Pneumonia Detection Using Deep Learning Methods

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ABSTRACT

A child dies of pneumonia every 39 seconds, around children dies in a year according to UNICEF, pneumonia is respiratory infection which affects the lungs, causes problem in breathing, pneumonia is detected by chest X-ray commonly, but chest X-ray of other diseases could be similar to pneumonia like lung cancer, infection etc. In order to tackle this issue, many deep learning techniques are being used in medical imaging for identifying the disease at early stages. CNN is widely using for identification and classification of diseases.In addition, features learned by pre-trained CNN models on large-scale datasets are much useful in image classification tasks, the functionality of pre-trained CNN models utilized as feature-extractors followed by different classifiers for the classification of abnormal and normal chest X-Rays. In 2019 December covid-19 diagnosed and spread whole over the world covid-19 pandemic disturbed whole world, CNN widely used for covid-19 detection using chest X-ray images datasets. In our research various deep learning models, ANN, CNN, VGG19 to detect pneumonia, and got results 94.44, 96.68, 98.27 accordingly.

Keywords: pneumonia; children; deep learning models; ANN; CNN; VGG19

INTRODUCTION

Pneumonia is respiratory infection which affects the lungs, pneumonia causes air sacs in lungs, lungs consist of small sacs called alveoli, when people breath air fills in alveoli, when a pneumonia patient breaths it fills with pus or fluid, it cause problem in breathing and its painful, pneumonia can be because of viruses, fungi, bacteria, or it environment effects on it like air pollution, sophisticated atmosphere etc.[1]A child dies of pneumonia every 39 seconds, Pneumonia kills more children than any other infectious disease, claiming the lives of over 800,000 children under five every year, or around 2,200 every day, this includes over 153,000 newborns[2]. There are types of pneumonia like infectious pneumonia and non-infectious depending on different medical research bases infectious pneumonia is classified to bacteria, virus, mycoplasmas, chlamydial pneumonia, non-infectious termed as immune-associated pneumonia, pneumonia further classified as CAP(community-acquired pneumonia), HAP(Hospital-acquired pneumonia) and VAP(ventilator-associated pneumonia) these categorized on different medical pathogenesis[3].

Large number of pneumonia cases and it's high death ratio attracted researcher and scientist towards this issue for detecting pneumonia methods, several techniques have been used for diagnosis, Radiology-based methods are useful to detect pneumonia, for pulmonary diseases chest X-ray, CT Scans and Magnetic Resonance Imaging(MRI), from these X-rays is most popular and effective, almost every hospital have X-ray facility, other two techniques CT scan and MRI options are available in big medical centers, X-ray can be used for detecting others diseases too [4].

X-ray provides similar results for different disease, than it gets difficult to recognize that patient is suffering from pneumonia or other disease like cancer, or any other infection, for this purpose the advanced techniques are need to detect more accurately and are help to cure for this at earlier time. From many years Computer Aided Designs have become hot research topic in the area of medical imaging, machine learning and deep learning have been facilitating in breast cancer detection, lung nodules detection, mammograms and in other diseases, deep learning models CNN used widely for extracting useful feature in images classification, feature extraction further improved from transfer learning methods, in this method CNN model generic features from large scale datasets.

RELATED WORKS

In the 21st century several corona viruses have disturbed the world, which had caught humans in severe pneumonia, these viruses named (MERS, SARS, and COVID-19) had digested millions of precious lives in order to overcome this problem and to know the reason, origin of these pandemics and viruses, researchers and scientists need to inspect the structure and the ways in which virus causes infection, studying and research will help to overcome with viruses and pneumonia[5]. From many years experts are busy finding the exact solution for pneumonia cure and

the techniques detect, for its testing chest X-ray, CT Scan, blood culture, fluid sample, bronchoscopy are used, Medical image analysis, process plays role to find better results, researcher are using chest X-ray images to identify, here an intelligent computational framework and ML and DL techniques to detect pneumonia, in this have used Deep Convolutional Neural Network(DCNN), transfer learning techniques VGG to find better results.

Chest X-ray is not sufficient to tell accurately about pneumonia, in this research have tried to develop an algorithm which can detect thoracic diseases, in this research they have used many existed CNN models using different classifiers for classifying abnormal and normal chest X-rays, these models extract information form images datasets and they used feature selection algorithms, for reducing the deep features they used ML classifier and ML classifier, DT, LDA and linear regression, and they got good results, to use ML algorithms provides better results. Here in this researcher developed classical deep learning network DenseNet, consisting of 121 layers of CNN models to diagnose the pneumonia, this method achieved higher F1 score, this team worked on to see the effect of imbalanced classes, they introduced Weighted Binary Cross-Entropy loss, difference between Binary Cross Entropy loss was the different weights of imbalanced classes was according to no of each class[3].

