Using X-Ray / CT Images with CNN for COVID Detection

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***Abstract*: COVID-19, which began with the reporting of unknown causes of pneumonia in Wuhan, Hubei province of China around New Year 2020, has rapidly become a global pandemic. The Novel COVID-19 pandemic has caused a devastating effect on daily lives, public health and the global economy. It is very critical to detect the positive cases as early as possible, so as to prevent the further spread of this pandemic and to quickly treat affected patients. The need for fast, automatic and reliable detection tool has increased and there are no accurate automated toolkits available. COVID detection using CNN is an auxiliary diagnostic tool which uses Machine Learning and Image Processing Techniques for accurate detection of novel coronavirus through chest X-Rays and Radiographs of suspects. It can be used by radiologists for initial scanning and detection.**

***Keywords*: COVID-19, Convolutional Neural Networks, COVID Detection, CT Scan, X-Ray**

Introduction

The Novel COVID-19 pandemic has caused a devastating effect on daily lives, public health and the global economy. It's critical to detect the positive cases as early as possible so on to prevent the further spread of this pandemic and to quickly treat affected patients. The necessity for fast, automatic and reliable detection tool has increased and there are not any accurate automated toolkits available. COVID detection using CNN is an auxiliary diagnostic tool which uses Machine Learning and Image Processing Techniques for accurate detection of novel coronavirus through chest X-Rays and Radiographs of suspects.

Literature Review

Tulin Ozturk et al. developed a model to supply accurate diagnostics for binary classification (COVID vs. No-Findings) and multi-class classification (COVID vs. No-Findings vs. Pneumonia) using Artificial intelligence techniques and Radiology imaging. 17 convolutional layers were implemented and different filtering on each layer was introduced. [1]

Ravneth Punia et al. tried to develop a way that uses radiology, i.e. X-Rays for detecting the novel coronavirus and also released a dataset for the research community and further development extracted from various medical research hospital facilities treating COVID-19 patients. [2]

Garima Verma et al. proposed a Convolutional Neural Network (CNN) model to group and identify the occurrence of pneumonia disease from a given assortment of chest X-Ray image tests. The model could help alleviate the dependability and difficult challenges frequently confronted to manage therapeutic problems. Within the system, CNN algorithm has been used alongside different data augmentation techniques for improving the classification accuracies. [3]

Kalyani Kadam et al. presented a deep neural network based on convolutional neural networks and residual network along with techniques of identifying optimum differential rates using cosine annealing and stochastic gradient with restarts to achieve an efficient and highly accurate network which will help detect and predict the presence of pneumonia using chest X-Rays. [4]

Ali Narin et al. have proposed five pre-trained convolutional neural network based models for the detection of coronavirus pneumonia infected patient using chest X-Ray radiographs. Three different binary classifications with four classes (COVID-19, normal (healthy), viral pneumonia and bacterial pneumonia) by using 5-fold cross validation was implemented. [5]

Mohommed Aledhari et al. proposed a deep learning algorithm based on convolutional neural networks to identify and classify pneumonia cases from these X-Ray images. The model has the potential to predict at higher accuracy than human specialists. [6]

Shijo kido et al. developed an image-based computer-aided detection (CADe) algorithm by use of regions with CNN features (R-CNN) for detection of lung abnormalities and evaluated the performance of image-based CADx by use of CNN and that of image-based CADe by use of R-CNN for various kinds of lung abnormalities such as lung nodules and diffuse lung diseases. [7]

Zeenat Tariq et al. extracted spectrogram features and labels of the annotated lung sound samples and used them as an input to a 2D Convolutional Neural Network (CNN) model, normalized the lung sounds to remove the peak values and noise from them and created a deep learning model for high performance classification in lung disease diagnosis. [8]

Matthew Zak et al. implemented three deep convolutional neural networks pre-trained on the ImageNet dataset and assesed them in lung disease classification tasks using transfer learning approach and created a pipeline that segmented chest X-Ray (CXR) images prior to classifying them. [9]
Muchahid Barstugan et al. detected Novel Coronavirus using abdominal Computed Tomography (CT) images. The feature

extraction process was applied to patches to extend the classification performance. GLCM, LDP, GLRLM, GLSZM, DWT algorithms were used as feature extraction methods. [10]

