International Journal of Engineering Applied Sciences and Technology, 2021
Vol. 6, Issue 4, ISSN No. 2455-2143, Pages 74-77
Published Online August 2021 in IJEAST (http://www.ijeast.com)

DEEP LEARNING (CNN) MODEL FOR COVID-19 DETECTION FROM CHEST X-RAY IMAGES

Ahmed Mohamed Ahmed Abdelhady
Ismailia STEM High School, Ismailia, Egypt

Abstract - The Coronavirus disease outbreak result in many people to have severe respira- tory problems and it was recognized as a global health threat. Since the virus is targeting the lungs in the human body initially, chest x-ray imaging features were considered to be useful for the detection of the infection in the early stage. In this study, the chest x-ray data of 130 infected patients from an open data source that referenced Cohen J. Morrison P. Dao L., 2020 was used to build a CNN(Convolutional Neural-Network) model for the early detection of the disease. The model was trained with both infected and not-infected peoples' chest x-ray images with 100 epochs which led to 0.98 accuracy finally. In order to use this model as a professional diagnosis element, it is highly recommended it be improved with more images and the model can be restructured to get a better accuracy.

Keywords: The Coronavirus Disease 2019, Early Detection, Deep Learning, Chest X-ray Imaging, Global Health Threat.

I. INTRODUCTION

The COVID-19 (coronavirus disease 2019) infection which began in December 2019 in Wuhan, China has expanded all over the globe. The COVID-19 caused severe illnesses and was associated with high intensive care unit admissions and mortality so far. Along with the continuously increasing number of cases, medical companies started to produce test kits for the diagnosis. However, according to the Hematology Fellow Atilla Uslu from Ankara University School of Medicine, Uslu, Atilla(@ativitta)"We started to have cases where the coronavirus test was negative twice, but lung tomography seemed compatible with coronavirus. How the samples are taken from the mouth and nose affects the results. When not properly taken, these tests can produce incorrect results" 26 March 2020, 3:58 p.m. Tweet. Therefore, the CT scan images of the lungs play a lenient role in the early detection of the coronavirus disease. This study aims to build and develop a deep learning model for the early detection of the infection by using chest x-ray data. The main method is to use CNN (Convolutional Neural- Networks) for classifying and distinguishing COVID-19 positive and negative patients. The data which will be used to train the model is open - source dataset called COVID-19 image data collection on the Github platform. This study is limited to 130 patients' data for training the artificial intelligence model. This data which consists of chest x-ray images will be preprocessed, deep learning models will be created and trained, and the model will be tested to evaluate accuracy. In the methodology part, there will be the techniques used to create the model, train, and test along with the definitions subject-related specific terms as they have been used. In conclusion, accuracy and loss values after the test results will be inspected.

II. TRAINING METHODOLOGY

2.1 Dataset Introduction

The coronavirus disease can be distinguished via several unique characteristics on the CT scan and the chest x-ray images. In order to build effective infection control and the dynamic early detection mechanism against COVID-19, images which belong to infected and not-infected people should be gathered in a dataset. The COVID-19 image data collection states this urgent need as follows, "Think about a case where all the practitioners and radiologist have been infected and there is nobody to help us efficiently".[4] Therefore, this kind of datasets are playing an important role in diagnosis. This research used 130 sample chest x-ray training images and 18 sample chest x-ray test images from an open source data collection called Joseph Paul Cohen and Paul

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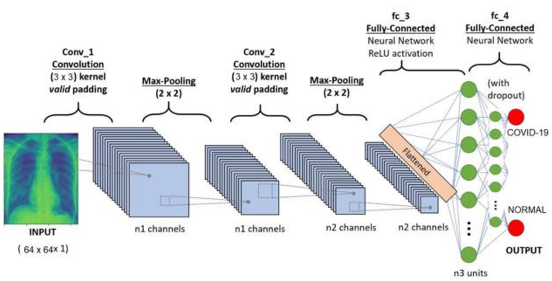
Morrison and Lan Dao COVID-19 image data collection.

2.2 Deep Learning Model for Classification

Figure 1.1. Convolutional Neural-Network Structure.



Convolutional Neural-Network was used to create this artificial intelligence which is used to create a sequential artificial neural network. A Convolutional Neural-Network can take in an input image, adjust the variables which are used to train the model and create the perfect equation to differentiate one image from another. "The Convolutional Neural-Network structure and the connectivity of the layers were inspired by the human brains' visual cortex that is a part of the cerebral cortex of the human brain that processes the visual data".[5,6] The CNN model which was created for this research has two convolution layers and two max pooling layers which can also be seen in the Figure 1.1. Convolution layer here is the first layer which constitutes the backbone of the artificial neural-network and extracts features from an input image by preserving the relationship between pixels. Output of every convolution layer and max pooling layer is a 3D tensor of shape height, width and channel. In this deep learning model, 3 by 3 matrices and 32 output channels were used for each convolution layer because of the limited number of data and CPU. Therefore, the main objective of the convolution operation was to extract features such as first edges and, as the more layers were added, the more complex shapes from the input image could be extracted. The second layer is called max pooling and the pooling layer is responsible for reducing the size of the convolved feature map by protecting the spatial invariance and decreasing the power required to process the data. There may be more convolution and pooling layers depending upon the number of images to be processed and the central processing unit. After the Flattening operation, flattened matrix of features was transferred to the fully connected layer. Also, in this layer there are two dense layers consisting of 256 nodes in the first layer and 1 node in the second layer for the result of the classification.

