Ai Based Computer Aided Diagnosis With Chest X-Rays Using Convolutional Neural Networks (CNN)

Karan Mahesh[1], Humaira Begum[2], Kalaiarasan K[3], Dhanasekar J[4]
[1, 3, 4]Dept of Computer Science & Engineering
[2]Assistant Professor, Dept of Computer Science & Engineering
[1, 2, 3, 4] KCG College of Technology Chennai, India.

Abstract- *Chest diseases are very serious health problems in the life of people. Some of the commonly occurring diseases are Pneumonia, Cardiomegaly, Mass and Hernia. A chest X-ray is an easy, quick, and effective test that has been used by doctors for quite a long time. To help the Radiologists with the diagnosis of these diseases, an AI based model can be created to classify the input X-Ray images into one of the above mentioned diseases. Such a model can be created with Neural networks. The dataset for this project is taken from the National Institutes of Health (NIH) website. The proposed system makes use of a Convolutional Neural Network. The CNN is trained by passing to it the dataset. Adam optimization technique has been used to train the model. The trained model is then saved and used to classify user inputs. The system prompts the user to input a chest X-ray. The trained neural network model classifies the input X-ray into one of the 5 classes: Hernia, Cardiomegaly, Mass, Pneumonia and Others. The average accuracy achieved for the 5 classes is 89%.*

Keywords- Chest X-rays, Convolutional Neural Network, Adam optimization

I. INTRODUCTION

Chest X-Ray images are the best known way for the diagnosis of the chest diseases mentioned above and observing the chest x-ray is a tedious task as it can consume time and requires patience and experience from the radiologist side.A major health sector issue in India is lack of Diagnosis support systems and doctors to serve large number of patients in Rural areas. Rural Areas lack Radiologists and Hundreds of cases are handled by a single doctor. This causes unnecessary delay and the patients are forced to wait for a longer duration of time.One other problem that the doctor faces is that the diagnosis of diseases from Chest X-Rays can be subjective for some reasons such as the appearance of disease which can be unclear in chest X-ray images or can be confused with other diseases. In some cases, diseases can be wrongly identified due to this confusion. Therefore, there is a need for a computerized system to help assisting the radiologist in examining the x-ray images. Recent developments in the deep learning field, especially convolutional neural networks(CNNs) showed great success in image classification. The main idea behind CNN is creating an artificial model like a human brain visual cortex. The main advantage of CNN, it has the capability to extract more significant features from the entire image rather than hand-crafted features. Researchers developed different CNN based deep networks and these networks achieved state of results in classification, segmentation, object detection and localization in computer vision. Besides the natural computer vision problems, CNNs achieved very successful results in solving medical problems such as breast cancer detection, brain tumor segmentation, Alzheimer disease diagnosing, skin lesion classification etc.

II. RESEARCH AND COLLECT DATA

Jie Chen, Olli Silvén and MattiPietikäinen [1] developed a model for the diagnosis of Chest X-rays in 2016. The model created could only classify the given input image into ‘Healthy’ or ‘Unhealthy’ classes. The model aims at saving the time of the doctors as most of the X-rays usually come from Healthy people. Hence the doctors would only have to spend time to diagnose the X-rays that are classified as Unhealthy.The dataset for the model had been enhanced using Scale Space Theory (SST), meaning the more images had been included by flipping, cropping, rotating the original images. These augmented images have been used in CNN model training and fine tuning.Another challenge faced during the handling of the dataset is that many images varied in illumination, poses and scales. These variations had then been rectified using image alignment techniques. Finally, the Model was fine-tuned by initially training the CNN and then further adding more images and retraining it.

