# A deep learning algorithm to detect coronavirus (COVID-19) disease using CT images

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**Background.** COVID-19 pandemic imposed a lockdown situation to the world these months. It faced the around globe researchers and scientists serious efforts from its detection to its treatment.

**Methods.** Pathogenic laboratory testing is the gold standard but it is time-consuming. Lung CT-Scans and X-rays are of the other common methods applied by the researchers is the analyzing to detect for COVID-19 positive cases. In this paper, we propose a deep learning neural network-based model as an alternative fast screening method that can be used for detecting the COVID-19 cases by analyzing the CT-scans.

**Results.** Applying the proposed method on a publicly available dataset collected of positive and negative cases shows its ability on distinguishing them by analyzing each individual CT image. By selecting random train an test images, the overall accuracy of the model is in average 84% without any image pre-selecting or preprocessing.

# A Deep Learning Algorithm To Detect Corona Virus (COVID-19) Disease Using CT Images

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## Abstract

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## Introduction

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) simply called as corona virus or COVID-19 is currently one the most life-threatening problems around the world. Coronavirus disease 2019 (COVID-19) is a highly infectious disease caused by severe acute respiratory syndrome coronavirus 2 ( *Wang et al., 2020*). The disease first originated in 31 December 2019 from Wuhan, Hubei Province, China and since then it has spread globally across the world. The cumulative incidence of the causative virus (SARS-CoV-2) is rapidly increasing and has affected 196 countries and territories and on 4 May 2020, a total of 3,581,884 confirmed positive cases have been reported leading to 248,558 deaths (*Coronavirus - worldometer*). The impact is such that the World Health Organization(WHO) has declared the ongoing pandemic of COVID-19 a Public Health Emergency of International Concern (*Daksh Trehan,2020*).

Pandemic caused by COVID-19 has major difference by other related viruses, such as Middle East Respiratory Syndrome (MERS) and Severe Acute Respiratory Syndrome (SARS), which is its ability to spread rapidly through human contact and leave nearly 20% infected subjects as symptom-less carriers (*Mallapaty,2020*).

Pathogenic laboratory testing is the gold standard but it is time-consuming, therefore, other diagnostic methods are needed to detect the disease in a timely manner. COVID-19 makes some changes in CT images which. We afraid that this changes may be neglected during visual inspection and we hypothesized that a Artificial Intelligence's method might be able to detect COVID-19's positive cases and provide a clinical diagnosis ahead of the pathogenic test, thus saving critical time for disease control .

The main contribution of this paper is to propose a prediction mode based on CNN deep learning method, which is able to be trained by some CT images of corona virus infected lungs and CT images of healthy lungs. The trained model is then able to classify any new CT image as positive and negative COVID-19 at a faster speed.

## Related works

Several efforts have performed by researchers in detecting coronavirus affected cases using radiographical images. Alibaba has developed AI solutions to predict the duration , size and peak of the outbreak, which is tested in real world in various regions of China and claimed to have 98% accuracy (*Huang et al.,2020*).

As the virus spreads to the lungs of the people infected by COVID-19, they may suffer from pneumonia. Many deep learning studies have proposed to detected the disease using chest X-ray and CT images of lung (*Toğaçar et al.,2019*). A deep learning model for pneumonia classification is proposed in (*Stephen et al.,2019*). Their model has convolution layers, dense blocks, and flatten layers. The input image size of the model was 200 * 200 pixels. They achieved to 93.73% success rate.

Chouhan et al. in (*Chouhan et al.,2020*) have classified the images of pneumonia into three classes: bacterial pneumonia, virus pneumonia, and normal images, using a deep learning models. Firstly, they applied some preprocessing methods to remove noise from the images. Then, they used augmentation technique images and trained their model using a transfer learning. They achieved to 96.39% of overall classification accuracy.

Authors in (*www.medrxiv.org ,2020*) used pathogen-confirmed COVID-19 cases (325 images) and 740 images diagnosed with typical viral pneumonia. Their internal validation reached to an overall classification accuracy of 89.5%. Their external testing dataset reached to an overall accuracy of 79.3%.

Toğaçar et al. in (*Toğaçar et al.,2020*) have proposed a deep learning method to classify chest X-ray images to detect corona virus infected patients. their dataset consists of three classes, namely: normal, pneumonia and coronavirus images. They achieved to 99.27% classification rate.

