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Detecting COVID-19 from X-ray images using AI

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Abstract

An innovative model for automatic COVID-19 detection using raw chest X-ray images is presented. The proposed model is developed to provide accurate diagnostics for binary classification, computed tomography (CT) and X-ray have vital roles in early diagnosis and treatment for covid disease. Clinical centers had insufficient test kits, which are also producing a high rate of false-negative results, so doctors are encouraged to make a diagnosis only based on clinical and chest CT results/chest x-rays. It is a challenging task to provide expert clinicians to every hospital due to the limited number of radiologists. Therefore, simple, accurate, and fast AI models may be helpful to overcome this problem and provide timely assistance to patients. Although radiologists play a key role due to their vast experience in this field, the AI technologies in radiology can be assistive to obtain accurate diagnosis. Additionally, AI approaches can be useful in eliminating disadvantages such as insufficient number of available RT-PCR test kits, test costs, and waiting time of test results.

Keywords—CNN, Sequential Model, Deep Learning

1. INTRODUCTION

An early evaluation of Artificial Intelligence (AI) against COVID-19. The main areas where AI can contribute to the fight against COVID-19 are discussed. It is concluded that AI has not yet been impactful against COVID-19. Its use is hampered by a lack of data, and by too much data. Overcoming these constraints will require a careful balance between data privacy and public health, and rigorous human-AI interaction. It is unlikely thatthese will be addressed in time to be of much help during the present pandemic. In the meantime, extensive gathering of diagnostic data on who is infectious will be essential to save lives, train AI, and limit economic damages.

II EXISTING METHODS

Normal method to test covid-19 is by swab test, which involves taking samples through nose and also by blood test. These take minimum of 3 days to provide the result. It involves lot of human interaction which makes the process risky. It could not able to identify the level of lung damage which cannot able to show the seriousness if any.

III MOTIVATION

Due to the existing situation in which human interaction should be minimal we wanted to adopt a new model which reduce human interaction and provide covid-19 results with utmost accuracy.

IV RELATED WORK

In this paper [1] the aim of the study is to evaluate the performance of state-of-the-art convolution neural network architectures proposed over the recent years for medical image classification. With transfer learning, the detection of various abnormalities in small medical image datasets is an achievable target, often yielding remarkable results. The results suggest that Deep Learning with X-ray imaging may extract significant biomarkers related to the Covid-19 disease, while the best accuracy, sensitivity, and specificity obtained is 96.78%, 98.66%, and 96.46% respectively. Since by now, all diagnostic tests show failure rates such as to raise concerns, the probability of incorporating X-rays into the diagnosis of the disease could be assessed by the medical community, based on the findings, while more research to evaluate the X-ray approach from different aspects may be conducted.

This paper [2] It is reported that many 'suspected' cases with typical clinical characteristics of COVID-19 and identical specific computed tomography (CT) images were not diagnosed. Thus, a negative result does not exclude the possibility of COVID-19 infection and should not be used as the only criterion for treatment or patient management decisions. According to the mentioned reasons, the results of real-time RT-PCR tests must be cautiously interpreted. In the case of real-time RT-PCR negative result with clinical features suspicion for COVID-19, especially when only upper respiratory tract samples were tested, multiple sample types in different time points, including from the lower respiratory tract if possible, should be tested. Proper sampling procedures, good laboratory practice standard, and using high-quality extraction and real-time RT-PCR kit could improve the approach and reduce inaccurate results.

This [3] paper article is to inform the audience of diagnostic and surveillance technologies for SARS-CoV-2 and their performance characteristics. We describe point-of- care diagnostics that are on the horizon and encourage academics to advance their technologies beyond conception. Developing plug-and-play diagnostics to manage the SARS-CoV-2 outbreak would be useful in preventing future epidemics.

In paper [4] Chest X-ray is the first imaging technique that plays an important role in the diagnosis of COVID-19 disease. Due to the high availability of large-scale annotated image datasets, great success has been achieved using convolution neural networks (CNNs) for image recognition and classification. In this paper, we validate and adopt our previously developed CNN, called Decompose, Transfer, and Compose (DeTraC), for the classification of COVID-19 chest X-ray images. DeTraC can deal with any irregularities in the image dataset by investigating its class boundaries using a class decomposition mechanism. The experimental results showed the capability of DeTraC in the detection of COVID-19 cases from a comprehensive image dataset collected from several hospitals around the world. High accuracy of 95.12% (with a sensitivity of 97.91%, a specificity of 91.87%, and a precision of 93.36%) was achieved by DeTraC in the detection of COVID-19 X-ray images from normal, and severe acute respiratory syndrome cases.

