, 64)
Layer-3	MaxPool2D	(None, 50, 50, 64)
Droput-0	Dropout	(None, 50, 50, 64)
Layer-4	Conv2D	(None, 50, 50, 64)
Layer-5	MaxPool2D	(None, 25, 25, 64)
droput-1	Dropout	(None, 25, 25, 64)
Layer-6	Conv2D	(None, 25, 25, 128)
Layer-7	MaxPool2D	(None, 12, 12, 128)
droput-2	Dropout	(None, 12, 12, 128)
Flatten	Flatten	(None, 18432)
Layer-8	Dense	(None, 64)
Droput-3	Dropout	(None, 64)
Predictions Dense	Dense	(None, 2)

4. Dataset preparation:

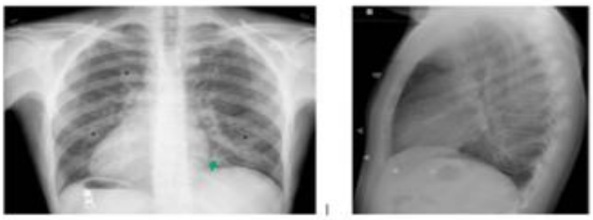
For this research, we worked on different data-sets [16] [17] these open source public data-sets contain CXR images of Covid-19 positive patients, patients having bacterial pneumonias (MERS, SARS, and ARDS.) Also the data-set used has been taken from two different sources Kaggle and GitHub making. our data contains CXR images of different patients from two data-set.

Figure 6: illustrates some of the dataset's examples. Normal cases are on the first row, whereas COVID-19 cases are on the second. [19].



We show here Some examples from data-set. for the same person which have a Covid 19 by Chest X-ray PA show 2 different view.

Figure 7: Some examples from dataset. For the same person by chestx-ray PA shows 2 differents view [19].



In this study, we used a dataset which contains 538 of COVID-19 and 180 Normal X-ray images. The COVID-19 X-ray and normal X-ray images are collected from the GitHub repository and Kaggle repository.

The dataset was examined in the proposed model. We use this dataset for machine learning architectures such as MLPNN and CNN for detection of COVID19 cases

Finally, the proposed model's performance was trained, validated, and evaluated. The following are the image categories found in the dataset.

TABLE 4: Dataset and class.

	COVID-19 images		**Normal images**		**Total number of images**
Dataset	*Train*	*Test*	*Train*	*Test*	
Numbers	376	162	125	55	718
Views	PA (x-Ray images)		PA (x-Ray images)		
Type	jpg, png, jpeg		jpg, png, jpeg		

B. Classification Module:

Module which specializes exclusively in image classification. The module's output must be a single probability value between 0 and 1 indicating the presence or nonappearance of Covid internationally, — for example as a function of the entire image as a whole. For starters, this module will allow us to globally classify the sample into two classes: images with Covid cases and images without any trace of Covid, and its output will have a direct influence on the detection module's predictions.

C. Evaluate the results: from an educational standpoint.

5. Model Validation:

There are several ways to validate model performance. The confusion matrix is one of the most widely used techniques.. The diagonal values of the matrix represent correct predictions for each class, while other cell values represent a number of incorrect predictions.

The performance of deep transfer learning models was measured using Performance Metri Criteria. They are as follows:

5.1 Performance Metrix

For the performance of deep transfer learning models, criteria were utilized. These are the following:

Accuracy = *(VB + VA) / (VB + VA + FB + FA)* (a)

Recall = VA / (VA + FB) (b)

Specificity = VB / (VB + FA) (c)

Precision = VA / (VA+ FA) (d)

F1-Score = 2x((Precision x Recall)/(Precision + Recall)) (e)

In Equation (a) and (e), VA, FA, VB, and FB denote the number of True Positives, False Positives, True Negatives, and False Negatives, respectively. Given a test dataset and model, VA is the proportion of positive (COVID-19) that the model correctly labels as COVID-19; FA is the proportion of negative (normal) that the model incorrectly labels as positive (COVID-19); VB is the proportion of negative (normal) that the model correctly labels as normal, and FB is the proportion of positive (COVID-19) that the model incorrectly labels as negative (normal) [22].