Zahangir et al. in (*Zahangir et al.,2020*) have proposed a multi task deep learning algorithm for this purpose. They have used and compared CT scan and X-ray images in their model. They achieved around 84.67% testing accuracy from X-ray images and 98.78% accuracy in CT-images, meaning that CT scan images are more accurate. They have also tried to determine the percentage of infected regions in CT and X-ray images.
Zheng et al. in (*Zheng et al.,2020*) have proposed a 3D deep neural network to predict the probability of COVID-19 infectious. They have used 499 CT volumes for training and 131 CT volumes for testing. Their algorithm reached to 90.1% overall accuracy.
Performance of different deep learning methods have compared together by applying them on pneumonia X-ray images (*Baltruschat et al.,2020*).

## Materials & Methods

Artificial intelligence improves the representations needed for pattern recognition using a machine composed of multiple layers, uses raw data as input (*Goodfellow et al.,2016*). Deep learning is a semi-supervised technique for labeling datasets. For instance, if a deep network is fed with several tumor cells, it can interpret an image to detect insignificant aspects (*Li ,2017*).
Since the last few years deep learning techniques completely changed the scenario of many research fields by promising results with highest accuracy, especially, in medical image processing fields, such as retina image, chest X-ray, and brain MRI images(*Mahmud et al. ,2018; Harsono, Liawatimena, Cenggoro, 2020*).

### Convolutional Neural Networks (CNN)

Convolutional Neural Networks (CNN) have more usage in computer vision and medical image analysis tasks compare to other deep learning classifiers, and it is proved that has more accurate results in mapping of image data to an expected output. (*Panwar,2020*). CNN has multiple layers, as other types of artificial neural network models, and it can process the high volume of data with higher accuracy and less computational cost. Its basic structure consisted of convolution, pooling, flattening, and fully connected layers (*Goodfellow et al.,2016*). CNN can extract the features from the images, and classify them. This unique characteristic can applied on medical images and provides a great support in the advancement of health community research (*Choe,2020*).
CNN models have self-learning abilities helps them to achieve superior and human-like classification results on multi-class problems. They compromised of a chain of a convolution layer (Conv) with a rectified linear unit (ReLu) activation functions, pooling layers (Pool) and batch normalization operation. They also have multilayer perceptrons which each neuron in a layer is connected to all neurons in the next layer. Layers convolute inputs with kernels and filters of the convolutions increase across the whole visual field. The hierarchical network structure provides high-level feature maps, reduced computation complexity and improved

overall accuracy, because their processes compose more complex patterns using smaller and simpler patterns depending on the hierarchical patterns (*Budak et al. ,2020; Ucar, Ferhat, and Deniz Korkmaz, 2020, Raghu et al., 2020*).

**Data Collection**

The data used in this paper is downloaded from publicly available dataset (*Rahimzadeh et al., 2020*). They have collected 15589 CT images of 95 positive patients and 48260 images of 282 negative persons. The pictures are 16bit tiff format and 512*512 size. Each person has three folder, each folder includes some images representing a breath sequence. Fig. 1 is showing some image samples.

Fig. 1: Samples of COVID-CTset images (*Rahimzadeh et al., 2020*)

In some images of a breath sequence, the inside of the lung is visible. In some of them (eg. first and lost images of a sequence), inside of the lung is not clear. Fig. 2 shows some sequential images.

Fig. 2: Samples of sequential COVID-CTset images

## Proposed Method

A deep learning model based on convolutional neural network (CNN) is proposed in this paper to distinguish positive and negative COVID-19 cases. In some researches some preprocessing stages are applied on images to select special images of a breath sequence or highlight lung infected area, before entering them to the classification algorithm (*Rahimzadeh et al., 2020*). In order to have a fully automated algorithm, in this paper no preprocessing, preselecting or ROI selecting is performed on images. Fig. 3 is showing the proposed model. As it is shown, it is consisted of three steps. In each step a convolution layer (Conv) is used. It is a 2-D convolutional layer which applies sliding convolutional filters to the input image. The layer moves the filters along the input and convolves the input by them vertically and horizontally, and computes the dot product of the input and the weights, and then adds a bias term . In our proposed model, the size of used filter is selected as 3×3. The number of filters are selected as 8, 16, 32 for the first, second and third step, respectively.

To reduce sensitivity of CNN to network initialization and speed up its training, a batch normalization layer is used between convolutional layer and nonlinearities. it normalizes each input channel across a mini-batch.

