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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.

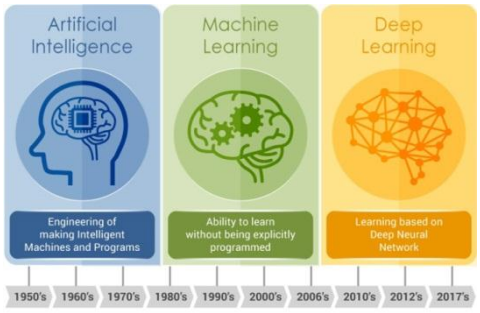


Fig-1: Classification of AI, ML, DL

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.

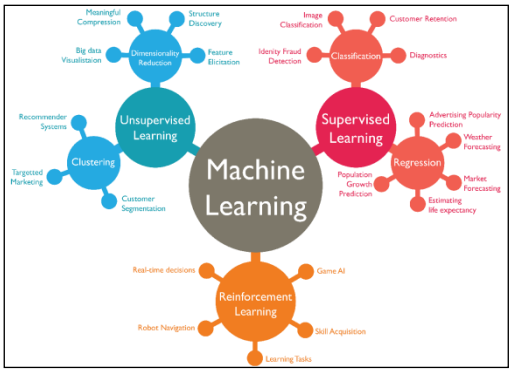


Fig-1.2: Machine Learning Algorithms

- 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.

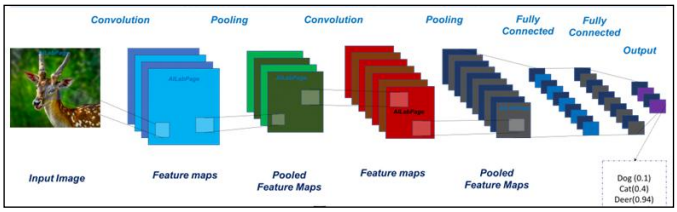


Fig-1.4: Convolutional Neural Network

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.

2. RELATED WORK:

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 gathered a database of fifty thousand images from Stanford Radiology and these X-ray images has been labeled as either normal or abnormal. Original images are of size 300u0x3000 pixels. For this project, 5000 images were used and fourteen types of diseases were labeled out of 30805 unique patients. Some patients may have more than one x-ray image, so in this case we considered image as a separate patient for the purpose of training and prediction.

4. SYSTEM DEVELOPMENT:

This project was 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 used MATLAB software for this.

4.2 Data Augmentation:

Since we are working on large data set, we implemented data augmentation to prevent over fitting. While training the image in CNN, we first flipped each image in different angles. Also, we flipped left or right.

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. Also, we used a filter for convolution.

Following specifications were used in CNN:

Table-1: CNN Specifications

Batch Size in CNN	77 Images
Number of Iterations to train an image	10 Times

Thus, we selected 77 images out of 5000 at a time and we trained each image 10 times through a CNN to get highest accuracy.

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. RESULTS:

By applying different equations in MATLAB, we could train the network to find a disease in chest x-ray and name of the disease was displayed on output window, and 'no findings' was displayed for normal x-ray. Our system gave highest accuracy with an error of 1%.

5.1 Dataset Usage:

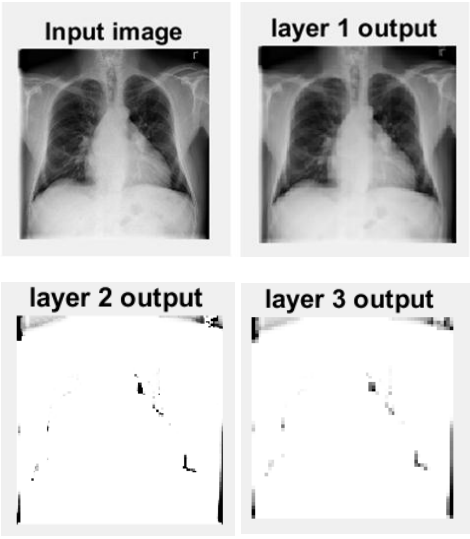
Typically, a CNN model has large data size for higher efficiency. But, practically exploring and training such large data volume would affect model performance so we chose to train a batch of 77 images. After randomizing the data, we found that as data set increased, our sysatem accuracy increased. However, more the number of iterarions, more the accuracy in image training. Thus 5000 images are sufficient to achieve our target.

5.2 Input Image:

Original image was of size 3000x3000 pixels, which is very high size for DL. So we decided to downsample the chest x-ray images to 256x256 pixels. By reducing the pixel size, it did not affect the accuracy since resolution was not that important. It might be that, increased image resolution does not provide significantly different information.

5.3 Output:

The output images of chest x-rays which are downsampled and processed are shown below. Initially the chest x-ray image is given as input to the system and layer by layer output is generated. Also, the image with its label is found and displayed on GUI.



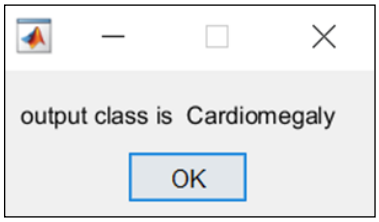


Fig-5.3: Output of the system

6. CONCLUSIONS

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.

We can make few updates and can improve the system in a number of ways.

- We can improve our project in number of ways. More detailed per-processing can be achieved which can crop lungs in details.
- More number of diseases can be included so that the system can diagnose a large number of lung diseases.
- By using different type of architecture, the system can be developed with higher level of accuracy.

Hence, we have developed a system which will provide valuable information to doctors to diagnose a disease. The project classifies normal and abnormal chest x-rays and provides primary care physicians with significant information to decrease the time for diagnosis and hence improves the current standard of care.

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