Hybrid Classification Model by Using CNN to Detect COVID-19 & Chest Related Problems

Narisetty Srinivasarao
Assistant Professor,Department of CSE
Lakireddy Bali Reddy College of Engineering (Autonomous)
Mylavaram, Krishna Dist., Andhrapradesh - 521230
nsr543@gmail.com

Tiyyagura Chandra Reddy
UG Student, Department of CSE
Lakireddy Bali Reddy College of Engineering (Autonomous)
Mylavaram, Krishna Dist., Andhrapradesh - 521230
chandra.tiyyagura@gmail.com

Kokkiligadda Pushpa Latha
UG Student, Department of CSE
Lakireddy Bali Reddy College of Engineering (Autonomous)
Mylavaram, Krishna Dist., Andhrapradesh - 521230
pushpalathayamini@gmail.com

Killamsetti Suguna
UG Student, Department of CSE
Lakireddy Bali Reddy College of Engineering (Autonomous)
Mylavaram, Krishna Dist., Andhrapradesh - 521230
killamsettisuguna@gmail.com

Bhimavarapu Bhavana Reddy
UG Student, *Department of CSE*
Lakireddy Bali Reddy College of Engineering (Autonomous)
Mylavaram, Krishna Dist., Andhrapradesh - 521230
bhsony123@gmail.com

***Abstract*— The COVID-19 pandemic has created havoc on the lives of many people and their health all over the world. It has been increasing very rapidly, one must find an effective model/method to detect COVID-19 in order to help the Health Care System. Chest X-ray is one of the reliable diagnostic technologies, which helps in the identification of COVID-19. Despite the fact that there are numerous deep learning methodologies for identifying COVID -19, these methodologies are useless if they only detect one type of illness while ignoring the others. This study proposed a Hybrid Classification model based on CNN (Convolutional Neural Network) for more efficient detection of COVID-19 from Chest X-Rays. Using CNN, this study differentiates COVID-19 affected chest X-Ray images from normal chest X-Ray images and eight additional chest disorders (Cardiomegaly, Atelectasis, Infiltration, Effusion, Nodule, Pneumonia, Mass, Pneumothorax). The Hybrid Classification Model contains two classifiers, Classifier-1 and Classifier-2. In Classifier-1, it contains the information about Normal Chest X-rays images and chest X-ray images that have been affected by COVID-19 and whereas in the Classifier-2, it contains the information about other 8 chest diseases. For getting highest accuracy of Classifier-1 and Classifier-2 models, we are using several models i.e., ResNet50, InceptionResNetV2, VGG16, DensNet121 and Mobile Net. Based on all these models we are considering ResNet50 for Classifier-1, and DensNet121 for Classifier-2, Because these two models had given the highest accuracy compared to other models.**

Keywords*— *Deep Learning, Convolutional Neural Network, Classification, Data Augmentation, Segmentation, Chest X-Ray.

I. Introduction

COVID-19 began in China in December 2019, and by March 2020, it had spread to every corner of the world. COVID-19 is a disease caused by a newly identified virus, Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2). The most common symptoms of COVID-19 are fever, cough, loss of taste or smell, and severe respiratory complications. It is a virus that can be transmitted by physical contact. COVID-19 detection can help to stop the virus from spreading. This model was used to avoid physical contact with people who were infected by the virus; to detect COVID-19, we must purchase COVID kits and perform blood tests, as well as computed tomography (CT) scans and X-rays; to perform all of these tests, the cost will be high; we can perform all of the Computed tomography (CT) and X-rays by machines; however, we cannot conduct blood tests by machines because machines do not know how to insert needles. The model could assist radiologists in their analysis of the condition. This could also benefit people living in rural areas.

X-rays or scans are used to image the inside organs and structures of the human body. X-rays are a type of imaging that involves the use of radiation to produce images of the inside of our bodies. They're normally done by a radiographer with fixed equipment in hospitals. When compared to CT scans, it is less expensive and takes less time, whereas CT scans take a lengthy time. The production of CT scan reports takes a long time, but an X-ray can be received in minutes. Computed tomography (CT) scans combine X-ray images with computer technology to produce a detailed image of a specific part of the body component. They require highly specialised equipment and are performed in a hospital by a trained radiographer [1].

Deep Learning does not require manual feature extraction and accepts photos as input. It necessitates high-performance GPUs and a large amount of data. Convolutional neural networks (CNN), which are deep learning techniques, are used to extract and classify features. CNN is in charge of feature extraction and classification based on a variety of images. When the amount of data is increased, the performance of deep learning algorithms improves. Other learning algorithms, on the other hand, perform worse as the amount of data grows.

