Lung Disease Detection using X-rays using Deep Learning

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ITCS-5156 Fall 2022- Lee

October 2022

Abstract

This report is presented as a survey of previous work [1]*. Any assertions made within are subjective and do not represent those of the original author.*

Deep learning is one of the pioneering technologies that could change problems in the sector of healthcare. With the huge availability of data implementing Deep Learning is possible in the real world. Lung Disease we particularly focused on is pneumothorax which requires immediate medical care. It takes a long time to review every image and compile the report because the current imaging volumes are so large. The goal is to create an automated system to partition the affected area and anticipate X-rays with pneumothorax. This will aid in giving patients with pneumothoraxes top priority in their care. Automatic picture segmentation can help doctors diagnose and treat patients more accurately, speed up the diagnosis process, and work more effectively.

1 Introduction

A pneumothorax is when the lung has collapsed due to air entering the space around your lungs (known as the pleural space). In a healthy body, the lungs are touching the walls of the chest. Air can enter the pleural space through an opening in your chest wall or the lung. Air in the pleural space creates an increase in pressure around the lung and causes it to collapse. Pneumothorax is typically detected on chest X-ray, and examined by a doctor or a radiologist. However, this involves manual labor. Deep Learning programs based on Computer vision tasks using convolutional neural networks (CNNs) have been demonstrated to be quite effective for natural image processing tasks such as facial recognition, as well as medical image analysis tasks such as the reconstruction of CT and PET images or the detection of skin cancer. A CNN with learned image filters (i.e. convolutional layers) and classifiers (i.e. deep fully-connected layers) offers a better representation of data and a greater degree of generalizability than most traditional machine learning methods.

1.1 Problem Statement

Pneumothorax is a serious condition that can cause death if it is not diagnosed and treated at the earliest possible time. Chest X-ray images can be used to diagnose this condition. We need an expert and experienced radiologist to predict whether a person is suffering from pneumothorax or not by looking at the chest X-ray images. Everyone does not have access to such a facility. Moreover, in some cases, we need quick diagnoses. So we propose an image segmentation model to predict and give the output a mask that will assist the doctor in taking this crucial decision. Deep Learning has proved its worth in many areas and created state-of-the-art models. The purpose of this study is to utilize the power of these deep learning models to solve this problem.

1.2 Motivation and Challenges

The motivation behind the project is to help doctors and radiologists in the detection of pneumothorax and to make decisions faster. But due to huge volumes of data and the availability of experienced doctors and radiologists in developing countries such as India, Bangladesh, etc. takes more time to detect and treat the patients. An automated system that Diagnoses the disease and sends insights into lung segmentation of infected areas to the doctors will help users to get insights and easy to treat the patients with suitable treatments.

The main challenge in the domain of healthcare is the prediction of false positives and True negatives, which poses a greater threat because we are classifying the person with a disease as negative and who doesn't have the disease as positive. For the classification of the project, we use the classification metric "recall".

1.3 Concise Summary

The summary of my approach is to build a Deep Convolution Neural Network to classify the images. The images are passed to a Deep Learning model, adopting a DCNN Net (Deep Convolutional Neural Network/ConvNet) implemented using PyTorch. For the processing of image data, one has to use a Deep learning model and PyTorch is widely used today for image recognition applications.

2 Related Works

2.1 Diagnosis of Pneumonia from Chest X-Ray Images Using Deep Learning

In 2019, at the Scientific Meeting on Electrical-Electronics and Biomedical Engineering and Computer Science (EBBT) proposed the paper [2] by E. Ayan and H. M. Ünver which focused on the detection of pneumonia from chest X-rays images using Deep learning they have used transfer learning and fine-tuning in the stage of training Stage. Their survey is related to test results revealed that the Vgg16 network is more accurate than the X ception network with 0.87% and 0.82%, respectively. The X ception network, however, had better effectiveness in identifying pneumonia patients.

The proposed work is to create a CNN model which can extract more significant features from the entire image rather than handcrafted features [3], [4]. Researchers developed different CNN-based deep networks and these networks achieved a state of results in classification, segmentation, object detection, and localization in computer vision.