A classical deep learning network named DenseNet-121, which was a 121-layer CNN model to accelerate the diagnosis for pneumonia. In contrast to experienced doctors, the framework obtained a higher F1 score. Besides, in order to alleviate the effect of imbalanced classes, the team introduced Weighted Binary Cross-Entropy loss, whose difference between the Binary Cross Entropy loss was the different weights of imbalanced classes according to the number of each class.

Transfer learning models Alexnet and GooglNet used here to classify chest X-ray images, here they have divided datasets into training 68%, testing14.9% and validation17.1% sets, data augmentation and data processing techniques used to get better results, AUC 0.99, precision score 100 and recall score 97.33 developed AG-CNN model by Guan.

In Machine learning models for solving classification issues used to design and setting features manually, LeCun et al [6] proposed a CNN model which can extract images features from continuously stacked features extracted and results told about image belongs to which class automatically, numbers of increases in CNN, extracted features increases CNN knows difference between images better and its used back-propagation algorithm to update parameters.

METHODOLOGY
The suggested strategy approaches and its fundamental hypotheses were described in this part. The suggested approach's process is illustrated graphically in Figure 1.

In this section the procedures have been explained used to classify CXRs that have been confirmed to be positive or negative for pneumonia. The dataset used during activity has been described, as well as the technologies used to conduct the tests and analyses.

● **Dataset**
Anterior-posterior chest X-ray images were collected among retrospective cohorts of children patients aged one to five years old at Guangzhou Women and Children's Medical Center in Guangzhou [7]. All chest X-ray screening was done as part of the patients' regular medical care. To analyze chest x-ray images, every chest radiographs were first checked for quality assurance, with any scans that were poor quality or unreadable being removed.

After that, the diagnoses for the photographs were rated by two experts before being approved for use in the AI system. A third expert evaluated the evaluation set to make sure there were no grading problems. The dataset is divided into three directories (train, test, and val) with subdirectories for every image type (Pneumonia/Normal). There are 5,863 X-Ray photographs (JPEG) in total, divided into two groups (Pneumonia/Normal).

It shows the number of CXRs used in the model's training and validation in Table 1. It shows a sample difference among a normal CXR and a pneumonia positive CXR in Figure 2.
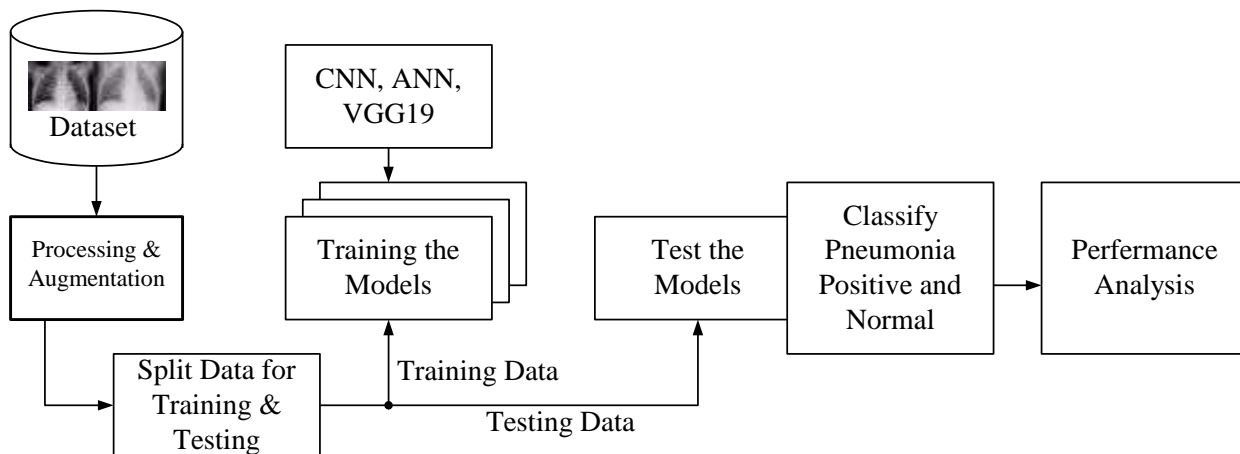

FIGURE 1: A flowchart of our proposed method

TABLE 1: Dataset layout and proportions of images taken for training, validation, and testing

	Normal	Pneumonia
Training	1341	3875
Validation	8	8
Testing	234	390
Total	1583	4273

(a)   (b)

FIGURE 2: (a) CXR of a normal individual; (b) CXR of a pneumonia positive patient.