Another Deep learning model related to chest x-rays was provided by EnesAyan, Halil Murat Unver [2] in 2019. The focus of this model was to detect Pneumonia in the given X-ray. Pneumonia is a commonly occurring disease in the lungs due to bacterial infection. Over 1 million people in the US are hospitalized with Pneumonia and over 50,000 of these people die. Early diagnosis is important for successful treatment. The diagnoses can be subjective for a various reasons like unclear x-ray images or can be confused with other diseases. Hence the authors felt the need for a computer aided diagnosis system to assist the Clinicians. EnesAyan, Halil Murat Unver [2] made use of two well known convolutional neural network models, The Xception and VGG16. The VGG16 model was better than the Xception having 87% and 82% as their respective accuracies. However, VGG16 was not as good as the Xception model in detecting the Pneumonia cases. Hence the learning from this is that every model has its own strengths on the same dataset. Even this model augments the dataset. This helps in reducing the overfitting and improves accuracy. Images from the original dataset were taken and were flipped, rotated, zoomed and shifted to form new images.The challenge here is that two models had to be trained separately (Xception and VGG16). The authors suggest that a single model can be created in the future by combining the strengths of the Xception and the VGG16 with the aim to achieve more successful results on diagnosing of Pneumonia from chest x-rays.

The third model taken into consideration was developed by Mei Han, Yu-Xing Tang and You-Bao Tang [3] in 2019. This model performs the same task as the model developed by Jie Chen, Olli Silvén and MattiPietikäinen [1]. It takes in an X-ray as input and gives the probability that the x-ray is normal. The model follows a different approach compared to the earlier models discussed above. The previous models gave as two values as output, each corresponding to the probability of the image belonging to the respective classes. This model only gives out one value. Such a neural network is called one class classifier.The model was trained only with normal images. The Adam's optimization algorithm was used for training the model.

III. STUDIES AND FINDINGS

To help the Radiologists with the diagnosis of these diseases, an AI based model can be created to classify the input X-Ray images into one of the five classes. Deep learning models are capable of learning highly complex functions. In some cases even the expert radiologists might miss out on the finer details in the X-Rays. In such cases a Deep Learning model could perform superiorly. The dataset for this project is taken from the National Institutes of Health (NIH) website. The dataset consists of 5561 frontal Chest X-Ray images. Each image has a resolution of 1024*1024*1 which is reduced to 400x400 before the training process. There are 1451 images for the normal class,1000 images for pneumonia, 2000 for mass, 111 for hernia and 1000 for cardiomegaly. 90% of this data is split as the training set. This is the data that is actually fed to the network so that can learn patterns and then apply and look for those patterns in future data to make accurate predictions. The remaining 10% of the images from the dataset are considered as the validation set. The validation set is used to test the performance of the networks. The performance of this model is estimated based on the accuracy achieved .Fig 1 shows the x-ray image samples from the dataset.