A rectified Linear Unit (ReLU) layer is used in each step to perform a threshold operation to each element of the input, meaning that each value less than zero is set to zero.

A max pooling layer is used in each step to run down-sampling by dividing the input into rectangular pooling regions, and computing the maximum of each region.

Fig. 3: The proposed model

In order to evaluate the proposed method, cross-validation technique is performed. For this purpose, the images in each category (ie positive or negative ) are divided into two groups, namely train, and test. Number of images in each group depends on application. In this research 10% of images in each category is selected randomly for training the deep learning model. The remained 90% of images is used for evaluation. By increasing the trainer images the processing time will increased and it is expected that the accuracy of the model will increased. A trained network could process any individual image immediately.

## Results

The original images have a size of 512*512. In order to reduce the processing border, resized images of 100*100 dimensions are used. Some training options should be defined for training the model. In this paper stochastic gradient descent with momentum (SGDM) optimizer is used. Initial learn rate is selected as 0.001. Maximum number of epochs can affect the training time. It is selected as 20 or 30.

Because of randomly selection of train and test images, the model is launched several times. Fig. 4 is showing a sample result.

Fig. 4: A sample of evaluation result of the model

## Discussion

As it shown the overall accuracy of the proposed model is more than 84%. It should be consider that in this research all CT images during a breath cycle is used, since the inside lung and also infected area can be seen in just few images, the accuracy rate is adequately high. Trained model can process any individual image in less than one second and predict its label almost immediately. It is expected that the accuracy increase by adjusting some parameters, but these parameters can increase the model training time.

## Conclusions

Detecting CVID19 positive cases from CT scan images would be helpful for doctors to detect the patients without performing timely and costly molecular tests. In this paper a machine learning model based on deep learning is proposed for this purpose. An available CT images is used. 10% percent of images are selected randomly and used for training the proposed model, while the model is evaluated using the remained images. The results implies the ability of the proposed model in classification of images. The accuracy of the model is around 84% while evaluating the model by all images.

## References

Budak, Ümit, et al. "DCCMED-Net: Densely connected and concatenated multi Encoder-Decoder CNNs for retinal vessel extraction from fundus images." Medical Hypotheses 134 (2020): 109426.

Choe, Jooae, et al. "Deep learning–based image conversion of CT reconstruction kernels improves radiomics reproducibility for pulmonary nodules or masses." Radiology 292.2 (2019): 365-373.

Chouhan, Vikash, et al. "A novel transfer learning based approach for pneumonia detection in chest X-ray images." Applied Sciences 10.2 (2020): 559.

Coronavirus - worldometer, link: https://www.worldometers.info/coronavirus/ , [online accessed]

Daksh Trehan, detecting-covid-19-using-deep-learning, (2020) https://towardsdatascience.com/detecting-covid-19-using-deep-learning-262956b6f981

Goodfellow I, Bengio Y, Courville A, Bengio Y. Deep Learning. MIT press Cambridge; 2016.

https://www.medrxiv.org/content/10.1101/2020.02.14.20023028v5, preprint

I Baltruschat, Ivo M., et al. "Comparison of deep learning approaches for multi-label chest X-ray classification." Scientific reports 9.1 (2019): 1-10.

I. W. Harsono, S. Liawatimena, T. W. Cenggoro, Lung nodule detection and classification from thorax ct-scan using retinanet with transfer learning, Journal of King Saud University-Computer and Information Sciences (2020).

Jaiswal, Amit Kumar, et al. "Identifying pneumonia in chest X-rays: A deep learning approach." Measurement 145 (2019): 511-518.

Li Y. Deep Reinforcement Learning: An Overview arXiv preprint arXiv:1701.07274.2017.

M. Mahmud, M. S. Kaiser, A. Hussain, S. Vassanelli, Applications of deep learning and reinforcement learning to biological data, IEEE transactions on neural networks and learning systems 29 (2018) 2063–2079.

Mallapaty, Smriti. "What the cruise-ship outbreaks reveal about COVID-19." Nature 580.7801 (2020): 18-18.

Panwar, Harsh, et al. "Application of Deep Learning for Fast Detection of COVID-19 in X-Rays using nCOVnet." Chaos, Solitons & Fractals (2020): 109944.

Raghu, Shivarudhrappa, et al. "EEG based multi-class seizure type classification using convolutional neural network and transfer learning." Neural Networks 124 (2020): 202-212.