The approach in a sequential process is Our first network is based on the X ception model. The second one is Vgg16 based model they have also used data augmentation, transfer learning, and fine-tuning techniques. they have trained both networks with identical parameters to compare them objectively. Additionally, using various measures, contrasted the effectiveness of the two networks on the test data. The findings demonstrate that the X ception model performs better at identifying pneumonia than the Vgg16 model. However, the Vgg16 model performed better when diagnosing typical cases. The Xception network is more successful in detecting pneumonia cases than the Vgg16 network. At the same time, the Vgg16 network is more successful at detecting normal cases.

All photos are resized for the target network model before the training phase. Because the Vgg16 network only accepts photos with 224×224×3 dimensions, the X ception network supports images with 299×299×3 dimensions.

2.2 Detection of pneumonia clouds in chest X-ray using image processing approach

In 2017, at the proceedings of the Nirma University International Conference on Engineering(NUiCONE) by A. Sharma, D. Raju, and S. Ranjan, [5] proposed an approach that detects pneumonia clouds in chest X-rays using the image processing approach where the images are resized into an optimal size so that it suitable for computational purposes. The main idea of this paper is to find the boundaries of the infected area of the lung and find the ratio between the infected part and the total part which gives the idea of how much pneumonia is infected in the lungs. By this, we can see the percentage of infection and by segmentation of lungs, doctors can treat the patients accordingly.

The methodology implemented by the authors is they have converted the images into a suitable size and performed a histogram equalization to enhance the quality of images and get a contrast image and apply an Algorithm to get the boundaries and calculate the total lung area and The ratio of areas of this non-cloudy lung region to the total area of extracted lung region, would give an indication of the amount of cloud formation in the lungs.

For calculating the lung boundary, For this purpose, we have a vertically split image into two halves, left and right. Then we selected 100 equidistant horizontal lines in each lung and looked for a pixel intensity gradient value greater than some threshold value of 30, along each horizontal line. The number 30 was chosen after attempting lung boundary identification using multiple threshold values and selecting the one that produced the best results.

In the next step we perform thresholding, which means the image is converted into a contrast image, Thresholding is used to separate the healthy lung tissue from the area that is afflicted by pneumonia. We have utilized Otsu thresholding for this. The image after thresholding provides us with a binary image with the remaining area as white and the dark area as black.

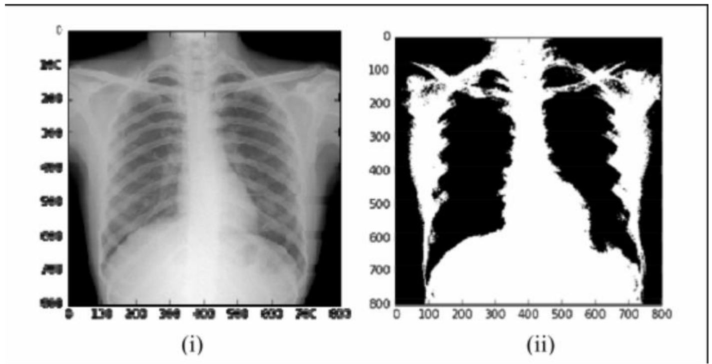

Fig 2.2.1: Image before thresholding (ii) image after thresholding of [5]

2.3 In Relation:

Both of these works demonstrate the idea of detection of lung disease using X-ray images but the approach used in each is different. The proposed papers have pros to include in the project. In the Second paper, the process of making the infected lung segmentations and comparing the ratio of uninfected with the whole lung gives an estimate and the first paper used CNN models to detect the infection. The target paper uses both these techniques and implements in an them intuitive approach.

3 Target of this survey

The project is a representation of the paper that is presented at the European Journal of Radiology and Authors Xiang Li, James H. Thrall, and Subba R. Digumarthy [1] proposed to detect pneumothorax using X-rays. In this paper, an eight-layer Convolutional Neural Network (CNN) was trained

The training was performed to minimize the error between the true labels of the patches and the predicted labels from the network, where the residual was back-propagated to update the parameters of each layer in the network. The training process consisted of 25 total passes through the whole training dataset for backpropagation optimization (i.e. epoch = 25), where the epoch number was determined according to training loss and validation loss with early stopping.

They have used the Adam optimizer for optimization with an exponential decay learning rate (initial learning rate = 10−3, weight decay = 10−8). After each training epoch, the network performance was evaluated on the validation dataset.

