PNUEMONIA DETECTION USING CNN'S

K.v.v.Ananthsai

Student ,B.pharmacy,
Maharajahs college of pharmacy,
Vizianagaram, Andhrapradesh, India

ABSTRACT

In today's world, image processing and machine learning have been the most trending technologies which are used in almost all applications from automation to healthcare. Machine learning (ML) is one of the core fundamentals of Artificial Intelligence (AI) which can solve real life problems. Healthcare is one of the major concerns where AI, ML, Deep Learning (DL) can solve the problems. One of the global healthcare problems is cancer. Cancer refers to a state where abnormal cells develop uncontrollably and affectively damage the healthy body tissue. Cancer often has the ability to spread throughout the body. And among all the cancers, lung cancer was the most common and deadly one. Most lung cancers are detected at a later stage. But if identified at an early stage can save lives. Pneumonia can be a sign of lung cancer and it can be detected using Chest X-ray in most of the cases. For certain applications, the machine learning models can be better or even surpass human professionals. Machine learning and Deep learning technologies play a vital role in predicting the Pneumonia before it gets worse. Hence the idea of this project is to implement a model for Detecting Pneumonia, using different DCNN Algorithms with different combinations of Activation functions and Optimizers, which plays a key role in obtaining the best DCNN model. This work proposes a sequential CNN model, which outperforms the existing standard models like VGG16 and VGG19. The proposed model achieves an accuracy of 95%, precision 93.5, recall 95, f1-score 94.5.

KeyWords – *Machine Learning, Artificial Intelligence, Lung cancer, Pneumonia,*

Deeplearning,Activationfunctions,Optimizers.

INTRODUCTION

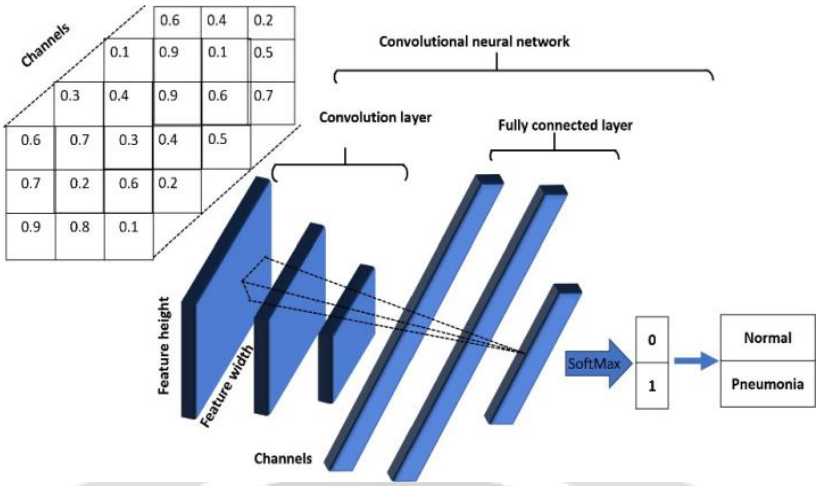
1.1 Overview

Health care is one of the major concerns and as per the records/statistics cancer is one the most common health problem which is identified in Indians. Cancer accounts for 3 million fatalities every year and is the third biggest cause of mortality worldwide and also the cause of one in every six deaths. Pneumonia can be a sign of lung cancer and it can be detected using CT scan or chest X-rays in most of the cases [5]. The symptoms of pneumonia are sore throat, headache and gastrointestinal issues with increase in severity it can lead to the symptoms like cough, fever, shortness of breath, chest pain etc and the conditions and the symptoms of pneumonia usually change rapidly, which makes the pneumonia detection complicated [1]. Pneumonia is one of the deadly diseases as it can affect the lungs severely by causing inflammation in the air sacs present inside the lungs and can lead to lung failure. These air sacs may be filled with mucus which causes prolonged cough with phlegm and exertion in breathing. Pneumonia may be because of a variety of causative agents such as bacteria, viruses and fungi [2].

