# Pneumonia Detection Using Deep Learning Algorithms

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***Abstract* - A disease that occurs in the lungs caused by a bacterial infection is pneumonia. In terms of the effective process of treatment, early diagnosis is a significant factor. The disease will usually be identified by an expert radiologist using chest X-ray images. For certain purposes, diagnosis can be subjective, such as the presence of diseases that may be unclear in chest X-ray images or may be confused with other diseases. Computer-aided diagnostic systems are therefore necessary to direct the clinicians. In this study, several research papers about automated computer-aided detection of pneumonia with help of deep learning and convolutional neural networks were reviewed and different models were compared based on their performance and accuracy along with a conclusion and future work.**

***Keywords – Deep learning, Machine learning, Convolution Neural Network.***

## I. INTRODUCTION

Pneumonia is a viral or bacterial disease found in the lungs. It primarily affects the small air sacs known as Alveoli and dry cough, chest pain, fever, and difficulty breathing are symptoms of pneumonia. To identify the disease, the patient undergoes the diagnosis test like chest X-rays (CXR), blood tests and culture of sputum to conform presence or absence of disease. The risk factors of the pneumonia include cystic fibrosis, chronic obstructive pulmonary disease (COPD), sickle cell disease, asthma, diabetes, heart failure, finally, a weak immune system. Researchers invented vaccines which prevent certain types of pneumonia disease. In general, bacterial pneumonia is treated with antibiotics. If the patient affected too hard, then he/she would undergo oxygen therapy which gives additional support to breath.

The concept of deep learning evolves from machine learning. The machine learning was first introduced by Donald Hebb on his book titled *The Organization of Behaviour*. From then, the implementation of machine learning algorithms took-place. Besides researchers had underwent numerous implementations and build steps for future through their success. Through deep learning, researchers had outputs which have various benefits in real world. There is no particular area which is dedicated for implementing this domine. At present, each and every industry adopting machine learning and deep learning technologies into their products, which turns-out user friendly. Every invention should reach common man and main motto of the researcher or scientists was the same. Particularly, in medical industry introduced deep learning products in their practises and overcame plethora of complex challenges in daily life. For treating with detection, decision, analyses, and in future scope processes, deep learning shows its output with maximum accuracy. From these technologies, diseases could be detected as fast as possible and can make better decisions.

Pneumonia is one of the diseases that would affect our breathing system and even could cause death if it is in outburst stage. For detection of this disease, the doctors would take time for identification. The output of this disease would threat entire world and grabs the entire medicine researcher's sight. The deaths, children who are under 5, because of pneumonia were outbroken around 800,000 in

2017 and this continuous for future years. Even though there were diagnosis processes for this disease, the deaths are recording at peak.

For treating pneumonia is different for children and adults because of their different symptoms. Moreover, the children are so sensitive to treat. The Antibiotics, antivirals, antifungals, analgesics, cough suppressants will be used in medication for pneumonia prevention. If it reaches to beast mode, then the patient undergoes oxygen therapy. Moreover, the patient should take self-care like taking rest, drink plenty of liquids, and do not overstrain body. To overcome from pneumonia a patient should undergo for these treatments.

The paper begins with Introduction in first section. The section2 is literature review which consists of the overview of the reference papers. Then section3 is deep learning overview; consists of basic introduction to the deep learning algorithms. Next, section4 is convolution neural network (CNN). As the review is mainly focuses on CNN, so there is particular section dedicated to it which consists of brief view of CNN and its architecture. Then section5 which is comparative study in which the comparison has done between algorithms respective with accuracies. Next, Section6 contains conclusion followed to it there are section7 and section8 which describes future work and references.

## II. LITERATURE REVIEW

P. K. Pawłowski et al. [1] In this paper, the work was done by Convolutional Neural Network (CNN), which is the deep learning method and tries extract each and every feature init. The dataset used was from Kaggle, online open-source platform to machine learning. Here, the data are in the form X-ray image of pneumonia lungs. They have implemented this training phase on four CNN models and these models were differentiated by dropout layers which are introduced in between them. While in training phase, pooling, forward and backward propagation methods were used in models. In this work, they had obtained better results. In model1 the accuracy was 89.74% followed by model2 with accuracy of 85.26%. Next model3 achieves an accuracy of 92.31% and finally the model4 obtained accuracy of 91.67%. Here, in model3 and model4 the dropout layers were introduced.