We took the following picture features from the 3D annotated region for every pneumothorax patient: 1) The relative size of the pneumothorax, or the ratio of the pneumothorax to the lung size, 2) A shape descriptor based on regional anisotropy, and 3) relative position of the pneumothorax as determined by the separation between the centroid of the pneumothorax region and the closest lung boundary.

First, the previously trained CNN identified picture patches collected from each patient in the test set depending on the likelihood of pneumothorax. The outcomes of patch-wise prediction were then combined to create a 3D heat map of the pneumothorax-prone areas. The largest connected component was then segmented out of the heat map using the region-growing method, creating a single region of pneumothorax. The previously trained SVM was then fed the image characteristics derived from the post-processed result, which carried out the prediction (i.e., diagnosis) of whether a certain patient had a pneumothorax or not.

The implementation of the project data is found from Kaggle and the project is taken as a base work done by medium implemented by Anik Manik and the project repository: Repository

3.1 Data cleaning:

X-ray images are provided in DICOM format, which consists of images along with additional information. I need to extract this information for EDA. Then I need to convert these images into PNG format to train my model.

Masks are given in run-length encoded format, I need to decode it to create a mask in PNG format for every image.

I need to split the data into train and validation sets for every image along with its original mask.

Augmentations I want to use:

1. crop
2. rotation
3. flip
4. bright
5. blur

For the semantic segmentation, UNET is used to segment the lung disease, encoder part of the UNET model with pre-trained DenseNet121 backbone with image net weights and kept the same decoder part.

3.2 Model Building:

There are many approaches to do some of them are

1. Stack several convolutional layers

This method of creating a neural network for this semantic segmentation job is primitive. In this method, we simply stack several convolutional layers (while maintaining the same padding to conserve dimensions) and output a segmentation map as a result.

2. Encoder/Decoder structure

Here, we first down-sample the spatial resolution of the input, creating feature mappings at a lower resolution that is highly effective at classifying the input into different categories through learning, and then we up-sample the feature representations into a full-resolution segmentation map.

3. U-Net architecture

3.3 Pipeline of Model

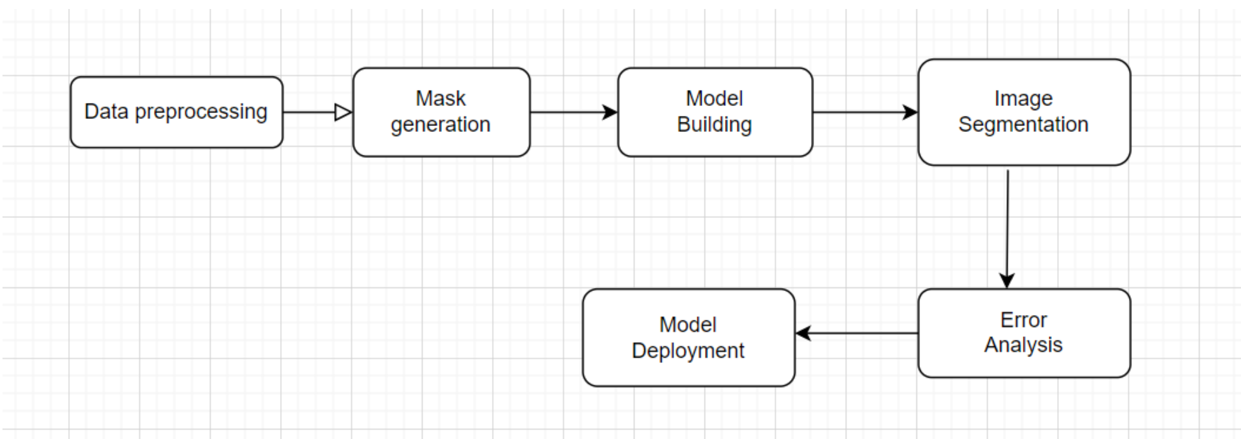

Figure 3.3.1: Framework of the process in a building project

The diagram represents the start and end of the project framework, the data is collected from kaggle[dataset] and is been divided into train, test, and validation datasets we have to convert the images from the dataset in the Data preprocessing step which makes the images which are in the format of png to rle a masked image which gives the contrast images which very use full in model training, I have used vgg16 as a pre-trained model for this project we train the model with the masked images and apply image segmentation which gives the infected area as output and Error analysis is performed to know the accuracy and performance of the model in testing and validation set of images, in the final step we make use of this model and build a flask application and deploy the project so that it can be used by final users.

