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Robust Technique to Detect COVID-19 using Chest X-ray Images

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Abstract— **COVID-19 typically known as Coronavirus disease is an infectious disease caused by a newly discovered coronavirus. Currently detection of coronovirus depends on factors like the patients' signs and symptoms, location where the person lives, travelling history and close contact with any COVID-19 patient. In order to test a COVID-19 patient, a healthcare provider uses a long swab to take a nasal sample. The sample is then tested in a laboratory setting. If person is coughing up then the saliva (sputum), is emitted for testing. The diagnosis becomes even more critical when there is a lack of reagents or testing capacity, tracking the virus and its severity and coming in contact with COVID-19 positive patients by a healthcare practitioner. In this scenario of COVID-19 pendamic, there is a need of streaming diagnosis based on retrospective study of laboratory data in form of chest X-rays using deep learning. This paper proposed a demystify technique to detect COVID-19 using assembling medical images with the help of deep nets. The study shows promising results with accuracy of 91.67% for diagnosis of COVID-19 and 100\% accuracy in proving the survival ratio.**

Keywords— Covid-19, chest X-ray images, convolution neural network, deep learning.

I. INTRODUCTION

Between 31 December 2019 and 16 May 2020, a number of around 4,503,836 cases of COVID-19 (in accordance with the applied case definitions and testing strategies in the affected countries) have been reported, including 307,295 deaths [1]. From statistics, it is proved that this COVID-19 is a life taking virus and, in order to combat with it, there is a crucial need of virus testing for early diagnosis and tracking the epidemic to reveal how many people are infected and can infect other people. Testing alone is not the only solution to fight with this virus. The question that strikes more is how reliable the test results are. That's since the method of precise Covid-19 testing requires coordination of a number of forms. To begin with, one must obtain the test units i.e. the long nasal swabs and chemicals required to handle them. These are at that point sent to expertly trained laboratory specialists who dissect the tests employing a polymerase chain reaction (PCR) machine, which can be difficult. And at last, there must be a framework to acknowledge tests and report results to the correct individuals. In some cases an individual can test negative even when they are wiped out. They may have the infection in their lungs, but not discharge it near the nose where it would adhere to the swab or the test was not taken accurately. So now we are more dedicated towards chest X-ray (CXR) to find the respiratory tract or lungs abnormality. Chest radiography will likely be the most commonly utilized modality for identification and follow up of lung abnormalities [2]. The absence or presence of pathological findings on CXR determines the lungs deformity and the main role is played by the radiologists to determine the findings of both lungs, in particular the lower lobes, and especially the posterior segments, with a fundamentally peripheral and subpleural distribution [3].

Numerous researches have been performed using X-ray images in diagnosing respiratory diseases and a large collection of X-ray is available in [4], [5] offering support in detection of pneumonia, lung inflammation, abscesses, and/or enlarged lymph nodes. For example, using the dataset of [4], the researchers predict the type of pneumonia and also its outcomes. Implementing deep learning technique of these X-ray images to find COVID-19 can be very beneficial. Previously it is been observed that deep learning (DL) algorithms are successfully applied on many medical images datasets [6] for detection of anatomical and cellular structures, tissue segmentation, computer-aided disease diagnosis and prognosis, and so on. Similarly in [7] DL technology is implemented on cancer imaging for detection and classification of cancer that helps patients to have proper treatment and increase their survival rate. The researchers in [8] used deep convolution neural network (CNN) for automated detection and segmentation of brain metastases on multisequence magnetic resonance imaging (MRI). In [9] DL technology is proposed for detection of anaemia from retinal fundus images. Following the similar research path, the researchers in [10], [11], [12] used DL for analyzing and diagnosing COVID-19 patients using medical images. In [10] the authors collected the data of COVID patients from the public sources train and test a DL based system, using transfer learning to identify COVID-19 characteristics and predict survival. In [11] authors used DL methodology to extract deep features and their classification model, i.e. resnet50 plus SVM achieved accuracy, FPR, F1 score, MCC and Kappa are 95.38%, 95.52%, 91.41% and 90.76% respectively for detecting COVID-19. In [12] the authors collected 453 computed tomography (CT) images of pathogen confirmed COVID-19 utilized 217 images as the training set and the inception migration learning model was utilized to establish the algorithm. The internal validation accomplished a total accuracy of 82.9% with specificity of 80.5% and sensitivity of 84%. The external testing dataset proved a total accuracy of 73.1% with specificity of 67% and sensitivity of 74%. In [13] the researchers introduced an alternative modeling method using Capsule Networks, called as the COVID-CAPS, handles small datasets and diagnosed COVID-19 with accuracy of 95.7% and in [14] researchers proposed supervised DL model to predict the COVID-19 infectious probability in chest CT scan. The other DL-based research works in this domain with their proposed techniques [15-21] and results are illustrated in Table 1.