1.2 Introduction to Convolutional Neural Networks

The CNN architectures are widely used for image processing & recognition, video analysis and etc. When an input image is given to a CNN, it assigns importance to various features in the image, and differentiates one from the others. The name 'convolutional' derived from the convolution operation from Mathematics, which involves the convolution of different functions. CNNs consists one input and one output layer and multiple hidden layers between them. The CNN's hidden layers typically consist of a lot of convolutional layers, which consists of

many filters with different sizes, these are responsible for the feature input



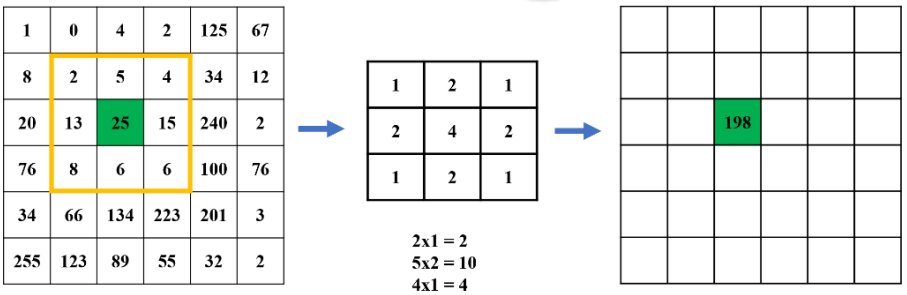
A General hierarchy of CNN layer

image and an Activation function followed by them to introduce the non-linearity [4]. The last layers i.e., the layers before the output layer are fully connected layers also called as dense layers, here every neuron is connected to all the neurons present in the next layer this supervises the wholesome findings from the convolution layers and provides a vector of N-dimension, where N stands for the total number of classes. CNNs can directly learn from the data provided, by optimizing its filters for feature extraction. In this context of pneumonia detection, it gives information on the image of the chest X-ray. The above figure provides a detailed overview of the pipelines, in particular the CNN architectures employed in this project are to have the challenging task of Pneumonia Detection.

1.3 Convolutional Operation

The convolutional layer is responsible for the convolution operation and it is the basic building block of a CNN and the major computations occur here. The convolution layer is the first layer of a convolutional neural network. It has kernel or a filter, which is responsible for feature extraction, it moves over the different areas of the image, checking if the desired feature is present. This process is called as a convolution.

A kernel or a filter is an array of 2 dimensional weights, it represents the different parts of the image. These filters are of different sizes, but the typical filter size is 3x3 matrix, this also determines the receptive field's size. Also, their number can be varied. One can specify the number of filters in each convolution layer as desired, if the model is developed by adding the convolution, pooling and other blocks. But for the standard models the number of filters and their sizes is predefined. The filter is then applied over the image and the product value is calculated between the input image pixel and the corresponding value in the filter. These product values are then summed up and fed into an output array. After that the filter shifts by a stride, repeats the same process until the kernel has passed all over the image. The final result obtained from the series of multiplication and addition from the input and the filter is known as a feature map.



2x1 = 2
5x2 = 10
4x1 = 4
13x2 = 26
25x4 = 100
15x2 = 30
8x1 = 8
6x2 = 12
6x1 = 6

2+10+4+26+100+30+8+12+6 = 198

Convolution operation

These values in the feature are known as weights and these weights in the feature identifier or feature detector will remain same as it moves over the image, this is also called as parameter sharing. Some parameters like the weights are adjusted during the training process known as backpropagation, which a very crucial step in training process of a convolutional neural network and gradient descent. However, there are three hyperparameters which will affect the volume size of the output that need to be set before training the neural network. They are,