When it comes to analysing diseases using computer models, artificial intelligence and machine learning stand out, and the Convolutional Neural Network (CNN) plays a major role in detecting them. CNN will thoroughly classify the images. CNN can identify trends that are difficult to notice by humans, such as the early stages of the disease.

II. Literature Survey

A fast and accurate model to detect COVID-19 in earlier from chest X-Ray images using deep learning technique CNN(Convolutional Neural Network). This study classifies the COVID-19 X-Ray image from normal and 14 other chest X-Ray images. It classifies the dataset into two classifiers(classifier1 and classifier2). The chest X-Ray image is passed to classifier1, it checks whether the image is related to normal or COVID-19. If the image is neither related to COVID nor normal, it is passed to the classifier2. The classifier2 verifies whether the image is classifying any one of the 14 diseases. They achieved an average testing and training accuracy of 92.52% and 96.04% from first classification by using ResNer50. The maximum accuracy achieved by classifier2 is 65.63% with ResNet50 and 65.63% with NasNetLarge, less accurate due to the large number of classes leading to overfitting problem [2].

DeTraC (Decompose, Transfer, Compose). It can deal with any inconsistency in the image dataset by defining its class boundaries using a class decomposition mechanism. In this research they used a combination of two datasets. Dataset 1 contains 80 samples of normal CXR images and Dataset2 contains 105 samples of COVID-19 and 11 samples of SARS. Data augmentation helped them to generate total of 1764 samples. DeTraC showed effective solutions for the classification of COVID-19 cases with high accuracy of 95.12% from a comprehensive image dataset collected from several hospitals [3].

Several experiments were performed for the high-accuracy detection of COVID-19 in chest X-ray images using CNN. SARS Cov-2 stands for Severe Acute Respiratory Syndrome Corona Virus 2, which is responsible for coronavirus. The dataset consists of 1583 healthy, 4292 pneumonia, and 225 COVID-19 confirmed chest X-Ray images. The experiments will be trained by using Deep Learning and Machine Learning classifiers, and also 38 experiments were performed by using CNN. In this study they used MobileNetV2, VGG19, Inception, Inception ResNet V2, Xception, these models are widely used for getting high accuracy. By using AI and DL techniques they were recognized images. By using these images and statistical data, they implemented and evaluated different architectures i.e., Network Architectures, state-of-the-art pretrained networks and some Machine Learning Models. Basically, In first architecture, it is capable of detecting two classes i.e., COVID-19/Normal and COVID-19/Pneumonia. In second architecture, it is capable of detecting three classes i.e., COVID-19, Normal, Other Chest Diseases. By using AI-based technologies, it will give valuable help to doctors for diagnosing COVID-19. For better understanding, it provides more information on CNN(Convolution Neural Network) with COVID-19 chest X-ray images [4].

A Convolutional Neural Network model called CNN-COVID. CNN-COVID model was trained and tested the Chest X-ray images to differentiate the COVID-19 positive and negative chest X-ray with analysis, classification, and high accuracy. This tool was utilised to differentiate between pneumonia induced by COVID-19 and pneumonia caused by other causes in chest X-ray pictures. The two datasets are classified in this study. Dataset I which consisted of 434 X-ray images,4030 X-ray images and Data Augmentation was used to create Dataset II .This model had an accuracy of Dataset I 0.9722 and Dataset II 0.9884. This CNN-COVID model was a sequential model those are Convolutional layer , Max Pooling, Fully Connected Layer. A new COVID-19 dataset is collected to improve the CNN-COVID accuracy for future work [5].

III. CNN Components

CNN model consists of different types of components:

A. Kernel / Filter / Feature extractor
B. Stride
C. Padding
D. Pooling
E. Flattening

A. Kernel / Feature Extraction

Kernel is also known as a filter or feature detector because it will detect the features from the input image. Kernel is represented in a matrix form, it will move over the input image by using stride value given and gives the output as a dot product by considering sub-region of input data.

Formula to calculate the output matrix size after doing convolution

$$0 = \left\lfloor \frac{i-k}{s} \right\rfloor + 1 \tag{1}$$

B. Stride

The amount of filter movement is called stride. It moved across the input image from left to right, top to bottom, with one-pixel value change on the horizontal position and one-pixel change in vertical position. The default value of stride in 1-D is 1 and in 2-D is (1,1) for height and width movement.

