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Detection of COVID-19 using X-Ray Images with Deep Neural Network

Deepti Chauhan[1], Chetan Agrawal[2], Prof. Sandeep Kumar Agrawal[3]
Research Scholar[1], Assistant Professor[2,3]
Department of CSE[1,2,3]
RITS, Bhopal[1,2], RJIT, BSF Academy Gwalior[3]

Abstract- *In recent years, deep learning has multiplied and has played an important role in image recognition, including medical imagery. CNN's have been well used in many diseases, including heart disease, malarial disease, Alzheimer's disease, various dental disorders, and Parkinson's disease. Convolutional Networks have been well used in detecting many diseases. In the case of COVID-19 patients with healthcare images such as chest X-rays and CT, as in other cases, CNN has a significant prospect. The World Health Organisation has described Coronavirus or COVID-19 as a global pandemic (WHO). The cumulative confirmed cases of COVID-19 were 19.18M and deaths of 0.716M worldwide as of 8 August 2020. In preventing the spread of this virus, identifying positive patients with Coronavirus is very significant. A CNN model to detect COVID-19 patients from X-ray chest images is proposed for this conquest. An analytical research tests one more CNN model with various convolution layers, named DenseNet (Dense Convolutional Network), which are applied to the X-ray image dataset, consisting of 80 images related to COVID-19 patients and 100 related to healthy people images. DenseNet model has generated a precision of 0.92, recall of 0.951, F1 score of 0.94, and accuracy of 96.23%. Results have indicated that the DenseNet model has outperformed other existing models.*

Keywords:- Convolutional Neural Network, DenseNet-161, dropout, accuracy, transition layer.
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Introduction

Deep Learning (DL) refers to a subfield of Machine Learning (ML), which is inspired by the human mind's daily functioning. DL has the functionality of learning without any additional labeled details. These features made it famous among Artificial Intelligence and Big Data analytics [1]. DL has also been widely used in various fields such as autonomous vehicles, face recognition, object detection, image classification, and many others [2]. Convolutional Neural Network (CNN) is a DL algorithm that has had great success in solving problems such as text analysis, object recognition, and pose detection. CNN has made significant achievements in its conventional medical image market [3].

CNN is an Artificial Neural Network (ANN) based deep learning algorithm which has evolved significantly in recent times [4]. CNN is based on the concept of the human nervous system. The idea of using artificial neurons was first suggested in 1943. This discovery inspired building models for helping in the ability to identify or recognize images like recognition [5]. This model is known to be a source of inspiration for CNN. CNN is composed of artificial neurons that have the property of evolution through learning. LUCC is superior to other algorithms because LUCC makes excellent judgment. It only requires very little preprocessing of the input data, which yields highly accurate and precise results. CNN is widely used for object detection and image recognition, particularly for medical imaging. CNN networks including Alexnet [6], and VGGNet [7] are popular CNN image models and deliver good performance in realistic scenarios.

The planet is facing a deadly outbreak of the Coronavirus, which was first identified in December 2019 [8]. This disease has been spreading rapidly and posing a real danger to public health. Transmission rate and mode of transmission are essential to understanding the existence of infectious diseases like COVID-19. According to the World Health Organization (WHO), respiratory droplets of size greater than 5 – 10 microns serve as modes of transmission [9]. This is a significant danger to public health because of the lack of necessary safety measures. There are substantial growth and mortality rate with this disease: 2%-5%. According to World Health Organization (WHO), to 8 August 2020, the worldwide reported cases of a severe acute respiratory syndrome (SARS) is 19.18 million with a fatality rate of 0.716 million. On 11 January 2020, there were only 41 confirmed cases, but it increased more than 10,000 times to 43,109 in just one month (11 February 2020). This disease had spread so quickly in the next three months that it took a stunning count of four million on May 11, 2020. Too many precautionary steps of wearing masks and keeping a distance from each other had not lowered patients' numbers. Many people have hope that the population growth factor will decrease more and more because of mass consciousness. Early detection is the most effective way to restrict the spread of this virus. The WHO showed a few rapid and high definition diagnostic tools for COVID-19 detection, including genesis Real-Time PCR Coronavirus (COVID-19) detection for the cobas 8800 and cobas SARS-CoV-2. CNN can aid in automated positive patient identification and it will save both time and money.