Inspiring from the work of [10-14], we used CXR images and built CNN based algorithm for diagnosis of COVID-19 by differentiating it from the rest of respiratory tract diseases such as Middle East respiratory syndrome (MERS), Severe acute respiratory syndrome (SARS), Acute Respiratory Distress Syndrome (ARDS) and also answering the survival chances.

Our study is divided into three sections. Section II addresses the data setup and collection from participants, section III illustrates the basic methodology we adapted, section IV shows the main results and discussion and finally section V addresses the conclusion and future directions.

II. Data Collection

The data used in this study is compiled using two publicly available datasets. The first dataset we used was provided in [10] In this database there are a total of 320 chest X-ray images out of which 259 images are of MERS, SARS and ARDS (pneumonia cases). These images are collected and extracted from different websites and online publications. The rest of 3347 images we used is from [4] for better DL classifier training and performance. Hence total of 3606 images are used in this study. 80% of images are used for training and 20% of images are used for testing the system. 3347 out of 3606 images are related to other diseases i.e MERS / SARS / ARDS / SARS-Cov-2 / without chest disease. The remained 259 are of COVID positive patient.

III. Methodology

The goal of this study is based on four main objectives related to the answers of the following questions:

1. Do patient is infected with COVID-19 or not?
2. Is the patient infected with COVID-19 going to survive or not?
3. According to data what is the most common age ratio of COVID-19 positive patients?
4. According to data what is the ratio of male and female infected with COVID-19?

The main methodology of this study is depicted in Figure 1. According to this, we first collected the images of CXR and arranged the data for detection of COVID-19 and others. In initial stages we converted all the images into grayscale afterwards arranged it into two classes i.e. COVID-19 and other diseases (i.e. SARS, MERS and ARDS). If COVID-19 is detected then it is further classified to find the survival rate of patients. For this we used DL convolution neural network (CNN) with seven layers. The architecture of CNN is defined in Figure 2.

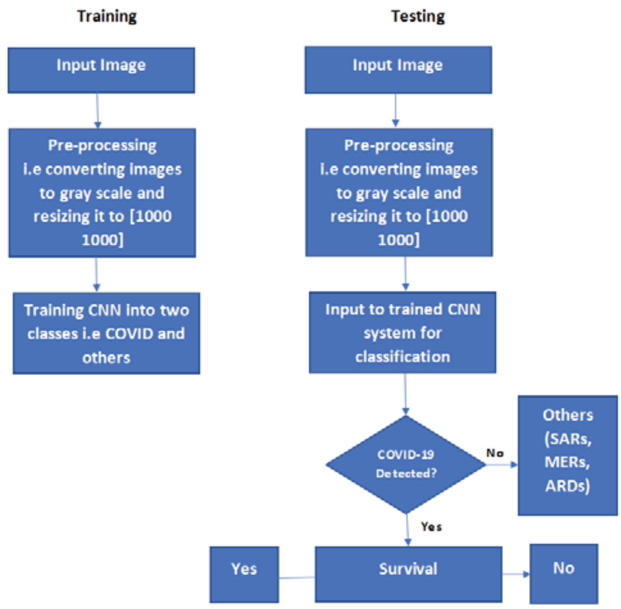


Fig. 1. Flow chart of the system.

IV. Results and Discussion

The results of image processing and feature analysing COVID-19 are shown in Figure 3 which gives 91.67% accuracy as also depicted in Figure 6. Afterwards we further classified the data to find the survival ratio for which we again trained the CNN for feature extraction as shown in Figure 4(a). Figure 4(b) presents the confusion matrix. The accuracy of this classifier is 100% as depicted in Figure 7. The green color in Figure 3 and Figure 4(a) shows the images correctly predicted and red color shows the false detection. According to our study, the histogram results in Figure 5(a) and 5(b) emphasizing the age and sex of people infected mostly by this virus.