Amit Kumar Jaiswal et al. [2] shows research work on implementation of Mask-RCNN, a deep neural network. In this research data was taken from GitHub, which is the online platform of data collection, and type of data is Chest X-rays (CXRs) images. The unique feature of this work was to introduce a neural network which differentiate the global and local extracted features. While implementation had done on two algorithms, which are, ResNet50 and ResNet101. In addition, they had implemented data augmentation technique to acquire better accuracy. They carried out with training and got 30% by ResNet50 and 97% through ResNet101. Besides, they tried to create an ensembled model, combination of above two models, and got accuracy of 21.8%.

D.H. Kim et al. [3] this area of work refers to the bone fracture. The model which had used was deep convolution neural network and involves the transfer learning methodology. The name of model was Inception v3 and was trained on the bone fracture data. The dataset was in form of radiographs and these were split in to 80:10:10, i.e., Training data, Validation data, Testing data. The data, which are radiographs, had undergone through some data pre-processing. The accuracy they obtained through this model was 95.4%. The accuracy does consist of conditions. They took the accuracy value when the sensitivity and specificity was maximum, i.e., 0.9 and 0.88.

Jonathan Rubin et al [4] did research on implementation of Dual Convolutional Neural Networks. The Dual Net Architecture copies routine clinical practice by at the same time preparing both frontal and horizontal (lateral) CXR pictures acquired from a radiological test. In this model the required dataset was MIMIC-CXR dataset is the biggest delivered chest x-beam, which was taken from Kaggle. They train profound convolutional neural networks to perceive different basic chest dis-facilitates on the so far biggest assortment of chest radiographs – the MIMIC-CXR dataset. And then they depict and assess CNN models for preparing frontal, just as parallel chest x-beams, which have gotten less consideration from past examination endeavours. Besides, they create different models for anteroposterior (AP) and poster anterior (PA) frontal view types. Finally, the DualNet design acknowledges a couple of frontals (PA or AP) and horizontal information pictures. Two convolutional neural networks are prepared in equal for each information also, their yields are linked together before a last completely associated layer makes a multi-label expectation. They carried out the accuracies are 62.5% using Dual Net PA + Lateral and 59.3% by using Dual Net AP+Lateral.

Taufik Rahmat et al [5] shows research work on implementation of Faster R-CNN. This model is all about the headway of CNN dependent on Regional paradigm to handle the object detection and classification. They start with a model called Regional-CNN (R-CNN) (Girshick, Donahue, Darrell, and Malik, 2014) followed with Fast R-CNN (Girshick, 2015) and Faster R-CNN (Ren, He, Girshick, and Sun, 2017). Regional paradigm means to improve the exactness of object detection, while Fast and Faster focuses to improve the presentation of the whole models. A couple of works have been done that applied R-CNN and Faster R-CNN in medical area. The required dataset MIMIC-CXR dataset was taken from Kaggle. From R-CNN model, they observe that this model is facing problems like slow performance. So, Fast R-CNN was proposed to overcome the above-mentioned challenges. The method is improved by adding two key features like amalgamate all models into one model (consists of feature extraction, classification, and

detection) and the need of running CNN per region is reduced to only once per image. These CNN characters are shared among all regions at a layer called Region of Interest (ROI) pooling layer. The term 'faster' represents the development of Fast R-CNN that is faster in producing the results. Faster R-CNN to address the performance issue by establishing Region proposal Network (RPN) layer and eliminate the current region proposal inception at early stage. The acquired accuracy was 62%by using the Faster R-CNN.

Rachna Jain et al. [6] shows research work on implementation of CNN and Transfer Learning. In this research data was taken from Kaggle, which is the online platform of data collection, and type of data is Chest X-rays (CXRs) images. The unique feature of this work was to introduce a neural network which differentiate the global and local extracted features. While implementation had done on four algorithms, which are, VGG16, VGG19, ResNet50 and InceptionV3. In addition, they had implemented data augmentation technique, dropout was employed to reduce overfit to acquire better accuracy. Training was carried out and got 87.28% by VGG16, 88.46% by VGG19, 77.56% by ResNet50 and 70.99% through InceptionV3.

