The Islamia University of Bahawalpur

Department of Artificial Intelligence

SOFTWARE DESIGN DESCRIPTION

(SDD DOCUMENT)

for

<Lungs Disease Pneumonia Detection Using Deep Leaning AI>

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Revision History

Name	Date	Reason for changes	Version

Application Evaluation History

Comments (by committee) *include the ones given at scope time both in doc and presentation	Action Taken

Supervised by

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Signature_______________

1 Introduction

There are various respiratory diseases that can affect the lungs. One of these is pneumonia, which kills about 1.6 million people annually. In addition to that tuberculosis, pneumothorax and countless others are a threat to human beings. It is estimated that lung diseases are responsible for the deaths of around 3 million people annually. Traditionally, an individual can be diagnosed with lung disease through various tests, such as a blood test and a chest X-ray examination. Pleural effusions (PE) are fluid buildups in the pleural cavity that are frequently a sign of a more serious illness such heart problems, pneumonia, or colon cancers. They've also been discovered to be prognostic indications, such as in the case of acute pancreatitis. Pneumothorax is a pleural illness that causes air to collect in the pleural space. Because air is less thick than lung parenchyma, the pneumothorax region will take on the structure of the lungs and lung cavity, occupying the upper portions of the lungs. Pulmonary fibrosis is a lung condition caused by scarring and damage to lung tissue. It's more difficult for your lungs to perform properly because of this thicker, rigid tissue. As your pulmonary fibrosis progresses, you will become increasingly breathless. When your airways or the little sacs at the end of them don't expand as they ought to when you breathe, you get atelectasis. A lung nodule is a tiny irregular spot that can be discovered during a chest CT scan. These scans are performed for a variety of purposes, including lung cancer screening and checking the lungs if you have symptoms. The majority of lung nodules detected on CT scans are not cancerous. They are more commonly caused by previous infections, scar tissue, or other factors. Cardiomegaly is a term used to describe the expansion of the heart, which is usually caused by a cardiac problem. Cardiomegaly can be caused by a number of disorders that impact how the heart works, including high blood pressure,

Pneumonia is known to be one of the most dangerous diseases. WHO recently estimated more than 1 million premature deaths all over the world. According to the World Health Organization Systemic, pneumonia causes nearly 15% of all deaths. India, with 158,176 deaths in 2016, continues to have the highest number of pneumonia infant deaths in the world. The report, released on World Pneumonia Day, found that by 2030 nearly 11 million children under five were likely to be killed by the infectious disease.

Infections of one or both lungs leading to inflammation of their air sacs are known as pneumonia. Whenever the air sac becomes swollen or stuffed with pus, coughing with sputum or pus, fever, chills, and dyspepsia (purulent substance) can occur. There are several types of organisms that can cause pneumonia, including bacteria, fungi and virus. Viral pneumonia and bacterial pneumonia show very similar signs and symptoms. Symptoms of viral pneumonia, on the alternative hand, can severe than the ones of bacterial pneumonia. Pneumonia is recognized in kids beneath Neath the age of 5 who have a cough and/or issue respiration, without or with fever, and who have short respiration or after inhalation, their chest moves in or retracts, resulting in a reduction chest wall (in a wholesome person, the chest expands for the duration of inhalation). AI based deep learning has been used to enhance the overall accuracy of computer-assisted analysis (CAD), mainly within side the area of clinical imaging. As a function extraction and class method, DNN using AI based convolutional neural networks (CNNs) helps to diagnose pneumonia in Chest X-rays. Using the chest x-ray we can examine the pneumonia in the body of any person. To tackle the issue of this system we are going to make model which can help to detect pneumonia using x-ray. Pneumonia is the major disease of lungs. Which destroy the all respiratory system of a human body.

Artificial intelligence and Deep learning techniques are capable of examining chest X-rays in order to detect patterns that can confirm the presence of COVID-19-induced pneumonia. Pneumonia is a respiratory disease that causes inflammation in one or both lungs, resulting in symptoms such as cough, fever, and difficulty breathing. Early detection of pneumonia is essential for effective treatment and improved patient outcomes. In modern medicine, a Chest X-ray image is the most important diagnosis for pneumonia. In another word, a pneumonia patient requires a chest X-ray to diagnose. In the Chest X-Ray - pneumonia detection project, we discussed the vectors that may help to detect pneumonia in X-ray images. We conduct a comprehensive analysis to list the differences between normal lung and infected (pneumonia) lung images. By incorporating with CNN image classification algorithm, we concluded the result that was able to prove the expectation. After analyzing and preprocessing all the chest X-ray images, we use the knowledge of transfer learning to improve diagnostic performance by feature fusion. CNN is an example of a deep neural network specialized in image analysis. Therefore, it is widely used in the field of computer vision. For instance, image classification, image clustering, object detection, and neural style transfer.