CNN has been doing spectacular in the world of medical imaging technology. It has been applied to thousands of various diseases and anomalies in recent years. CNN makes coronary artery disease (CAD), identifies stages from bright-field microscopy of malaria-infected blood, and detects Parkinson's disease through EEG signals [10]. The researchers have also developed different CNN models to identify dental images, diagnose skin diseases, study Alzheimer's disease, and many other diseases. CNN has excellent value in COVID-19 identification by X-ray or CT image. A CNN model for identifying COVID-19 positive patients using the chest X-ray images has been proposed in this paper. With little resources and little time, this model is effective in detecting Coronavirus patients with great accuracy. This paper provides a comparison of CNN models to detect COVID-19. Testing (COVID-19) on a much greater scale would save both energy and time.

We present related studies in section 2, and identification of the models in section 3. Results are shown in section 4 and finally the conclusion in section 5.

II. Literature Survey

A lot of research is being carried out on COVID-19 patient image data. Only a few researchers have suggested different classifications of chest X-ray pictures, whereas others have considered computerized tomography (CT) images. Narin et al. [11] proposed three networks based on ResNet50, InceptionV3, and Inception-ResNetV2 for classifying patients from chest X-ray photo(s). In ResNet50, ResNet performs with 98% accuracy. In comparison, V2 and V3 have 98% accuracy. Although the method using 100 images is accurate for a lower number of images, it would perform poorly for a greater number of images. Zhang et al. [12] proposed a Digital light processing (DLP) computer for detecting Coronavirus patients using chest X-ray images. These researchers have then reviewed 100 chest X-ray images of 70 COVID-19 patients and 1431 X-ray images of other pneumonia patients and classified them as those affected by COVID-19 and non-COVID-19, respectively. This algorithm has three main elements: backbone networks, classification head, and anomaly detection head. At the last end of the backbone network is an 18 residual CNN layer pre-trained on the ImageNet dataset. This model can diagnose major depressive disorder cases and non-major depressive disorder cases with an accuracy of 96 percent and 70.65 percent, respectively.

Hall et al. [13] found several patients with lung cancer according to DL-scan analysis of a chest x-ray image. They have achieved an overall accuracy of 89.2% using the existing pre-trained ResNet50 model. Sethy et al. [14] have also employed advanced research methods to prevent Coronavirus disease spread. Their model uses ResNet50 plus SVM, which achieved accuracy and F1-score of 95.38% and 91.41%, respectively. Apostolopoulos and Mpesiana used CNN self-supervised transfer method for detecting COVID-19 on x-ray images [15]. COVID-19 trained model has handled 224 chest X-ray images of infected people, 714 images with pneumonia, and 504 images of normal people. The model achieved an accuracy of 96.78% and a sensitivity and specificity of 98.66% and 96.46%, respectively. Chen et al. used the CT images of patients to examine COVID-19 using COVNet architecture [16].