The paper [5] introduces an approach to eliminate the passage of Covid-19 while attempting to test the body temperature in hospitals. They introduced a helmet through which one can detect the body temperature through its cameras and sensors incorporated. The planned sensible helmet is integrated into three segments. the primary section of the system involves the input supply of the mechanism that consists of the thermal camera, optical camera and itinerant application. The processor development was the second section of system development. Optical camera and infrared thermal camera that provided information concerning the temperature at that the various focuses of interest were found. The helmet gives immediate indication in case of high temperature detected and the information is updated in the web to notify the people. The helmet workingwas efficient and was of high demand from the hospitals.

This paper [6] involves artificial intelligence for detecting Covid-19 from the x-rays of human. CNN is used to handle this project, as it is more suitable to find image patterns. The reason behind this is to avoid human involvement in confirming the results through the x-rays. Lesser the humans less will be the scope for passage of Covid-19 to people. They took a dataset of 260 images, in which, 130 are of normal human lung x-rays and 130 are of Covid-19 affected people's lungs. Deep learning method and its techniques were used to read the image and to detect the Covid-19 from the lungs by focusing on the lungs area and avoiding the external reason. CNN detects the image of required area and then divide them into parts. These are then converted into categories and will be checked according to the given conditions for the detection. The experimental study was implemented using the Google Collaboratory environment and python. The measurement of performance of model was measured in terms of accuracy, sensitivity, specificity, PPV and NPV, F1 Score. The proposed model for detecting COVID-19 achieved 100% accuracy.

In this paper [7] we are detecting covid-19 in early stages helps a lot in preventing ourselves from further higher risks that causes loss of lives. So it is best to identify whether a person has been infected with covid in the initial stages. Generally, people notice the change in their health after facing the symptoms for two – three days and then visit doctor and the doctor inquires the patient about the symptoms facing by the patient, travel history of the person and the temperature measurements. Usually this is a long time. These results suggest that sensor data can incrementally improve symptom-only-based models to differentiate between COVID-19-positive and COVID-19- negative symptomatic individuals, with the potential to enhance our ability to identify a cluster before more spread occurs. Such a passive monitoring system might be correlative to virus testing, which is generally a one-off, or uncommon, sampling test.

In this [8] paper they try introduce a technique to identify COVID-19 using biosensors, and the advantages of using biosensors over conventional method to detect COVID -19. There are so many methods to detect virus but they do have limitations like, low accuracy and sensitivity, requirement ofhighly qualified technical person for the complex operation involved in detection process. Biometric sensors are mostly based on detecting the surface proteins of the virus and the internal genetic material. Biosensors consist of chemical or biological receptors and transducers. The function of receptors is to interact specifically with target analyte and the transducer converts the recognition process into quantitative signal. In this paper they also mentioned about the latest trends in the biosensors for detection of SARS- CoV-2, like Piezoelectric immunosensor, which is for SARS-CoV, it detects Spike protein S1, this helps to detect diseases like Influenza Virus; Adenovirus; RSV; MERS.Another type of biosensor is Thermal Biosensor, which is also used for detection of SARS-CoV, by detecting RNA- dependent RNA polymerase (RdRp) gene and also helps in detecting diseases like MERS; SARS-CoV-2.

