Chest Abnormality Detection from X-ray using Deep Learning

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Abstract - *This paper is based on the concept of deep learning to find abnormalities in chest x-rays. Heart and lung disorders accounts more than one million deaths annually in India, which is considered as one of the most serious problem. So, it is very important to find a way out by getting more accurate and timely diagnosis of such diseases from x-rays. In this paper, we are using convolutional neural network to train the neurons which will help in finding the input x-rays as normal & abnormal images. We are using digital image processing techniques and expert radiologist advice to create a pipeline that will be applied to neural network which will result in finding a particular disease.*

*Key Words***:** Deep Learning (DL), ML, CNN, MATLAB, Chest x-ray.

1. INTRODUCTION

Chest abnormalities are recognized to be main reason behind the deaths caused worldwide. There are different types of chest diseases which can be categorized by proper analysis of X-rays. This paper covers fourteen types of chest diseases and X-ray of these diseases are considered as input. Deep learning technique has been considered to be one of the most emerging & advanced techniques in recent years in computer aided systems. This allows us to visualize the results immediately and with great accuracy. CNN is considered to be extremely effective system in image processing as it provides accurate assessment of a disease by both image acquisitions and image interpretation. Many diagnostics need an initial research process to find abnormalities manually, so computerized tools such as DL and ML are the key elements to improve diagnosis by providing identification of findings that require treatments and to support expert work. DL is rapidly proving to be the best platform to carry out the findings and get best results. The input to our algorithm will be chest X-ray images with a label of normal/abnormal. We will then use CNN to output a classification of normal/abnormal per image. Using number of hidden layers, we will achieve our findings.

Following are some key points that everyone should be well aware of before proceeding to our topic. Data science is a wide field which includes 3 main categories Artificial Intelligence, Machine Learning and Deep Learning.
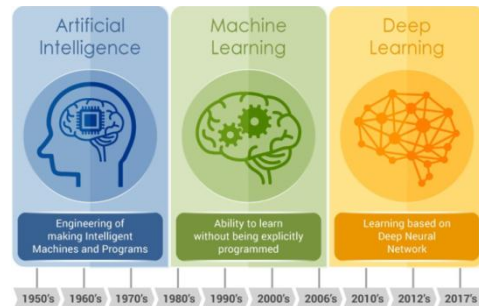

Fig-1: Classification of AI, ML, DL

1.1 Artificial Intelligence (AI)

AI is the science and engineering of making intelligent machine with the help of computer programs. It is a way of making computer to think intelligently same like human brains. AI is implemented by studying how human brain thinks, how it learns, decides and works to find a solution to a problem. AI is considered to be an important tool to carry out complex tasks. Its application includes medical diagnosis, computer search engines, voice recognition, and handwriting recognition. AI covers variety of areas such as Machine Language (ML), neural network, Deep Learning (DL). Goals of AI include reasoning, planning, learning and ability to move and manipulate objects.

1.2 Machine Learning (ML)

It is an application of AI that gives computer system with ability to automatically learn and improve from past experience without being programmed. It is based on developing an algorithm that analyses the data and make predictions, it includes range of computation where designing algorithm and programming algorithm explicit becomes difficult and unfeasible. ML is considered to be used to devise complex models and algorithms that lend themselves to prediction in commercial use and this is known as Predictive Analysis. This analysis allows researchers, data scientists, engineers to produce reliable and repeatable decisions, uncover the hidden data through learning from previous relationships and trends in data. Main applications of ML include disease diagnostics, medical image interpretation, and real time applications such as best route of UBER Rides. ML has two main widely adopted methods. Supervised learning and unsupervised

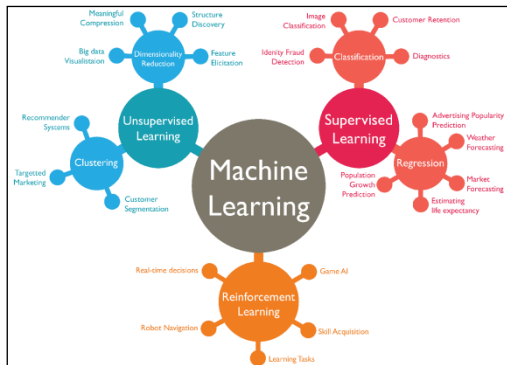learning are further classified as semi supervised and reinforcement.

Fig-1.2: Machine Learning Algorithms

- Supervised Learning algorithm has output which is to be predicted from given set of predictors (variables). Its example includes Decision Tree, Random Forest, K-Nearest Neighbors (KNN).

- Unsupervised Learning algorithms do not have output to predict. It is used against data that has no historical labels. Its examples include Apriori Algorithm, K-Means.

- Semi-supervised Learning algorithm is used for same applications like Supervised but it uses both labeled as well as unlabelled data for training.