Rahimzadeh, Mohammad, Abolfazl Attar, and Seyed Mohammad Sakhaei. "A Fully Automated Deep Learning-based Network For Detecting COVID-19 from a New And Large Lung CT Scan Dataset." *medRxiv* (2020). Datdaset: *https://github.com/mr7495/COVID-CTset*

Stephen, Okeke, et al. "An efficient deep learning approach to pneumonia classification in healthcare." Journal of healthcare engineering 2019 (2019).

Toğaçar, Mesut, Burhan Ergen, and Zafer Cömert. "COVID-19 detection using deep learning models to exploit Social Mimic Optimization and structured chest X-ray images using fuzzy color and stacking approaches." Computers in Biology and Medicine (2020): 103805.

Wang, Chen, et al. "A novel coronavirus outbreak of global health concern." The Lancet 395.10223 (2020): 470-473.

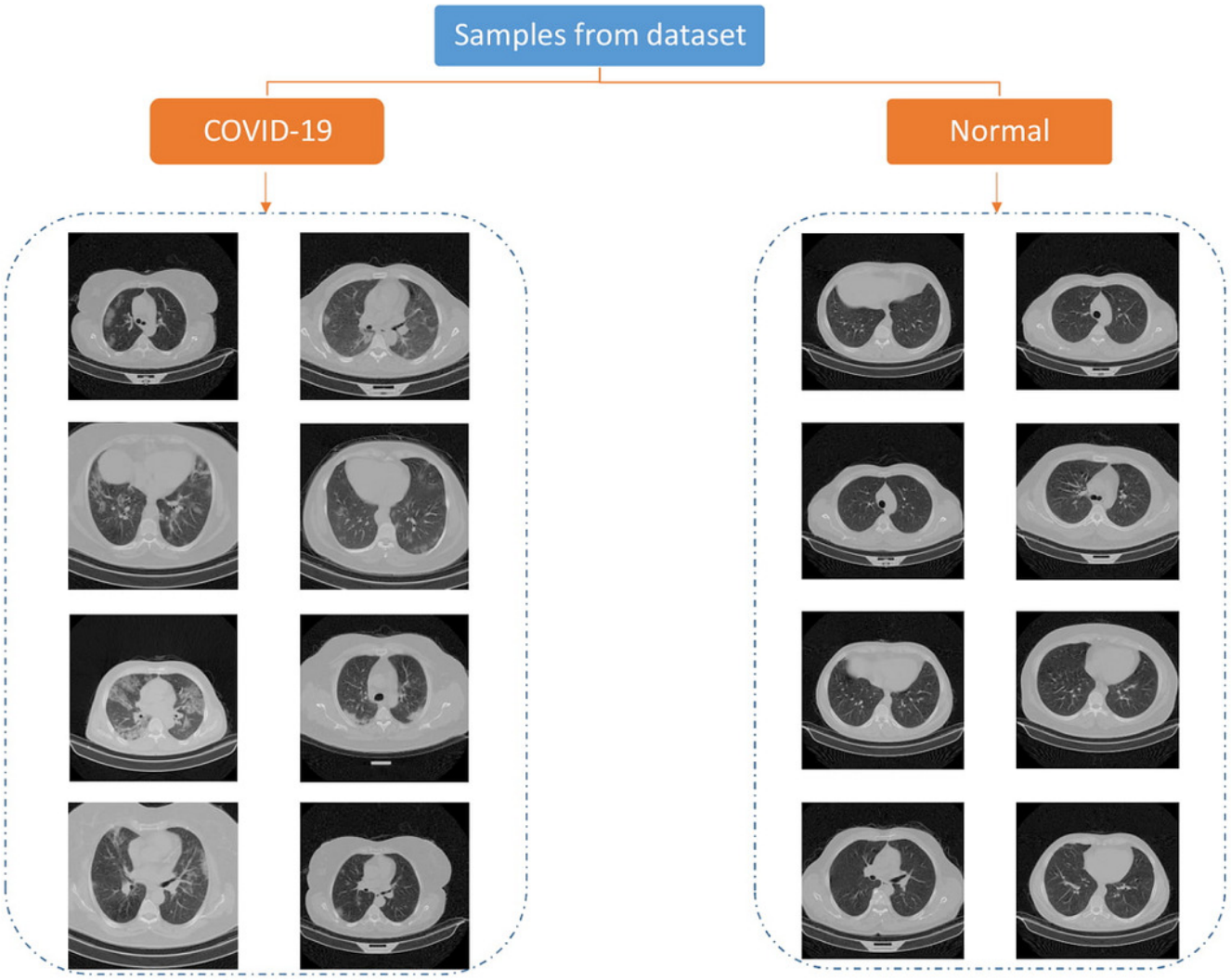
Zahangir Alom, Md, et al. "COVID_MTNet: COVID-19 Detection with Multi-Task Deep Learning Approaches." arXiv (2020): arXiv-2004.

