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Classification of COVID -19 in Chest X-Ray Images

Mayur Pralhad Musale, Rohan Yogesh Jangle, Saurabh Jagannath Fulpagar, Amit Arun Kasture

Department of Computer Engineering, Late G.N.Sapkal College of Engineering, University of Pune, Nashik, India

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Abstract:

The COVID-19 may be a reason for pneumonia and it is estimated to have a huge impact on the healthcare system. Beforehand diagnosis is very important for right treatment in order to possibly decrease the increasing stress on the healthcare system. The standardized image diagnosis testing techniques to detect the pneumonia are CXR(Chest X-rays) and CT Scan(Computed Tomography). As we know CT scan is the best technique but chest X-ray are still helpful because it is inexpensive, quicker and more widespread. This study targets to determine pneumonia caused due to COVID-19 from other variants and also healthy lungs of a person using only Chest X-ray images.

Keywords — **CNN, pneumonia, CXR, COVID-19, Chest X-ray images.**

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I. INTRODUCTION

The most recent novel coronavirus, officially named as Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), leads to the Coronavirus Disease named COVID-19. The COVID-19 may cause illness to the human respiratory system, feverishness and coughing and in some immoderate cases can cause a severe pneumonia. Pneumonia is a type of infection that causes redness and swelling mainly in the lungs' air sacs called alveoli responsible for the oxygen exchange. Pneumonia may be caused because of other microorganisms besides SARS-CoV-2, such as fungi, bacteria and other viruses. Various characteristics can causing its severity: weak or impaired immune system, chronic diseases like asthma or bronchitis, elderly people and smoking. The treatment depends on the organism accountable for the infection, but usually requires antibiotics, cough medicine, fever reducer and pain reliever. Depending on the symptoms, the patient needs to get into hospital; in critical cases the patient must be admitted into an ICU(intensive care unit) to use a mechanical ventilator to assist breathing. By CXR image analysis, we are capable of observing that texture is one in every of the foremost visual attributes present in those images. So, we've decided the extraction of features from CXR images by exploring some popular characteristics descriptors, and also a pre-trained CNN model, to not neglect the power of representation learning approaches. Hence, for the classification, using the extracted features from CXR image, we've applied some popular multi-class classification algorithms. Here, we review the state-of-the-art methods for COVID-19 detection, adaptation to the detection of COVID-19 cases. Normal classification strategies are inhibited by the truth that the info is usually both incomplete and heterogeneous. To resolve this two-fold problem, we're going to propose a CNN algorithm here, which correctly and effectively classifies COVID-19. There are basically two ideas behind the proposed algorithm that first, for each

instance to be categorized it chooses the features adaptively and another, measures the distances to other instances in a novel way. The CNN was executed and tested on a COVID-19 dataset given by the Italian society of medical and intervention radiology society. It had been also compared to three other algorithms of its category. The test results show that the CNN can efficiently and accurately Classification of COVID -19 in chest X-ray images Mayur Pralhad Musale, Rohan Yogesh Jangle, Saurabh Jagannath Fulpagar, Amit Arun Kasture Department of Computer Engineering, Late G.N.Sapkal College of Engineering, University of Pune, Nashik, Indiacategorize COVID-19 patients. The comparison results show that the CNN algorithm greatly outperforms all other algorithms of this category in terms of four metrics: recall, precision, Fscore, and accuracy.

II. RELATED WORK

Problem Statement:

We are going to introduce a system which is based on Digital Image Processing and Deep Learning to extract deep local features from each image. If user gives a chest X-ray image as input then system will classify the image as an Image with COVID-19 affected lungs or healthy lungs.

Literature Survey:

In past few months, World Health Organization (WHO) has announced that a new pandemic called COVID-19 has been outspread aggressively in many countries around the world. Diagnosing the COVID-19 is generally associated with the pneumonia symptoms, which can be disclosed by various genetic and imaging testing methods. Early and quick detection of the COVID-19 can contribute to control the spread of this pandemic disease. Imaging testing methods can provide a quick detection of COVID-19, and accordingly contribute to control the spread of the virus.

