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COVID-19 DETECTION FROM CHEST X-RAY IMAGES USING CNN

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Abstract: COVID-19 is an infectious disease caused by a newly discovered corona virus. The pandemic has become the cause for a dramatic loss of human life. Though there are various vaccines that are being manufactured for coronavirus, lakhs of cases are still arising worldwide. So, to prevent the spread of the pandemic, quick and effective testing is necessary. Many researches have recently shown that chest x-rays are found to be highly predictive of COVID-19. Though the chest X-Rays cannot solely be used for determining COVID-19, the persons with positive results could be quickly isolated due to the instantaneous nature of the chest X-Ray testing. In this work, we are trying to predict whether a person has COVID-19 from their chest X-Ray image by image classification using Convolutional Neural Networks learning.

Index Terms: **Chest X-Ray, COVID-19, Corona Virus, Convolutional Neural Networks, Machine Learning, Deep Learning**

I. INTRODUCTION

During March 2020, when the whole country was under the lockdown due to COVID-19. It was just a beginning. Later, the cases increased rapidly. At that time still, researchers were working on vaccine. People were even scared how can they know whether they are infected with COVID-19 or not. The lockdown was very difficult for the daily wagers, middle class families and the poor. For testing of COVID-19 people need visit the clinic and the fees was high. We have come up with a project to make all these things easy and our country safe.

Our aim is to predict a person is infected or not. We have collected a data which consists of around 13000 images which include both the chest x-rays of COVID-19 infected and those who are not infected. These dataset helps us to predict the results. The Data Preprocessor is the module that takes the responsibility to preprocess the images in the dataset. Image Classifier is the module that takes the responsibility to predict the class of the given chest x-ray image. In this work we are using CNN for classifying the images. Prediction Visualizer is the module that takes the responsibility of communicating the prediction results by providing textual information and visual explanations using Grad-CAM (Gradient Weighted Class Activation Maps), possibly in a web interface.

This work's purpose is to help make our country COVID-19 free. Our project helps a person to test himself in a easy manner without any difficulty. People are often scared that even if they go for testing, they may get infected or they may not survive further. In our process a person needs to visit any clinic or hospital for X-ray. Based on the given data we can predict that whether the person is infected or not. It will be helpful for the people, if they are tested positive, then they a treatment or can be home quarantine. Here we are collecting the data of the persons who are infected and training the input data by using technique like CNN (Convolutional Neural Network). CNN is used for classification of images. For example, let us consider data which consists of images of living things and Non-living things, CNN easily classifies the images into living and non-living things. In this work it is the case of negative or positive. After classification need to compare the data using trained dataset, by comparing few key points we can predict the result.

II. LITERATURE SURVEY

Existing System: COVID-19 tests are usually done with PCR (Polymerase chain reaction) tests. These tests look for the presence of antibodies of the infection. This method has some flaws and issues.

PCR Testing: This test directly checks for the existence of viral RNA. It is possible to detect this before even the antibodies are formed in the body or even symptoms are present. So, we can conclude whether a person has been affected by an illness or not in very early stage.

Lateral flow test: These tests can be made to analyze various body fluids, in case of COVID-19, tests analyze sample collected from the back of someone's nose and throat. After which, the swab is placed into a tube of liquid, later, a sample of this liquid is placed on a small absorbent pad within the disposable testing kit.

Antibody testing: This test tells us what ratio of the people have been infected. This test doesn't tell us who is infected. That is because antibodies are generated a 7 to 14 days, by which time the virus would be cleared from the body. The test does tell you who has been infected and who is immune to the virus.

Disadvantages of Existing system: These tests take more time for the better results. The tests are costly for middle class people. Long turnaround times- in a few cases, RT-PCR tests give the result very quickly, within 24 to 48 hours, but there have been reports of instances with results taking over a week. False Negatives (and Positives)- Result showing that a person is COVID-19 negative when they are in fact infected with COVID-19. False-Positive and False-Negative rates are high enough to cause concern. False-Positives have been studied to range up to 37%. Uncomfortable- Some people find deep nasal swabs to be uncomfortable. It is more prominent in kids. Some people find it difficult to be amid so many people in a clinic, when they suspect that a few of them might be COVID-19 positive.