• Processing & Augmentation

Deep learning models typically require a large quantity of data to train on in order to work properly. In the case of ANN, CNN and VGG19, tens of thousands of photos are required, which is a daunting task from a practical standpoint. Standardized of characteristics (pixel values), lightening transforms, random rotations and shifting, rotating, resizing, shearing, magnifying, and other procedures used in image augmentation effectively double the size of an entire dataset. For more variation and augmentation of training data, the training images had been dynamically resized, sheared, magnified, and rotated horizontally in this technique.

• Models

Considering of its dominance in terms of effectiveness, deep learning is all the rage these days. Major technology companies are investing heavily in DL since it has become critical in every business as a means of making machines smarter. Among many deep learning algorithms CNN and ANN are employed in this research work. Transfer learning occurs when a machine learning model is used to solve one problem and then used as a starting point to solve another problem, as the name suggests. When there isn't enough data to address a problem, transfer learning is frequently applied. So VGG19 is also used to experience the performance of transfer learning in this research work alongside of the deep learning models.

• CNN

CNN systems are feed-forward network containing convolutional, pooling, flattening, and fully connected layers that use appropriate activation functions. CNN is a deep learning strategy for analyzing information with a uniform grid, such as photos, that is influenced by the structure of animal visual cortex and meant to learn spatial hierarchies of characteristics, from low- to high-level patterns, automatically and adaptively [8]. Convolutional neural networks (CNNs) are made up of three types of layers (or building blocks): convolution, pooling, and fully connected layers. The first two layers, convolution and pooling, extract information, while the third, a fully linked layer, transfers those features into final output, such as classification. A convolution layer is an important part of CNN, which is made up of a stack of mathematical operations like convolution, which is a particular sort of linear operation.

Because a feature can appear anywhere in a digital image, pixel values are stored in a two-dimensional (2D) grid, i.e., an array of numbers, and a small grid of parameters called kernel, an optimizable feature extractor, is applied at each image position, CNNs are highly efficient for image processing. Extracted features can evolve hierarchically and progressively more complicated as one layer feeds its output into the next layer. Training is the process of adjusting parameters like kernels to reduce the discrepancy between outputs and ground truth labels using optimization algorithms like backpropagation and gradient descent, among others. In this work 3 convolutional layers, relu and softmax as activation function were used.

• ANN

The backbone of deep neural networks and the deep learning framework is Artificial Neural Networks (ANN). ANNs are powerful models utilized in a variety of domains, including regression and classification problems, as well as certain unique applications such as character recognition, audio recognition, and face recognition. The severe simplicity of human neural networks is represented by ANN models. Artificial neurons, which are computational units that are comparable to the neurons of the biological nervous system, make up an ANN. In general, the ANN model is made up of three layers: input, hidden, and output. Some signal connects each neuron in the nth layer to the neurons in the (n + 1) th layer [9]. A weight is applied to each connection. After multiplying each input by its associated weight, the output may be computed. To obtain the final ANN output, the output is passed via an activation function.

• VGG19

VGG-19 is a convolutional neural network that has been trained on over a million photos from ImageNet. The 19-layer network can classify photos into 1000 object categories, including a keyboard, mouse, pencil, and a variety of animals. As a result, the network has learned a variety of rich feature representations for a variety of images. The VGG19 model is a variation of the VGG model that has 19 layers in total (16 convolution layers, 3 Fully connected layer, 5 MaxPool layers and 1 SoftMax layer). Other VGG variations include VGG11, VGG16, and more. VGG19 has a FLOP count of 19.6 billion. The layers in the VGG19 model are as follows of Figure 3.
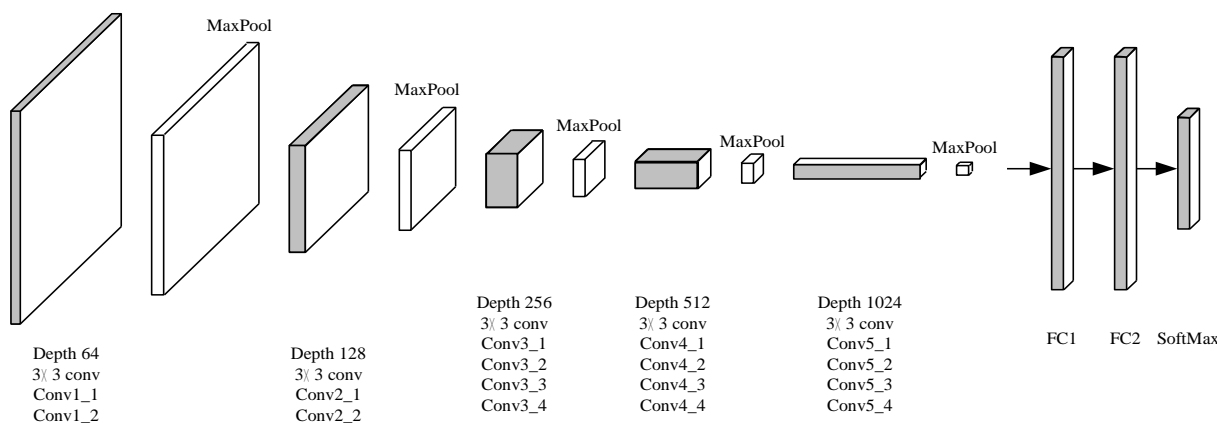
FIGURE 3: VGG19 model architecture