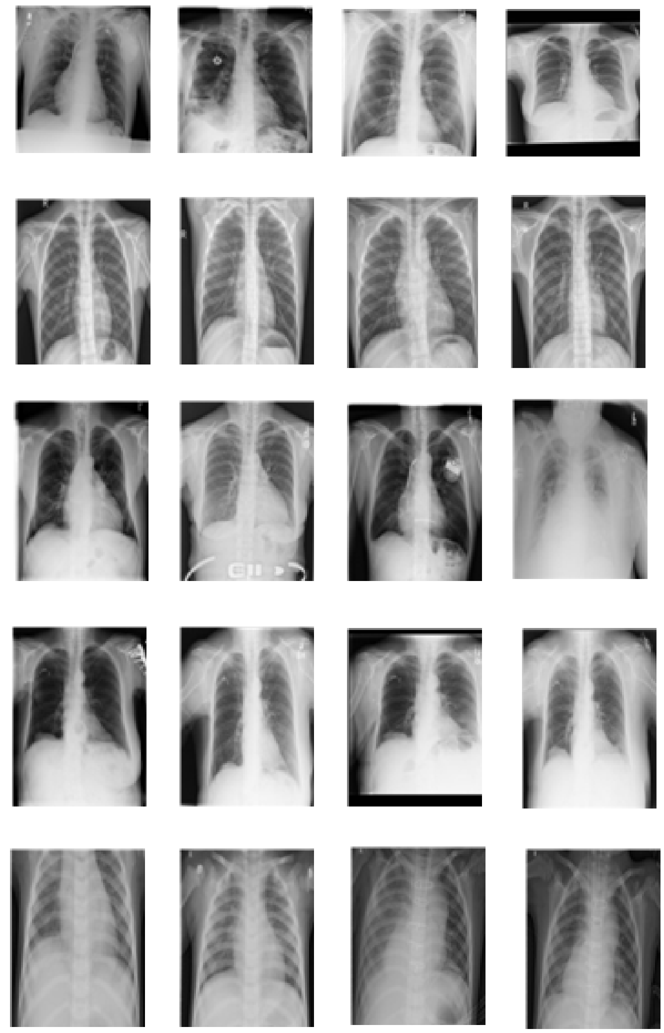

Figure 1.1 Sample Chest X-Ray. The first row corresponds to Normal X-Rays, the 2nd row corresponds to Pneumonia, the 3rd row corresponds to mass, the 4th row corresponds to cardiomegaly and the 5th row corresponds to Hernia.

A.Dataset Handling and Pre-Processing

The images from the dataset are read one after the other using the imread function from the opencv library in Python. The output from imread is added to a larger matix. The matrix that holds the images is then saved in the pickle format. This file is then loaded and used while training the CNN. Similarly, another matrix is created to hold the labels for all the images.

B. Convolutional Neural Network

Convolutional Neural Networks are based on the idea that it is sufficient to have a local understanding of the image and it is not necessary that every pixel be connected to every other pixel like in the case of Fully Connected Networks. As a result, the number of parameters in CNN are lesser and do not depend on the dimensions of the input. Fully Connected Networks usually have an error percentage of 8-12% while on the other hand Convolutional neural networks only have an error percentage of 3-5%.

In this study, we have used a model which has 10 convolutional layers with small receptive fields (3x3), 5 max-pool layers (2x2 size) and three fully connected layers, with the final layer has a soft-max activation function. Fig 2 shows our network architecture. In this model we have used ReLu(Rectified Linear Unit) activation function in the convolutional layers to increase the training speed without any change in the accuracy compared to the nonlinear functions such as sigmoid,tanh. It also helps to alleviate the vanishing gradient problem, which is the issue where the lower layers of the network train very slowly because the gradient decreases exponentially through the layers. The ReLu layer applies the function f(x)=max(0,x) to all the values in the input volume, thus changing the negative values to 0.

C. Adam Optimization

The Adaptive Moment Estimation or Adam optimization algorithm is one of those algorithms that work well across a wide range of deep learning architectures. It is recommended by many well-known neural network algorithm experts. The Adam optimization algorithm is a combination of gradient descent with momentum and RMS prop algorithms.First, it calculates an exponentially weighted average of past gradients, and stores it in variables VdW&Vdb(before bias correction) and VdWcorrected&Vdbcorrected (with bias correction).Then it calculates an exponentially weighted average of the squares of the past gradients, and stores it in variables SdW&Sdb (before bias correction) and SdWcorrected&Sdbcorrected (with bias correction).Finally updates parameters in a direction based on combining information from “1” and “2”.

Steps to implement:

Initialize VdW, SdW, Vdb and Sdb to zero.
On iteration T, compute the derivatives dw&db using current mini-batch.
Update VdW and Vdb like momentum.
VdW = ß1 x VdW + (1- ß1) x dW
Vdb = ß1 x Vdb + (1 – ß1) x db.
Update SdW and Sdb like Rmsprop.
SdW = ß2 x SdW + (1- ß2) x dW2
Sdb = ß2 x Sdb + (1 – ß2) x db2.

In Adam optimization implementation, we do implement bias correction.