TABLE I. MEDICAL IMAGING TECHNIQUE FOR CORRECT DIAGNOSIS AND MONITORING OF COVID-19 PATIENTS

[Reference]	Dataset detail	COVID-19 Application Scenarios	COVID-Net model	Results
[15]	50 CXR with 25 confirmed positive COVID-19 cases	analyze the normalized intensities of the X-ray image to classify the patient status either negative or positive	COVIDX-Net includes seven different architectures of deep CNN models, such as modified Visual Geometry Group Network (VGG19) and the second version of Google MobileNet	COVIDX-Net have been successfully done based on 80-20% of X-ray images for the model training and testing phases. The VGG19 and Dense Convolutional Network (DenseNet) models showed a good performance of automated COVID-19 classification with f1-scores of 0.89 and 0.91 for normal and COVID-19, respectively
[16]	13,975 CXR images across 13,870 patient cases	detection of COVID-19 cases from chest X-ray (CXR) images	performed an audit on the proposed COVID-Net to gain better insights into how COVID-Net makes decisions, and validate	COVID-19 sensitivity 80%, and (ii) COVID-19 positive predictive value (PPV) 80%
[17]	127 X-ray images diagnosed with COVID-19 in the database	Proposed deep model for early detection of COVID-19	Darknet-19, which consists of 19 convolutional layers and five pooling layers, using Maxpool. These layers are typical CNN layers with different filter numbers, sizes, and stride values. Here 17 layers are used instead of 19	Obtained accuracy of 98.08% and 87.02% for binary and multi-classes.
[18]	320 images in total, classed in two categorize: 160 images for patients affected by COVID-19 and 160 Normal images.	detect the coronavirus pneumonia infected patients	Deep Transfer Learning (DTL) method using Convolutional Neural Network (CNN) based models InceptionV3 and ResNet50 with Apache Spark framework for the classification of COVID-19	The experimental results proved that this model achieved high accuracy of 99.01% for InceptionV3 and 98.03 for the ResNet50 model
[19]	NA	AI based approached for detection of COVID-19 using chest x-rays	NA	The proposed AI based approaches in the literature for detection of COVID-19 shows promising results such VGG19 with 98% of accuracy, ResNET with 96%, ResNet50 with 95% of accuracy, and InceptionV3 with 96%.
[20]	dataset with CXR images of 50 normal and 50 COVID-19 patients (100 images in total). All images were resized to 224x224 pixel size	automatic detection system as a quick alternative diagnosis option to prevent COVID-19 spreading among people	three different CNN based models (ResNet50, InceptionV3 and Inception- ResNetV2 using 5-fold cross validation	ResNet50 model provides the highest classification performance with 98% accuracy among other two proposed models 97% accuracy for InceptionV3 and 87% accuracy for Inception-ResNetV2
[21]	1427 X-Ray images. In which 224 with confirmed Covid-19, 700 with confirmed common pneumonia, and 504 of normal conditions	coronavirus detection using chest X-ray images	CNNs were compiled utilizing the optimization method called Adam. The training was conducted for ten epochs, with a batch size of 64	with transfer learning, an overall accuracy of 97.82% in the detection of Covid-19 is achieved

	Name	Type	Activations	Learnables
1	imageinput 1000x1000x1 images with 'zerocenter' normalization	Image Input	1000×1000×1	-
2	conv 20 2x2x1 convolutions with stride [1 1] and padding [0 0 0 0]	Convolution	999×999×20	Weights 2×2×1×20 Bias 1×1×20
3	batchnorm Batch normalization with 20 channels	Batch Normalization	999×999×20	Offset 1×1×20 Scale 1×1×20
4	relu ReLU	ReLU	999×999×20	-
5	fc 2 fully connected layer	Fully Connected	1×1×2	Weights 2×19960020 Bias 2×1
6	softmax softmax	Softmax	1×1×2	-
7	classoutput crossentropyex with classes 'COVID-19' and 'Others'	Classification Output	-	-