EXPERIMENTATION AND RESULTS

In this section, the many experiments have been gone over and the CXR dataset has been run using several topologies in order to find the best one for classification. The experimental results and a summary of the three procedures were employed.

For two class classification for pneumonia diagnosis, the accuracy of these three techniques had been evaluated. Table 2 compares the performance of respective CNN, ANN and VGG19 for two class's classification scenario.

**TABLE 2:** Accuracy score for 2 class classification of CNN, ANN and VGG19

Model	ANN	CNN	VGG19
Accuracy	94.44	96.68	**98.27**

From Table 2 it is observed with the accuracy of 98.27 percent VGG19 is outperforming other deep learning models CNN and ANN. A summary of the performance of various models ANN, CNN and VGG19 with input shape 224

and activation function RELU are in Table 2. In this research work the model of VGG19 is better than the model of ANN and CNN for accuracy.
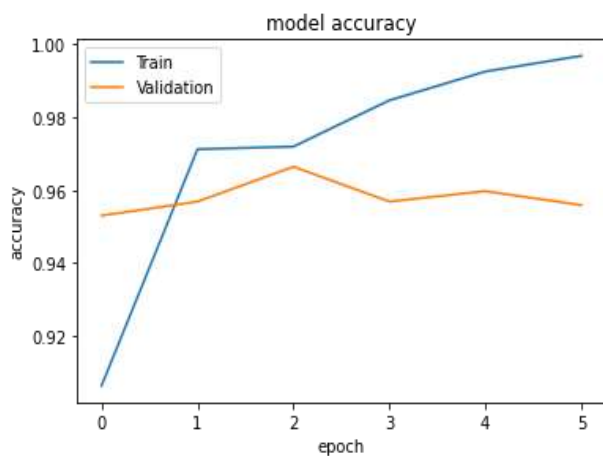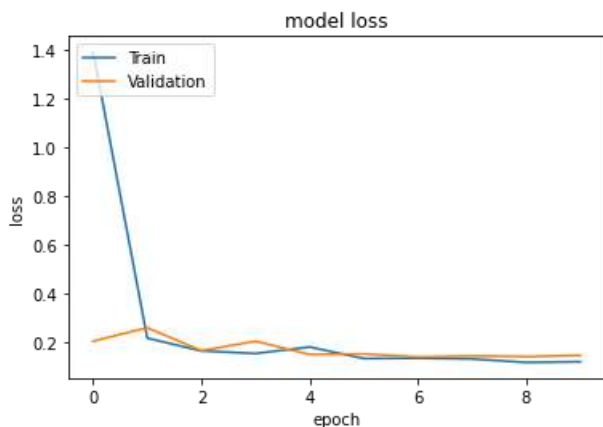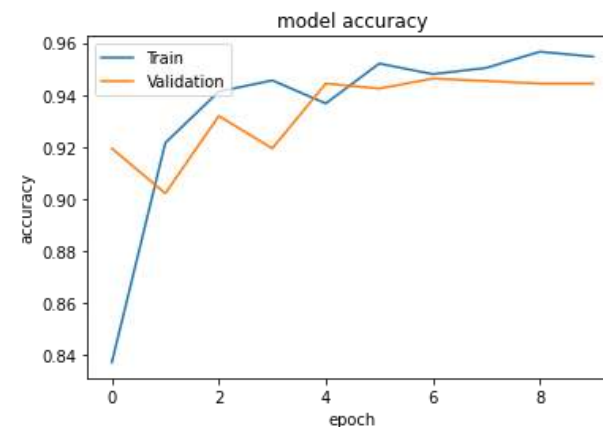