Proposed System: Many researchers have recently shown that chest x-rays are found to be highly predictive of COVID-19. Though the chest X-Rays cannot solely be used for determining COVID-19, the persons with positive results could be quickly isolated due to the instantaneous nature of the chest X-Ray testing. In our work, we are trying to predict whether a person has COVID-19 from their chest X-Ray image by image classification using Convolutional Neural Networks in deep learning.

Advantages of the Proposed System: This can take less time for giving results. This method of testing can be cheaper than existing methods. X-Ray scanning is a painless endeavor. The scans help doctors diagnose and treat the patients. X-rays are noninvasive.

III. DATASET

We used *COVID-19_Radiography_Dataset to* train our model in this work. We procured it from *Kaggle.com.* This dataset was made by a collaborative effort by a team of researchers. These researchers were from Qatar University, University of Dhaka and their collaborators were from Pakistan and Malaysia. They worked together with doctors to create this dataset of chest X-Ray images. This dataset was made in stages. They increased the number of images in each stage. This dataset won the COVID-10 Dataset Award by Kaggle Community. At the time of this work, the dataset contains over 21.2k files. Out of which, there are 3616 COVID-19 affected chest X-Rays, 6012 Lung Opacity, 1345 Viral Pneumonia and 10.2k Normal Chest X-Rays.

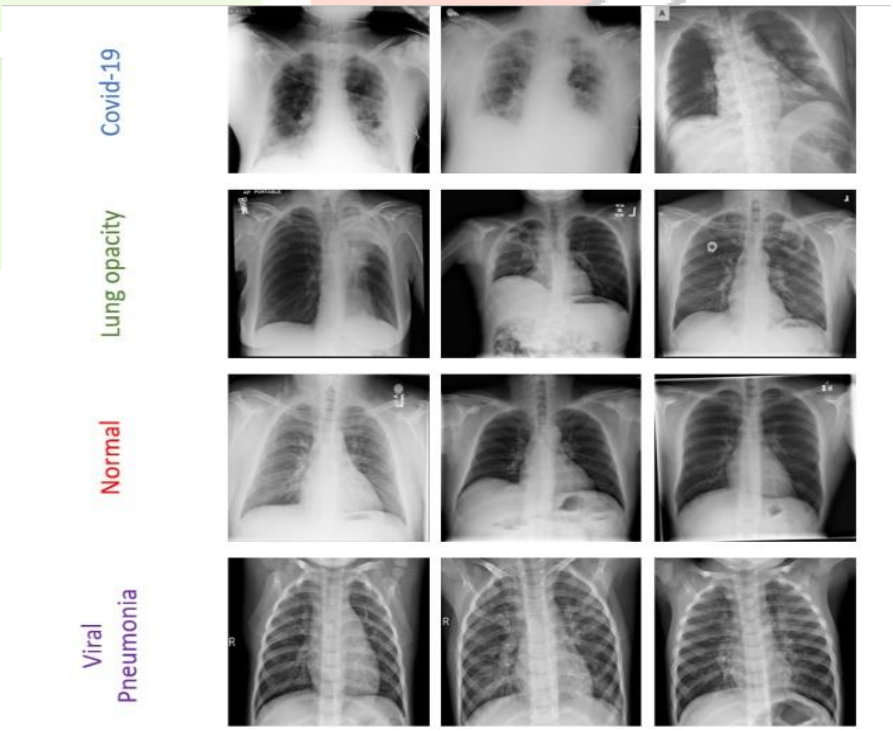

Figure 1) Sample depiction of the Dataset

IV. SYSTEM DESIGN

System Architecture: Many researches have recently shown that chest x-rays are found to be highly predictive of COVID-19. Though the chest X-Rays cannot solely be used for determining COVID-19, the persons with positive results could be quickly isolated due to the instantaneous nature of the chest X-Ray testing. In our work, we are trying to predict whether a person has COVID-19 from their chest X-Ray image by image classification using Convolutional Neural Networks in deep learning. We are using 3 modules to get the results: 1) Data Pre-processor 2) Image Classifier 3) Prediction Visualizer.

