Deep Learning Pneumonia Detection

using

Chest X-Ray Image

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**Abstract:**

Pneumonia is an infection of the lungs commonly caused by bacteria called Streptococcus pneumoniae but also caused by fungi and viruses.

The general symptoms of Pneumonia are chest pain, fever, cough and having trouble in breathing. This infection can be present in one or both lungs. Most of when the natural defence system of our body allows the germs to invade and replicate themselves within the lungs. To destroy these organisms’ white blood cells, accumulate very rapidly. When that happens air sacs of lungs called alveoli gets filled because of so much white cells along with bacteria and fungi. Thus, breathing may be laboured.

This infection can be detected by various methods some of them are used more often such as Chest X-Ray, Blood tests, such as Complete Blood Count (CBC) and, Pulse oximetry is also used to measure how much oxygen is present in your blood, as Pneumonia can keep lungs from getting enough oxygen into your blood. As we are developing an automatic system for detecting pneumonia that would be benefit both the patient for treating the disease without any delay particularly in remote areas and doctors as they can spend more time on treating patients. So, we will use Chest X-Ray method to diagnose pneumonia and automate using deep learning algorithms. Due to the popularity of deep learning algorithms in image analysing, Convolution Neural Networks (CNNs) have gained much attention for image classification for disease detection. In addition, features learned by pre-trained CNN models on large-scale datasets are much useful in image classification tasks. In this work, we appraise the functionality of pre-trained CNN models utilized as feature-extractors followed by different classifiers for the classification of abnormal and normal chest X-Rays. We will analytically determine the optimal CNN model for this purpose. Statistical results obtained demonstrates that pre-trained CNN models employed along with supervised classifier algorithms can be very beneficial in analysing chest X-ray images, specifically to detect Pneumonia.

**Introduction:**

Computer Aided Designs (CAD) have become the major research domain in machine learning. The CAD systems have already been proven to facilitate to various areas of medical industry primarily in detection of breast cancer, mammograms, lung nodules etc. In the procedure of implementing Machine Learning (ML) techniques to X-Ray images, significant features are of uppermost importance. Implementation of Deep Learning (DL) models specifically Convolution Neural Networks (CNNs) have potential of extraction of useful features in image classification. The process of extraction demands learning methods where pre-trained CNN models learn the generic features on largescale datasets and then later transferred to the task of requirement. The dataset we are using is splitted into *train, test,* and *val*. *Train* contains training data that is images which we will use to train our model, similarly, the *test* and *val* also contains Normal and Pneumonia images which will be used to test our model. There are a total 5856 images consisting of normal and pneumonia images both. The classification used with high and rich extracted features have shown improved performance in classification of images.

Chest screening subroutines that are used mostly for sensing lung nodules can be used in detection of other illness such as pneumonia, effusion, cardiomegaly, etc. Among these diseases, pneumonia is an infectious, deadly and contagious which strikes to many people, mostly people who are aged above 65 and suffering also from chronic diseases such as asthma or diabetes. In the procedure of diagnosing pneumonia, chest X-Rays are considered as the most effective method to determine the extent and location of the septic region in the lungs. However, examining chest radio-graphs is not a leisurely task for radiotherapists. In chest X-ray images, appearance of pneumonia can be hazy and can be misapprehended with other diagnoses. The evaluation of chest X-Ray specifically in case of Pneumonia, it can be misleading because of other problems such as having congestive heart failure, lung scarring, can mimic symptoms of Pneumonia.

This is the main reason behind the misclassification of the X-ray images in the dataset. Thus, the task is challenging and the development of an algorithm for detecting thoracic diseases like Pneumonia would increase the accessibility of clinical settings in remote areas as well.

In this study, we evaluated the performance of different variants of pre-trained CNN models followed by different classifiers for classifying abnormal and normal chest X-Rays.

The crucial contributions of this study are as follows:

(a) comparative analytical study of different pre-trained CNN models as feature-extractors for analysing chest X-Rays,

(b) presentation of these models with different classifiers to propose ideal classifier in the same field of classification,

(c) evaluation of optimal pre-trained CNN model with hyperparameter tuning of the best analysed classifier to further meliorate the performance.

**Related Work:**

In recent time, Machine learning (ML) algorithms exploration in the detection of thoracic diseases has gained attention in research area of medical image classification. Lakhani and Sundaram in 2017 proposed a method of detecting pulmonary tuberculosis following the architecture of two different DCNNs AlexNet and GoogleNet. Lung nodule classification that is used to do both detect and diagnosing lung cancer proposed by Huang et al. also adopted deep learning techniques. Performance of different types of Convolutional Neural Networks (CNNs) for abnormality detection in chest X-Rays was proposed by Islam et al. using the publicly available OpenI dataset. Wang in 2017 released a larger dataset of chest X-Ray for the better understanding of machine learning in chest screening. Pranav Rajpurkar and Jeremy Irvin, et al. also explored this dataset for detection of pneumonia at a level better than radiologists, they referred their model as ChexNet that uses DenseNet-121 layer architecture for detecting all the 14 diseases from a lot of 112,200 images available in the dataset. After the CheXNet model, Benjamin Antin et al.(2017) came up with a logistic regression model for the detection of Pneumonia while using the same dataset. Wong *et al.* demonstrated that the common CT findings of bilateral involvement, peripheral distribution, and lower zone dominance can also be appreciated on chest X-ray. Pulkit Kumar and Monika Grewal in used the cascading convolutional networks and contributed their research for multilabel classification of thoracic diseases. Zhe Li in 2018 came up with a convolutional network model for disease identification and localization.