(a)
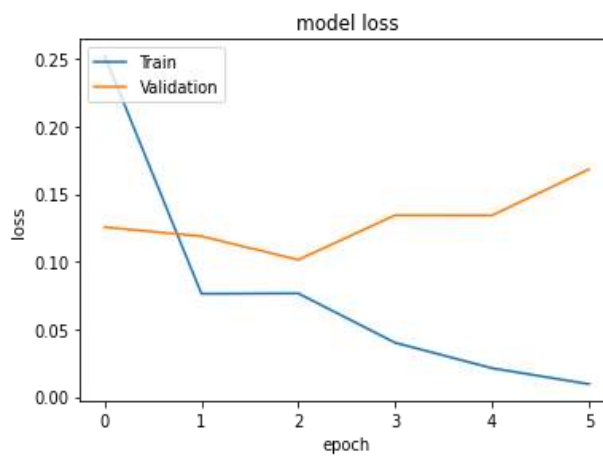
(b)

FIGURE 4: Per epoch for CNN algorithm. (a) Model accuracy; (b) Model loss

(a)

(b)

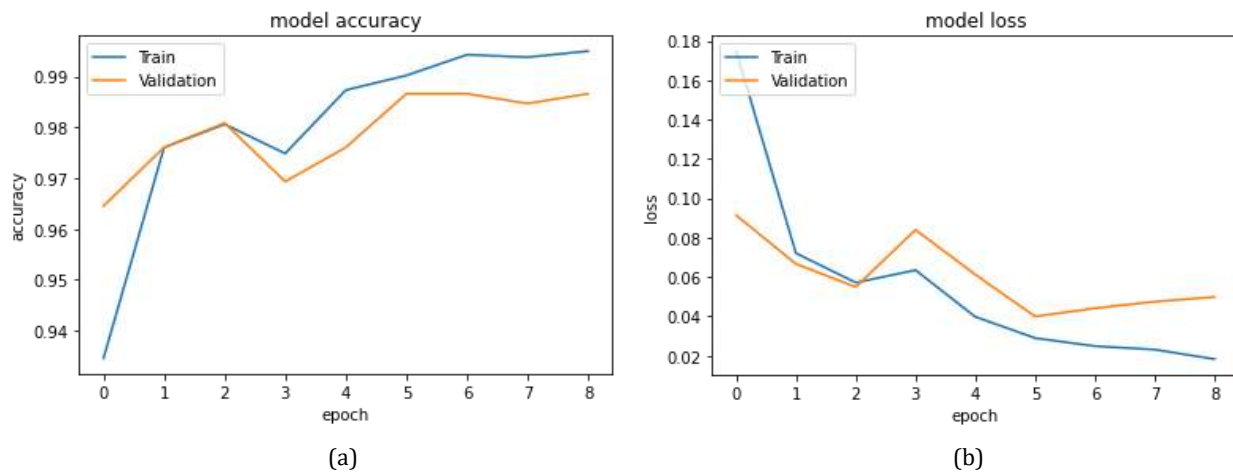**FIGURE 5:** Per epoch for ANN algorithm. (a) Model accuracy; (b) Model loss

FIGURE 6: Per epoch for VGG19 algorithm. (a) Model accuracy; (b) Model loss

They depict the training and validation accuracy in Figure 4, Figure 5, and Figure 6, as well as the training and validation loss, acquired during the training phase for each epoch with all the models. The training and validation accuracy all above 90% for ANN 94% for CNN and 97% for VGG19, and the training and validation losses were both less than 0.15, indicating that the VGG19 model has the potential to achieve good results. Furthermore, during training, the training accuracy and training loss appear to be reducing.

CONCLUSION

Large number of pneumonia cases and its death ration attracted the researcher and scientists towards it's more accurate cure at early stages, deep learning techniques, model are used in medical imaging for the cure of lung cancer, covid-19 detection etc. The chest-X-ray datasets those are taken from Kaggle and are trained it on different deep learning models; ANN, CNN, and VGG19 have been used. The achieved higher accuracy from VGG19 transfer learning model has been got. In future the large and complex data using transfer learning model like AlexNet, GoogleNet and VGG19 will be tried. The system will be developed in which pneumonia detection gadget easily available for the clinics and the hospitals.

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