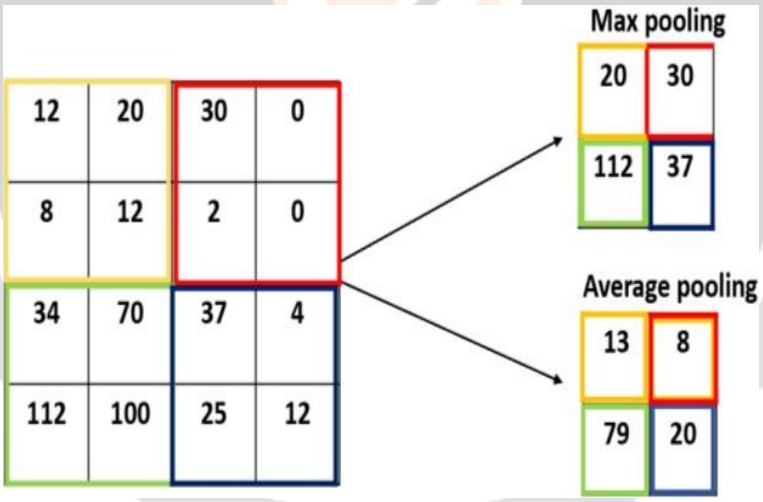
- The number of filters in each layer affects the depth of its output. For instance, if a convolution layer has 16 filters that layer will give an output containing 16 different feature maps i.e., depth of 16.
- Stride is the shift in the number of positions (pixels), that the kernel shifts accross the input matrix. Typical value of stride for convolution is 1 and its value of two or more is rare, a larger stride gives lesser values in the feature map and hence gives a smaller output.
- Zero-padding, means zeros are added to the input image to make equivalent to the size of the filter.

Finally, these convolutional layers convert the input image into significant numerical values, which allows the neural network to interpret and extract the relevant patterns.

1.4 Pooling Operation

Pooling operation is also known as the down sampling, as this operation reduces the number of values in the feature map. Likewise, the convolution operation, the pooling operation also sweeps a filter over the input image but the pooling filter does not have any weights. It is classified into Max Pooling and Average Pooling.

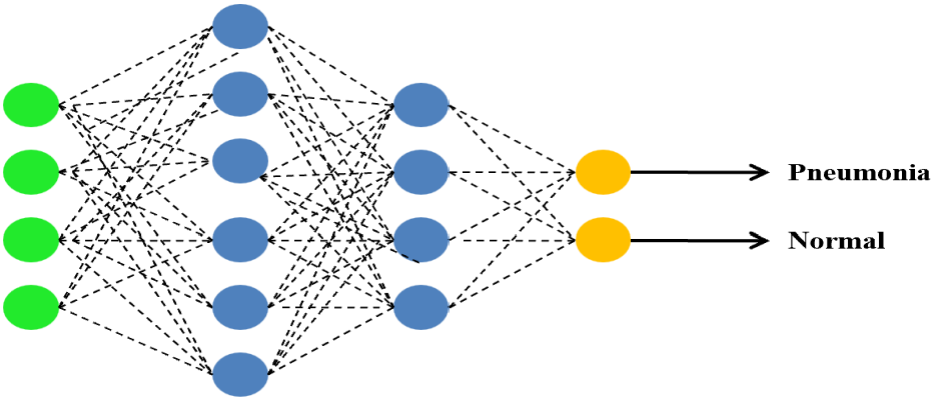
In Max Pooling operation, the maximum value in the field is considered and the remaining values are discarded. Whereas in Average Pooling operation, the average of all the values in the field is considered.



Pooling operation

1.1 Fully – Connected Layer

The name fully-connected layer justifies the name itself. Here the neuron of one layer connects to all the neurons of the next layer. In former layers, the input image's pixel values do not have direct connections to the output layer. Instead, these layers process and transform the data through intermediate connections, allowing for the extraction of more complex features. But, every node in the fully connected layers is directly connected to the