The risk of pneumonia is increasing every day worldwide. Because pneumonia is caused by bacteria and viruses, x-rays can help diagnose pneumonia. Pneumonia can be treated in its early stages by consulting a specialist radiologist with a person's chest x-ray. However, in some cases, an experienced radiologist cannot tell whether a person has pneumonia. Or you can't see it with the naked eye. This type of situation can be fatal in many cases. In some countries, there are not enough doctors to treat patients. Therefore, a computer support system capable of identifying infected and non-infected individuals is needed. This automated system solves the problem of poor people who do not have the money to consult a professional radiologist. Therefore, we aim to achieve this by proposing a model using deep learning methods.

2 Design methodology and software process model

CNN models have been created from scratch and trained on Chest X-Ray Images (Pneumonia) dataset on Kaggle. Keras neural network library with TensorFlow backend has been used to implement the models. Dataset consists of 5216 training images, 624 testing images and 16 validation images. Data augmentation has been applied to achieve better results from the dataset. The four models have been trained on the training dataset, each with different number of convolutional layers. Each model was trained for 20 epochs, with training and testing batch sizes of 32 and 1, respectively. The following sub-headings further explain the above stages in depth.

The CNN model provides better results and accuracy. So we are using CNN for our model. Here is the description of convolutional neural network.

CNN Architecture

CNN models are feed-forward networks with convolutional layers, pooling layers, flattening layers and fully connected layers employing suitable activation functions.

Convolutional layer:

It is the building block of the CNNs. Convolution operation is done in mathematics to merge two functions. In the CNN models, the input image is first converted into matrix form. Convolution filter is applied to the input matrix which slides over it, performing element-wise multiplication and storing the sum. This creates a feature map. 3 × 3 filter is generally employed to create 2D feature maps when images are black and white. Convolutions are performed in 3D when the input image is represented as a 3D matrix where the RGB color represents the third dimension. Several feature detectors are operated with the input matrix to generate a layer of feature maps which thus forms the convolutional layer.

Activation functions:

All four models presented in this paper use two different activation functions, namely **ReLU** activation function and **softmax** activation function. The ReLU activation function stands for rectified linear function. It is a nonlinear function that outputs zero when the input is negative and outputs one when the input is positive. The ReLU function is given by the following formula: This type of activation function is broadly used in CNNs as it deals with the problem of vanishing gradients and is useful for increasing the nonlinearity of layers. ReLU activation function has many variants such as Noisy ReLUs, Leaky ReLUs and Parametric ReLUs. Advantages of ReLU over other activation functions are computational simplicity and representational sparsity. Softmax activation function is used in all four models presented in this paper. This broadly used activation function is employed in the last dense layer of all the four models. This activation function normalizes inputs into a probability distribution. Categorical cross-entropy cost function is mostly used with this type of activation function. The softmax function is used at the output layer.

Pooling layer:

Convolutional layers are followed by pooling layers. The type of pooling layer used in all four models is max-pooling layers. The max-pooling layer having a dimension of 2 × 2 selects the maximum pixel intensity values from the window of the image currently covered by the kernel. Max-pooling is used to down sample images, hence reducing the dimensionality and complexity of the image. Two other types of pooling layers can also be used which are general pooling and overlapping pooling. The models presented in this paper use max-pooling technique as it helps recognize salient features in the image.

Flattening layer and fully connected layers:

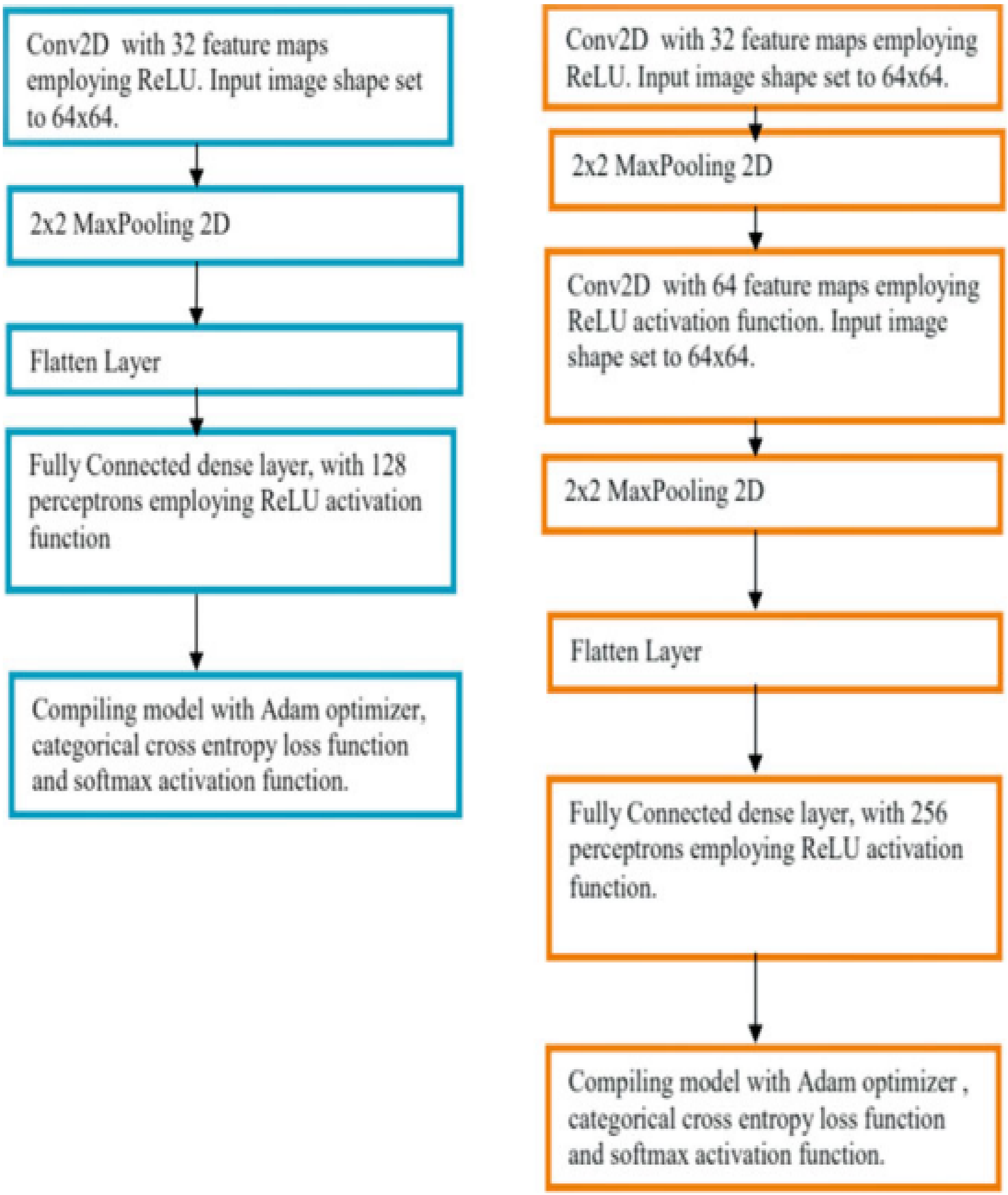
After the input image passes through the convolutional layer and the pooling layer, it is fed into the flattening layer. This layer flattens out the input image into a column, further reducing its computational complexity. This is then fed into the fully connected layer/dense layer. The fully connected layer has multiple layers, and every node in the first layer is connected to every node in the second layer. Each layer in the fully connected layer extracts features, and on this basis, the network makes a prediction. This process is known as forward propagation. After forward propagation, a cost function is calculated. It is a measure of performance of a neural network model. The cost function used in all four models is categorical cross-entropy. After the cost function is calculated, back propagation takes place. This process is repeated until the network achieves optimum performance. Adam optimization algorithm has been used in all four models.

Reducing overfitting:

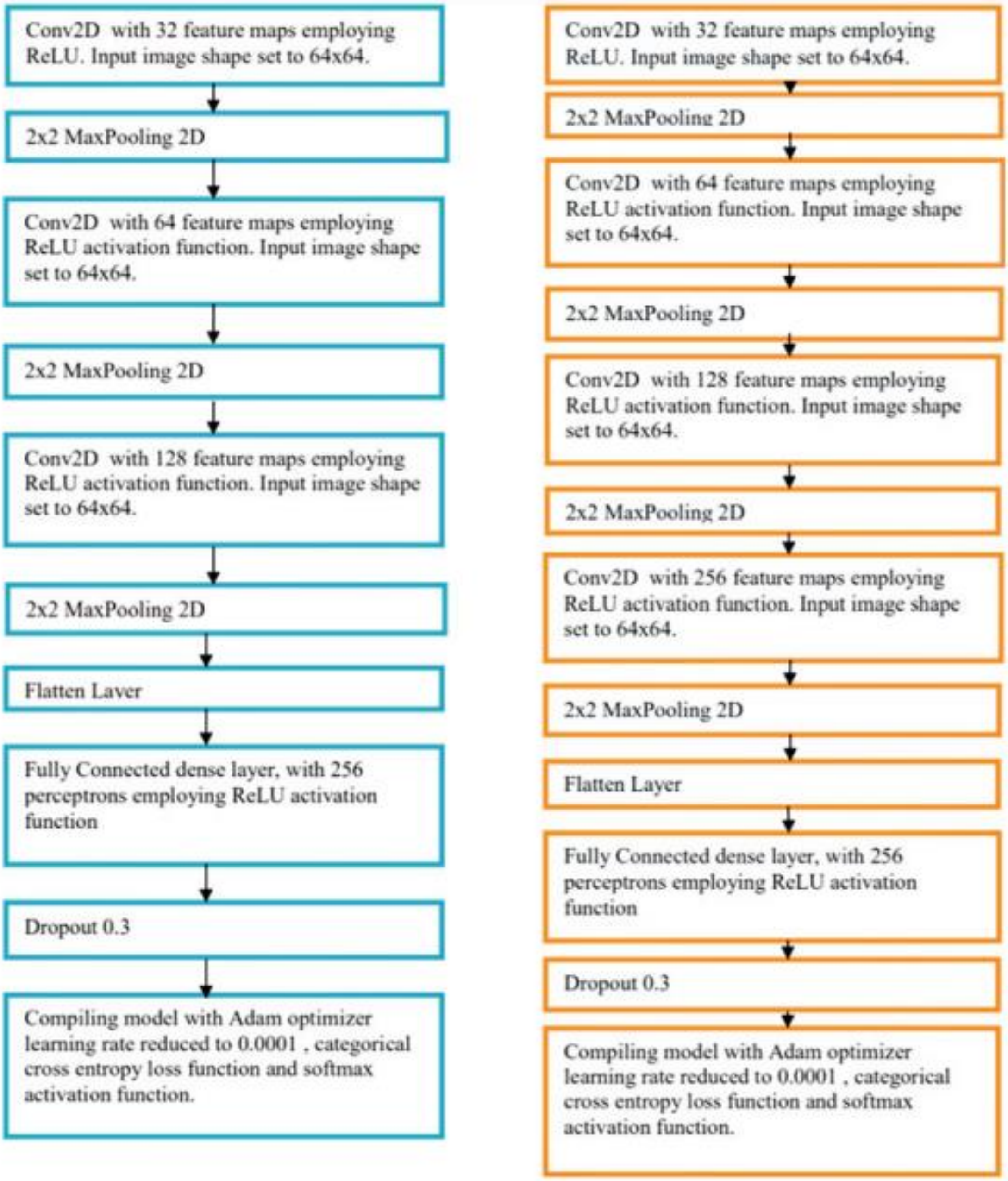
The first model exhibits substantial overfitting; hence, dropout technique was employed in the later models. Dropout technique helps to reduce overfitting and tackles the problem of vanishing gradients. Dropout technique encourages each neuron to form its own individual representation of the input data. This technique on a random basis cuts connections between neurons in successive layers during the training process. Learning rate of models was also modified, to reduce overfitting. Data augmentation technique can also be employed to reduce overfitting.

Algorithm of CNN classifiers:

The algorithms used in the convolutional neural network classifiers have been explained in Figs. 1 and 2. Figure 3 shows the flowchart of the overall schema of research. The number of epochs for all the classifier models presented in this paper was fixed at 20 after training and testing several CNN models over the course of research. Classifier models trained for more number of epochs have showed overfitting. Several optimizer functions were also trained and studied. Adam optimizer function was finalized to be used for all classifiers after it gave the best results. Initially, a simple classifier model with convolutional layer of image size set to 64 * 64, 32 feature maps and employing ReLU activation function was trained. Fully connected dense layer with 128 perceptrons was utilized. To improve the result, the second classifier model was trained with one more convolutional layer of 64 feature maps for better feature extraction. The number of perceptrons in dense layer was also doubled to 256, so that better learning could be achieved. The third model was trained for three convolutional layers with 128 feature maps in third convolutional layer for more detailed feature extraction. Dense layer was kept unchanged. Dropout layer was introduced at 0.3, and learning rate of optimizer