Fig. 2. CNN Architecture

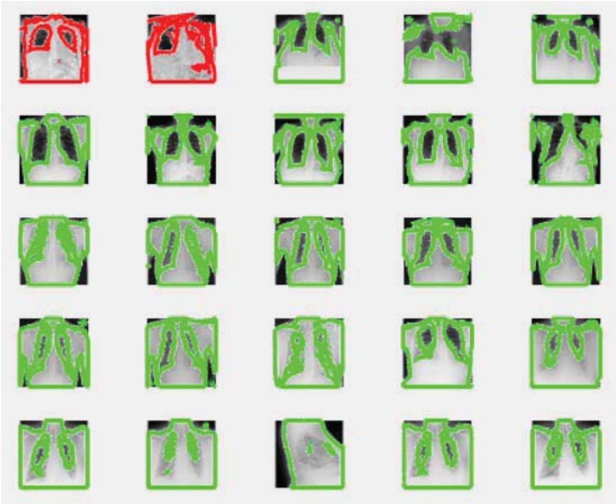
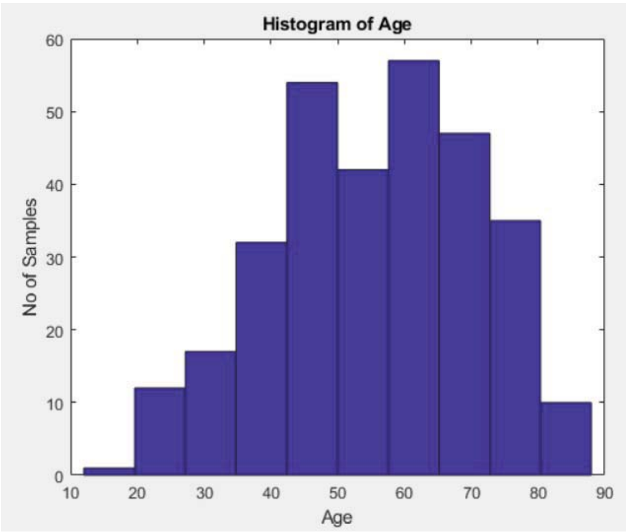
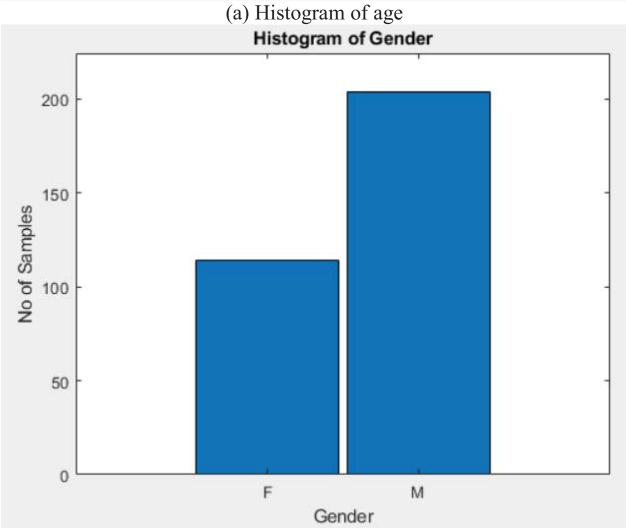