6. Results:

The experimental setup as well as the experimental results are presented in this section. "Experimental details" explains the MLP and CNN implementation specifics. In Experimental results, we report on the performance of the suggested method (MLP) and compare it to a CNN.

6.1 Expérimental setup:

Python 3.8.8 programming language was used to train the proposed models MLP and CNN. All experiments were performed on a jupyter notebook.

A) Experiments details using MLP model:

We used the Adam optimizer to optimize model weights and minimize the categorical cross-entropy loss function, after training the model for 20 epochs. We also employed the Early Stopping technique to avoid overfitting by stopping training after the validation score stopped improving (Early Stopping callbacks (patience = 10 epochs)). Our network is good, as our training history graphic demonstrates, based on our training data:

Figure 8: Training history plot for Loss Validation Loss (MLP).

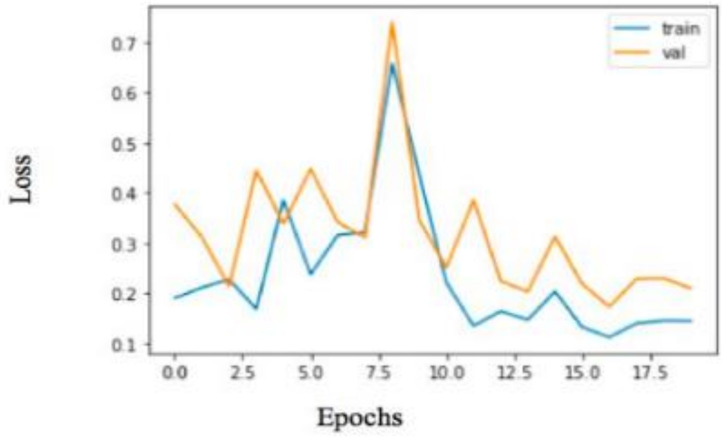


Figure 8 depicts the examination of training and testing results with the loss. This Machine learning training history plot with accuracy curves shows that our model performs excellently on our COVID-19 X-ray training data, which was used in our Keras/TensorFlow model.

Figure 9: Accuracy ,validation accuracy (MLP).

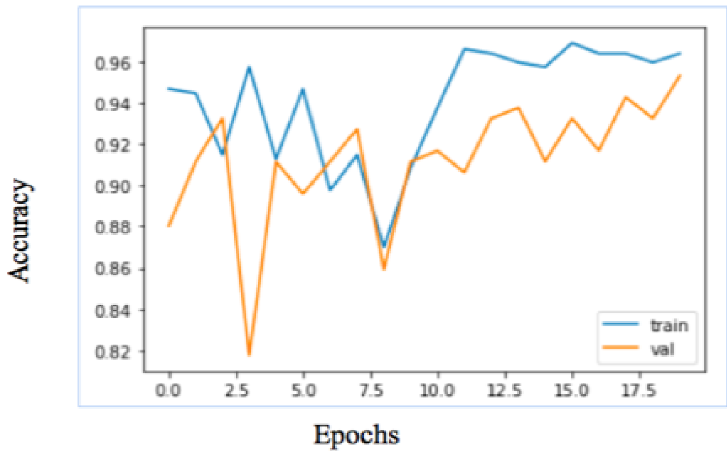


Figure 9 describes the training and testing result analysis with the Accuracy, which illustrates the model accuracy for our model as it improves with subsequent epochs.