2.3 Image Preprocessing and Data Generation

This section is reserved for the image preprocessing by using the Keras library. Here, the study focused on data augmentation. Data augmentation means artificially producing brand new training data from the already existing training data. The intent is to expand the training data with new samples. For example, changing the direction, position and alignment of the object.

2.4 Training the Fully Connected Neural Network

The model was trained by using 130 images which are belonging to 2 different classes in the training data, and 18 images which are belonging to 2 different classes in the test data. The flattened output is fed to a feed-forward and fully connected artificial neural network layer and back-propagation method is applied over each iteration of training. The fully connected neural network improves the quality of the model and in every iteration, parameters approach to the values which satisfy better accuracy. Over a series of epochs, the model was able to differentiate between certain dominating features in images.

III. CONCLUSIONS

The new COVID-19 is latching its' spiky surface proteins to receptors on healthy cells on human lungs, therefore it plays a significant role at the early detection of the virus by using the chest x-ray data. The main purpose of the CNN model was to differentiate between the chest x-ray images of the infected people and not-infected people for the early detection of the COVID-19 disease.

3.1 The Final Accuracy and Loss

The final accuracy level of the deep learning model is recorded as 0.98 and the loss is recorded as 0.04. Also, accuracy-loss evolution values can be observed in the

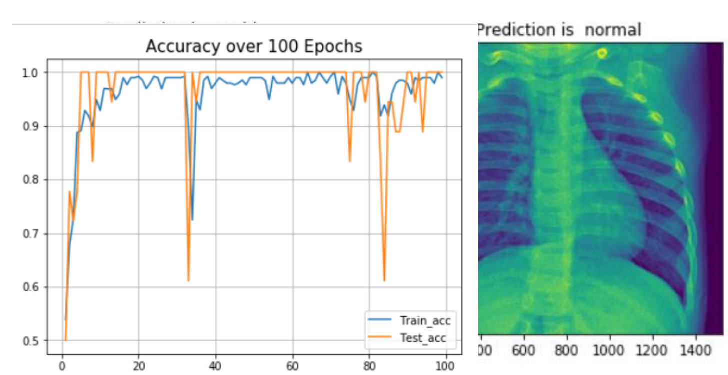


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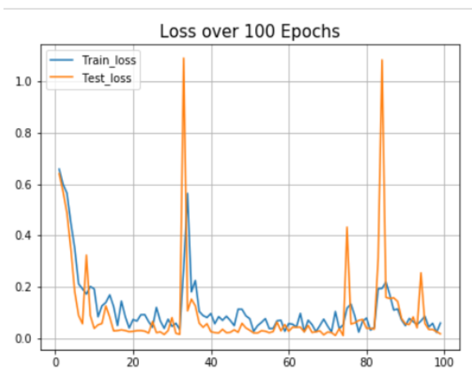
Figure 1.2. The deep learning model answers nearly the 0.98 of the chest x-ray images of the patients correctly and distinguishes between the infected and not infected lungs, which is the first target region of the human body.

Figure 1.3. Accuracy-Loss Graph



As the number of patients is increasing, it is getting more challenging to inspect and diagnose this high number of cases. However, a powerful machine can diagnose billions of patients in one day.

3.2 Limitations and Future Research

This study is limited to analyzing 130 patients' data. As a future work, the number of data which is used to train the CNN model can be increased and the general structure of convolutional neural network can be restructured so that it will be able to analyze images in more detail. Also, there will be a graphical user interface to enable application for the use of doctors and radiologists at the hospitals and health centers. For now, the deep learning model gives an output as in the Figure 1.2. In the Figure 1.4., the model has been tested with single-prediction data images. The image at the left-hand side belongs to a real COVID-19 patient and the models' prediction was also aligned in that class. The image at the right-hand side belongs to a normal patient and the models' prediction is normal also. This was the proof that this model at the background can be improved to serve as a real diagnosis application.

Figure 1.4. COVID-19 and Normal Classification.

In summary, an application that is able to show the skills of providing the probability of the infection will be a lifesaver solution to this kind of epidemics and reduce the speed of the disease. Also the role of the doctors, radiologists and practitioners should be taken into consideration at the testing phase of this kind of applications. The results suggests that creating a deep learning model that distinguishes between normal and infected peoples' chest x-ray images could be a solution for early detection and diagnosis of coronavirus disease.

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