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Classification of COVID-19 using Chest X-ray Images with Deep Learning Techniques-CNN & ResNet-18

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Abstract: ***To classify the covid-19 images as infectious or normal, it has been evident that the chest X-ray is a powerful tool to diagnose due to its crucial characteristics of convenience, inexpensiveness and rapid pace. The work aims to determine covid-19 in the infected patients by training models with the dataset using convolutional neural networks (CNN) and ResNet-18 and to draw comparisons in their performances respectively. To handle the dataset by applying various operations to simplify and to make it ready for training, validation and testing procedures of both the algorithms involved. The accuracies obtained on testing CNN and RESNET-18 models are 96.07% and 96.67% respectively. Hence the objective of the work is achieved and the results are obtained by implementing covid-19 classification using chest x-ray images with CNN and resnet-18 models.***

Keywords: ***Coronavirus (COVID-19) Infection, Deep Learning, Convolutional Neural Network (CNN), Resnet-18, Transfer Learning, Chest X-ray Images.***

I. INTRODUCTION

The tragedy befalls Covid-19, "severe acute respiratory syndrome coronavirus 2" (SARS-CoV-2) which is an infectious disease with fever, cough, cold as the most common symptoms and some least common symptoms as headache, diarrhea etc. has severely created a massive disturbance in life which has, in turn, resulted in an immense imbalance in the development sector. But similarly, on the brighter side, it has created numerous necessities and requirements which gave us the opportunities for a better future. One of such necessities which we are interested in and would like to work on is the necessity to improve existing medical screening and clinical management of covid-19 and utilize it for its detection. In this work, we deal with an image dataset which is taken from Kaggle. Many pre-preparatory operations are performed on the dataset to make it easy for learning the model. The pre-processing of the dataset is then followed by dataset division where here the dataset is split into 1. Training dataset 2. Validation dataset 3. Testing dataset. Here we use two deep learning algorithms namely convolutional neural networks (CNN) and ResNet-18 to classify the models. And then we measure their accuracies and analyze their performances.

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II. PRE-PROCESSING OF RAW MEDICAL IMAGES

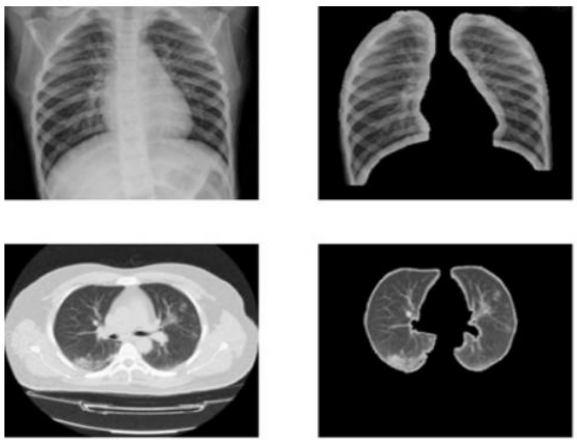
Developing a medium to detect and understand the interior abnormalities inside the human body through various imaging techniques is termed medical imaging. Commonly used medical imaging modalities are X-ray and CT images. But because of the low intensity, the contrast of images etc., we may not obtain accurate results. So, for this reason we must surely perform some pre-processing operations for images to eliminate irrelevant for better results.

A. Image Resizing

To make a dataset we need to collect data from various sources and hence the size varies everywhere. Hence, we need to standardize the image dimensions to make the next process easier.

B. Image Segmentation

An image has lot of features and regions each individually have its significance. But we need some regions which belong to our study. So, to achieve that a crucial operation needs to be performed to get our region of interest (ROI) and for the covid-19 the ROI is the lung region. This helps in reducing the computational complexity by separating the lung region from the background. This can be shown in the below figure.



a) Lung Images b) Segmented Lung Images

Fig. 1.Samples of Image Segmentation

C. Image Enhancement

Enhancing the visual perception quality is very essential for disease diagnosis which is termed image enhancement. The technique which is used for image enhancement is histogram equalization.

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This technique helps in the distribution of intensity levels over the pixels of the image. Adaptive Histogram Equalization helps to distribute the values only in small regions. But this may lead to over-amplification of noise within the region. CLAHE (Contrast Limited Adaptive Histogram Equalization) cuts off the over enhancement of noise caused by AHE. Samples of images are attached below.