Zheng C, Deng X, Fu Q, Zhou Q, Feng J, Ma H, Liu W, Wang X. Deep learning-based detection for COVID-19 from chest CT using weak label. medRxiv. 2020 Jan 1.

Ucar, Ferhat, and Deniz Korkmaz. "COVIDiagnosis-Net: Deep Bayes-SqueezeNet based Diagnostic of the Coronavirus Disease 2019 (COVID-19) from X-Ray Images." *Medical Hypotheses* (2020): 109761.

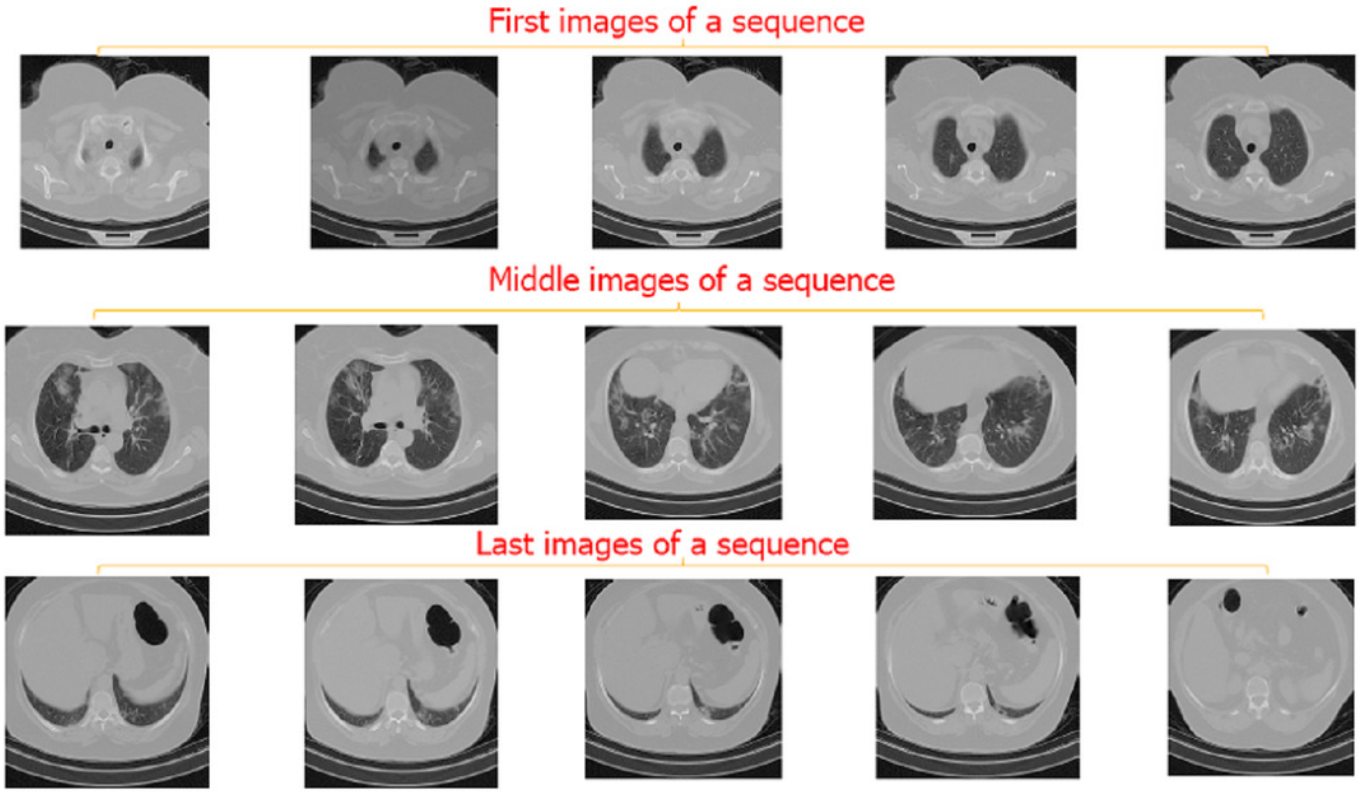
# Figure 1

Samples of COVID-CTset images (*Rahimzadeh et al., 2020*)



