Covid-19 Detection Using Advanced CNN and X-rays

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Abstract As the Covid-19 pandemic surfaced worldwide, various newer technologies came ahead to help humanity to survive and live a better life. While medical science worked on vaccine development, Artificial intelligence and advanced computing helped in segregating millions of drugs to counter this novel coronavirus disease. Deep learning also came up with an alternative detection model. In this work, we present the detection method with computer vision using advanced CNN (Convolutional Neural Network) and architecture used is VGGNet. Since the virus is a new variant of the coronavirus also named as SARS-2 (Severe Acute Respiratory Syndrome Coronavirus 2) by WHO (World Health Organization), requires a different technique for testing and detection. The detection procedure used to take too much time to confirm the infection. The techniques utilized to this point of time is limited and which creates an impossible type of situation to test a huge crowd of the population like India. So, it’s high time to come up with an alternative system for the Covid-19 Tests. Hence this paper came up with detection and partial confirmation of Covid-19 using X-ray images by applying a deep learning Algorithm. By enhancing the images and classifying the features we can easily differentiate between Covid-19 affected people and Normal people X-ray images of the chest. This pandemic highly affects our lungs. X-ray images may be one of the viable options.

Keywords Convolutional neural network · Covid-19 · Deep neural network · Pandemic · SARS-2 · Vaccine development
1 Introduction

The consequences of the spread of Covid-19 in the world are death tolls, lockdown, loss of economy, the uncertainty of future but certain preventions such as social distancing, face covering, and diagnosis of the cases results in slowing down the spread [1]. Currently, the Techniques available for detecting Covid-19 is very costly, and time taking besides its production is limited to certain countries. Since the development of new testing kits and using new tech may take a lot of time and thus it will be fatal for all of us as the virus is contagious [2]. So, there has to be a technique that is easily available and it can tell about the initial development of symptoms and not fully but partial detection of this pandemic virus. As every feature of an image can be extracted using a Deep Neural network and convolutional neural net (also called ConvNet) [3] which can enhance the features beyond the human eyes and can easily classify the images of different categories after having trained over large images of ImageNet [4]. Due to these developments, now-a-days various emotions can be identified in Google photos. Today Google has already worked on the system which identifies you out of millions of images. Facebook’s face recognition system has become so advanced that Duty guards are being replaced with automatic surveillance systems.

So, after several months of the pandemic, there is enough data available on this pandemic to train and analyze for the detection of the infection using image processing techniques. As the X-ray images of people who are affected and normal people are available to overcloud. If it can be trained to a machine to learn how a normal X-ray image of the chest looks and how affected X-rays? Li et. al. [5] presented on the introduction of KELM (Kernel Extreme Learning Machines), a better classifier than softmax so the performance of CNN could be promoted. Thus, if a machine once trained to identify it could easily tell that certain X-ray images are affected and further testing can be done to verify. This method has the possibility of detecting disease through the proposed method.

2 Previous Works

Not many works about Covid-19 have been proposed yet, but many works around image classification can be found out. Emotion recognition software is elsewhere. And these work on the training of images in large amounts. Jmour et al. [6] presented their paper and they talked about convolutional neural networks and classification of images which talked about transfer learning technique also called fine-tuning, introducing reusing of pre-trained models On ImageNet for great accuracy while building the new model. Supe et al. [7] worked on image processing for medical Images where how clearly, they explained about the processing of images in detection of tumors, detection of internal organ failures, if they could clearly understand the internal damages why can’t we use these X-rays techniques
to detect abnormality in the lungs? There is a need to just implement the details. Besides that, we know that Covid-19 affects mostly our lungs.

Sultana et al. [8] worked on the article of advancement in convolutional neural networks where they wrote how ConvNet has advanced from LeNet-5 to the latest SENet model. Today the work on these technologies is such that no details of the image are left behind. They drove the conclusion that Today’s era of googleNet, CPU based implementation trained using DistBelief [9] comes from VGGNet as shown in Fig. 1 developed by Krizhevsky [10] which is a deeper configuration of AlexNet, this is a concept we have used in this work.

Once we train the images our system can be fruitful with the main objective of the proposed research work is to use the Neural Networks and convolutional networks to achieve the following goals:

- To find an alternative Testing method for Covid-19 +ve people which is feasible and easily available.
- To replace the old time-consuming method with an automatic system that could be automated and utilizing the image classification methods.

3 Theory System Architecture

To understand how our system works it needs to know the basics behind the Image classification and ConvNet. Here it starts with how computers read an image as shown in Fig. 2. Overview of the computer vision Model will clear out all the doubts and it will clearly understand, how this can be possible.

This work has come with computer vision techniques to classify normal and COVID affected X-ray images. To understand the working of the proposed method, it needs to dive deeper into how Convolutional Neural Networks help in classifying the images by feature extraction. Simple raw images can be classified by a simple Neural network and fully connected layer but when it comes to RGB images simple Neural Net fails and it needs convolutions to build on these images as shown in Fig. 3.

CNN the neuron in a layer will be only connected with the only few of the neurons in the next layer unlike all the neurons connected in the fully connected layer so CNN is preferred.
CNN works by putting the convolution filters to extract features. Each filter is like a feature and it runs over the image to extract each feature out of the image and then we apply the pooling layer to compress the image besides keeping the important features in the image. It compares the image piece by piece which is very obvious from the Fig. 4 below. It gets better at seeing similar things by roughly matching the pieces at different locations in the image.

After having the normalized image with the input layer, we apply convolution, relu, and pooling layer in multiple amounts and stack it to have the image with less size but enhanced features. This stack of layers is applied to fully connected layers which can be seen in Fig. 5 below.