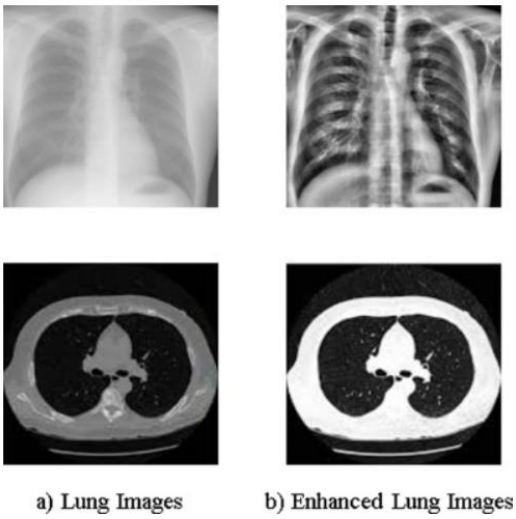

Fig. 2. Samples for Image Enhancement

III. DATASETS

The Dataset contains data that needs to be prepared for the next procedures and this needs a controlled division of data to make it sufficient for the entire process. So they are split as 1. Training dataset 2. Validation dataset 3. Test dataset. The training data is used to train the model during the learning process. The validation dataset helps to evaluate the model and optimize model selections. The testing dataset is used to examine the model and check how the model has performed. Sometimes when the dataset is insufficient or not as huge then the results might not be very accurate. So to deal with data scarcity, we introduce two strategies namely 1. Transfer Learning 2. Data Augmentation.

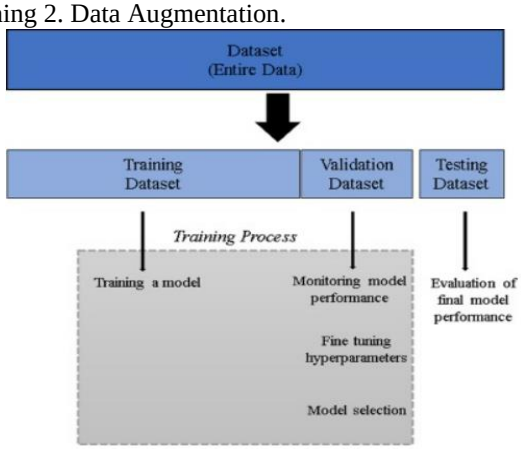

Fig. 3. Split of the available dataset

A. Transfer Learning

The primary goal of transfer learning is reutilization ie, using a model trained for a specific task to another task. The main application of transfer learning is that it reduces the training time and also computationally less expensive as only few layers are retrained. It does not require huge amount of data as the models are already trained.

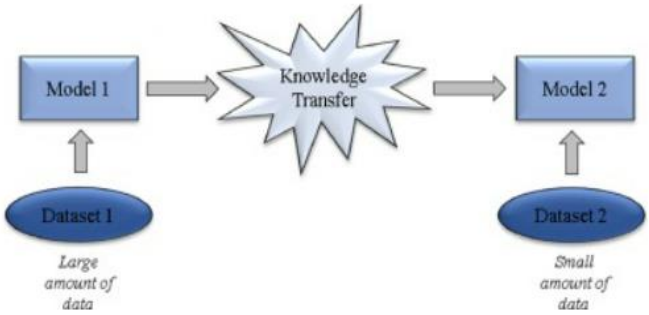

Fig. 4. Concept of Transfer Learning

B. Data Augmentation

Another strategy to handle this data scarcity problem is data augmentation. It increases the size of dataset by increasing number of samples by making slight variations in the already existing data. This augmentation helps to reduce overfitting and acts as regularizer. It also helps to increase the accuracy of the prediction. Augmentation is only on training dataset ie, either position augmentation or color augmented. The figure is displayed below.

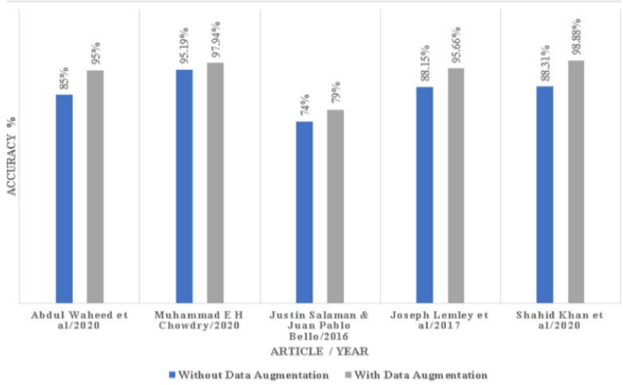

Fig. 5.Accuracy of models with and without data augmentation

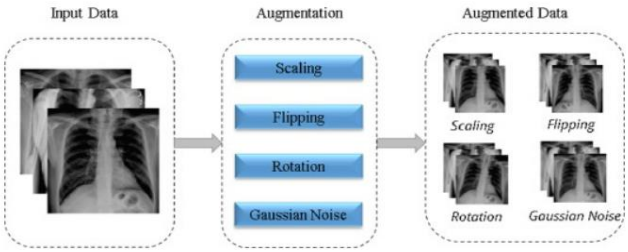

Fig. 6. Sample results of data augmentation

- **Position Augmentation**

The pixel position of the image changes in this position augmentation. The most used techniques are scaling, flipping, rotation and cropping.