Using these methods, this research group has obtained a sensitivity of 95%, a specificity of 96%, and an area under the receiver operating curve of 0.96. Islam et al. proposed a DL model based on CNN and LSTM [17]. This classification is based on normal, COVID 19, and pneumonia with 1525 X-ray images in each category. This article's CNN-LSTM model achieved an overall accuracy of 99.4 percent and an F1 score of 98.9. Hemdan et al. [18] introduced a deep learning approach called COVID-Net in classifying COVID-19 radiographs. This curriculum is based on only 25 chest X-ray images of each of the classes. Chowdhury et al. [19] used deep learning to find COVID-19 in chest X-ray images. This work classifies the patients into two different subgroups—those suffering from viral pneumonia and those suffering from viral pneumonia and COVID-19. They used 423 cancer of the lung, 1485 viral pneumonia images, and 1579 normal chest X-ray images for training and validation. This method achieved an accuracy of 99.70 percent and an F1-score of 99.70 percent. Ozturk et al. [20] performed multi-class and binary classification using the Darknet model. This model has utilized 500 chest X-ray images of normal and 127 COVID-19 chest X-ray images for training and validation of their model. Binary tree classifier achieved an average overall accuracy of 98.08%, whereas it reduced to 87.02% in multi-class classification. Abbas et al. [21] used CNN (Decompose, Transfer, and Compose), which can classify positive COVID-19 subjects. It has used 80 chest X-ray images in the training phase and 105 COVID-19 images in the evaluation phase and derived an accuracy of 95.12%. Afshar et al. [22] also participated in detecting COVID-19 from chest X-ray images.

Most scholars working in detecting COVID-19 also use pretrained models for their model-building. These models have been trained on more simplified datasets than ImageNet. Here, a sequential CNN model is proposed to understand and train because of its simplicity. Besides, this model is trained and validated with less dataset and more convolutional layers so that the model handles extra data.

III. Proposed Methodology

In this section, the first discussion will be on Convolutional Neural Network, then data collection and finally the DenseNet model which is the novelty of this paper.

3.1 Convolutional Neural Network

The COVID-19 detection system consists of several essential steps—collecting data, pre-processing data, categorizing data, developing a model, and evaluating and analyzing it. The architecture of the system that detects COVID-19 combined with CNN is shown in Figure 2. First and foremost, the dataset needed for training and validating the machine learning model was collected and sorted out. The data is moved, sized, and normalized. After this step, all the data were categorized by the categories of the model. This is all done with the same environment and database. The trained models are analyzed based on accuracy, precision, recall, F-1 score, and ROC curve. The next subsection discusses the framework of data modeling and deep learning models.

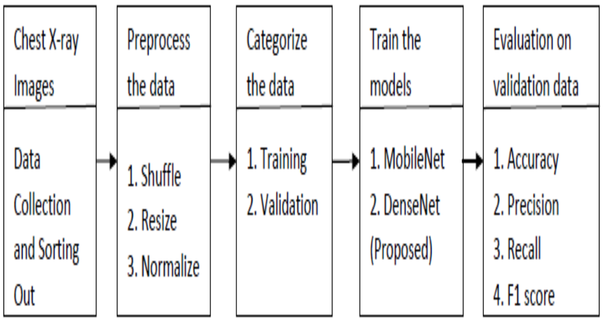

Figure 1: X-ray image classification steps.

3.2 Dataset Preparation

For training and validation, 201 chest X-ray images of COVID-19 patients obtained from open GitHub repository by Cohen et al. COVID-19, SARS, ARDS, pneumocystis, streptococcus, chlamydophila, E.coli and many others. Some conditions are caused by bacteria, legionella, varicella, lipoid, bacterial, pneumonia, mycoplasma pneumonia and flu. Only X-rays with a post adolescent period of ages 12 to 93 years will be taken into consideration. Besides also require non-COVID-19 chest X-rays from Kaggle dataset of Pneumonia. This has 5863 pictures in two categories—normal and pneumonia. Besides, we have also used 201 real chest X-ray images for training and testing purposes. The entire dataset is primarily split into two categories: training and validation. For each dataset, training and validation datasets contain types of X-ray images grouped into two types: ‘normal' and ‘COVID-19'. The number of X-ray images per sub-category is 161 and 40, respectively. This dataset will be referred to as "Dataset 1."

Another dataset is created from the combination of repositories [23]. A dataset of 295 chest X-ray images are created and used for training and testing of the model. One dataset of 659 normal chest X-ray images are obtained randomly from [24]. All of this data are divided into a training and a validation set. The dataset is significant because it contains 236 COVID-19 and 600 normal chest X-ray images. At the same time, the validation set contains 59 chest X-ray images that are normal. We have now collected 954 chest X-ray images as Dataset 2. This is shown in Table 1.