Pranav Rajpurkar et al. [7] shows research work on implementation of algorithm using ChexNet, a 121-layer convolutional neural network consists of DenseNets which classifies 14 different diseases. In this research data was taken from GitHub which consists of over 100,000 frontal view X-ray images with 14 diseases. In this research a comparison was done among four practicing academic radiologists with the performance of ChexNet. Training was carried out and got 76.8% on detection of pneumonia, 80.94% on detection of Atelectasis, 92.48% on detection of Cardiomegaly, 86.38% on detection of Effusion, 73.45% on detection of Infiltration, 86.76% on detection of Mass, 78.02 on detection of Nodule, 88.87% on detection of Pneumothorax, 79.01% on detection of Consolidation, 88.78 on detection of Edema, 93.71% on detection of Emphysema, 80.47% on detection of Fibrosis, 80.62% on detection of Pleural Thickening and 91.64% on detection of Hemia. In addition to this ChexNet achieved state of art results on all 14 pathology classes and also had a margin of >0.5 AUROC over previous state of art results.

Petros-Pavlos Ypsilanti's et al. [8] shows research work on implementation of stochastic attention-based model that is capable of learning what regions within a chest X-ray scan should be visually explored in order to conclude that scan contains a specific radiological abnormality. A Recurrent Attention Model (RAM) was implemented which consists of Glimpse Layer, Encoder and Core RAM. The classification performance of the RAM model alongside with the performance of state-of-the-art convolutional neural networks trained and tested on the same dataset. RAM, using 5 million parameters, reaches 90.6% and 91.0% accuracy for the detection of medical devices and enlarged hearts, respectively.

Arpan Mangal's et al. [9] had their research on some of the COVID detection using the chest x-rays through the deep learning algorithms. In this work, they created a model with convolution layer and named as CovidNet which helps to detect the COVID-19 disease. As they mentioned that the RT-PCR test would take too long time for final results and also highlighted about the time efficiency of their model during detection. The data used for training model was chest X-rays. They claimed that their model works with efficiency of 90.5% with 100% sensitivity.

A Fourcade's et al. [10] shows research work on deep learning in medical image analysis and gave the deliberate audit of the distributions utilizing CNN innovation for clinical picture examination, accessible in the National Library of Medicine data base (PubMed) and inspected 352 articles in the PubMed data set and avoided 327 things for which execution was not evaluated (survey articles) or for which undertakings other than discovery or order, like division, were surveyed. The 25 included papers were distributed from 2013 to 2019 and were identified with a huge range of medical specialties. A lot of qualitative medical images were important to train the CNNs, often resulting from international collaboration. The most widely recognized CNNs like AlexNet and GoogleNet, intended for the analysis of natural images, demonstrated their relevance to medical images.

Paras Lakhani et al. [11] shows research work on Automated Classification of Pulmonary Tuberculosis by using Convolutional Neural Networks. The best-performing classifier had an AUC of 0.99, which was a gathering of the AlexNet and GoogleNet DCNNs. The AUCs of the pretrained models were more prominent than that of the undeveloped models (P<.001). Expanding the dataset further expanded exactness (P esteems for AlexNet and GoogleNet were .03 and .02, individually). The DCNNs had difference in 13 of the 150 experiments, which were aimlessly looked into by a cardiothoracic radiologist, who accurately deciphered each of the 13 cases (100%). This radiologist-expanded methodology brought about an affectability of 97.3% and particularity 100%. Deep learning with DCNNs can precisely characterize TB at chest radiography with an AUC of 0.99. A radiologist-increased methodology for situations where there was contradiction among the classifiers further improved accuracy.

## III. DEEP EARNING OVERVIEW

Machine learning and Deep learning refers same. In machine learning the features form data should be explicitly given by user but in deep learning the algorithm itself took the main features in the data. In other words, the machine learning has lower computational power compared to the deep learning.

There are some deep learning algorithms which had already made to solve the complex problem. Some deep learning algorithms are feed-forward neural network, convolutional neural network, recurrent neural network, long short-term memory networks, auto encoders, and etc. In all algorithms, there are three types of layers: input layer, hidden layer, output layer. The major computational part will be done in hidden layer. Before knowing deep learning algorithms, one should know about the perceptron, basic cell or neuron, in machine learning.

- *Perceptron*- It the basic part of the machine learning or deep learning algorithms in which the manipulation of data as well as the classification will takes place. There are four main parts in perceptron: input layer, summation function, activation layer, output layer. The architecture of perceptron is shown in figure1 which is below.