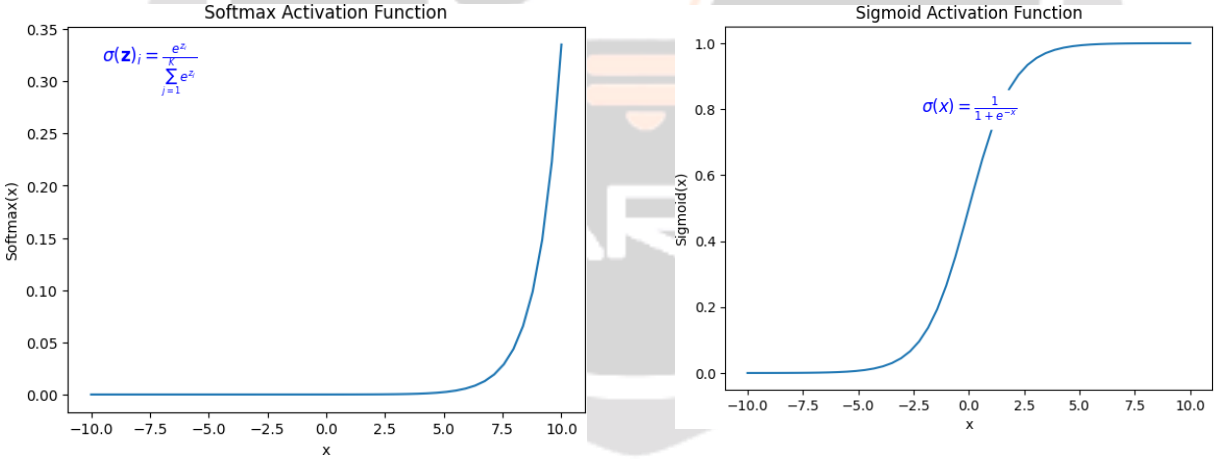


output layer. This layer is responsible for the task of classification or detection based on the features extracted.

Fully Connected layer

1.1 Activation Function & Optimizer

The main goal of the Neural Networks is to model the complex relations within the data provided. The Activation functions give the flexibility to the neural networks to capture the desired patterns and features. The activation function of each layer is the transformation applied



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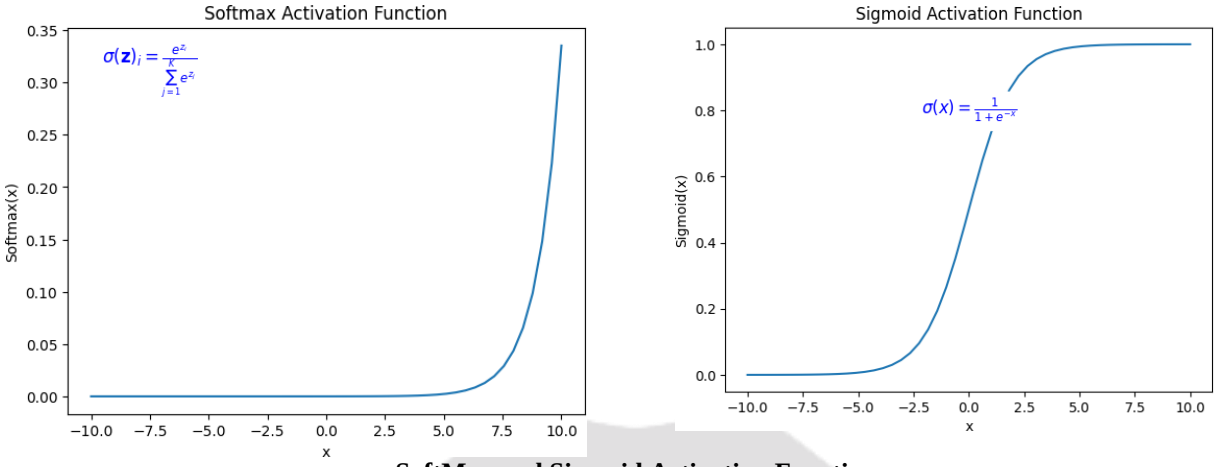


SoftMax and Sigmoid Activation Functions

LITERATURE SURVEY

Pneumonia is one among the deadly respiratory diseases induced by the pathogens bacteria, viruses, or fungi, and known to be highly prevalent and possibly fatal disease [1]. The air sacs in lungs are inflamed and may be occupied with pus and causes coughing along with fever and exertion in breathing [2]. Typically, Pneumonia is extremely hazardous in infants and the old age people also the fatal rate is more in these age groups. Every year, around 450 million people were being affected by pneumonia and over 4 million deaths were being reported [1]. Deep learning achieved enormous success in predicting many fatal diseases like pneumonia [3]. Research on Cancer has undergone numerous transformations and a significant breakthrough over last few decades [6].