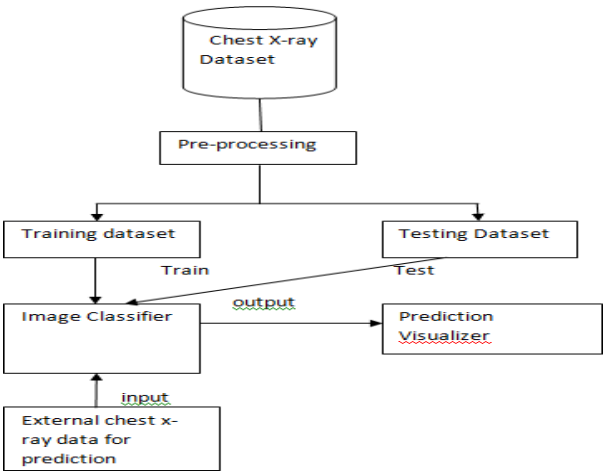

Figure 2) Architecture of COVID-19 Detection from Chest X-Ray Images using Deep Learning

MODULES:

Data Pre-processor: Data Preprocessor is the module that takes the responsibility to preprocess the images in the dataset. For example, cropping and resizing the images to the predetermined resolution and format to provide the input expected by the model. It is also responsible for dividing the dataset into training and testing datasets.

Image Classifier: Image Classifier is the module that takes the responsibility to predict the class of the given chest x-ray image. - (i.e., to predict whether the x-ray belongs to a COVID infected patient or not.) For performing this classification, we intend to try by implementing transfer learning by modifying and using state of the art CNN models trained on ImageNet data - like VGG16, InceptionV3, and so on.

Prediction Visualizer: Prediction Visualizer is the module that takes the responsibility of communicating the prediction results by providing textual information and visual explanations using Grad-CAM (Gradient Weighted Class Activation Maps), possibly in a web interface.

V. VGG-16

It is a Convolutional Neural Network architecture. In 2014, it was submitted to Large Scale Visual Recognition Challenge 2014(ILSVRC2014) by Karen Simonyan and Andrew Zisserman. The model achieved 92.7% accuracy on ImageNet dataset. ImageNet is one of the largest datasets available. It contains over 14 million annotated images. It won the first place in Image localization task, and second place in Image Classification task.

VGG-16 has 16 convolution layers. Its uniform architecture makes it very appealing to people. VGG-16 only has 3x3 convolutions, but to compensate it has lots of filters. Among the machine learning community, it is the preferred choice when it comes to extracting features from images.

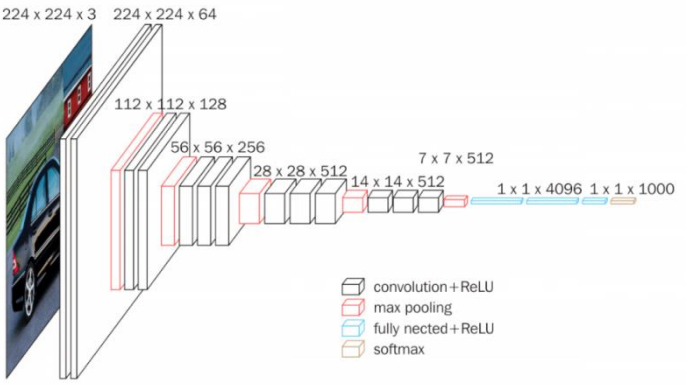

Figure 3) Overview of VGG-16 Model

VI. IMPLEMENTATION

Algorithm: The process we had setup and used is as follows:

a. Setup the environment in Google Colab.
b. Load the *COVID-19 Radiography Dataset.*
c. Preprocess the data.
   i. Resize the images to dimension 224 x 225
   ii. Divide the data for training and testing.
d. Import VGG-16 CNN model and load the weights pre-trained on ImageNet Dataset.
e. Modify the output layers of the model to suit the output classes.
f. Perform training the trainable weights of the model on the available training data.
g. Test the trained model on the available testing data.
h. To predict the class of a new CXR image, load the image, perform preprocessing, input it to the model, display the results in textual format, and visualize the layer activations of the model using Grad-CAM (Gradient-weighted Class Activation Map) heatmap.