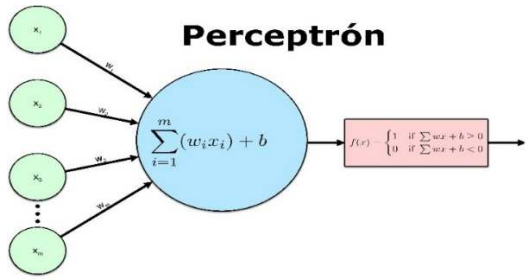



**Figure 1** – Perceptron [25] Architecture

Here the formulas for summation:

Summation: - $x_1w_1+x_2w_2+\ldots\ldots+x_nw_n$ ---- (1)

- *Feed Forward Neural Network (FFN)* - Feed forward neural is a network in which the data flow during manipulation should be in one direction, i.e., from input to output layer. In feed forward, the concept of back-propagation was absent, means, there is no learning of knowledge from previous task. This network falls under supervised learning. The basic architecture of the feed forward neural network was show in figure2.

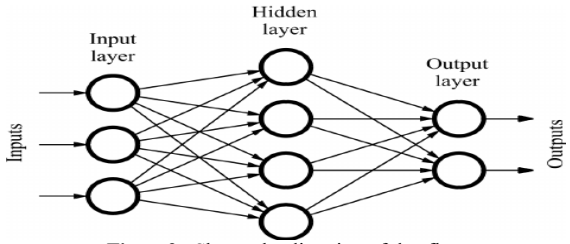



**Figure2**– Shows the direction of dataflow

- *Convolution Neural Network* – Here the actual use of deep learning comes here with convolution networks. The applications like image recognition, document analysing, understanding climate come under convolution networks. Here, convolution neural network the extraction of main features, like edge detection, will be automatically takes place. For running these deep learning algorithms, we should have more computational power for boosting in time.

- *Recurrent Neural Network* – Here the neural recurrent neural network does works like feed forward neural network. But the only difference is in RNN the data flow was in loop. In RNN, the concept of memory was introduced to remember the values through the instance, which is used in time series prediction and it is a key advantage over all of deep learning algorithms.

- *Auto Encoders* – The auto encoders are one of the algorithms in deep learning which is used to minimize the dimension of the data, or in other words dimensionality reduction.

There are several applications like image compression, image denoising, feature extracting, image generation. There are several types of the auto encoders. The basic one-layer auto-encoder is called vanilla auto encoder. The architecture of the auto encoder is shown in figure.

Encoder – In the encoder, decrease in the data dimension takes place.

Decoder – In the decoder, it tries to visualize the compressed data.

Bottleneck – The Bottleneck contains the least dimension representation of the data.

Here, the bottleneck plays the crucial role in the auto encoders. Because it consists of lower dimension data and in also known as Latent Space. In six types of basic auto encoders: under complete, Sparse, denoising, contractive, stacked, deep auto encoders.

## IV. CNN-First Step Of Deep Learning

The deep learning had its first breath or became popular by using convolution neural network. In the CNN, it has the ability of detecting the features automatically. In the convolution neural networks, there are several neurons in the hidden layers. The positive side of the CNN is computation, but the laptops or computers should have high graphical processing unit. In the convolutional networks, the convolution layers play crucial role for data manipulation. In the CNN, there are some terms like activation function, padding, pooling layer, dropout layer, and fully connected layer.

The activation function play has its unique role in decision making during data manipulation. There are several activation functions in convolution neural network. The most common and popular function is Rectified Linear Unit (ReLU). Because, it has its own path while dealing with negative values during computation. The most used

activation function at the output layer is Softmax, which deals with cumulative probability. It works like, the output with most cumulative probability value is considered.

We can say that the dimension reduction takes place from the padding. Here the padding is the process to create data groups in which the pooling applies.

Pooling layer helps in the dimension reduction. There is no loss in the features by extracting form data. There are two types of pooling in convolution layers: max pooling, Average or mean pooling. In max pooling, the highest value will be taken from group of selected data. As similar, in mean pooling the mean of all data which will be taken from selected data. These two pooling types plays a significance role in gather features from data.

Dropout layer can make the perceptron idle in hidden layer. As in convolution layers, we basically do manipulations thousands in number which may be enrouted to over-training. So, dropout layer prevents this glitch and can used to reduce overfitting in model while training the data.

Fully Connected layer, in general, the two-dimensional data is used during training in convolution layers. But the problem is these algorithms like feed forward, recurrent neural network or any algorithms does not support the multi-dimensional data while training or testing. But, the fully connected layer helps in converting the mutli-dimension data to the single dimension data, which is used to train model.

