Nat. Volatiles & Essent. Oils, 2021; 8(5): 3165-3173

Deep Learning System Detection of COVID-19

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Abstract

Infectious disease like corona virus (COVID-19) surveillance is crucial. Artificial intelligence (AI) is well adapted for identifying patterns to curb worst effects of COVID-19. Corona infection becoming an common complication nowadays can be diagnosed using deep learning system by the analysis of a CT(Computed Tomography) scan in less than sixty seconds with accuracy as high as 92% and a recall rate of about 95% on test data sets as compared to rapid diagnostic tests. It is proceeded with the help of an open-source deep learning platform Google Colab, where Convolutional Neural Network (CNN) methodology analyzed CT images for the detection of lung disorders. This work elucidates about different architectures like scratch program, Densenet, VGG-16 that are programmed for classifying normal cases, positive COVID-19 cases and positive pneumonia cases providing different results in terms of accuracy.

Keywords: Computed Tomography, Neural Network, Deep Learning, VGG-16 architecture.

I. INTRODUCTION

A novel corona virus (nCoV) is a new strain that has not been previously identified in humans. Today With the number of COVID-19 cases crossing 20 million marks, the healthcare system across the globe is struggling against the management of COVID-19[1]. In India, COVID-19 has proved challenging initially for both identifying the COVID patients and diagnosing the same. However, the use of deep learning over the past few years has rendered the health line workers and the government for solutions, to stall this roadblock.

The corona virus disease pandemic has been taking an unprecedented spread and has become a threat to almost all countries, with more than ten thousand cases having been reported worldwide every day [2]. There is an urge for treating the disease where the disease has to be identified correctly with better accuracy results. Multiple strategies, testing methods, treatments and preventive measures are taken to handle the current outbreak.

A. COVID-19

Corona viruses (CoV) are identified as large family of viruses which can cause illness ranging from the common cold to more severe diseases to human such as Middle East Respiratory Syndrome (MERS- CoV) and Severe Acute Respiratory Syndrome (SARS-CoV). It is a dangerous respiratory and vascular disease due to infected with severe acute type respiratory syndrome coronavirus 2 (SARS-CoV-2). Corona viruses are zoonotic, which means they can be transmitted between animals and people [2].

B. Structure and Multiplication

The coronavirus virus's Structure is spherical to pleomorphic enveloped particles as shown in figure 1. The envelope is studded with projecting glycoproteins. It is surrounded by a core consisting of matrix protein enclosed within which is a single strand of positive-sense RNA (Mr 6×10^6) which is associated with another material nucleoprotein. The attachment to the host cell is carried by envelope glycoproteins [2].

Multiplication happens in such a way that human corona viruses enter the human cells, by specific receptors predominantly [1]. A sialic acid-containing receptor and amino peptidase-N and have been identified by it. When the virus enters the host cell, the genome is transcribed and translated. A unique feature of replication is that all the mRNAs form a nested set with common 3 ends and only the unique portions of the 5 ends are translated.

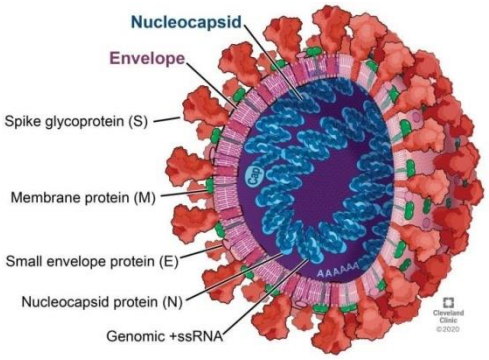

Fig 1. Structure of corona virus

C. Signs and symptoms

The symptoms generally are different, but usually they include fever and a cough. People may have different symptoms for the same infection, and the symptoms may change over time. For example, one person may have a low fever at the start of the disease, and loss of smell and taste, and another person may have a common fever and shortness of breath which develops difficulty breathing a week later. However, initially for people without any prior ears, nose, and throat (ENT) disorders, loss of taste combined with loss of smell is associated with COVID-19 with a specificity of 95% in most cases [1]. The incubation period which is the time between becoming infected with the virus and showing symptoms, may range from one to fourteen days. Some common symptoms include:

- High / Low Fever
- Cough regularly
- Fatigue
- Difficulties in breathing
- Smell and Taste loss.