Feature extraction is an important part as classification can be done with any kind of image be it raw images or self-centered images. This is called feature extraction. Only a neural network once applied the image will make up the model.
but will not be accurate in the case of complex images. ConvNet can classify simple to complex image sets. Thus, this becomes a very useful part of our program.

Once the matrix of the given input layer image is supplied to the fully connected layer. This layer with SoftMax function classifies the image based on the probability reference as shown in Fig. 6.

4 Proposed Model Building

The proposed model building consists of the following steps.

- Load/Process the dataset.
- Normalize the dataset/encode it.
- Derive the ImageNet inbuilt model.
- Make the deep fully connected layer.
- Train the CNN-DNN model.
- Test the CNN-DNN.
- Here evaluates the model to proceed to
- Observation section.
In the proposed model we load the dataset from a GitHub repository [11] of Dr. Cohen where data is constantly updated with the help of various scientists and doctors who are constantly working ahead to find a solution to this pandemic. In this dataset, we take away 25 X-ray images of affected people and 25 normal people X-ray images. This link also contains a dataset for SARS, MERs outbreak in the past is as available [12]. In the given code below, we specify the path to the dataset and output path after the model building. It can well observe the affected dataset in Fig. 7.

Now we are ready to preprocess the dataset. Initially, we will capture each image path from the dataset directory and then we will extract the class level from each path as either COVID or normal. Then load the image and convert it into RGB and 224 × 224 pixels to be fit for the convolutional neural network input layer. Once this is done, we will go on to Normalize our intensity to [0, 1] besides converting our label and data into NumPy arrays. Here you can view the above-mentioned process performed below in the code.

Continuing with our preprocessing process once we bring the label to [0, 1] we work with a hot encoder which will encode our label to 1 for COVID+ affected people X-ray images and 0 for normal X-ray people. Besides we will split our dataset into 80% of the dataset for testing purposes while 20% for testing or validating the model which is as follows in the code.

![Fig. 7 Model building](image-url)
After preprocessing we move ahead with training our dataset. As we have very few datasets available so the model may not be accurate. That’s why we will take the help of already heavy models from ImageNet (which is a collection of huge image datasets having millions of images). The VGG16 (Fig. 1) model is trained from there we derive the ImageNet model without the fully connected layer as in the code then we go ahead with building the fully connected layer as $\text{POOL} \Rightarrow \text{FC} = \text{SOFTMAX}$. Then the final model has a base model and on top of that, we have a fully connected layer besides we will freeze the weights of the convolutional layer so that only the fully connected layer gets trained here in our training.

Note: VGG16 model which is trained from ImageNet architecture works on the convolutional layer which is well capable of extracting the features of the images, which is a very important part of the classifying the X-ray images correctly.

After the model building is done, it needs to run the training process without any delay besides it will compile the model using binary cross-entropy key ingredients for the classification process. To simplify it, the process converts our dataset into a list of numerical values but the main work based on the probability of classification is done by the optimizer.
Figure 8 shows a screenshot of the training process. It is observed that the accuracy of around 90% is achieved. Let’s get that validation done in the result and observation section Fig. 9.

Figure 8 Training in progress

Figure 9 Classification table for evaluation metrics
5 Results and Observation

After training the model, it needs to be validated, besides it will use confusion matrix as a tool to predict the accuracy, sensitivity, and specificity as shown in the code below and results follows:

```python
# calculate the confusion matrix and use it to derive the results
# con = confusion_matrix(testy.argmax(axis=1), predit.argmax())
# total = con[0][0] + con[1][1] + con[1][0] + con[0][1]
# accuracy = con[0][0] / total
# sensitivity = con[0][0] / (con[0][0] + con[0][1])
# specificity = con[1][1] / (con[1][1] + con[1][0])
# show the confusion matrix, accuracy, sensitivity, and specificity
print(con)
print(f'Accuracy: {accuracy:.2f}
Sensitivity: {sensitivity:.2f}
Specificity: {specificity:.2f}')
```

Here in the result, it can well observe that with the help of the confusion matrix, the accuracy of around 90% with a sensitivity of 1.000 and specificity around 0.800 is achieved. Let’s go on to plotting the results now to visualize the outcome in a much better way below is the included classification table for the references.

With the help of pyplot in python, we can easily see the plot of Covid-19 detection using an X-ray. The plot is as per the training which took place. Let’s describe the plot in detail below.

From the plot, we can observe that training loss and validation loss both are decreasing with the number of epochs, moreover both training and testing sets are synchronous.

Training accuracy, in the beginning, was random for a few epochs but later training accuracy increased heavily and validation accuracy constantly increased with several iterations. The best part is that in the end having 25 epochs training and validation is no different. Figure 10 can show that red line training loss is decreasing. While working on the model if it needs to go with further training or not that is all determined by these kinds of plot. It helped us in generalizing our model. The model works well with training and testing this can be well seen from the plot in Fig. 10. The accuracy of the model can be verified from the evaluation metric table Fig. 9 and the ROC curve in Fig. 11.
6 Conclusion

The research work focuses on convolutional neural networks to classify the images after extracting the deep features of the X-rays. Through this work, it is demonstrated to find out an effective method to detect the virus quickly as compared to the testing kit. As Covid-19 affects our epithelial cells, lungs, and effective regions of the chest, so, X-ray can be the most viable and easily available method as of now to detect the coronavirus. Although a very well qualified medical professional can easily tell the difference by manually looking at the X-ray images. But again, that is what we lack because doctors are at risk so there is a dearth need for automation, and here is this we propose. We have achieved an accuracy of 90% but as we are not medical practitioners nor professionals so we don’t guarantee that it.
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