Md. Jamil et al. proposed a Deep CNN for fast and reliable identification of COVID-19 infection cases from the patients' chest X-Ray images. Deep learning techniques were used to analyze chest X-Ray images for efficient and reliable COVID-19 screening. [11]

Ferhat Ozghur Catak et al. proposed a model for COVID-19 diagnosis, applying a deep CNN technique supported using raw chest X-Ray images belonging to COVID-19 patients using the five different architectures of well-known pre-trained deep CNN models such as the VGG16, VGG19, ResNet, DenseNet, and InceptionV3. [12]

Hemdan EDD et al. introduced a new deep learning framework named COVIDXNet to assist radiologists to automatically diagnose COVID-19 in X-Ray images. COVIDX-Net included seven different architectures of deep convolutional neural network models, like modified Visual Geometry Group Network (VGG19) and therefore the second version of Google MobileNet. Each deep neural network model was used to analyze the normalized intensities of the X-Ray image to classify the patient status either negative or positive COVID-19 case. [13]

Sonali Agrawal et al. presented the random oversampling and weighted class loss function approach for unbiased fine-tuned learning (transfer learning) in various state-of-the-art deep learning approaches such as baseline ResNet, Inception-v3, Inception ResNet-v2, DenseNet169, and NASNetLarge to perform binary classification (as normal and COVID-19 cases) and also multi-class classification (as COVID-19, pneumonia, and normal case) of posteroanterior CXR images. [14]

Parnian Afshar et al. proposed an alternative modeling framework based on Capsule Networks, referred to as the COVIDCAPS, being capable of handling small datasets, which is of significant importance due to sudden and rapid emergence of COVID-19. [15]