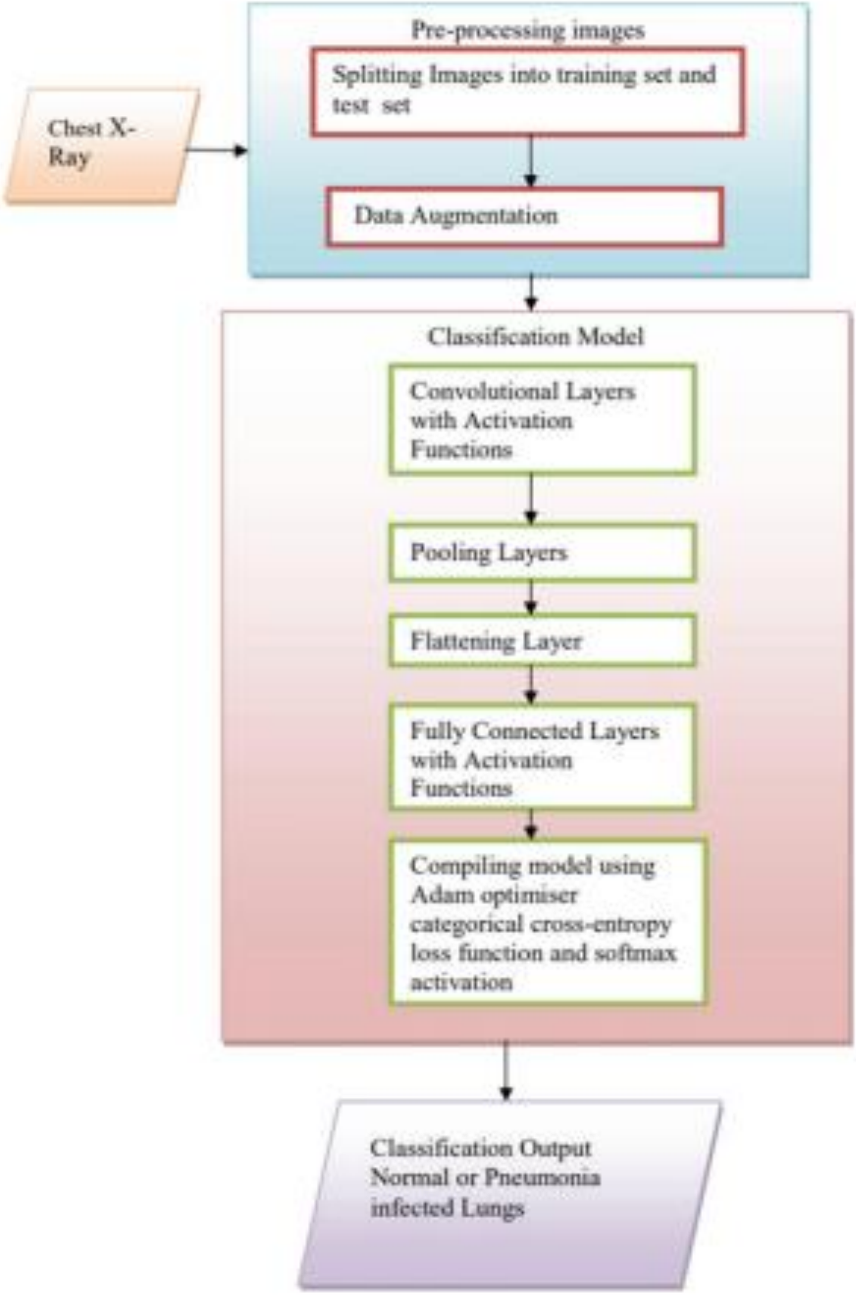


Fig(1) Algorithm of CNN Classifier model 1 (left) model 2 (right)



Fig(2) Algorithms of CNN Classifier model 3 (left) model 4 (right)

lowered to 0.0001 to reduce the overfitting. The final fourth classifier model was trained for four convolutional layers with 256 feature maps in fourth convolutional layer. Dense layer, dropout layer and learning rate were kept same as third classifier model. The results have been summarized in the subsequent section of this paper. Dataset. Chest X-Ray Images (Pneumonia) dataset of 2 GB size has been imported from Kaggle , with total of 5856 jpeg images split into Train, Test and Val folders each divided into category Pneumonia and Normal. Chest X-ray images (front and back) were selected from pediatric patients of one- to five-year olds from Guangzhou Women and Children's Medical Center, Guangzhou. Figure 4 provides



3 System overview

The System uses the CNN but in most cases, they are using the X-ray images and detection of the early stages of the lung diseases. The existing System has its own advantages and disadvantages but most important disadvantages is that they are not trained enough to classify the real time images. To overcome this, we can use the deep learning techniques to increase the accuracy of the model to produce more precise output even when we use the real time dataset.

There are the steps that are used in the model back ground

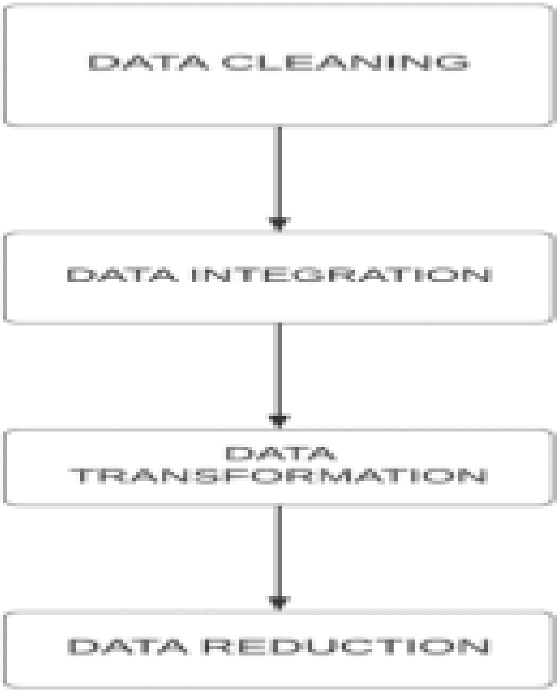
Data Collection:

Data for the project was manually gathered from a variety of sources and cross-referenced with publicly available information. Because the initiative is centered on classifying different diseases. The datasets are sorted into folders and then trained separately.