Padding layer, We can say that the dimension reduction takes place from the padding. Here the padding is the process to create data groups in which the pooling applies.

The below figure3 shows the basic CNN architecture: -

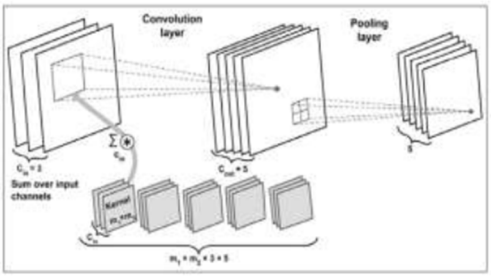
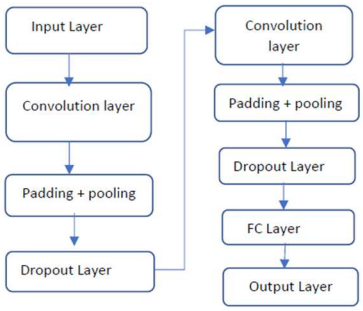



**Figure 3** – Overview of the convolution layers

The below flowchart1 is flow of the Convolution Neural Network: -




**Flowchart 1** – Flowchart of Convolution Neural Network

## V. COMPARATIVE STUDY

From the literature review, the table was created to differentiate the models along with their accuracies and dataset taken. The dataset consists of the chest X-rays when patient infected with disease and radiographs which is used to detect bone fractures. These datasets were trained on several different models which include transfer learning models. The models Vgg16, Vgg19, ResNet50, Inception, Modified CNN, ChexNet, R-CNN, CNN, Mask-RCNN, Transfer Learning (CNN), Dual Net architecture were used in comparative table. Here, from table1 the highest accuracy was obtained by the model Mask- RCNN and used for the detection of the pneumonia using x-rays as their data.

**Table 1** – Comparison Between the various models along with their respective accuracies

| REFERENCE PAPER | DATASET | DATA TYPE | MODEL | ACCURACY |
|---|---|---|---|---|
| [1] | Chest X-rays | X-rays | CNN | 92.31% |
| [2] | Chest X-rays | X-rays | Mask-RCNN | 97% |
| [3] | Wrist Images | Radiographs | Transfer Learning (CNN) | 95.4% |
| [4] | MIMIC-CXR | X-beams | Dual Net | 62.5% |
| [4] | MIMIC-CXR | X-beams | Without Dual Net | 59.6% |
| [5] | MIMIC-CXR | X-rays | R-CNN | 62% |
| [6] | Chest X-rays | X-rays | Vgg16 | 87.28% |
| [6] | Chest X-rays | X-rays | Vgg19 | 88.46% |
| [6] | Chest X-rays | X-rays | ResNet50 | 77.56% |
| [6] | Chest X-rays | X-rays | Inception V3 | 70.99% |
| [6] | Chest X-rays | X-rays | Modified CNN | 92.31% |
| [7] | Chest X-ray 14 | X-rays | ChexNet | 63.3% |

| | | | | |
|---|---|---|---|---|
| [8] | Chest X-ray | X-rays | Recurrent Attention Model | 91.0% |
| [9] | Chest X-ray | X-rays | CovidNet | 90.5% |
| [11] | Radiographic Reports | X-rays | AlexNet-TA | 93.3% |
| [11] | Radiographic Reports | X-rays | GoogleNet-TA | 95.3% |
| [11] | Radiographic Reports | X-rays | AlexNet-TA + GoogleNet-TA (Ensembled) | 96.5% |

## VI. CONCLUSION AND FUTURE WORK

The main motto of this paper is to visualize the different convolution neural network frameworks and their respective performances towards the disease: pneumonia. More than couple of techniques, Vgg16, Vgg19, ResNet50, Inception, Modified CNN, ChexNet, R-CNN, CNN, Mask-RCNN, Transfer Learning (CNN), Dual Net architecture, were discussed in this paper including some transfer learning algorithms. From our work, Mask-RCNN showed better results in pneumonia detection with max accuracy. The deep learning algorithms has its benefits when comparative to machine learning algorithms. But the main problem is computational cost and is high. In each and every problem, like detection, prediction, classification, recommendation systems in medical industry adopting deep learning algorithms for better precise decisions. Moreover, the deep learning algorithms gives the results in no less than time which could be helpful to doctors in case of treatments. At present, deep learning techniques are using in radiology: radiotherapy. Google had already started its collaboration with one of the universities in England to work in radiotherapy.

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