To maintain the image quality of all photos at the same time, they are all converted to 224 x 224 pixels. All the chest x-ray images that are used for training and validation of the model are in a side view. Figures 3 and 4 present two categories of COVID-19 positive and Normal cases from the training and the validation dataset respectively. All models are validated, trained and tested on the several datasets.

3.3 Modeling of Convolutional Neural Network

The input image size is 64x64x1, and then it passes through a 2-D convolutional layer with dimensions 112x112. From the beginning, the passage has dimensions of 56 x 56 and progresses to 28 x 28, 14 x 14, and finally 7 x 7. With 1000 layers, the X-rays are classified into Normal pneumonia and COVID-19.

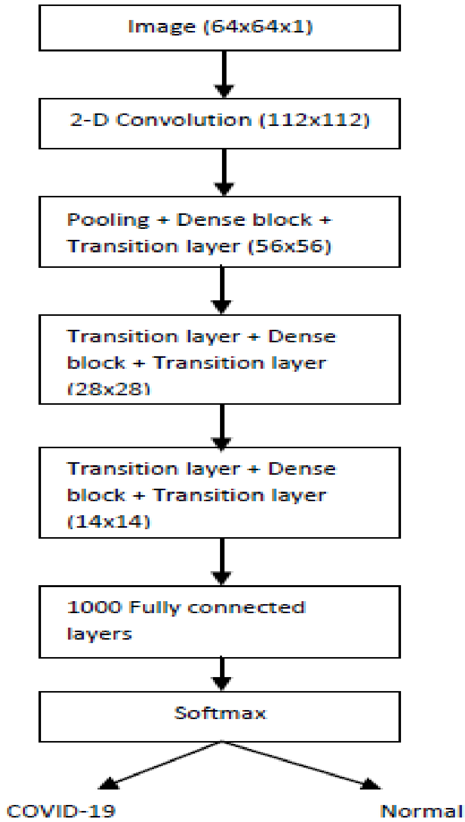

Figure 2: Flowchart of DenseNet-161 model.

Each layer in DenseNet can obtain all preceding layers' input and pass along its feature-maps to all subsequent layers. Each layer is receiving information from all others. A network will not need to have many layers if multiple input channels are combined (so, it has higher computational efficiency and memory efficiency). DenseNet architecture is shown in Figure 2.

IV. Experimental Results

The DenseNet model is implemented using a python programming language. The metrics used for evaluating the model are precision, recall, F1 score, and accuracy. The implemented models are VGG 16, Inception v3, Decision tree, and the DenseNet-161. Table 1 has shown the comparison of all the existing models with the proposed models based on the different evaluation parameters.

Table 1: Comparison table of the existing model with the proposed model.

Models	Precision	Recall	F1 score	Accuracy (%)
VGG 16	1	0.94	0.97	91.15
Inception v3	0.69	0.76	0.72	85.8947
Decision tree	0.62	0.50	0.56	87.3684
DenseNet - 161 (Proposed)	0.92	0.951	0.94	96.23

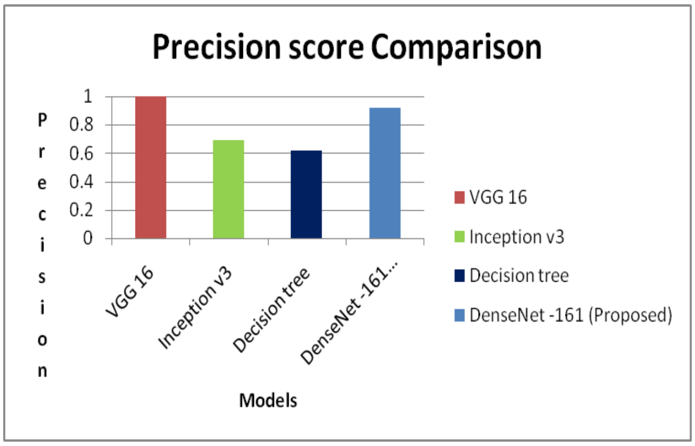

Figure 3: Precision comparison of the models.