Scientists have used different techniques, such as early screening in the beginning stage, in order to identify cancer types before they trigger symptoms [6]. Furthermore, they have developed novel approaches to predict Cancer at early stage. With the advancement of rapid technologies in the medical science field, significant amount of cancer data has been collected and are made available to the medical research community. A subcategory of Artificial Intelligence, Machine learning (ML) connects the problem of learning from data samples to the more general idea of inference [1]. A wide range of Machine learning techniques and feature selection algorithms have been extensively used for predicting many diseases from the past 2 decades. More than 7500 articles have been published in the area of ML and Cancer according to the recent PubMed studies.

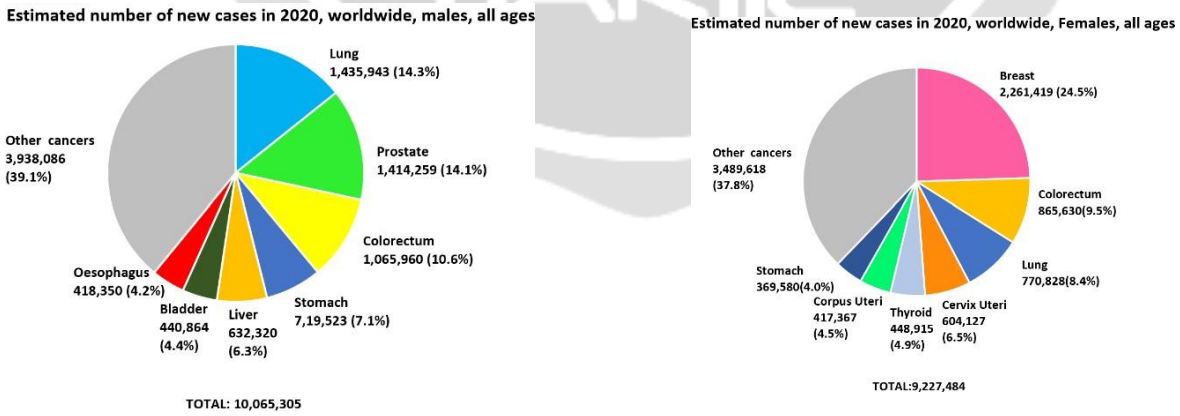


FIGURE 2.1 PIE CHART OF HEALTH CARE PROBLEM

While certain tests may take prolonged analysis and time but relaying on chest X-ray will help the doctor to estimate the condition in less time [3]. Using conventional data analysis techniques is challenging due to the complexity of the medical data. Therefore, relying on deep learning offers a great solution to extract the useful information from such complex and complicated medical data [3]. When compared to other models, the CNN models offer higher accuracy. Additionally, using DCNN yields excellent performance and efficiency [4].

Table-2.1: Literature Survey

S.No	TITLE	AUTHOR	YEAR OF PUBLICATION	JOURNAL/ CONFERENCE NAME	WORK
1	Interpretable Pneumonia Detection by Combining Deep Learning and Explainable Models with Multisource Data	Hao Ren, Aslan B. Wong	2021	IEEE Access	Have done their work on this research and proposed a multi- data interpretative approach for Pneumonia diagnosis. They have used different algorithms like SVM, Random Forest, Decision Tree and MulNet combined with chest X-ray images and medical reports. In order to help doctors in better understanding the diagnosis outcomes or medical reports, their model offers an interpretive diagnostic information. Their outcomes demonstrated that their approach outperformed the approach of relying just on reports. They got an accuracy of 79% and 86% for SVM and Random Forest respectively and 87% for both Decision Tree and MulNet.
2	Detection of Pneumonia using Chest X-Ray Images and Convolutiona	Trisha Nag, Saurabh Singh Rajawat	2021	International Conference on Reliability, Infocom Technologies	have outlined the method used for utilizing the machine learning algorithms to analyze the data for predicting Pneumonia. They used the Chest X-Ray images in JPEG format.