Longer-term damage may happened to significant organs (particularly, the lungs and the heart), and few patients who have recovered from the acute phase of the disease but they continue to experience the following range of effects after that

- Severe fatigue

- Memory loss
- Low grade fever
- Muscle weakness
- Breathlessness and
- Other symptoms occurs months afterwards

D. Diagnosis

Several testing protocols for the disease corona virus has published by the World Health Organization (WHO). But it is proposed that the real-time reverse transcription polymerase chain reaction (RT-PCR) is the standard method of testing. This test is typically done on respiratory samples obtained by a nasopharyngeal swab; however, a nasal swab or sputum sample may also be used. Within a few hours to two days the results are available generally [1].

Blood tests can also be used, but this method requires two blood samples for the test taken two weeks apart, and the results may have little immediate value.

Chest Computed Tomography scans are helpful to diagnose COVID-19 in individuals with a high clinical suspicion of infection but they are not recommended for routine screening. Figure 2 is the test kit that is used for detecting corona virus infection.

Fig 2. Test kit for COVID-19

E. Deep Learning

The artificial intelligence (AI) is essentially wherever the machines can do tasks with the requirement of human intelligence. Also deep learning encompasses machine learning (ML), where machines can learn by experience and can acquire skills without involvement of human.

Deep learning is a subset of machine learning where artificial neural networks, algorithms inspired by the human brain, learn from large amounts of data [7].

Data science has an important element that is nothing but deep learning, which includes predictive modeling and statistics. The data scientists are benefited by the above tools. These tools are helpful for them in collecting, analyzing and interpreting large amounts of data. This process is faster and easier with the help of deep learning. At its simplest, deep learning can be thought of as a way to automate predictive analytics. The following figure 3 describes the general flow process of deep learning for any example.

Fig 3. Deep Learning process

II. DATASET

The datasets required to carry on the project was downloaded from Kaggle and the real- time CT scan images where got from Scan Point, Pollachi District. Kaggle, a subsidiary of Google, is an online community of data scientists and machine learning practitioners.

Kaggle was started in 2010 by offering machine learning competitions. Nowadays it offers a public data platform, Artificial Intelligence education and a cloud-based workbench for data science. The CT images downloaded from Kaggle are shown from figure 4 to 6 and figure 7 differentiates between COVID and Pneumonia.

Fig 4. COVID positive CT

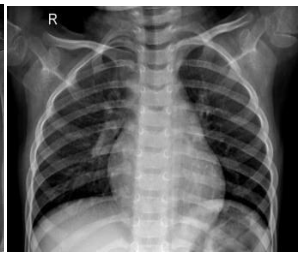

Fig 5. Normal CT

Fig 6. Pneumonia CT

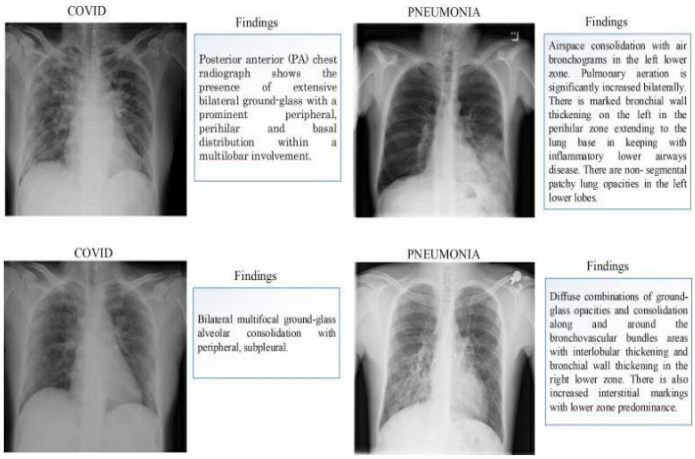

Fig 7. Analysis between COVID and Pneumonia

III. PROPOSED METHODOLOGY

The design and methodology for classification of data's is implemented by python programming in Google Colab platform. The block diagram as shown in the figure 8 show the outline of the project carried out.