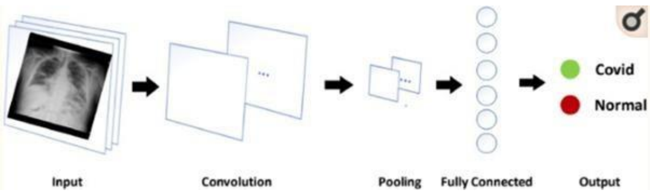
In this paper [9] they discussed about chest CT having high sensitivity foe detection of COVID -19 and how Artificial Intelligence (AI) has the potential in differentiating COVID-19 scans from the other scans. In this paper for the model development and testing they have collected reports of patients of different gender and different countries, because of having highly diverse multinational dataset, helps to achieve sufficient performance accuracy of the algorithm. There are controversies in using CT scans for diagnosing COVID-19, as the results also overlap with the diseases like influenza and pneumonia. The methods involved in the article are COVID-19 study population, Control study population, Algorithm development, Lung segmentation model, Image classification model, Statistical analysis, Data availability, Code availability. There are limitations for this article, like training model is limited to the patients with positive RT-PCR testing and COVID-19 related pneumonia on chest CT to differentiate between COVID-19 related disease and pathogens.

This paper [10] discusses about detection pre-symptomatic of COVID -19 with help of wearable devices. Smart watchis the wearable device discussed in this paper. Previously wearable devices are used in the early detection of Lyme disease and some other viral infections like atrial fibrillation. In this paper they discussed on detecting COVID-19 infection based on the heart rate signals from thefitness tracker or the smart watch. They also discussed plan to examine the relation of heart rate signals and effect of infection on activity and sleep. They developed an online detection algorithm to identify early stages of the infection. Methods involved are Participant recruitment, Metadata collection and surveys, My PHD app for wearable device data collection, Wearable devices and data types collected, Wearable device data pre-processing, Symptoms and other metadata processing, RHR-Diff offline anomaly detection, HROS-AD offline anomaly detection, Activity and sleep analysis, CuSum online detection.

III PROPOSED WORK

The proposed model depends on the working of deep learning based CNN. The applied parameters in this model are tabulated in which consist of 16 layers. The first layer indicates the input layer and is fixed with the size of 224 x 224 x 3 pixels which makes it a RGB image. The layers are the combination of Convolution+ReLU and Max Pooling layers. These layers are part of the pre-trained Model proposed in and trained on the ImageNet dataset. ImageNet contains around 15 million annotated images from 22,000 different categories and VGG16 was able to achieve 92.7% accuracy on ImageNet. Therefore, we used the VGG16 model as depicted in for feature extraction as a base model. Then we have applied a transfer learning model using the proposed 5 different layers and trained the proposed model on the COVID-19 dataset. The overall architecture of the proposed CNN model which consists of two major parts: the feature extractors and a classifier (sigmoid activation function). Each layer in the feature extraction layer takes its immediately preceding layer's output as input, and its output is passed as an input to the succeeding layers. The proposed architecture in consists of the convolution, max-pooling, dense, dropout and classification layers combined together. The feature extractors comprise conv2x2, 32; conv2x2, 64; conv2x2, 128; max-pooling layer of size 2×2, and a RELU activator between them. The output of the convolution and max-pooling operations are assembled into 2D planes called feature maps, and we obtained sizes of feature maps, respectively, for the convolution operations and sizes of feature maps from the pooling operations, respectively, with an input of image of size $150 \times 150 \times 3$.