System Architecture

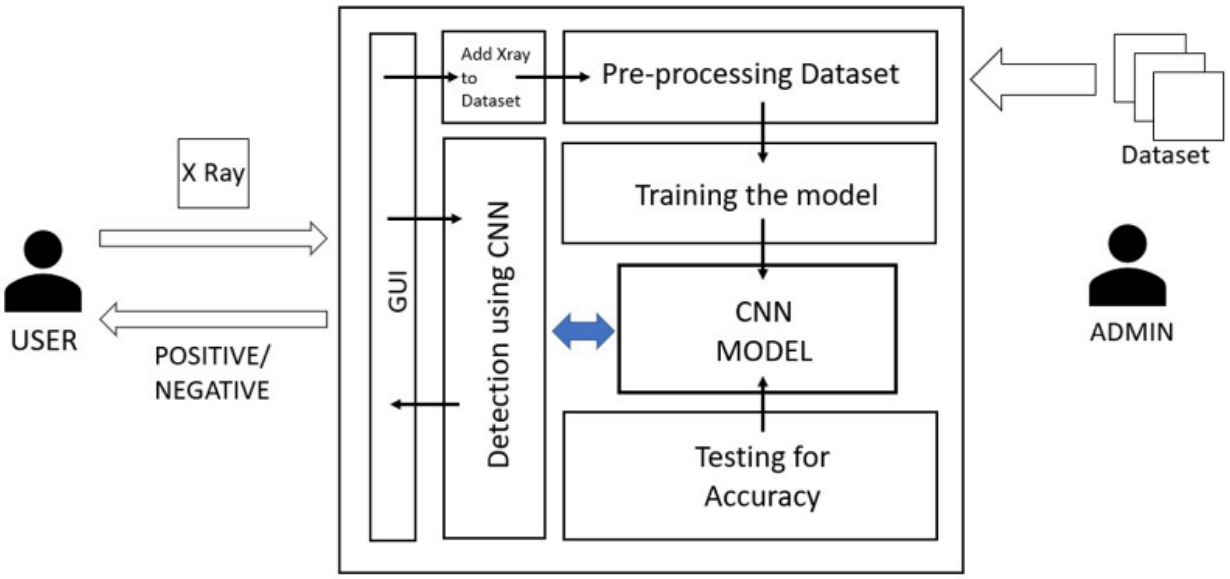

Fig. 1: System Architecture

A. Data Collection and Pre-processing: The X-Ray images from two different datasets are collected. First is the dataset "ieee8023/covid-chestxray-dataset" which is an open dataset of COVID-19 cases with chest X-Ray images or CT Scan images. The dataset is constantly updated with new X-Ray images as and when shared by people all over the world. The second dataset is a free dataset from kaggle - "Chest X-Ray Images (Pneumonia)" which the images of non COVID-19 people are to be selected. The dataset selected contains all types of X-Rays of which some may not be useful for further processing. Only the required X-Rays are filtered out and the actual dataset is created for further processing.

B. Training the CNN: This dataset is used to train a CNN which can distinguish the images into COVID or Non-COVID. CNN structure has a convolution layer that extracts features from the input with the filters it applies, a pooling layer to reduce the size for computational performance, and a fully connected layer, which is a neural network. By combining one or more such layers, a CNN model is created, and its internal parameters are adjusted to accomplish the objective.

C. Testing the Accuracy of CNN: A testing dataset is given as input to the CNN, based on the outputs of which the accuracy of CNN is judged. The performance of a proposed model is evaluated and confusion matrix are formed.

D. Graphical User Interface: A desktop based GUI is developed wherein the users can manually upload their X-Ray images and the system will predict the output using the pre-trained model. The GUI has an upload window where the user can upload the files which are stored on their system and the output will be displayed as COVID or Non-COVID.

E. Updating the Dataset: The images manually uploaded by the user are added back to the original dataset, so as to contribute to the constantly updating dataset as well as to increase the performance of the training of the system.

F. Classification using CNN: Thorough testing of the system for automatic as well as manual inputs and evaluation of the performance by experts(radiologists). User will upload his X-Ray / CT scan into the system and using the CNN, the image will get classified into COVID or Non-COVID. The name Convolutional Neural Network indicates that the network employs a specialized kind of linear operation called convolution on the data to reduce its dimensionality. Convolutional networks are simply neural networks that use convolution in situ of general matrix operation in a minimum of one among their layers. CNN have an input layer, and output layer, and hidden layers. The hidden layers generally contain convolutional layers, ReLU layers, pooling layers, and fully connected layers.

G. Testing of the System: Thorough testing of the system for automatic as well as manual inputs and evaluation of the performance by experts (radiologists).

Algorithms

Convolutional Neural Network: Convolutional neural network is one of the most popular ANN. It is widely utilized in the fields of image and video recognition. It works on the principle of convolution. It is very similar to multi-layer perceptron, except it contains series of convolution layers and pooling layers before the fully connected neuron layer. It has three important layers:

- **Convolution Layer:** It is the primary building block and perform computational tasks based on convolution function.
- **Pooling Layer:** It is arranged next to convolution layer and is used to reduce the size of inputs by removing unnecessary information so computation canbe performed faster.
- **Fully connected layer:** It is arranged to next to series of convolution and pooling layer and classify input into various categories.

The CNN model selected for implementation is InceptionV3.

InceptionV3

InceptionV3 is the third generation of Google's Inception CNN, which was started as module for Googlenet, originally introduced during the ImageNet Recognition Challenge. Inception helps classification of object in the world of computer vision. One such use in life sciences was proved when the model aided in the research of Leukemia.