Computed Tomography (CT Scan) and Chest Xray (CXR) are the imaging techniques which can play a crucial role in the diagnosis of COVID-19 disease. The previous and old aged concept of image diagnosis systems has been exhaustively explored through several approaches ranging from feature engineering to feature learning. Convolutional Neural Network (CNN) is one of the most favoured and successful techniques in the diagnosis of COVID-19 disease from digitised lungs images. A number of reviews has been carried out to call attention to recent contributions in COVID-19 detection [2, 4]. For example, in [3], a CNN has been applied based on Inception network to detect COVID-19 infection within CT Scan. In [9], a modified version of CNN, ResNet50 pre-trained network was provided to categorize CT Scan images into three different classes: images having healthy lungs, COVID-19 affected lungs and bacterial pneumonia affected lungs. CXR images have been used in [7] by a CNN assembled based on different modified ImageNet pre-trained models for extraction of high level features. Those extracted features were put into the Support Vector Machine (SVM) as a machine learning classifier to identify the COVID-19 cases. Moreover, in [8], a modified CNN architecture named wiSP-Net based on transfer learning has been applied to categorize the CXR images into four different classes: normal lungs, bacterial infected, nonCOVID-19 and COVID-19 viral infection. In [9], a dataset containing CXR images of patients with pneumonia, confirmed COVID-19 affected cases, and normal cases, is used to calculate the performance of state-of-the-art CNN architectures, previously proposed for medical image classification. The study recommended that transfer learning can extract significant features accompanying the COVID-19 disease. By discussing the related work, it is noticeable that despite the success of deep learning in the classification of COVID-19 from CXR and CT Scan images, data irregularities have not been explored. It is usual in medical imaging particularly that datasets contain different kinds of irregularities

like overlapping classes that can affect the resulting accuracy of machine learning models.

OBJECTIVES:

1. To analyse and determine the advantages of Image Processing, Machine Learning in COVID-19 detection.
2. To make recommendation on improvement on the current used X-ray system.
3. To design and construct Image Processing and Machine Learning based COVID-19 detector application prototype.

III. METHODOLOGY:

Supervised Machine Learning:

The supervised learning technique is more frequently used in machine learning because it tackles with straightforward tasks and is easy to implement. Data inputs are named with the answer that the algorithm should start at, whichhelps the machine pick out patterns in the future, better differentiate data, or make predictions. Supervised learning is classified into two categories of algorithms and is perfect for problems where there are reference points available.

Classification:
A classification problem can exist when the output variable is of a certain category.

Regression:
A regression problem can exist when the output variable is a true value that changes like currency, mass, measurements.
We can regularly utilize supervised learning to teach ourselves or anyone else a new task. It's kind of like being given a test with the answer set. Once you have the task completed, this technique can be used to similar process and information.

Digital image processing:
Digital image processing is the technique that uses a digital computer to process digital images through an algorithm.

It allows a broad range of algorithms to be applied to the input data and can avoid problems such as the build-up of noise and illegal activity during processing. Since images are defined over two or more dimensions, digital image processing may be modelled in the form of multidimensional systems. The generation and improvement of digital image processing is extremely affected by three factors: first, the development of computers; second, the evolution of mathematics (particularly the creation and betterment of discrete mathematics theory) third, the demand for a wide range of applications in environment, agriculture, military, industry and medical science has been increased over a period of time.

Algorithm :

Convolutional Neural Networks(CNN) In machine learning a map is created containing feature data then classifier is applied on this feature map to solve the problem. Every problem in map has unique data set and unique strategies which are applied, are different for every problem. Hence, to overcome this issue CNN is used to generate features automatically and combine it with the classifier.

Four layered concepts we have to understand in CNN :
-Convolution of the image
-ReLu (Rectified Linear Unit)
-Pooling
-Fully Connected Layer

1. Convolution Of the Image :
Convolution is being translational invariant. Intuitively, which means that every single convolution filter indicates an interesting feature

and the CNN algorithm learns which features consist the resulting reference.
Four steps in convolution :
-Line up feature and image.
-Multiply each feature pixel with related image pixel.
-Add all values and find the total.
-Divide that sum by total number of pixels present in that feature.

2. ReLU Layer :
Rectified Linear Unit (ReLU) is an activation function. ReLU transformation function activates a node only if the input is greater than a certain amount, and when the input is less than zero, the output becomes zero, but as the input increases over a certain threshold, it has linear relationship between dependent variable.

3. Pooling Layer :
This is the layer where we reduce the size of image stack into a smaller size stack. Pooling activity is implemented after passing through the activation layer.
We perform this by following below four steps: -
Pick the window size.
-Pick the stride.
-Run the window with filtered images.
-From every window, choose the maximum value.

4. Fully Connected Layer:
The last layer in the network is fully connected, which means that neurons of previous layers are connected to each neuron in upcoming layers. This imitate high level reasoning where all possible pathways from the input layer to output layer are studied.
Fully connected layer is the last layer where the classification happens actually

IV. CONTRIBUTION

Feature Extraction :
Earlier for feature extraction the modified version of CNN like ResNet and ImageNet were used. Here we are using only CNN instead of any its modified version like ResNet or ImageNet for extracting the deep local features from the image from training dataset. For this deep learning work we are using keras library which wraps efficient numerical computation library tensorflow and allows us to define and train the neural network.