IV SYSTEM ARCHITECTURE



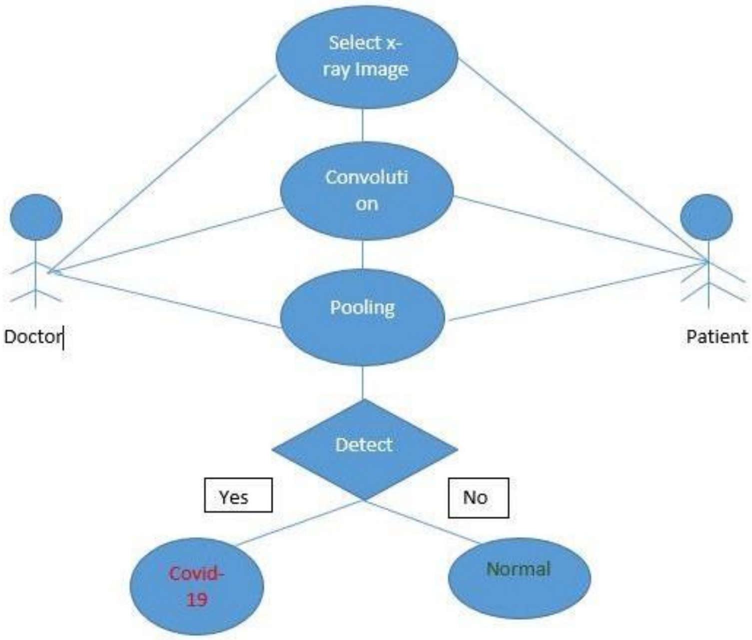
V MODULAR DESIGN

A. Use Case Diagram

The purpose of a use case diagram is to capture the dynamic aspect of a system. A use case is a written description of how users will perform tasks on your website. It outlines, from a user's point of view, a system's behavior as it responds to a request. Each use case is represented as a sequence of simple steps, beginning with auser's goal and ending when that goal is fulfilled.

Actors Involved:-

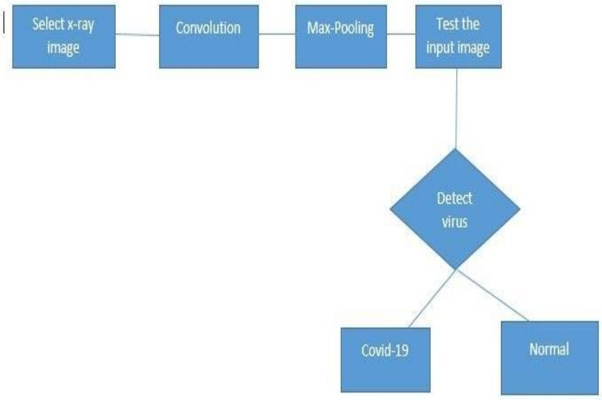
1. Doctor



2. Patient

B Flowchart

A flowchart is a picture of the separate steps of a process in sequential order. It is a generic tool that can be adapted for a wide variety of purposes, and can be used to describe various processes, such as a manufacturing process, anadministrative or service process, or a project plan.

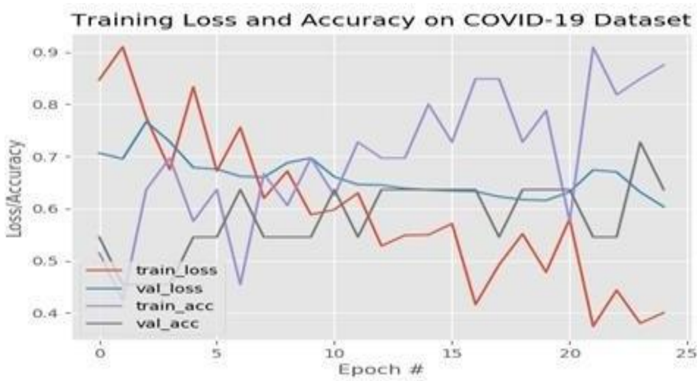


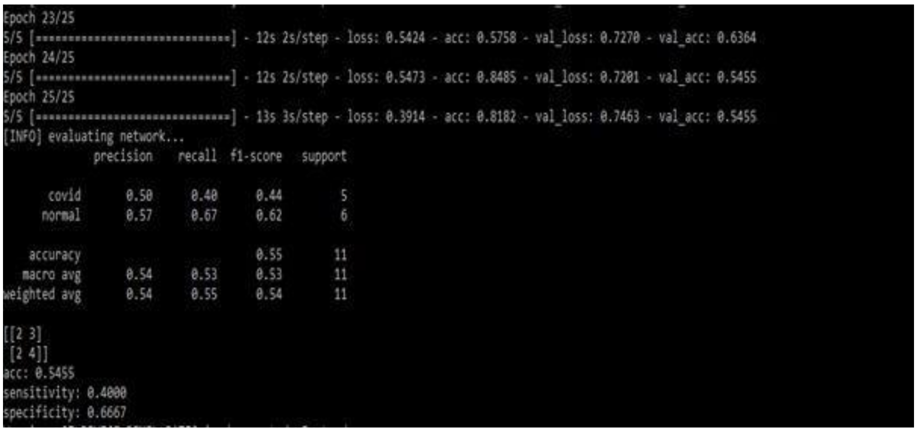
V EXPERIMENTAL RESULTS

To evaluate and validate the effectiveness of the proposed approach, we conducted the experiments 10 times each for three hours, respectively. Parameter and hyper parameters were heavily turned to increase the performance of the model. Different results were obtained, but this study reportsonly the most valid.