B) Experiments details using CNN model:

Figure 10 and 11 discusses the result analysis of training and testing with the Accuracy and loss for CNN Model:

Figure 10: Training history plot for Loss and Validation Loss (CNN)

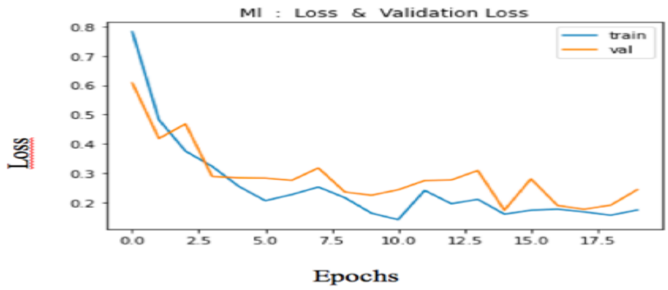
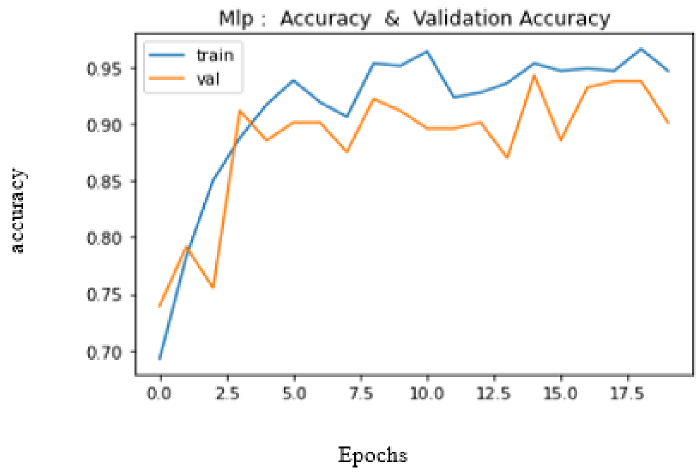


Figure 11: Training history plot for accuracy and Validation accuracy (CNN).



6.3 Experimental results:

From Figure 9, we discuss the analysis of the results of training and testing with accuracy which shows the model accuracy for our model (MLP) as it improves with successive epochs and when comparing with the analysis of the CNN results in Figure 10 and 11, we deduce the MLP register of the model good results than CNN.

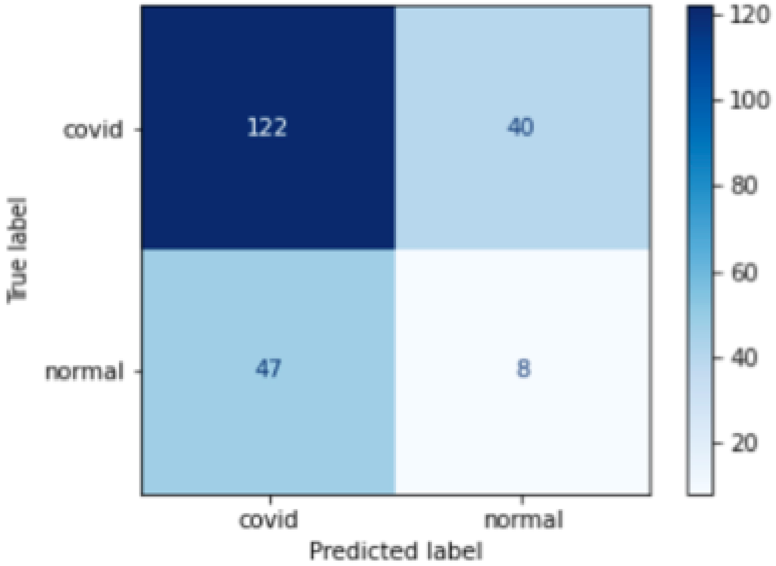
In the second phase of our experiments, we compared the MLP to a standard CNN trained on the same data. The CNN architecture is presented in Table 3.