Classification :
Earlier for class decomposition the AlexNet pretrained network based model was used. Multiclass classification was performed there. Here we are using CNN for binary class classification of feature extracted from the image taken from testing dataset and to compare those with the extracted feature set of training dataset.

Transfer Learning:
In transfer learning the machine will store the extracted features from the testing image too. So that machine will generate more accurate results in future. So, if not enough large dataset is available for training then also we can get better results using transfer learning. Earlier for transfer learning same ImageNet pretrained model were used. We are using unmodified version of CNN for transfer learning.

Dataset Used:
Here we have used the ‘chest X-ray images’ dataset available on kaggle.com. There are 80 % images are being used for training purpose and 20% images are being used for testing and validation purpose.

Evaluation :
For the evaluation of performance we have adopted: Accuracy, Specificity and Sensitivity

$$\text{Accuracy} = (TP + TN) / n$$

$$\text{Sensitivity} = TP / (TP + FN)$$

$$\text{Specificity} = TN / (TN + FP)$$

Here, in case of COVID-19 affected case TP is true positive and in normal case TN is true negative. And FP and FN are incorrect model predictions that is false positive and false negative in COVID-19 situation.

Here we are coping with binary class classification. So, we are using confusion matrix here for model evaluation.

TP, FP, TN and FN for specific class named i are given by :

$$TPi = \sum_{i=1}^{n} x_{ii}$$

$$TNi = \sum_{j=1}^{c} \sum_{k=1}^{c} x_{jk},\ j \neq i,\ k \neq i$$

$$FPi = \sum_{j=1}^{c} x_{ji},\ j \neq i$$

$$FNi = \sum_{j=1}^{c} x_{ij},\ j \neq i$$

ARCHITECTURE:

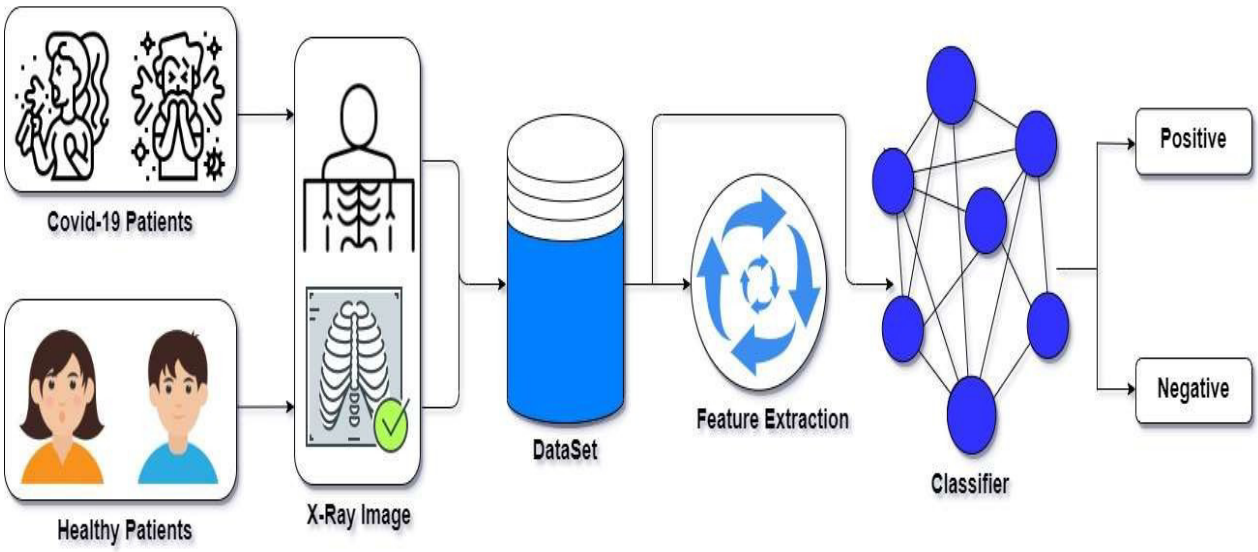

Fig.2 System Architecture

Results Images:

Results:

Case	Accuracy	Sensitivity	Specificity	Precision	Recall
Normal	0.93	0.98	0.84	0.93	0.98
Covid-19	0.94	0.84	0.98	0.94	0.83

V. CONCLUSION

As the COVID-19 pandemic spreading worldwide, the number of covid cases keeps growing rapidly. To find a method that can help in the diagnosis of this disease in people, using a cheaper and faster method, is important to avoid overwhelming the healthcare system. In this context, the use of deep learning techniques to identify the pneumonia diseases in CXR(Chest X-ray) images has been proposed in the literature and may help in this diagnosis. However, after we are handling images taken from patients stricken of pneumonia caused by various types of pathogens and we are attempting to predict a selected kind of pneumonia (in this case, COVID-19), the matter turns into an even more challenging and difficult task.

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