C. Padding

Padding is mainly used for solving the Border Problem. It is used when the edge pixels play’s an important role in classification task. If an input image is padded and then it passed into the CNN model to give the more accurate analysis of images.

Formula:

$$0 = \left\lfloor \frac{i-k+2p}{s} \right\rfloor + 1 \tag{2}$$

D. Pooling

Pooling is one of the important components that makes CNN very effective. Pooling is used to reduce the size of input image size in order to reduce the computation power. It has two types of operations. Max pooling: In max pooling it takes the max value from the sub matrix selected and places that max value in the output matrix.

E. Flattening

Pooled feature map obtained before the flattening layer is passed into the flattening layer in order to make it into a single column matrix which is then given as an input to the neural network for processing.

F. Dropout

Dropout is the method of randomly ignoring the neurons. This method is mainly used to prevent the overfitting problem. Overfitting means that the neurons the co-dependent of each other. For example, dropout (0.2) means it randomly ignores the 20 percent of neurons from the fully connected network.

IV. METHODOLOGY

A. Data Preprocessing

Data Preprocessing plays a vital role before feeding the data to a model. Data preprocessing is an important stage since the data accuracy and the relevant information that can be extracted from it has a direct impact on our model's capacity to learn.

B. Data Augmentation

In this case, we used the techniques to increase the data size by generating new data from the old data. Cropping, flipping, rotation, scaling, brightness, contraction, and color augmentation are some of the techniques we had utilized for the generation of new data. By slightly modifying the previous data, data augmentation was utilized to expand the amount of data available.

V. PROPOSED HYBRID CLASSIFICATION MODEL

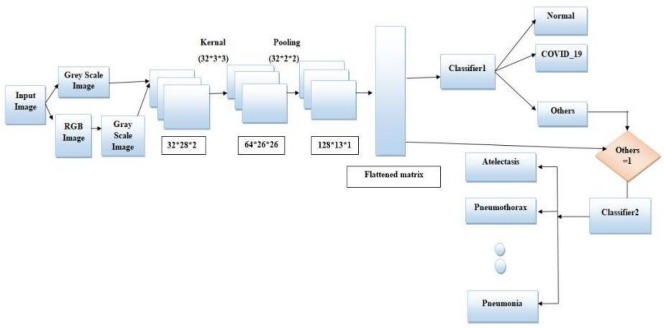


Fig. 1. Hybrid Classification Model

Consider an input image (chest x-ray image), if the image is a grayscale image it is directly passed to the convolutional layer, or else the image is transformed to grayscale and then delivered to the convolutional layer if it is an RGB image. If we pass this grayscale image directly to the fully connected network, it will take more computational power. In order to reduce this problem, we are applying CNN components. Firstly apply a kernel of size 3x3, which is also known as the filter or feature detector because it will detect the features from the input image [6]. We had taken an input image of size 299x299. It is passed to the kernel, its size is reduced to 268. Now we have 32 feature maps of size 268 x 268. And then it is passed to the pooling layer. In this layer, the dimensionality of image is reduced by extracting maximum and important features are extracted. In the pooling layer, an image's dimensionality is decreased to 136. As the size of an image is decreasing we have to increase the feature maps from 32 to 64,128 and soon in order to extract tiny features also. The output of the pooling layer is flattened to a single-dimensional array [7].

The flatten will represent each feature of an input image, each value will rep-resent one of the features. Now, this flattened matrix is passed to classifier1, it will classify whether the image belongs to normal chest x-ray or COVID-19 chest x-ray or others. If classifier1 shows more accuracy towards the others, then the image is passed to classifier2. In classifier2 it will check whether the chest was affected by one of the other 8 diseases and it specifies the disease among the 8 disorders. Pneumonia, Atelectasis, Cardiomegaly, Effusion, Infiltration, Mass, Nodule, and Pneumothorax are the eight disorders [8].VGG16, ResNet50, VGG19, GoogleNet are the four models trained for both the classifiers for Hybrid Classification [9].

VI. DATASET

This hybrid classification study consists of two datasets named, NIH Chest X-Ray Dataset and COVID-19_Radiography_Dataset. These two datasets are taken from Kaggle.com. NIH Chest X-Ray Dataset contains a total of 74,996 chest x-ray images belonging to 8 classes (Atelectasis, Cardiomegaly, Effusion, Infiltration, Mass, Nodule, Pneumonia, Pneumothorax). There are 13808 chest x-ray images in the COVID-19 Radiography Dataset, which are divided into two classes: COVID-19 and normal [10]. The training, validation, and testing datasets are split 70:20:10 respectively. The following table shows the number of photos in each class in classifier1 and classifier2 in the training, testing, and validation categories.