Pre-processing

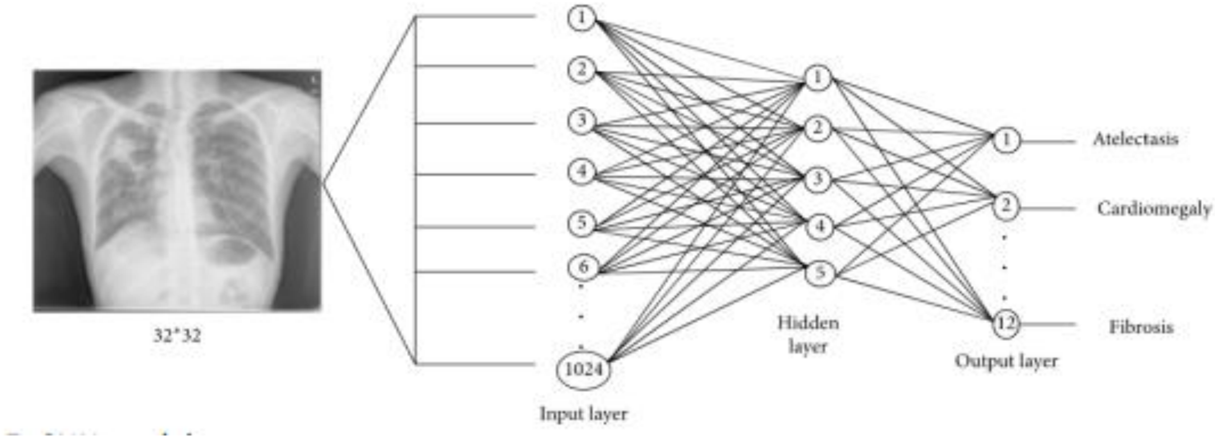
By pre-processing the data, meaningful insights can be extracted from the data, thus improving the quality of the data. In Machine Learning, pre-processing refers to the process of preparing (cleaning and organizing) raw data for building and training Machine Learning algorithms. Here the data is processed in four steps. They are

- **Data quality:** assessment It is possible to receive data in a variety of formats when you collect data from different sources. you are likely to receive information in a variety of formats. For example, if we are collecting images in different websites then we need to change every image into single format.
- **Data cleaning:** As we have collected data from different sources, we have to remove unwanted information and and irrelevant data. It helps the data to run efficiently without any errors.
- **Data transformation:** We have already begun cleaning data; the data transformation will start changing the data into the proper format we have to download and use in other formats.
- **Data reduction:** As we are handling more data's, even after cleaning and changing it. We have enough data set than we need it. Data reduction makes the analysis more easier and most accurate.



Algorithm and Model

A classification algorithm is a quantitative process of mapping input data to a certain category using a classifier. Classifiers come in a variety of forms. One of them is Convolutional Neural Network. A convolution is a quantitative process that transforms one function into another and calculates the cumulative of their integer combination. It is intimately linked to the Laplace and Fourier transforms. Cross-evolution's work in a similar fashion to convolutional layers. The first layer of a CNN is crucial since it connects the input image to the first layer's receptive fields. CNNs are the most widely used deep learning algorithm, and they are made up of brains with adaptable prejudices and parameters. Several inputs are received by each node. The sum of the inputs is then calculated. The sum is then fed into a convolution operation, which generates an output. CNN differs from other neural networks because it includes several convolutional layers. When training, CNNs usually have two elements: feature extraction and classification. Convolution is applied to the input using a kernel during the feature extraction stage. Following that, a feature map is created. During the classification stage, the CNN calculates the likelihood that the image parts to a given class or label.



The image has been converted to grayscale. After that, noise removal and contrast enhancement are completed to generate enhanced photos. CNN divides it into two categories: no findings and other labelled diseased lungs, and so it identifies lung diseases. The X-rays' small characteristics serve as a template for feeding the classifier. The part of the sickness that has been recognized is depicted in the diagram.

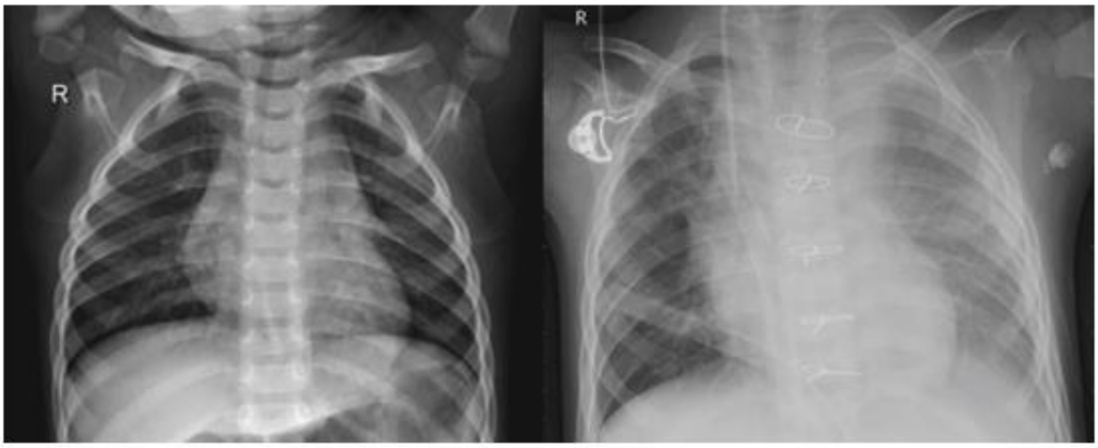


Fig. 4 Left image depicts normal lungs and right image depicts pneumonic lungs

$$\boldsymbol{Accuracy} = \boldsymbol{TP} + \boldsymbol{FN}/\ (\boldsymbol{TP} + \boldsymbol{FN}) + (\boldsymbol{FP} + \boldsymbol{TN})$$