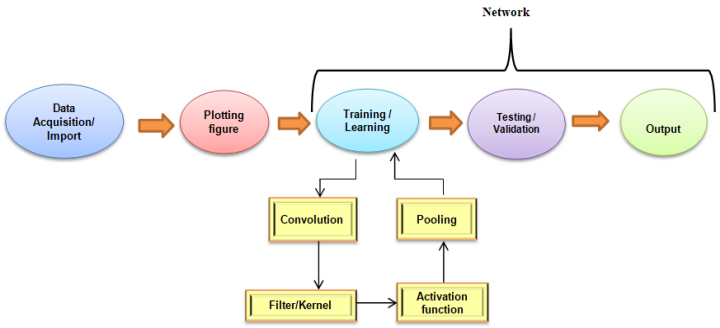

Fig 8. Proposed Methodology

Necessary library files and datas are imported to the Colab. The datas are viewed and labeled to check if the datas are imported properly. Then the datas are trained for different convolutional layers where filter and kernel sizes are assigned. Activation function is given as ReLU function and given to testing phase where they are validated. Later the program is trained for epochs and output is checked for accuracy [4].

SOFTWARE: The program is carried out in python fashion in Google Colab platform where the images are imported directly from Kaggle for training and testing. The library files used for implementing the program are listed below:

- NumPy: It stands for Numerical Python, which is a library consists of multidimensional array objects and a collection of routines used to process those arrays. With help of NumPy, the mathematical and the logical operations on arrays

can be performed [6].

- Matplotlib: It is one of the most popular Python packages used for data visualization. It is a cross-platform library for making 2D plots from data in arrays. It provides an object-oriented API that helps in embedding plots in applications using Python GUI toolkits. It can be used in Python and IPython shells, Jupyter notebook and web application servers also [6].

- Keras: It is an open-source library that provides a Python interface for artificial neural networks. Keras acts as an interface for the TensorFlow library. Keras contains numerous implementations of commonly used neural-network building blocks such as layers, objectives, activation functions, optimizers, and a host of tools to make working with image and text data easier to simplify the coding necessary for writing deep neural network code.

- Os (Operating system): It is possible to automatically perform many operating system tasks. The OS module in Python provides functions for creating and removing a directory (folder), fetching its contents, changing and identifying the current directory, etc.

IV. RESULTS AND DISSCUSSIONS

The objective of the project is to classify COVID-19 positive cases, Normal cases without COVID and Pneumonia positive cases using deep learning platform. The Magnetic Resonance Images and Computed Tomography of the three different cases is fed to the program and the results are simulated for various architectures resulting in different accuracy. The following Convolutional Neural Network (CNN) methodologies analyzed CT images for the detection of lung disorders [3].