Fig. 3. Detection of COVID-19 patients using features

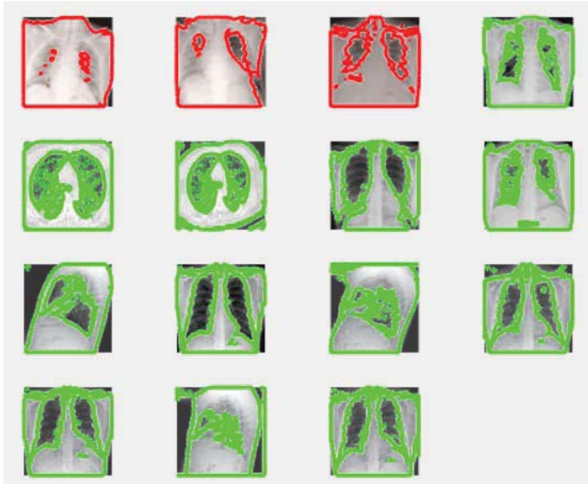


(a) Histogram of age

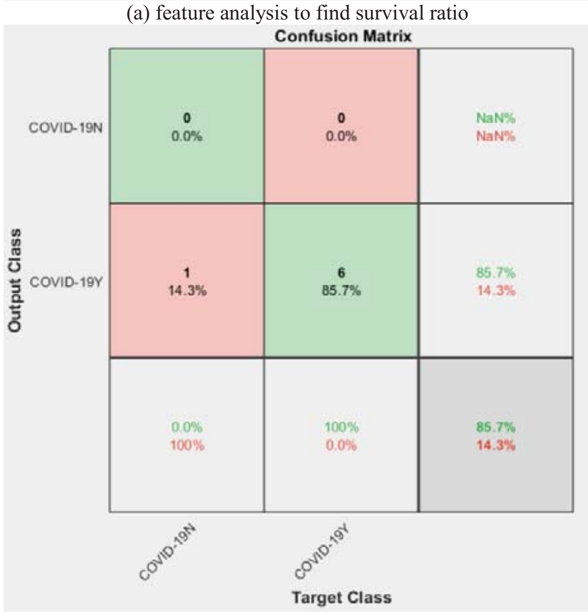


(b) Histogram of sex.

Fig. 5. Demographics results based on age and sex



(a) feature analysis to find survival ratio



(b) Confusion matrix of classifier for survival analysis

Fig. 4. Analysis of COVID-19 patients survival

V. Conclusion and Future Directions

This research provides a great insight to early diagnosis and tracking the condition of COVID-19 patients. In this study we used deep learning CNN technique on chest X-ray images of patients and classified them into two classes of patients with and without COVID-19. The accuracy we obtained is 91.67%. After the positive diagnosis of COVID-19 patients, we aimed to track the progression of disease which may help healthcare professionals work on the correct dynamics and treatment of patients. This research also proposed classifier to track the survival rate of COVID-19 patients which also provides good result with 100% accuracy. This study also concluded that till now this virus has affected more males than females of age around 50-60 years. This research addressed the current problems faced by healthcare professionals in tackling the COVID-19 epidemic. Our future directions will be focused on applying this technique in real time clinical data and improving the accuracy of our study.

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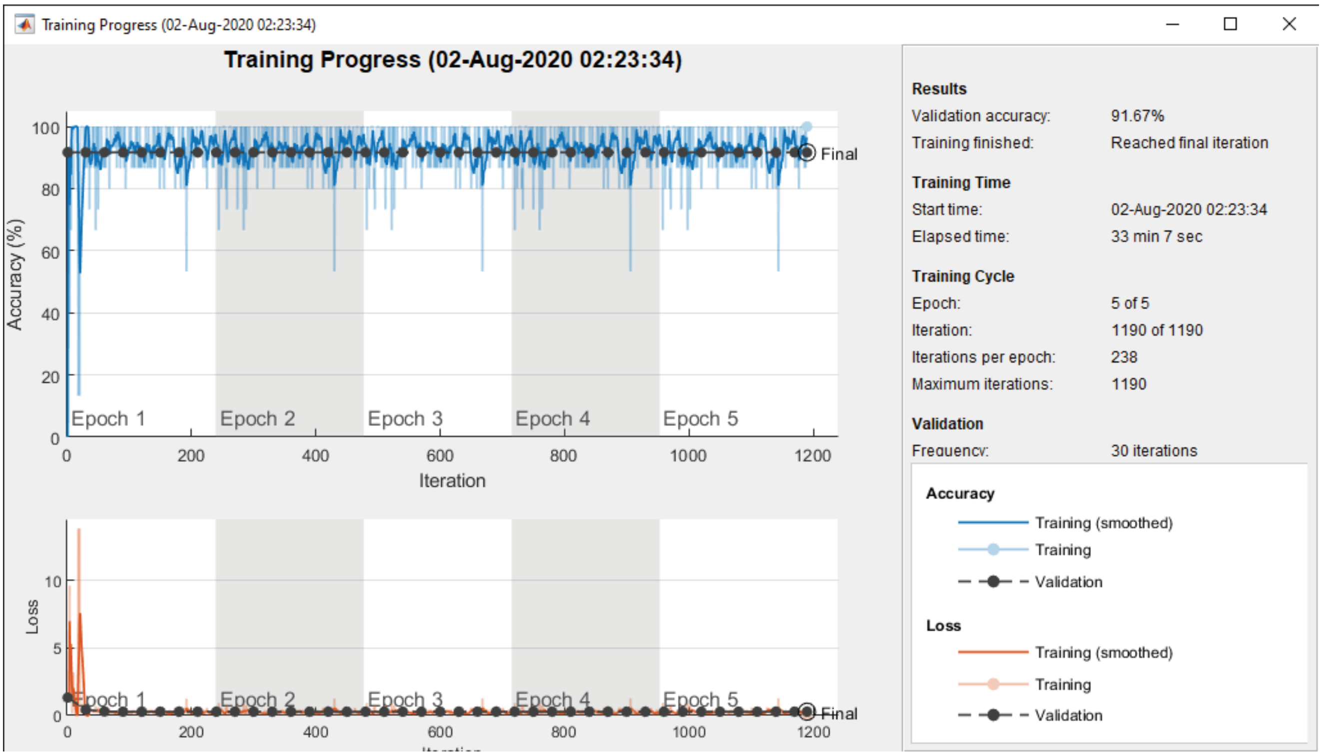