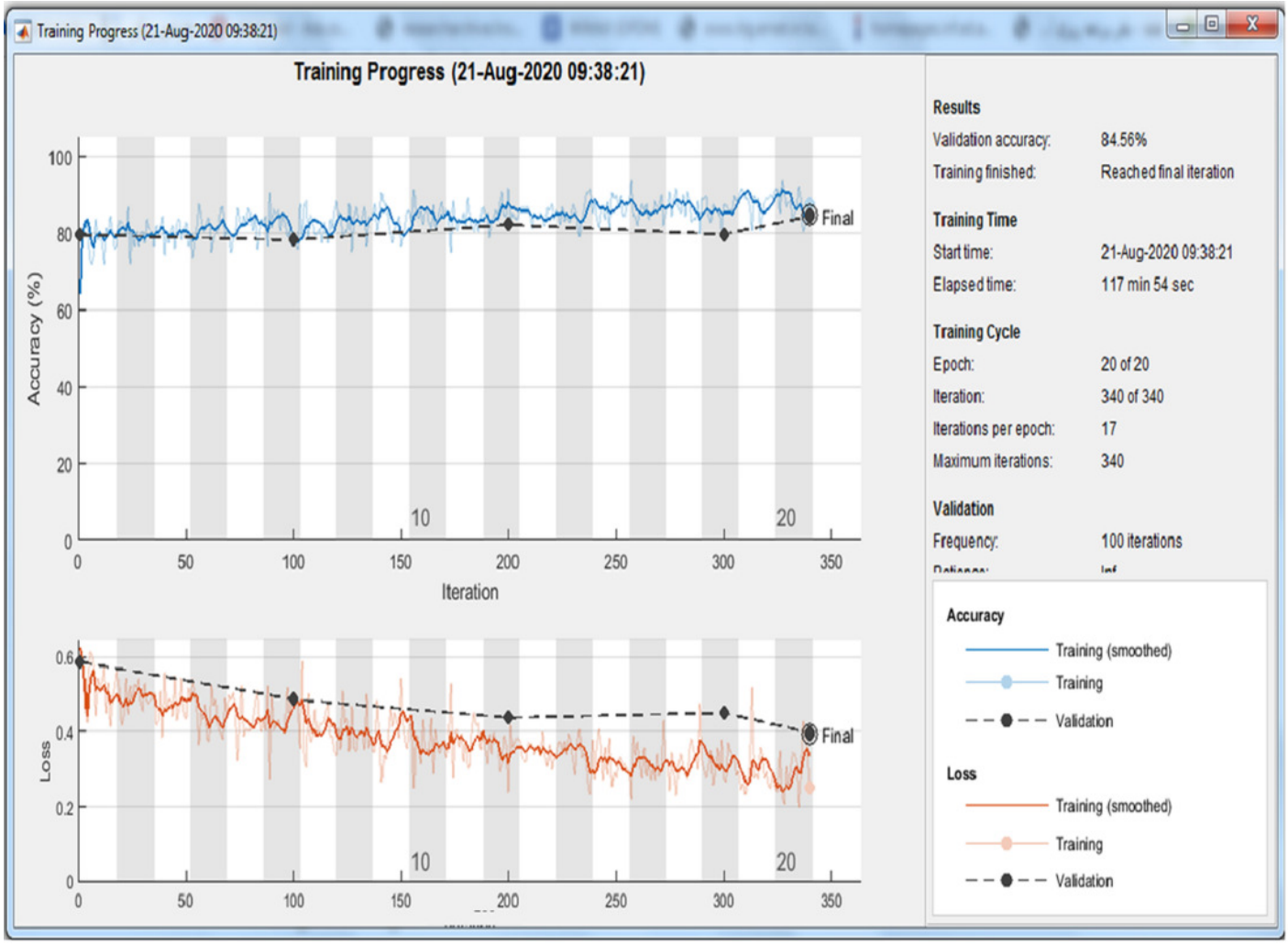
# Figure 2

Samples of sequential COVID-CTset images (*Rahimzadeh et al., 2020*)



# Figure 3

A sample of evaluation result of the model



# Figure 4

The proposed model