TABLE I. TUNNING LAYERS FOR CLASSIFER1, CLASSIFIER2

Classes	Training set , n	Validation set ,n	Testing set ,n
Classifier1			
COVID	2531	723	362
Normal	7134	2038	1020
Others	52497	14999	7500
Classifier2			
Atelectasis	3497	999	500
Cardiomegaly	7000	2000	1000
Effusion	7000	2000	1000
Infiltration	7000	2000	1000
Mass	7000	2000	1000
Nodule	7000	2000	1000
Pneumonia	7000	2000	1000
Pneumothorax	7000	2000	1000

VII. EVALUATION PROCESS

The goal of this study is to see if the chest x-ray is altered by COVID, normal, or any of the other eight disorders. Using CNN, it distinguishes COVID-19 chest X-Ray images from normal chest X-Ray images and eight other chest X-Ray abnormalities. We used a variety of CNN models for performance evalua-tion, including ResNet50, AlexNet, GoogleNet, and VGG16. The outcome is determined by accuracy and performance [11].

TABLE II. TRAINING,VALIDATION,TESTING.

Model	**Training Loss**	**Training Accuracy**	**Validation Loss**	**Validation Accuracy**	**Testing Loss**	**Testing Accuracy**
ResNet50 Classifier1 Classifier2	1.585 27.77	0.940 0.598	1.376 32.88	0.966 0.524	1.641 31.17	0.914 0.508
InceptionResNetV2 Classifier1 Classifier2	1.221 8.736	0.878 0.503	1.599 0.697	0.902 0.537	1.218 9.187	0.830 0.596
VGG16 Classifier1 Classifier2	1.746 17.87	0.887 0.556	0.759 19.75	0.949 0.532	2.881 17.233	0.907 0.504
DensNet121 Classifier1 Classifier2	0.988 7.387	0.884 0.590	0.710 6.095	0.929 0.530	0.848 5.600	0.902 0.502
MobileNet Classifier1 Classifier2	1.724 9.998	0.825 0.525	1.043 9.196	0.914 0.528	1.452 13.76	0.833 0.513

VIII. Activation Function

A. SoftMax

In CNN, the Activation function is a crucial component. The Activation function calculates weights and adds a basis to decide whether or not the neurons should be activated. Backpropagation is the process of updating the weights and basis of the neurons of the error output in neural networks [12]. The activation function will apply a non-linear transformation to the input, allowing the task to be completed. In our model, we utilized the SoftMax function.

The SoftMax function is a type of a sigmoid function This SoftMax method was used to classify multiple classes [13]. 0 to 1 was the output range. For the out-put layers, the SoftMax function was mainly used.

$$\sigma(\vec{z})_i = \frac{e^{z_i}}{\sum_{j=1}^{K} e^{z_i}} \tag{3}$$

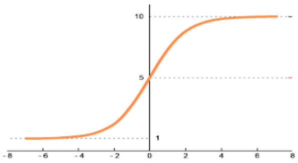


Fig. 2. Graph of SoftMax

B. ReLu

ReLu is Rectified Linear Unit. We used this ReLu in hidden layers. It is a non-linear activation function. The range of ReLu is [0 to Infinity]. It was most Widley used function.

$$y = max(0, x) \tag{4}$$

Because it includes fewer mathematical calculations, ReLu is less computationally expensive than tanh and sigmoid [14]. Because ReLU is non-linear in nature, we may simply backpropagate errors and have the ReLU function activate many layers of neurons. Only a few neurons are active at a time, making the network sparse and efficient for computation [15].