A. Scratch Architecture

A scratch program was performed with 224*224 input shape of the data where four convolution layers of 16, 32, 64, and 128 was given with kernel size of (3,3). The activation function is ReLU and pool size is assigned to be (2,2). With these parameters the output accuracy was only about 34% of validation accuracy and 33% of train accuracy as shown in figure 9.

```
Epoch 1/20
10/10 [==============================] - 1050s 105s/step - loss: 1395.6935 - accuracy: 0.3750 - val_loss: 0.9261 - val_accuracy: 0.6625
Epoch 2/20
10/10 [==============================] - 1050s 105s/step - loss: 0.9427 - accuracy: 0.6125 - val_loss: 0.9014 - val_accuracy: 0.6469
Epoch 3/20
10/10 [==============================] - 1033s 103s/step - loss: 0.9724 - accuracy: 0.6281 - val_loss: 0.7883 - val_accuracy: 0.7156
Epoch 4/20
10/10 [==============================] - 1053s 105s/step - loss: 0.8533 - accuracy: 0.6625 - val_loss: 0.8268 - val_accuracy: 0.6594
Epoch 5/20
10/10 [==============================] - 1063s 106s/step - loss: 0.8486 - accuracy: 0.6344 - val_loss: 0.8556 - val_accuracy: 0.6562
Epoch 6/20
10/10 [==============================] - 1091s 109s/step - loss: 0.8569 - accuracy: 0.6687 - val_loss: 0.7901 - val_accuracy: 0.7063
Epoch 7/20
10/10 [==============================] - 1121s 112s/step - loss: 0.8674 - accuracy: 0.6594 - val_loss: 0.8261 - val_accuracy: 0.6594
Epoch 8/20
10/10 [==============================] - 1127s 113s/step - loss: 0.8876 - accuracy: 0.6125 - val_loss: 0.8252 - val_accuracy: 0.6750
Epoch 9/20
10/10 [==============================] - 1133s 113s/step - loss: 0.8600 - accuracy: 0.6687 - val_loss: 0.8102 - val_accuracy: 0.6687
Epoch 10/20
10/10 [==============================] - 1128s 113s/step - loss: 0.8203 - accuracy: 0.6719 - val_loss: 0.8187 - val_accuracy: 0.6719
Epoch 11/20
10/10 [==============================] - 1115s 111s/step - loss: 0.8039 - accuracy: 0.6923 - val_loss: 0.8571 - val_accuracy: 0.6250
Epoch 12/20
10/10 [==============================] - 1123s 112s/step - loss: 0.8291 - accuracy: 0.6438 - val_loss: 0.7770 - val_accuracy: 0.6969
Epoch 13/20
10/10 [==============================] - 909s 91s/step - loss: 0.7881 - accuracy: 0.6719 - val_loss: 0.8347 - val_accuracy: 0.6687
Epoch 14/20
10/10 [==============================] - 611s 61s/step - loss: 0.8161 - accuracy: 0.6812 - val_loss: 0.8879 - val_accuracy: 0.6187
Epoch 15/20
10/10 [==============================] - 613s 61s/step - loss: 0.7994 - accuracy: 0.7375 - val_loss: 0.8566 - val_accuracy: 0.6781
Epoch 16/20
10/10 [==============================] - 615s 62s/step - loss: 0.8426 - accuracy: 0.6438 - val_loss: 0.8448 - val_accuracy: 0.6562
```

Fig 9. Accuracy data of scratch program

B. VGG-16 Architecture

VGG-16 architecture program was performed with 224*224 input shape of the data where convolution layers of 64, 64, 128,128,256,256,256,512,512,512,512,512 and 512 was given with kernel size of (3, 3).

The activation function is ReLU and pool size is assigned to be (2,2) [5]. The strides is of size (2,2), With these parameters the output accuracy was only about 67% of validation accuracy and 63% of train accuracy as shown in figure 10.

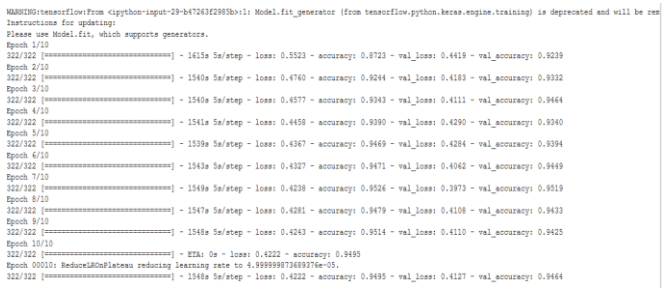

Fig 10. Accuracy data of VGG-16 program

C. Densenet Architecture

A Pretrained Densenet architecture program was performed with 224*224 input shape of the data and kernel size of (3,3) is given. The activation function is ReLU, pool size is assigned to be (2,2).