TABLE 5: Description a comparison of different models' performance in detecting covid-19 from dataset cxr images**.**

Method	**Data**	**Loss**	**Accuracy**	**Validation loss**	**Validation Accuracy**
MLP	X-ray images	0,144	0,96	0,209	0,957
CNN	X-ray images	0,174	0,94	0,244	0,901

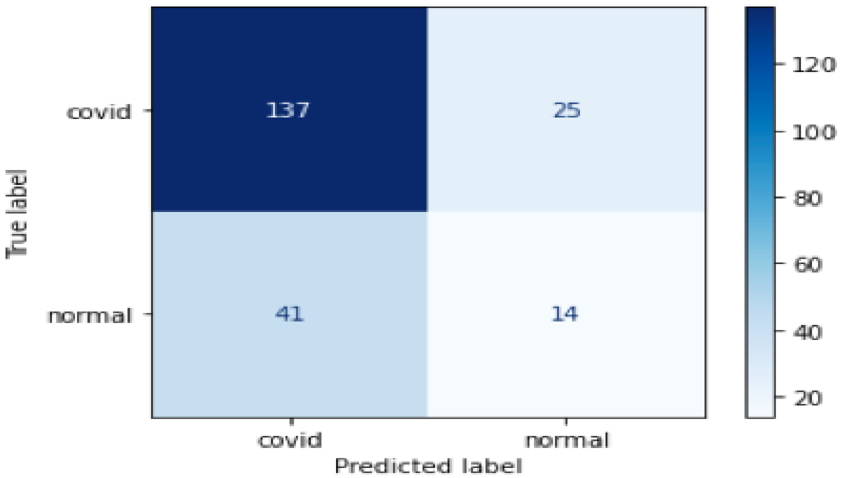
The confusion matrices of COVID-19 and normal test results of the models are shown in Figure 12. To begin, the model pre-trained model identified 122 of the COVID-19 as True Positive and 8 as True Negative. It displays the confusion matrices computed for the train and test sets. and demonstrates that the misclassified samples are insignificant. As the model trains with successive epochs, display the training and testing performance. We can observe that our model provides the best accuracy.

Figure12: Confusion matrix for the ensembling.



The confusion matrix in Figure12 demonstrates that our proposed model successfully classified 122 of the Covid19 patients based on the CXR pictures. Only 40 of the Covid19 patients were incorrectly classed as normal. Similarly, 8 cases were accurately identified based on CXR pictures. Only 47 patients were misidentified as Covid19.

Figure 13: Confusion matrix for the ensembling.



We can examine the confusion matrix in Figure 13 with model CNN, which shows that the model pre-trained model classified 137 of the COVID-19 as True Positive, while only 25 were incorrectly classified as normal. and 14 patients were accurately classified as Covid19, whereas 41 were incorrectly labeled as Covid19.

7. Discussion :

In this part, we investigate the suggested model's superior characteristics and limitations in comparison to state-of-the-art models. It is crucial to highlight, however, that due to differences in datasets, techniques, and simulation settings, a one-to-one comparison is not feasible.

Despite the fact that both strategies produced good outcomes with little difference, It should be noted that the suggested model will be tested using the COVID-19 radiology database. Given the amount of positive COVID-19 cases worldwide, one may claim that the database is insufficient. However, we don't believe you need be concerned. In this scenario, because the performance of the CNN network is determined by the amount of samples utilized in the training phase, just computation time and hardware resources must be addressed.

Another critical concern is that when X-rays are utilized to diagnose positive COVID-19 cases, infection can spread rapidly. In other words, whereas X-rays are a valuable tool for confirming positive COVID-19 cases, they may not be clinically significant for early detection.

As a future research area, we suggest using multi-CNN to extract features from CT images [23].and an MLP model for COVID-19 classification and detection.

8. Conclusion

The usefulness of pre-trained MLP in predicting COVID-19 from X-ray pictures is examined in this research. Another model was run to evaluate the efficacy of the MLP model. The premade MLP with two hidden layers and an output layer with two classes of Covid-19 cases and Normal cases was the most efficient model utilized in this investigation. The results demonstrate the superiority of pre-trained MLPs over single pre-trained CNNs. The results of the experimental research demonstrate that the pre-formed MLP is successful in the diagnosis of COVID-19.

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