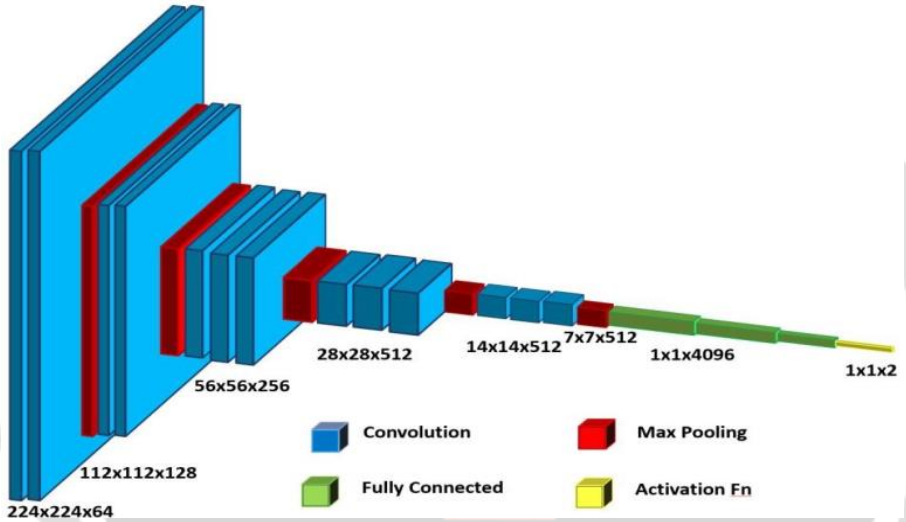
Standard & Proposed Architectures

3.1 VGG-16:

One of the best computer vision models to date is VGG16 (Visual Geometry Group), it is a type of CNN (Convolutional Neural Network). It incorporates five convolutional blocks, conv1, conv2, conv3, conv4, conv5 having convolution layers 2, 2, 3, 3, 3 respectively. These layers have 3x3 filter with stride 1 and always uses the same padding i.e. no zeroes are appended. And the number of filters in each convolution block are 64, 128, 256, 512 and 512 respectively. And five max pooling layers after every convolution block. This max pooling layer uses 2x2 filter of stride

2. Throughout the architecture, the convolution and max pooling layers are cascaded uniformly. Finally, it consists of 3 fully connected layers and followed by an activation function. The 16 in VGG16 signifies the total number of convolution layers in it along with fully connected layers. The five convolution blocks sum up to 13 convolution layers and with the 3 fully connected layers it becomes 16. The described architecture and model summary of VGG16 are shown in the following figures, fig 3.1 and fig 3.

FIGURE 3.1 VGG16-Architecture



Proposed CNN Model

The proposed CNN is a sequential CNN, where the layers can be added according the requirement and this revolutionized the performance of CNNs, as by adding different layers one can attain good accuracy and performance. Also, these custom CNN architectures are light weight compared to the existing standard architectures like VGG16, VGG19 and etc. The proposed architecture consists of 6 convolution blocks, where each block consists of 2 convolution layers within it and after each convolution block a Max pooling layer is added. Also, it consists of 4 fully connected layers and then a SoftMax activation function to give the classification output. The convolution blocks conv1, conv2, conv3, conv4, conv5 and conv6 consists kernels of size 3x3 and the number of filters in each conv block are 16, 32, 64, 128, 256, 512 respectively. This is different from those existing standard models, where the number of filters from the first convolution layer starts with 64 and doubles as it goes further, but in this proposed model the number of filters starts with quite small number and then it gradually increases. This progressive increase in the number of filters helps in attaining good accuracy and performance. And the kernel size in Max pooling layer is fixed throughout and is 2x2. The architecture and the model summary of the proposed CNN model are shown in the following figures fig 3.5 and fig 3.6.