Fig. 6. Detection of COVID-19 patients using CNN

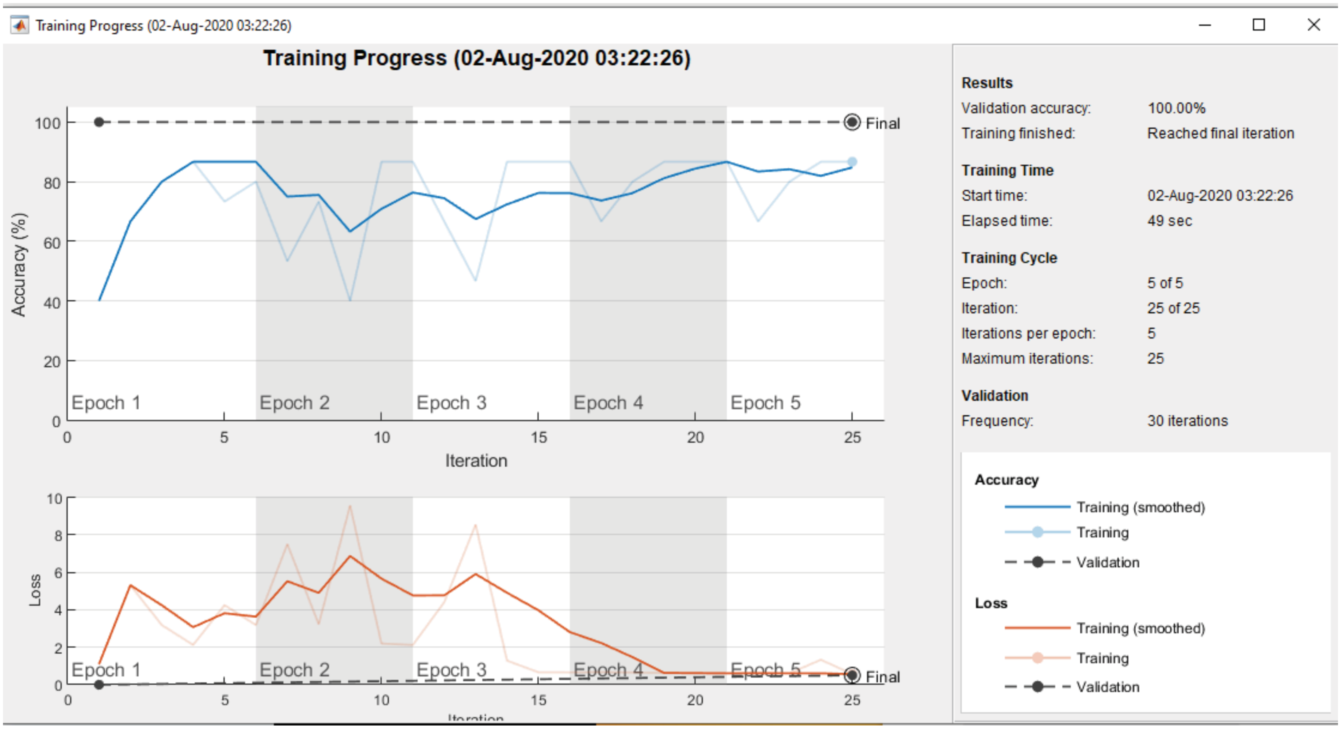

Fig. 7. Detection of COVID-19 patients survival using CNN