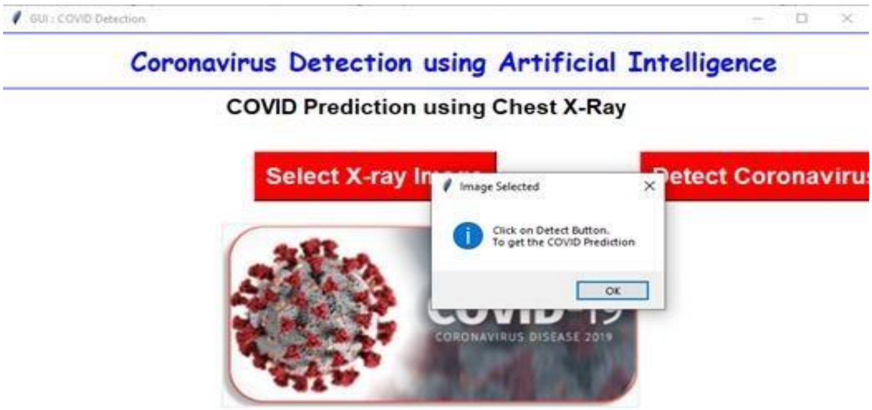
A. MODEL-1:

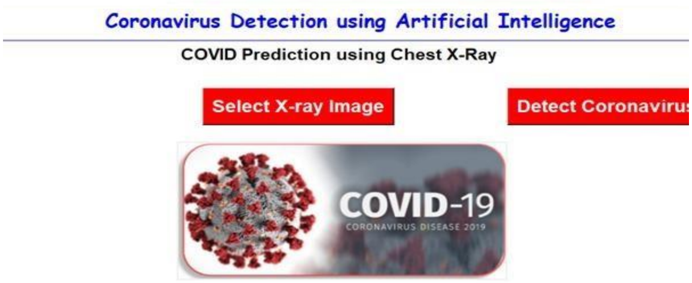
As explained above, methods such as data augmentation, learning rate variation, and annealing were deployed to assist in fitting the dataset into deep convolution neural network architecture. This was in order to obtain substantial results as shown in Figure. The final results obtained are training loss = 0.3914, training accuracy = 0.8182, validation loss: 0.7463, and validation accuracy of 0.5455.

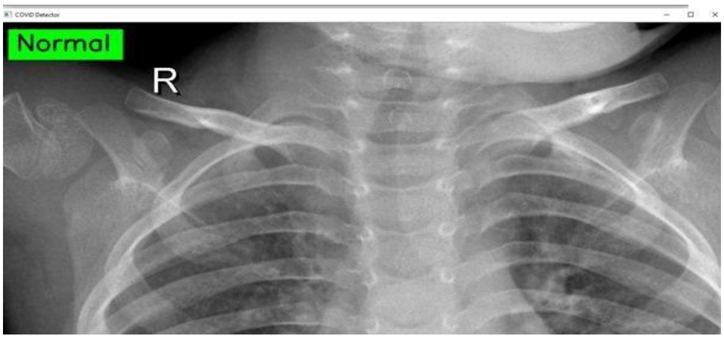




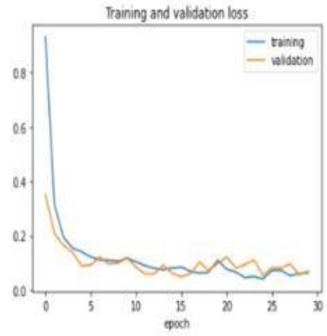
B MODEL-2:

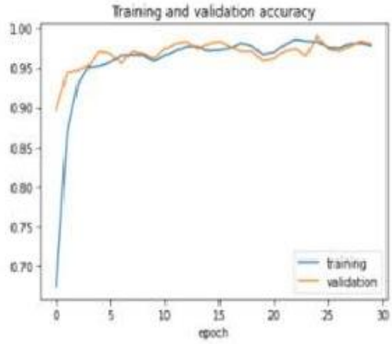


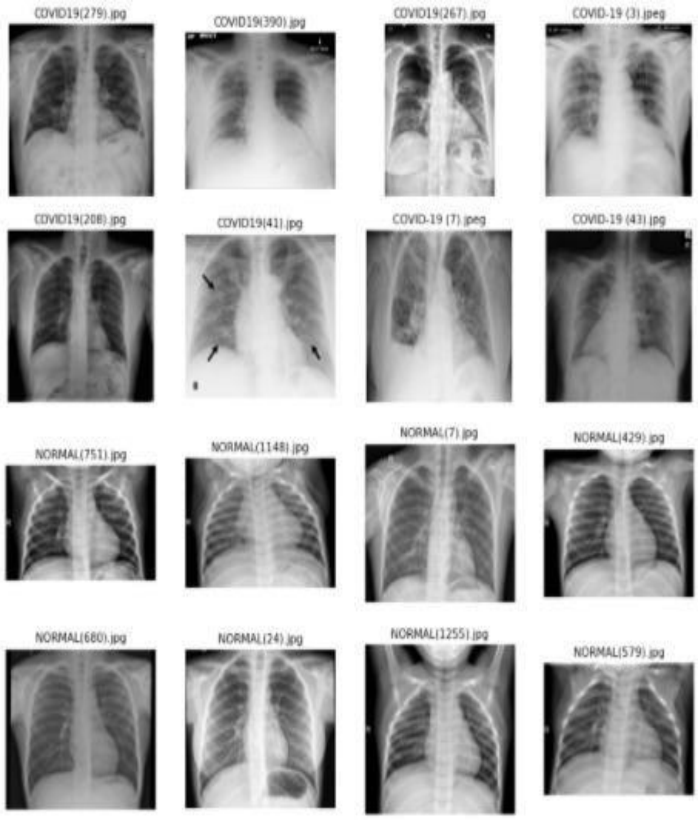




As explained above, methods such as data augmentation, learning rate variation, and annealing were deployed toassist in fitting the dataset into deep convolution neural network architecture. This was in order to obtain substantial results as shown in Figure 4. The final results obtained are training loss = 0.0411, training accuracy = 0.9869, validation loss: 0.0645, and validation accuracy of 0.9844.





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16/16 [==============================] - 9s 570ms/step - loss: 0.0935 - accuracy: 0.9587
test acc :0.9586777091026306 test loss:0.09353336691856384
```

CNN frameworks always require images of fixed sizes during training. Thus, to demonstrate the validation performance of our model on variant input data, we reshaped the X-ray images into $100 \times 100 \times 3$, $150 \times 150 \times 3$, $200 \times 200 \times 3$, $250 \times 250 \times 3$, and $300 \times 300 \times 3$ sizes, respectively, trained them three hours each, and obtained their overall average performance. The larger the size of the transformed images, the lesser the validation accuracy obtained. In contrast, smaller-sized training images induced a slight improvement in validation accuracy. Larger images also required more training time and computation cost, and the performances of 150 * 150 * 3 , 200 * 200 * 3 and 224*224*3image sizes were similar, respectively. Finally, we propose the 224*224*3 in vgg16 and 150 × 150 × 3in sequential (cnn)model since it produced better validation accuracy of approximately 81percent in model1, 97 percent in model2with a minimal training loss of 0.05.

MODEL1: Output (Prediction\ Recognition \ ClassificationMetrics)

Testing:

Accuracy (F-1) Score : 81.8%Loss : 0.055

MODEL2: Output (Prediction\ Recognition /\ClassificationMetrics)

Testing:

Accuracy (F-1) Score : 98.53%Loss: 0.05

VI CONCLUSION

We have demonstrated how to classify positive and negative Covid-19 data from a collection of X-ray images. We built our model from scratch, which separates it from other methods that rely heavily on transfer learning approach. In the future, this work will be extended to detect and classify X-ray images consisting of lung cancer and pneumonia. Distinguishing X-ray images that contain lung cancer and pneumonia has been a big issue in recent times, and our next approach will tackle this problem. In this project, we used VGG16 deep CNN architecture that relies on a class decomposition approach for the classification of COVID-19 images in a comprehensive dataset of chest X-ray images. Vgg16 showed effective and robust solutions for the classification of COVID-19 cases and its ability to copewith data irregularity and the limited number of training images too.

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