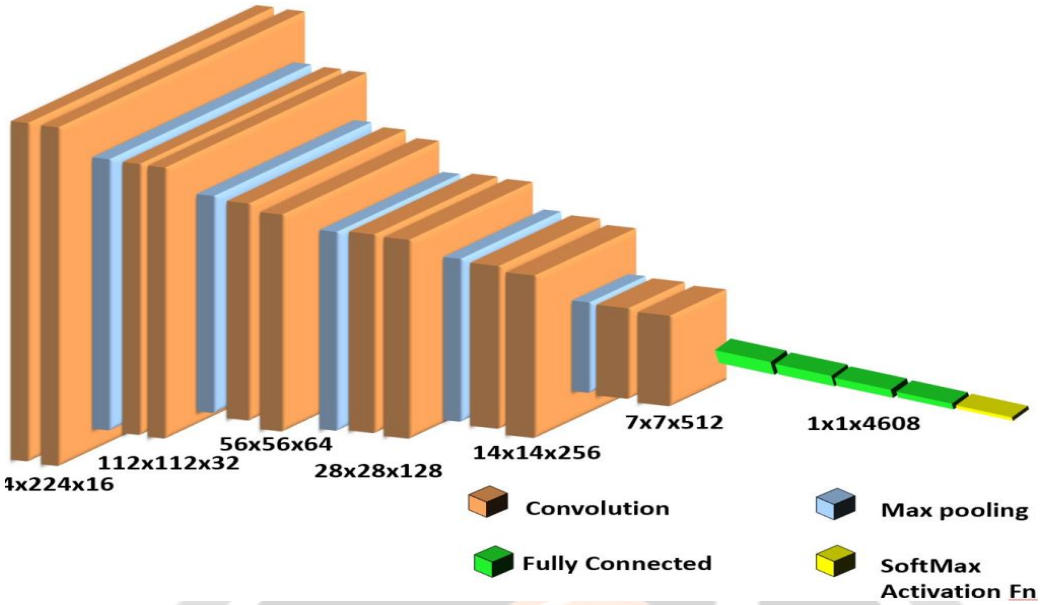


FIGURE 3.5 Proposed CNN Model Architecture

Conclusion & Future Scope

Algorithm	**Accuracy (%)**	**Research Work**
SVM	79	Hao Ren et al. [1]
CNN	85	Trisha Nag et al. [2]
Random Forest	86	Hao Ren et al. [1]
Decision Tree	87	Hao Ren et al. [1]
VGG-16 (SoftMax, RMSprop)	91.5	This Work
VGG-19 (Sigmoid, RMSprop)	91.67	This Work
CNN Model (ReLu, Adam)	95	Proposed

Table: Conclusion Table

Choosing the right activation function greatly impacts the performance of a neural

network. Tailoring activation functions to suit the characteristics of the data and the requirements of the network architecture is crucial for achieving better model performance. For instance, **VGG16** giving best performance with the combination of **SoftMax** and **RMSprop**. Whereas, **VGG19** giving best performance with the combination of **Sigmoid** and **RMSprop**. **Proposed CNN** model with **ReLu** as Activation function and **Adam** as Optimizer is observed to be the best model, as its performance is good as it is getting good performance metrices like accuracy, precision, recall, f1-score.

The classification of Pneumonia based on the cause like whether effected by Bacteria, Fungus and Virus.

- Creating Good User Interface where a user can upload the chest X-ray images and can get the output whether the person is healthy or effected byPneumonia.

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BIOGRAPHIES

K.V.V. Ananthsai is a B.Pharmacy student at the prestigious Maharaja's College of Pharmacy, India. Driven by a keen interest in artificial intelligence, I have been actively engaged in research on Convolutional Neural Network (CNN) algorithms. My dedication to this field holds promise for future advancements in the field of pharmacy and beyond.