3.4 Result of the final model

The model performance is shown graph as per loss as we can see as the number of epochs increased the loss the model reduced the training loss rather decreased and reached close to zero whereas the validation loss gradually increased but go flat after many iterations. The training loss is a metric used to assess how a deep learning model fits the training data. validation loss is a metric used to assess the performance of a deep learning model on the validation set. The validation set is a portion of the dataset set aside to validate the performance of the model.

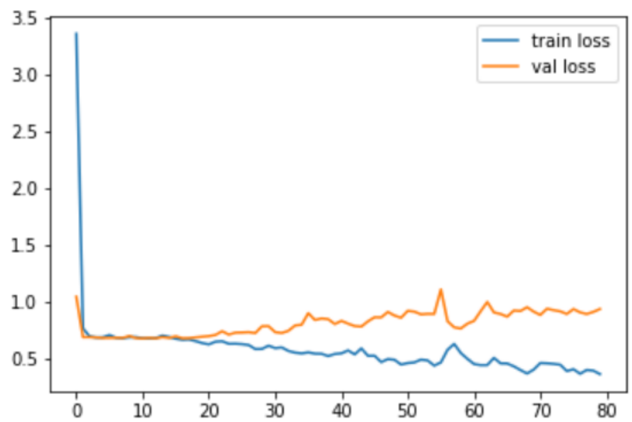

Figure 3.4.1 Result of the final model in terms of loss

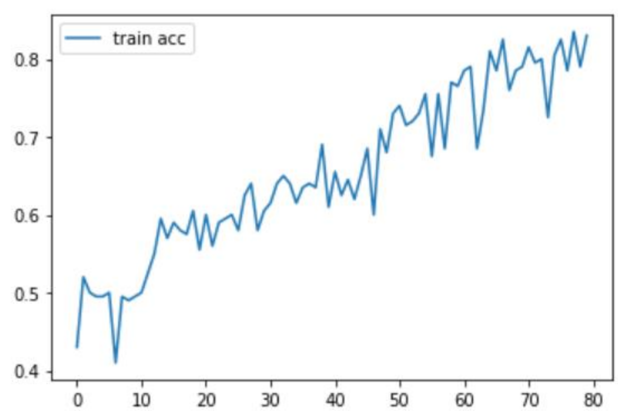

Figure 3.4.2: 1 Result of the final model in terms of accuracy

4. Experiments

For developing this project I have researched a lot and studied various modules regarding CNN and read various articles online in medium and other platforms and got to know various ways to detect lung disease and implementation of these in the real world.

I have tried to duplicate the works of Xiang Li, James H. Thrall, and Subba R . Digumarthy [XJS+19] but the results are identical. I got an accuracy of 92% which is nearly 3% lesser than the accuracy of the target paper presented.

After much experimenting with the number of convolutional layers, thinking about the number of fully connected hidden layers, as well as with various learning rates, Max pool sizes, strides, and padding, I finally came up with a final Deep neural network.

Utilizing Google Collaboratory, it took the model close to two hours to train. The model's Accuracy is 92%, which is a little less accurate than the model presented by the target paper which has a Test Accuracy of 95%.

4.1 My Conclusions and Afterthoughts

I believe that in the given time frame I haven't done my complete approach where I have taken the help of a base model produced by Medium article. I could implement the same project with different approaches although I have tested and tried many frameworks and models and arrived at the solution used in the project. The model's accuracy could be improved and used in the real world but it takes huge computational power and resources to use in the real world.

I want to express my gratitude for the well-planned and methodical way you approached these subjects throughout this brief semester. By increasing grasp of machine learning and its application is due in large part to the laboratories and instruction. I'm grateful.

5. Conclusion and Future Work

The deployed deep learning is performing very well and accurate in detecting the pneumothorax and hoping it will assist doctors and radiologists in decision making.

Given the time I couldn't able to produce a optimal result in this project but the end solution is able to detect with good accuracy. Because I am naïve to the concepts of deep learning it made the task to model the models. I have gained a lot of knowledge about convolutional neural networks during the project's construction, including how to use convolutions, max pooling, activation functions, and cost functions. I'm pleased that the Convolutional Neural Network I was able to build for image processing produced some good outcomes.

Even though our proposed model is well on the data, an application of healthcare is more complex to implement in the real world. Better models which are sophisticated can be used to detect Diseases.

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