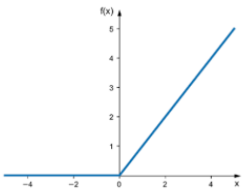
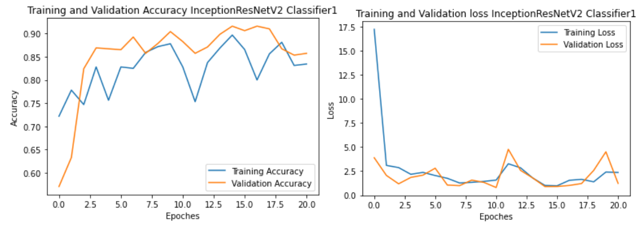
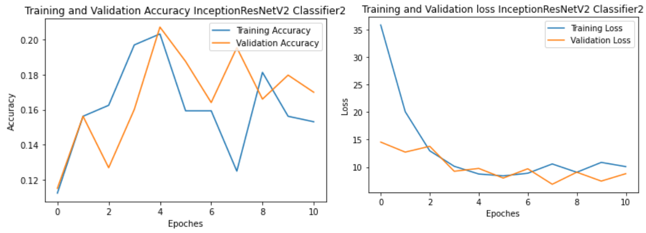
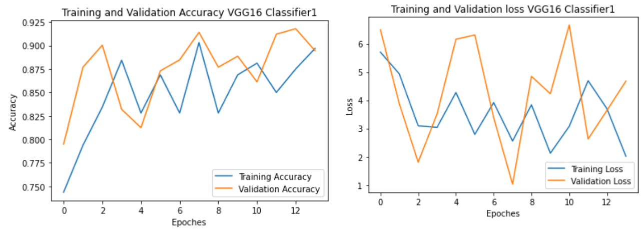


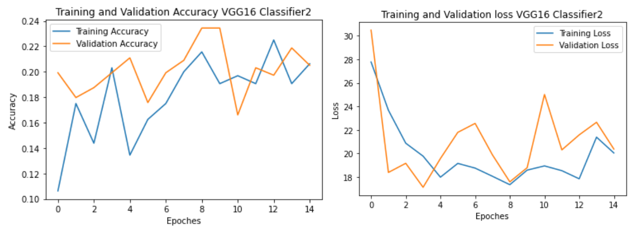
Fig. 3. Graph of Relu

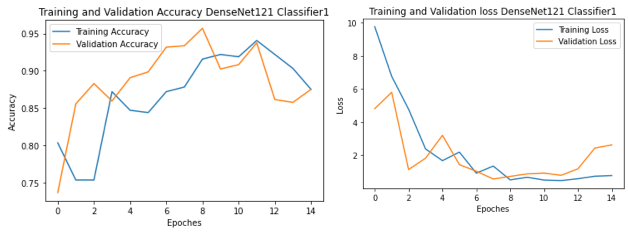
IX. Resutls & Output Graphs











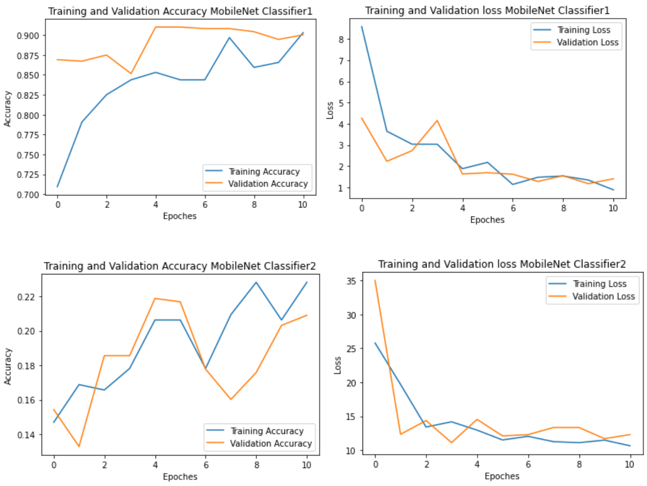


Fig. 4. Graphs describing training & validation accuracy (left), loss (right) during epochs for all models of classifier 1 &2.

CONCLUSION

Artificial intelligence and deep learning can recognise images for tasks that have been taught. Deep Learning accepts images as input and does not require feature extraction by hand. Although there are numerous deep learning approaches for identifying COVID -19, these methodologies are useless if they only detect one type of sickness while failing to detect others. This research introduces new idea called hybrid classification, which improves accuracy by reducing overfitting issues. We are going to divide this Hybrid Classification Model into two classifiers, Classifier-1 and Classifier-2. In Classifier-1, it contains the information about Images of normal chest X-rays and images of chest X-rays that have been affected by COVID-19 and whereas in the Classifier-2, it contains the information about other 8 Chest diseases. For getting Highest Accuracy of Classifier-1 and Classifier-2 models, we are using several models i.e., ResNet50, InceptionResNetV2, VGG16, DensNet121 and Mobile Net. Based on all these models we are considering ResNet50 for Classifier-1, and DensNet121 for Classifier-2, Because these two models had given the highest accuracy compared to other models. For Classifier-1, ResNet50 model gives an Accuracy of 93%(percent) and for Classifier-2, DensNet121 model gives an Accuracy of 53%(percent), this method yields good outcomes.

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