- **Color Augmentation**

The color of the image is modified by changing the pixel values of the image in this color augmentation. This is done by varying the brightness, contrast and saturation of the image.

- **Noise Injection**

Adding noise to an image helps in incrementing the dataset and also reduces overfitting.

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IV. DEEP NEURAL NETWORKS

Neural Networks are a set of algorithms that are designed to recognize a pattern. Deep neural networks are a branch of machine learning in which the training on large data is done which helps to predict the output from the newly given input.

A. Convolutional Neural Networks

CNN is mainly used for image classification which deals with different pattern recognition and feature identification problems. With the high observance of successful results, there has been a high increase of CNN in the medical field analysis. Some examples are heart diseases, lung diseases, dental diseases etc. In recent times it has come to the light that CNN plays a crucial part in covid-19 detection. CNN consists of multiple layers which are responsible for extracting distinguished layers from the images.

a) Architecture

Primarily CNN architecture has 3 layers namely: 1. Convolution Layer 2. Pooling Layer 3. Fully Connected Layer. The figure is displayed below. Feature extraction is the prime responsibility of the convolution and pooling layer and the fully connected layer is for classification purposes. The other two parameters dropout and activation function are also defined apart.

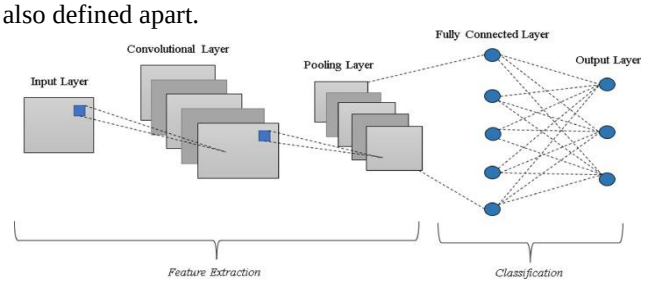

Fig. 7.The architecture of the Convolutional Neural Network

(1) Convolutional Layer

Extracting features from the input image is the prime responsibility of this layer. It has filters that are termed kernels. This kernel matrix whose size is generally smaller than the input size slides over the entire image from left to right and also from top to bottom and performs a dot function along with the input. The resultant is termed a feature map. The feature maps of the later layers are a combination of the feature maps of the earlier layers.

(2) Pooling Layer

The second layer of the architecture is the pooling layer. It is followed after the convolution layer which reduces the number of parameters and computations by performing down sampling. The maximal element of the feature map is shown up by using the most commonly used technique called the Max pooling.

(3) Fully Connected Layer

The fully connected layer is the last layer of the architecture where the input from the preceding stages is fed into the fully connected layer which classifies the image. Its dimensions are equal to the number of output classes.

(4) Dropout Layer

A dropout layer is used to randomly discard a few neurons which when present may lead to overfitting. Thereby this removal helps to the reduction in the size of the model.

(5) Activation Function

This layer helps to get the output from the previous layer and converts in such a way that can act as input for the next layer. This layer is essential to make the model learn complex patterns and this can be present at any layer of the network. It helps in adding nonlinearity to the model. Some commonly used activation functions are Rectified linear unit (ReLu), sigmoid, tanh etc.

B. ResNet-18

Resnet-18 is prepared on more than ten lakh images from the ImageNet database. This kind of training on a huge database helps to rich feature representations. The first two layers comprise of 7 X 7 convolutional layer with 64 output channels and a stride of two is followed by a 3 X 3 maximum pooling layer with a stride of two. There are four convolutional layers in each module with 7 X 7 convolutional layers and the final fully connected layer results in eighteen layers in sum. Hence the model is named as ResNet-18.

a) Architecture

We can get different layers of ResNet models by building a number of channels and residual blocks in the module. ResNet-152 is one of the examples. The structure of Resnet is simple and easy to modify. So all of the above factors have contributed to the widespread use of ResNet.