VII. TESTING

VGG-16(4 classes): We first trained our model to classify 4 classes, namely, COVID, Normal, Viral Pneumonia and Lung Opacity. We obtained 87% testing accuracy and 34% testing loss with this model.

Accuracy Graph: Graph of the change in training accuracy and validation accuracy overtime along training epochs for the transfer learning model with VGG-16 pre-trained model on 4 classes (COVID, Normal, Viral Pneumonia, Lung Opacity).

Loss Graph: Graph of the change in training loss and validation loss overtime along training epochs for the transfer learning model with VGG-16 pre-trained model on 4 classes (COVID, Normal, Viral Pneumonia, Lung Opacity).

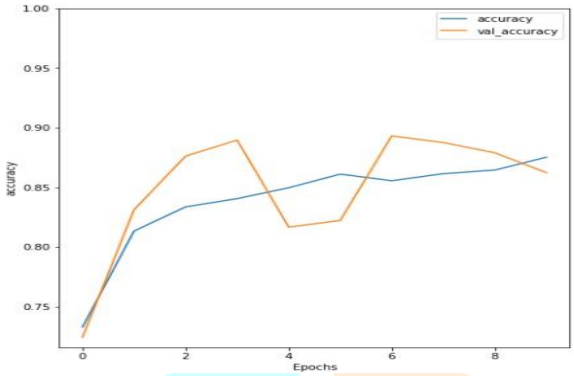

Figure 4) Accuracy graph with VGG-16 model for 4 classes

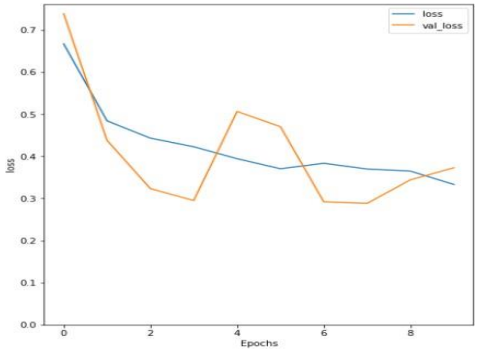

Figure 5) Loss graph with VGG-16 Model for 4 classes

VGG-16(2 classes): We then trained our model to classify two classes, COVID and Normal. We obtained 94% testing accuracy and 17% testing loss with this model.

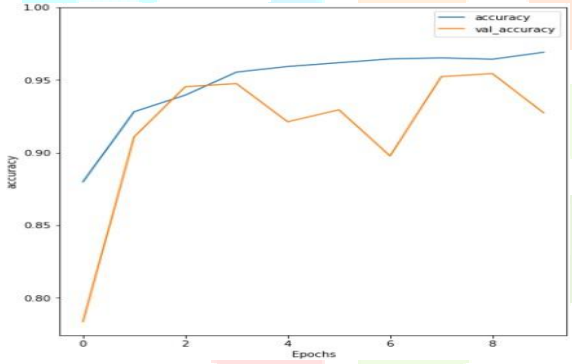

Figure 6) Accuracy graph with VGG-16 Model for 2 classes

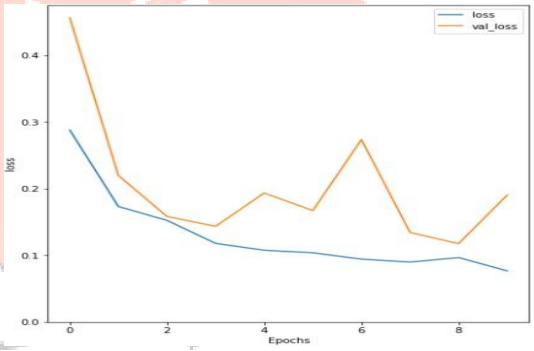

Figure 7) Loss Graph of VGG-16 Model for 2 classes

VIII. RESULTS

VGG-16 (2 classes model):