- Reinforcement Algorithms are used for Robotics, gaming and navigation where trial and error method is used. In this, machine is trained by exposing to environment where it trains itself and uses trial and error method. Machine learns from past experience and tries to capture best knowledge to make accurate decisions. Marco decision process is an example of this algorithm.

1.3 Deep Learning (DL)

It is a study of Artificial Neural Network (ANN) and related ML algorithm that contains number of hidden layers. DL was developed from ANN and now it is prevalent field of ML. DL uses unlabelled data, and works better for large amount of data thus giving highest accuracy. DL started relatively late but developed very rapidly in research. There are lots of DL models. Typical models include Auto Encoder (AE), CNN and Recurrent Neural Network (RNN). DL uses a cascade of many layers in which each successive layer uses the output from previous layer as input. It is based on learning of multiple layers of features hence giving higher level of feature extraction. In a deep network, there are many layers between input and output made up of neurons. DL is a going trend in general data analysis and CNN algorithms

have proven to be a powerful tool for broad range of computer aided tasks. CNN automatically learns higher level abstractions from raw data (images). Among all three tools, DL is rapidly proving to be the best tool where we could get the highest level of accuracy. In this paper, by using DL concept, we have been able to diagnose the disease in most accurate manner. We have used CNN algorithm which takes chest X-ray as its input, works on it by enhancing the image and gets the desired output.

1.4 Convolutional Neural Network (CNN)

In ML, a CNN is a type of Artificial Neural Network in which neurons are connected and this pattern is inspired by animal visual cortex. The remarkable characteristics of CNN are that the network uses the local receptive field and weight sharing. With these two strategies, the numbers of training parameters are reduced and hence network becomes less complicated. A basic CNN structure consists of some convolutional layers, pooling layers and fully connected layers. The convolutional layer is for feature extraction. The neuron input of this layer is connected to local receptive fields of previous layer. The pooling layer does feature mapping and this reduces the dimension of data, so it is easy to maintain the invariance of network structure. Convolutional layer uses kernels to convolve input image as well as intermediate feature maps. Generally a pooling layer is followed by a convolutional layer which can be used for reducing the dimension of feature maps and network parameters. Average pooling and max pooling are the most commonly used strategies. Following the last pooling layer in the network, there are several fully connected layers which enables to feed forward the neural network into a vector with a pre defined length. The drawback of this layer is that it contains many parameters which results in large computational efforts for training them.
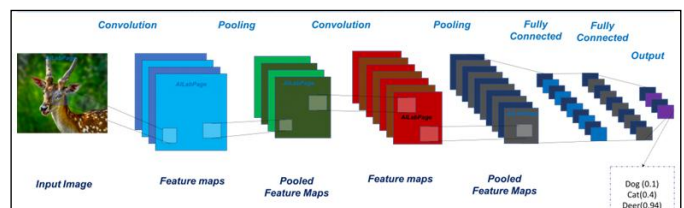

Fig-1.4: Convolutional Neural Network

CNN is most widely used by many researchers in recent years and it is considered to be an excellent model in terms of efficiency. CNN were applied for medical image processing till 1996.

The typical CNN architecture for image processing consists of convolutional filters which allow data reduction and noise elimination. These filters are applied to small portions of input image. These filters are learnt from training data.

The main power of CNN lies in DL architecture, which allows for extracting a set of features at multiple layers. To train a CNN, we need a large amount of labeled data from medical domain.

Let us study each layer of CNN in brief:

- Convolutional Layer: This layer does 2 dimensional convolution on the inputs. The dot products between weights and inputs are integrated across channels and filter weights are applied across receptive fields. The filter has same number of layers as input channels, and output volume has same depth as the number of filters. Size of a filter is selected small compared to input. The convolution layer is found to be the strength of the CNN. Convolution layers output after convolution is given to the input of the next one.

- Pooling Layer: CNN also have pooling layers, which is also called as sub sampling layers. It allows the CNN to reduce the dimensions by taking the mean or the maximum on patches of the image. It has 2 types of pooling: mean-pooling or max-pooling. Of course, we can also reduce the dimension with the convolutional layer, by taking a stride larger than 1, and without zero padding 1 and without zero padding but pooling layer makes the network less sensitive to small translations of the input images. This is another advantage of this layer.

- Fully Connected Layer: Fully connected layers in CNN are followed after several convolution and pooling layers. The output of these layers is transformed into a vector and then we add several perceptron layers. These several fully-connected layers convert the 2D feature maps into a 1D feature vector, for further feature representation. Fully-connected layers perform like a traditional neural network and it has 90% of the parameters in a CNN. It allows us to feed forward the neural network into a vector with a pre-defined length and we could either take it as a feature vector for follow-up processing or feed forward the vector into certain number categories for image classification.