**Dataset Description:**

The dataset used is ChestX-ray14, that was released by Wang et al. (2017), it is publicly available on the Kaggle platform which consists of 112,120 frontal chest X-ray images from 30,085 patients. Every image( radiographic ) in the dataset has been labelled with one or more out of different 14 thoracic diseases. The labels were concluded through Natural Language Processing (NLP) through text-mining disease-classification from the associated radiological reports and are expected to be more than 90% accurate.

For the sake of our project, following the approaches from the past will be treated the labels as the truth for the detection of Pneumonia. Openi was the largest public dataset of chest radio-graphs which consisted of roughly 4,143 X-ray images. But this dataset is the largest that we will be using.

1431 images out of the 112,120 images are found to be labelled with pneumonia and to maintain the dataset for binary classification, 1431 normal X-ray images that are labelled with ’No Findings’ have been selected from the dataset. All images have 1024 by 1024 resolution. Altogether, the final dataset used for the classification task is the subset of the original dataset which consists of 1431 positive image samples (images labelled with ’Pneumonia’) and 1431 negative image samples images labelled with ’No Findings’. After that the dataset is splitted into *train, test,* and *val*. *Train* contains training data that is images which we will use to train our model, similarly, the *test* and *val* also contains Normal and Pneumonia images which will be used to test our model. Then images were downscaled from 1024 by 1024 resolution to 224 by 224 resolution and given as input to the network.

**Problem motivation and Solutions:**

In this section we have the detailed description of the applied methodology. The proposed pneumonia detection system that uses the ’Densely Connected Convolutional Neural Network’ (DenseNet-169) is described in Figure 2. And then we see the architecture of the proposed.

Fig. 2. - 
Represents a flow diagram of our methodology applied.


**Fig. 2.**

Represents a flow diagram of our methodology applied.

First to reduce the computational complexity of the model which will increase if the images are given as input. That is why we are using Convolutional Neural Network and images were also downscaled from 1024×1024 into 224×224 pixels to reduce the heavy computation and make processing faster. Then we extract the features with CNN models and find the optimal model for the feature extraction among variants of CNN models.

After feature extraction, different classifiers such as Random Forest, Support Vector Machine etc. were used for the classification task and we found out the best results were found to be attained when Support vector Machine was used as classifier for the problem. So to have best results we will use SVM classifier for optimal model features extraction. Support vector machine is used to find a hyperplane in an N-dimensional space that distinctly classifies the data points. To separate the two classes of data points, there are many possible hyperplanes that could be chosen. Our objective is to find a plane that has the maximum margin, i.e., the maximum distance between data points of both classes. Maximizing the margin distance provides some reinforcement so that future data points can be classified with more confidence.



Possible hyperplanes

**Build-up:**

Text

Description automatically generated

Convolutional Neural Network has an excellent ability to perform image classification and it is preferred for classification problems. CNN model consists of Input layer, Number of hidden and dense layers and at last an output layer. For pre-training CNN models we have to evaluate the performance followed by Naïve Bayes and mainly Support Vector Machine(SVM).

In CNN model there is one input layer, hidden layer, Dense layer, and output Layer.

* So the first layer we will create is an input layer with 64 nodes and relu as  
  an activation function.
* And then we will add two more Conv2D layers with 64 nodes each and relu as an activation function.
* And then we will create one Dense layer with 128 nodes, and relu as an activation function.
* At last we will create an output layer with 1 node and sigmoid as an activation function.

We build some CNN models and then by observing the results as we find the optimal CNN model for the feature-extraction and detection and then use SVM as the classifier for the classification stage. As for the classifier also selected which showed the optimal i.e., highest scores with the different CNN models.

**Results and Discussion:**

The customized model that we have created is a combination of CNN based feature-extraction and SVM resulted in optimal solution for the detection or classification of Pneumonia labelled and normal Chest X-Ray images with features of model and hyper-parameter values of SVM classifier.

Scientific literature have shown the relevance of the combination of CNN based feature extraction and classifier in medical image analysis to improve the model performance.

By keeping in mind past approaches, we trained models with classifiers to determine optimal model for the purpose.

We observed from the comparative experimental results and trained CNN model that performed better same parameter values of SVM classifier is employed.

**Limitations and future scope:**

Early detection of pneumonia is crucial for determining the appropriate treatment of the disease and preventing it from threatening the patient's life Chest radiographs are the most widely used tool for diagnosing pneumonia , however , they are subject to inter class variability and the diagnosis depends on the clinicians ' expertise in detecting early pneumonia traces To assist medical practitioners , an automated CAD system was developed in this study which uses deep transfer learning based classification to classify chest X - ray images into two classes " Pneumonia " and " Normal

In the future , we may investigate techniques such as contrast enhancement of the images or other pre - processing steps to improve the image quality We may also consider using segmentation of the lung image before classification to enable the CNN models to achieve improved feature extraction .

Conclusion:

This deep learning model can classify the image with 91% accuracy. Now the model we have created will work fine on classifying the data it has never seen before. So we can use this model to predict whether the person is Normal or suffering from Pneumonia with the help of that person’s Chest X-ray image.