Input Image:

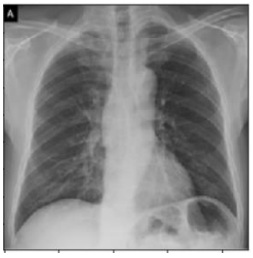

Figure 8) An input given to the 2 classes model

Output: The input given was a COVID affected chest X-Ray. As we can see, in the image, the output given by the model is COVID-19 positive.

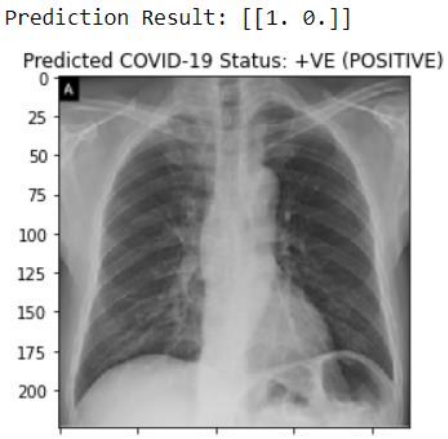

Figure 9) Prediction Status

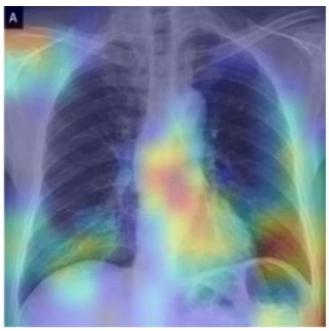

Figure 10) Gradient Class Activation Map superimposed on the X-Ray

VGG-16 (4 classes model):

Input Image:

Figure 11) Input given to the model.

Output: As we can see from the image, this X-Ray is of a COVID-19 affected person.

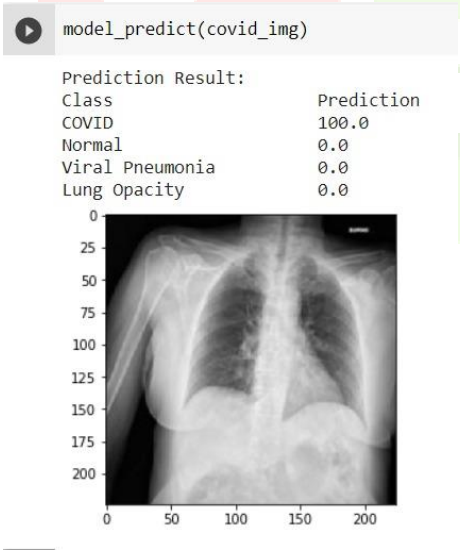

Figure 12) Prediction Result

Figure 13) Grad Cam Visualization

IX.CONCLUSION

To conclude and summarize, we are aiming to predict whether a person is infected by COVID-19 from their CXR (Chest X-Ray) image quickly and cost-effectively by performing image classification using Convolutional Neural Networks and Transfer Learning. We tried to predict the status of the patients from their chest x-rays using Transfer Learning based on the pre-trained models VGG-16 on overall 4 classes of chest x-ray data.

We managed to predict, with high accuracy whether a person is affected by COVID-19 or not. The model with 2 classes, had a remarkable 94% testing accuracy. The model with 4 classes on the other hand managed a commendable 87% accuracy. So, either of the model can be readily used to predict the presence of COVID-19 from a Chest X-Ray. We accomplished our objective.

X. FUTURE ENHANCEMENT

In future without using transfer learning, building state of the art COVID-19 detection models from chest x-ray scans would be much more accurate and helpful, but requires an extensive amount of data and processing power. AI-based application can be developed using various sensors and features to identify and help diagnose diseases. As healthcare prediction is an essential field for future, A prediction system that could find the possibility of outbreak of novel diseases that could harm mankind through socio-economic and cultural factor consideration can be developed.

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