2. RELATED WORK:

There have been many technical papers for the identification of problems in chest x-rays like detection of nodules in lungs, detection of PTB from chest radiograph, detection of cavities in lungs. Among these, few techniques are useful for our proposed system.

Earlier a wavelet based transform was used to decompose the chest x-rays to high and low frequency components. Then the line profiles were taken and represented by daubechies co-efficient and finally a statistical analysis was done to test whether these features can identify TB.

Later a statistical interpretation method for detecting pulmonary TB from Chest X-rays was proposed. It was done by applying a wavelet transformation on the chest x-ray and calculating twelve texture measures from wavelet coefficients, then they applied a Principle Component Analysis (PCA) on the chest x-ray and then they found that a misclassification probability by using probability ellipsoids and discriminant functions.

To classify all the pixels in the chest x-ray, we can use 4 statistical measures such as average, variance, coefficient of variation, and maximum PC value.

A Bayesian method of classification to detects TB cavities in Chest X-Rays. Then a gradient inverse coefficient of variation (GICOV) is used to detect the shape of potential cavities, a circularity measure and to describe textures.

The computer aided diagnosis for chest x-rays has been carried out from past 50 years and has achieved dynamic progress from basic prediction of lung x-ray to ML, and DL concept is emerging.

Initially, computer aided diagnosis was used for other type of diagnostic such as breast cancer localization by GoogLeNet and skin cancer classification by a network out of Stanford by Esteva et al. These networks were well designed and proved that CNN can be used in natural image classification as well as medical image classification and segmentation [1]. It was found that by using GoogLeNet, along with image augmentation and pre training on ImageNet, we can classify chest x-ray images as either frontal or lateral with 100% accuracy [2]. Also a network was created with the input image and it used five layers CNN and this was much effective that similarity based on image descriptors. Such a network could be used which will help doctors to search past cases easily and help inform their current or future diagnosis [3]. In 2016, a CNN was developed to detect specific disease in chest x-rays and diseases were labeled then they RNN to describe the content of annotated disease based on the feature of CNN and patient data [4]. They were able to achieve accuracy to the extent of 69% only. It might be because of relatively small data size of 7470 images. Recently in 2017, a successful CNN was developed to find specific disease and classify lung nodules with high accuracy [5].

Considering the above research work, it is a challenging task to develop a CNN which will provide a highest accuracy. Also, training large data set is also a challenging task. So, our work will be to first collect chest x-ray images from a radiology lab and to classify it as normal or abnormal. Later, we can label the abnormal chest x-ray image with a particular disease.

3. DATASET:

We need a database of few thousand images of chest X-ray from Radiology and these X-ray images has to be labeled as either normal or abnormal. Larger the dataset, stronger the CNN and highest is the accuracy of the system. For this project, we need a data of few unique patients. Some patients may have more than one x-ray images, so in this case we considered image as a separate patient for the purpose of training and prediction.

4. PROPOSED SYSTEM:

This project will be developed with image processing concept which included following steps:

4.1 Pre-processing:

The aim of pre-processing is to improve the image data that suppresses the unwanted distortions and enhances some image features that are used further. Pre-processing is needed because if we train a CNN, it will probably lead to bad performance. There are many sources which negatively affects the performance of CNN so, feature based methods for pre-processing can be used. Contrast variance, positional variance and angle variance are the major sources of variance. Initially we will process all images with histogram equalization to increase the contrast in an x-ray image. This will be helpful in enhancing the difference the bone and empty space in an x-ray. We will use MATLAB software for this.

4.2 Data Augmentation:

Since we are working on large data set, we need to implement data augmentation to prevent over fitting. While training the image in CNN, we need to first flip each image in different angles.

4.3 Network Architecture:

There are three basic types of algorithm in DL which includes supervised learning, unsupervised learning and reinforcement.

Out of which, our project is based on semi supervised learning in which training is done by exposing the data to environment where it trains itself and uses trial and error method. With lot of research, we finalized to form a five layer CNN network with one input layer, two convolutional layers and two sub-sampling layers.

4.4 Software used:

There are two software which are able to perform the backend operations of the system, i.e., Python 3.6.8 and MATLAB, both are able to perform machine learning algorithms for classification. For this system development, we decided to use MATLAB since it is high performance programming language, also it gives higher graphical capabilities and it is widely used for image processing applications.

5. CONCLUSION

In this paper, different ways to find abnormalities in chest X-ray are suggested. Along with this different ways of processing an image and finding the desired output is also mentioned. Amongst all the techniques, we conclude that using a well designed CNN, we can develop a system which will find a perfect diagnosis of a disease from chest x-ray. CNN helps in getting the detailed feature the image and thus finding the exact disease with highest level of accuracy. The only drawback of this system is that it becomes complicated when a data set is large in number and also becomes time consuming.

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