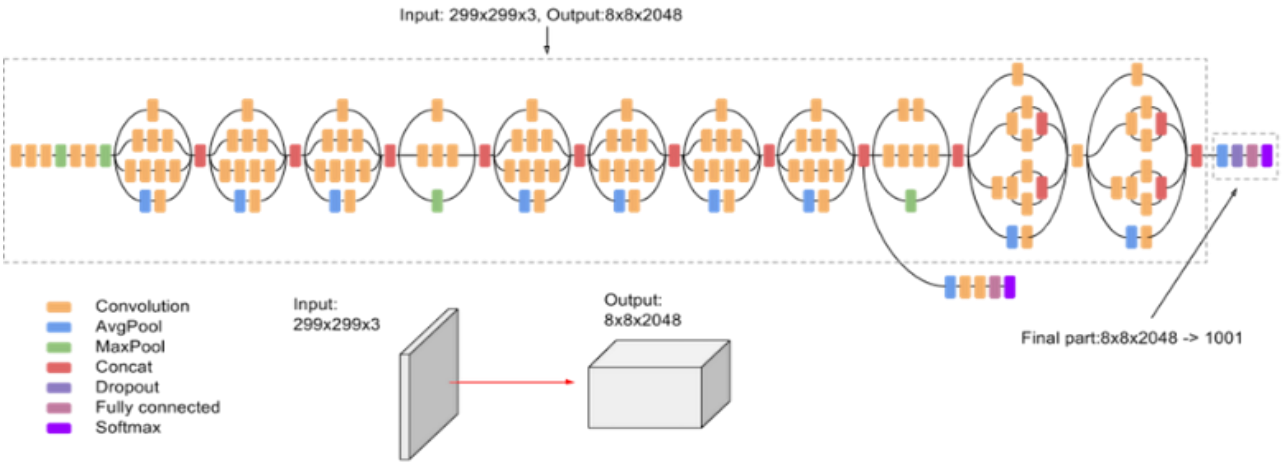

Fig. 2: InceptionV3

InceptionV3 has 48 different hidden layers. You can load a pre-trained version of the network trained on quite a million images from the ImageNet database. The pre-trained network can classify images into a thousand object categories, like keyboard, mouse, pencil, and animals. As a result, the network can now understand a rich feature representation for a wide range of images. The network takes an image of input size of 299-by-299.

Result Analysis

We performed experiments to detect COVID using the trained CNN Model. First we trained the model to classify images into COVID and non COVID. Then the performance of the model is evaluated thoroughly. The result of confusion matrix for

this binary classification are shown below:

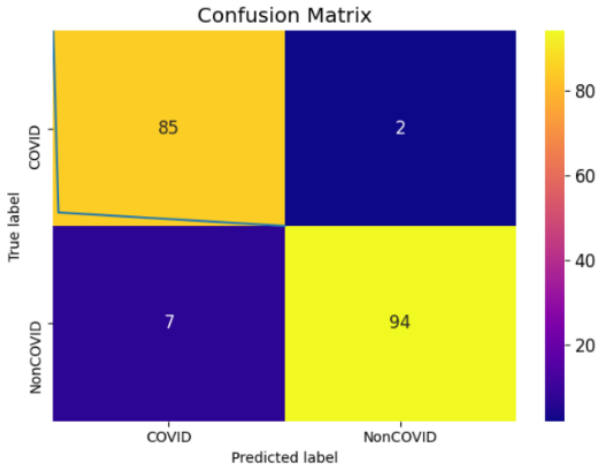

Fig. 3: Confusion Matrix

It can be noted that the number of false negatives is very less, which is very essential for the models with this severe implication, in order to prevent further spreading of the pandemic.

	precision	recall	f1-score	support
0	0.92	0.98	0.95	87
1	0.98	0.93	0.95	101
accuracy			0.95	188
macro avg	0.95	0.95	0.95	188
weighted avg	0.95	0.95	0.95	188

Fig. 4: Accuracy, Precision, Recall, f1-score

The model has achieved an overall accuracy of over 95 percent for detection of COVID-19. The precision, recall and F1 scores are 95 percent as well.

Conclusion

A deep learning based model to detect and classify COVID-19 is developed. The model is fully automated with an end-to-end structure without the need for manual feature extraction. The developed system is able to perform binary classifications in COVID or Non-COVID with a high accuracy. The performance of the developed model is assessed by expert radiologists and is ready to be tested with a larger database. This system can be used in remote places in countries affected by COVID-19 to overcome a shortage of radiologists.

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