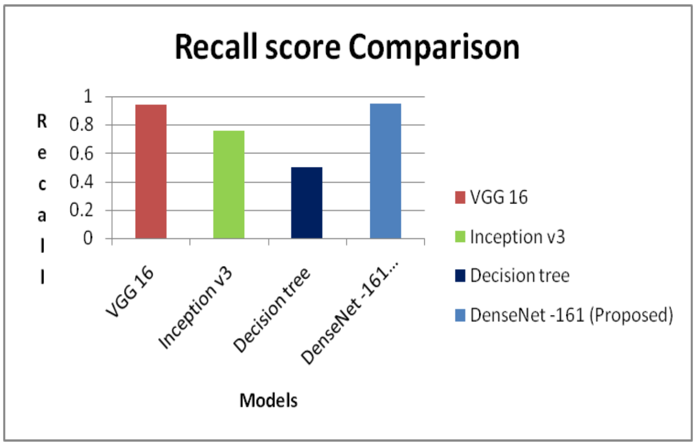

Figure 4: Recall comparison of the models.

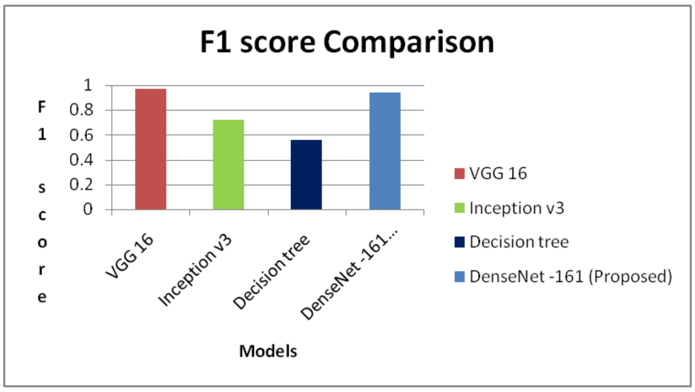

Figure 5: F1 score comparison of the models.

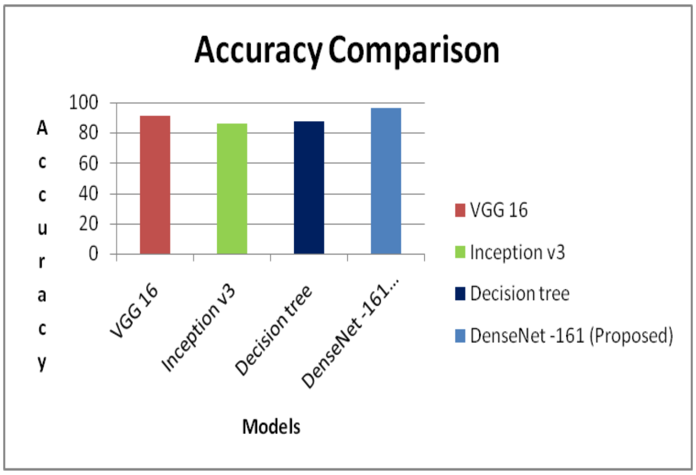

Figure 6: Accuracy comparison of the models.

From the above Table1 and the figures from 3 to 6 has clearly indicated that our proposed model DenseNet -161 has outperformed other existing models such as VGG-16, Inception v3 and Decision tree.

V. Conclusion

We have proposed a deep learning framework, i.e., COVID-19 detector, on our demonstration dataset. We present the dataset for the machine learning community to train and evaluate statistical machine learning models. We carried out a systematic experimental analysis of three existing models' performance with the proposed model named DenseNet-161. Such observations suggest there is the possibility of using X-ray images for COVID-19 diagnostics. This study focused on 201 chest X-ray images of COVID-19 patients downloaded from github. This research brought benefits for chest X-ray study and was compiled mainly in the 1950s. More COVID-19 images are needed to establish the plausibility of these models and to guarantee their accuracy.

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