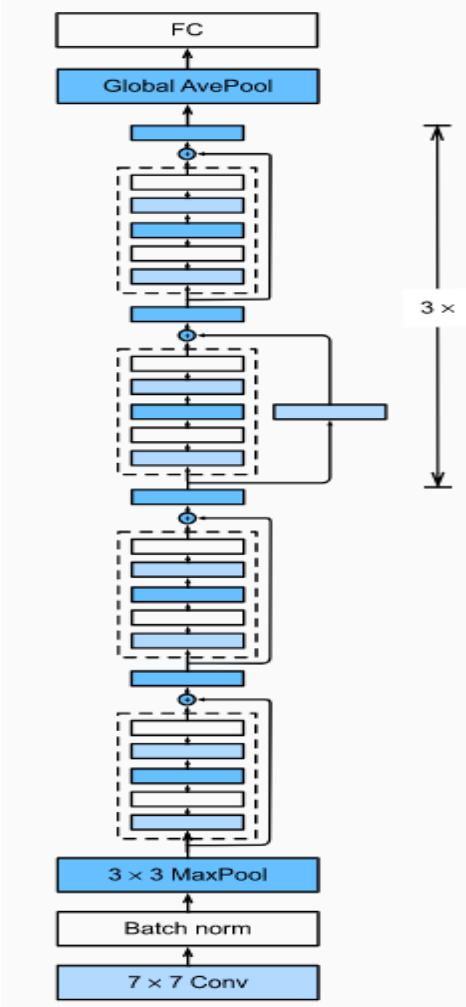

Fig. 8.The ResNet-18 architecture

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V. RESULT AND DISCUSSION

The below graph representations depict the training and validation losses and accuracies of the CNN model and ResNet-18 model respectively.

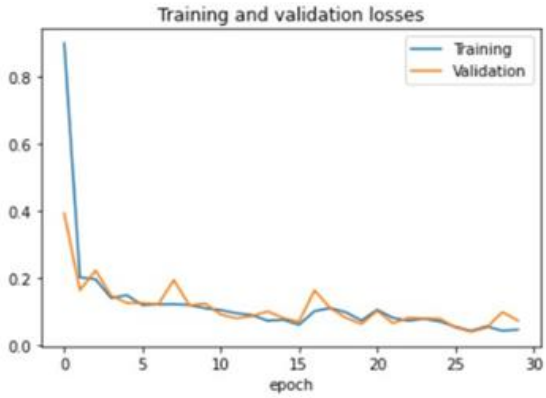

Fig. 9.Training and validation loss of CNN model

Fig. 10.Training and validation accuracy of CNN model

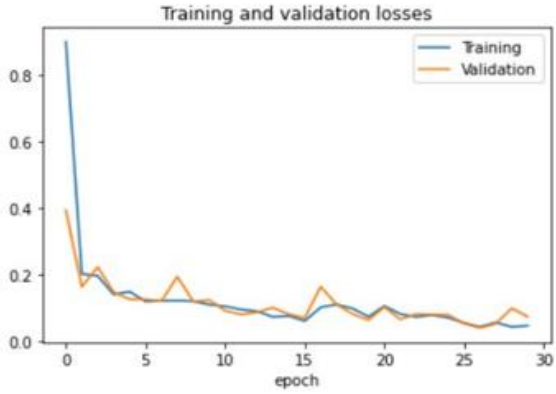

Fig. 11.Training and validation loss of ResNet-18 model

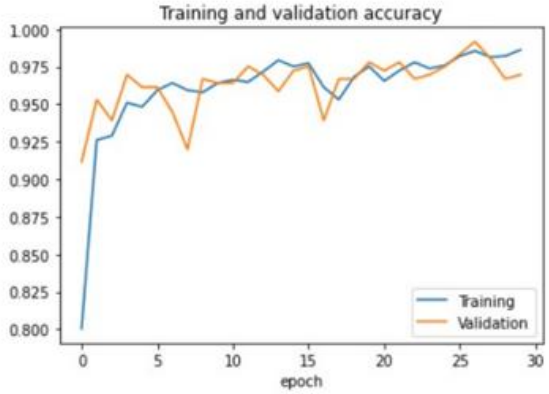

Fig. 12.Training and validation accuracy of ResNet-18 model

VI. CONCLUSION

In this work, a study for the detection of covid-19 infected patients through x-ray images has been performed and determined whether the patient is covid infected or not. This classification was held by mainly using two deep learning algorithms namely convolutional neural networks (CNN) and resnet-18. Both of these models were built, and calculated performances and results were compared for a better analysis. The accuracy percentage obtained in the case of CNN and resnet-18 is 96.07% and 96.67% respectively. Finally, we would emphasize that this analysis is not for clinical diagnosis and only for educational purposes. For future work, researchers can work on ultrasound datasets as only a limited number of studies have used ultrasound as a modality for covid-19 detection. In the future, researchers can look into other organs affected by the virus, as the lung region is taken as a severe infection stage.

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AUTHORS PROFILE

Kotra Sai Kirthana, pursued Bachelors of technology in Computer Science and Engineering at Gandhi Institute of Technology and Management, Visakhapatnam. Her strong desire for simplifying things and her passion for technology motivates her to pick complex problems to derive simpler solutions using various possible approaches. she likes to analyze the problem in different possible ways and draw the best optimal approach. she is enthusiastic to solve the real-life problems with the knowledge acquired in the field of computer science and technology. Her eye for detail helps to identify the errors and other miscalculations if present and aids to get back the system to its original optimal state.