VdWcorrected = VdW / (1- ß1t)
Vdbcorrected = Vdb / (1- ß1t)
SdWcorrected = SdW / (1- ß2t)
Sdbcorrected = Sdb / (1 – ß2t)
Update parameters W and b.
W = W – learning rate x (VdWcorrected / sqrt(SdWcorrected+ ε))
b = b – learning rate x (Vdbcorrected / sqrt(Sdbcorrected+ ε))

In this study, the value of learning rate = 0.001, ß1 = 0.9 and ß2 = 0.999.

IV. EXPERIMENTAL RESULTS

In this section, training strategies and test results were presented. Before the training phase, all images are resized for the target network model. Because, this model accepts images at 400x400x1 dimensions. The training parameters are set as follows, epoch size is set to 20, validation split set as 0.1, batch size as 8, categorical cross entry used as loss function, learning rate set as default value (0.001). We have used dropout regularization with a dropout rate of 20% for the fully connected layers. The proposed network is implemented by using Keras deep learning framework using Python programming language on a windows operating system and Nvidia 920mx 2GB. The training takes approximately140 minutes. The trained model is saved. Predicting the output for 500 images takes approximately one minute. The disease wise accuracy is provided by Table 1.1. The accuracy is calculated by passing 100 images for a disease and finding out how many out of those 100 did the Model correctly predict. Example) On passing 100 images of Mass, the model correctly classified 85 of those 100 images as Mass.

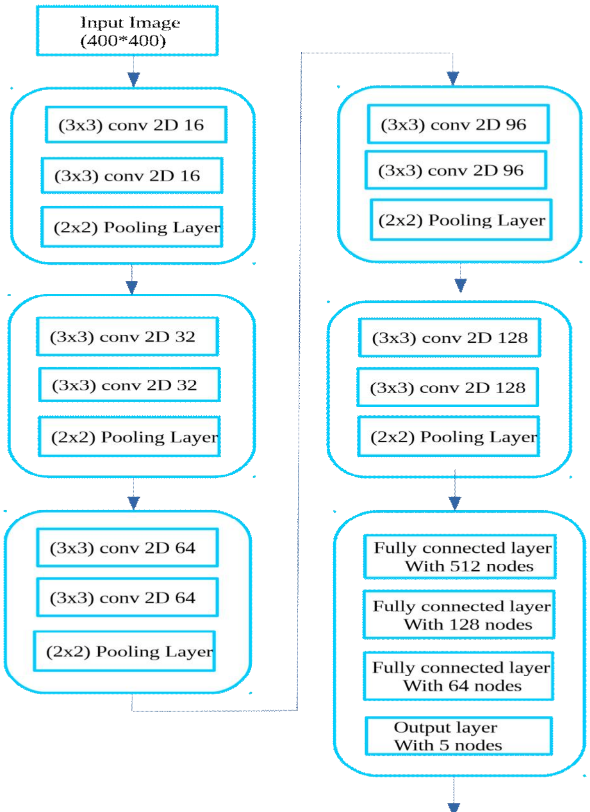

Fig 2. Architecture of the network

Table 1.1 Disease-Wise accuracy

Class	Accuracy
Pneumonia	97%
Hernia	89%
Mass	85%
Cardiomegaly	78%
No finding (None of the above)	96%

V. CONCLUSION & FUTURE WORK

Chest Diseases are a big problem in the lives of people. Chest X-Rays are the best way to identify Chest diseases. Rural areas lack radiologists and hence hundreds of cases are handled by a single doctor, also, the diagnosis of chest diseases from X-rays might be subjective and even the expert radiologists may fail to identify the minute details. Hence a Computer Aided Diagnosis system is recommended

A system has been developed using Deep Convolution Neural Network. The model takes an X-ray as input and tells the user if Hernia, Pneumonia, Mass, Cardiomegaly is present. The system aims to

- Reduce the workload of the doctor
- Provide fast and accurate results
- Reduce the chances of manual errors

Further improvements can be made to the developed model by trying to include larger dataset and retraining the model to improve the performance. It can also be extended to include some of the other diseases that pertain to the chest region.

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