With these parameters the output accuracy was only about 94% of validation accuracy and 92% of train accuracy as shown in figure 11. Model loss and accuracy graph was plotted as shown in figure 12 and 13 respectively [6]. The output was classified using gradcam technique as shown in figure 14.

Fig 11. Accuracy Data of Densenet program

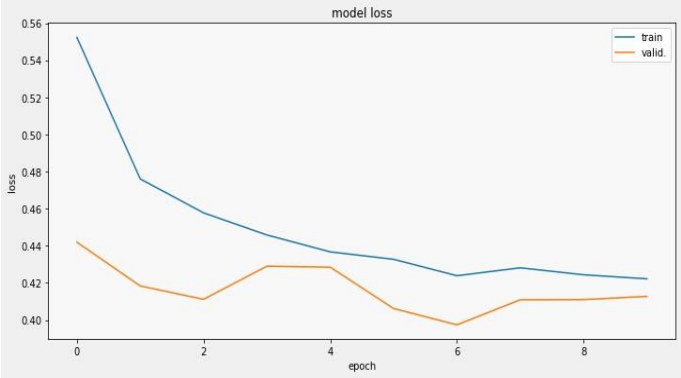

Fig 12. Model Loss Graph

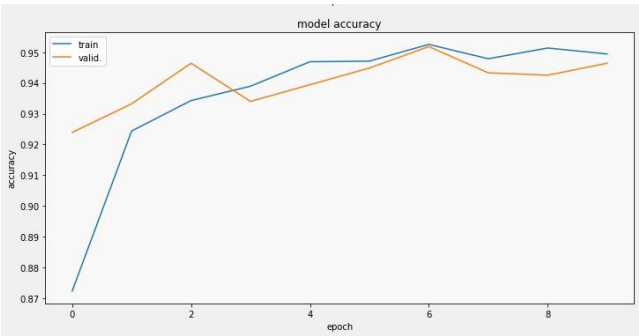

Fig 13. Model accuracy graph

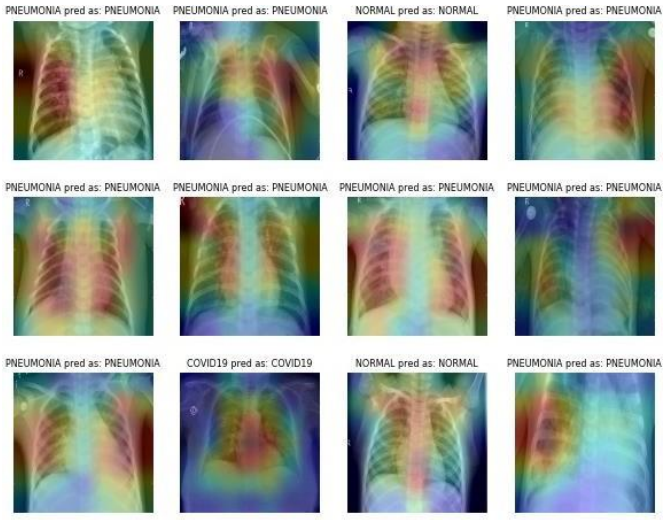

Fig 14. Gradcam output classification

V. CONCLUSION

Convolutional Neural Networks (CNN) is proved to be one of the best neural networks for image classification. Deep learning system for detecting covid-19 from other lung disorders was detected with about 94% of accuracy on validation data using DenseNet architecture. Scratch program and VGG-16 architectures predicted the disease with

less accuracy of about 34% and 67% on validation data respectively.

Major drawbacks of VGG-16 like vanishing gradient problem and more training time was overcame by DenseNet architecture. The project can be further developed for other lung disorder like lung cancer, pulmonary embolism etc are classified along with COVID-19 infection.

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