$$\boldsymbol{Sensitivity} = \boldsymbol{TP}/\ \boldsymbol{TP} + \boldsymbol{F}$$

$$\boldsymbol{Specificity} = \boldsymbol{TN}/\ \boldsymbol{FP} + \boldsymbol{T}$$

$$\boldsymbol{Precision} = \boldsymbol{TP}/\ \boldsymbol{TN} + \boldsymbol{FP}$$

$$\boldsymbol{F1\ score} = \mathbf{2} \times \boldsymbol{TP}\ /\mathbf{2} \times \boldsymbol{TP} + \boldsymbol{FN} + \boldsymbol{F}$$

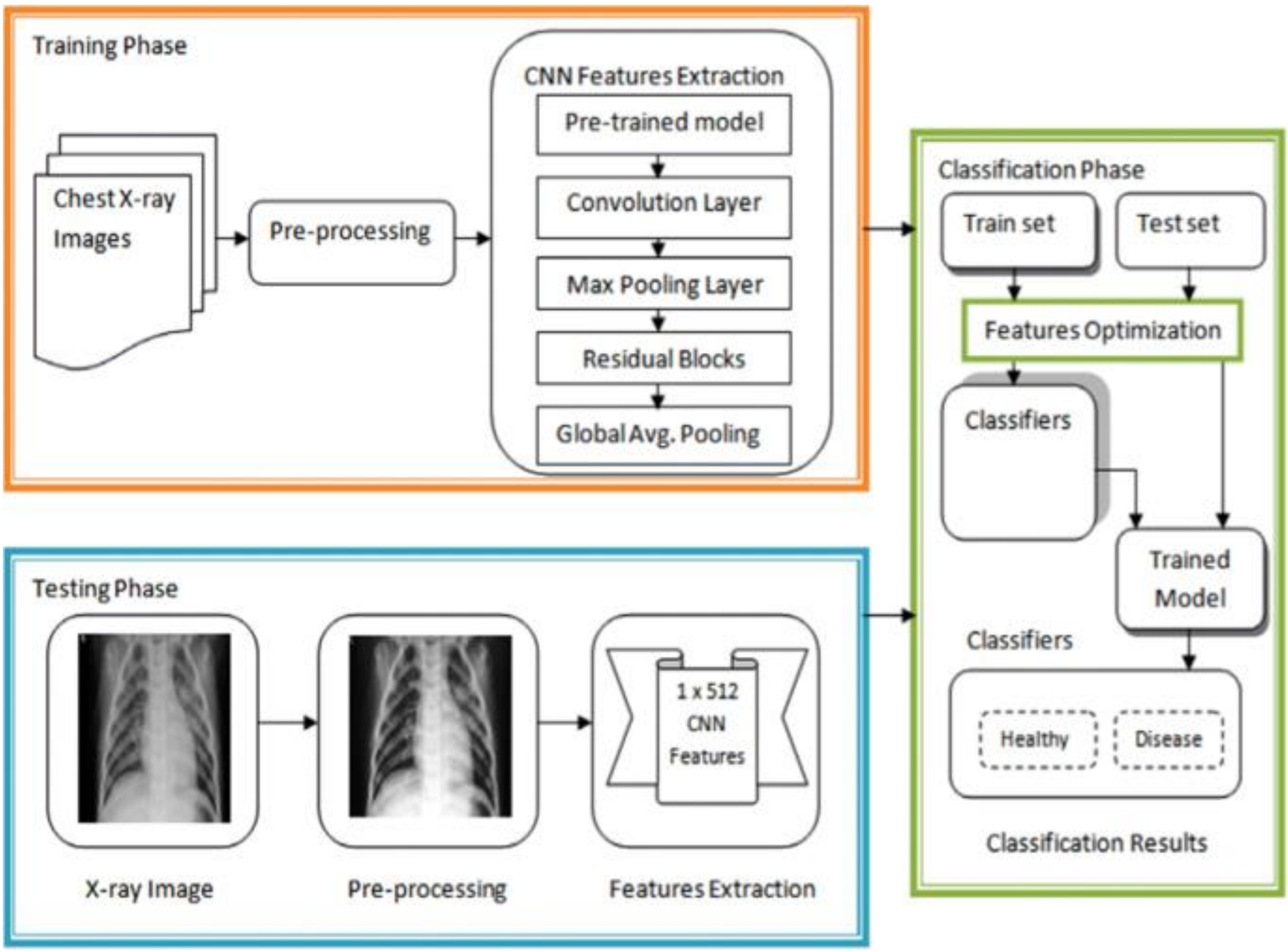
Various formulas for checking the states of model are given above.
In the above equations we classify the chest X-rays in 4 major section:

- False Negative (FN)
- False Positive (FP)
- True Negative (TN)
- True Positive (TP)

Here false negative are those X-rays which are normal x-rays and have been detected wrongly by the machine, false positive are those X-rays which are normal x-rays and have been detected correctly by the machine, True Negative are those cases which are pneumonia X-rays but have been detected as normal cases but the model and true positive are those case which are pneumonia cases and have been detected correctly by the machine. Here is an example of this confusion table:

	Predicted: NO	Predicted: YES
Actual: NO	TN = ??	FP = ??
Actual: YES	FN = ??	TP = ??

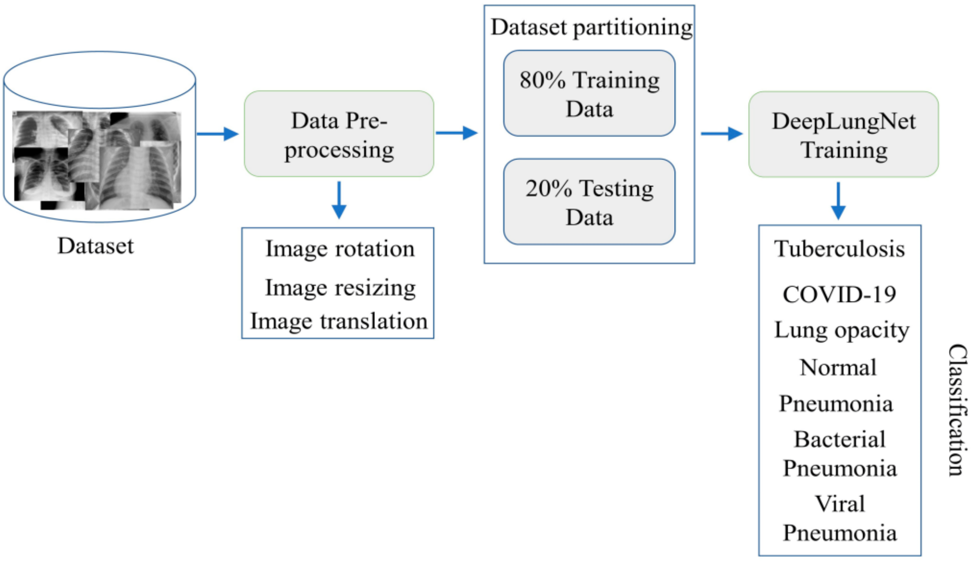
3.1 Architectural design



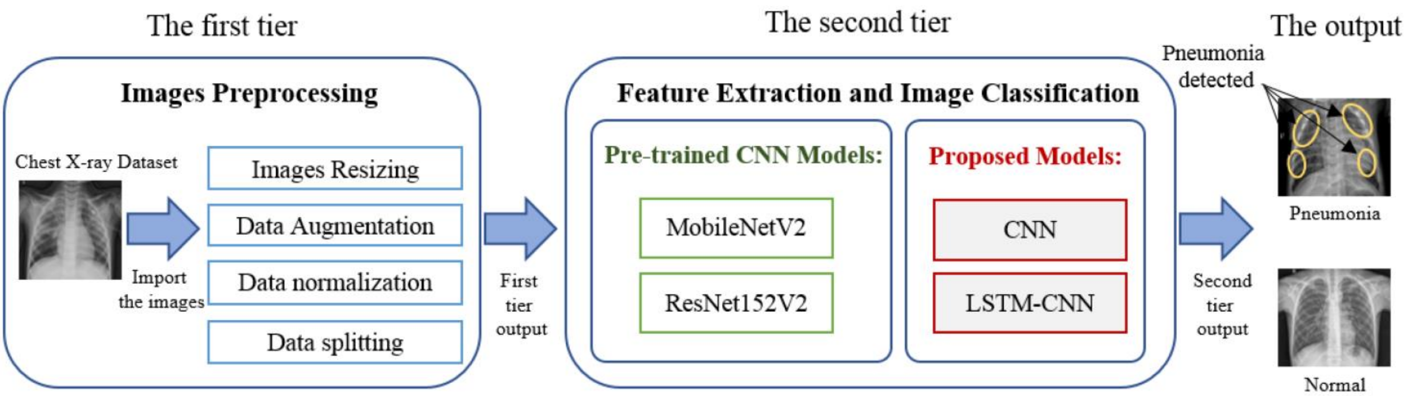
4 Design models [along with descriptions]

The applicable models may include:

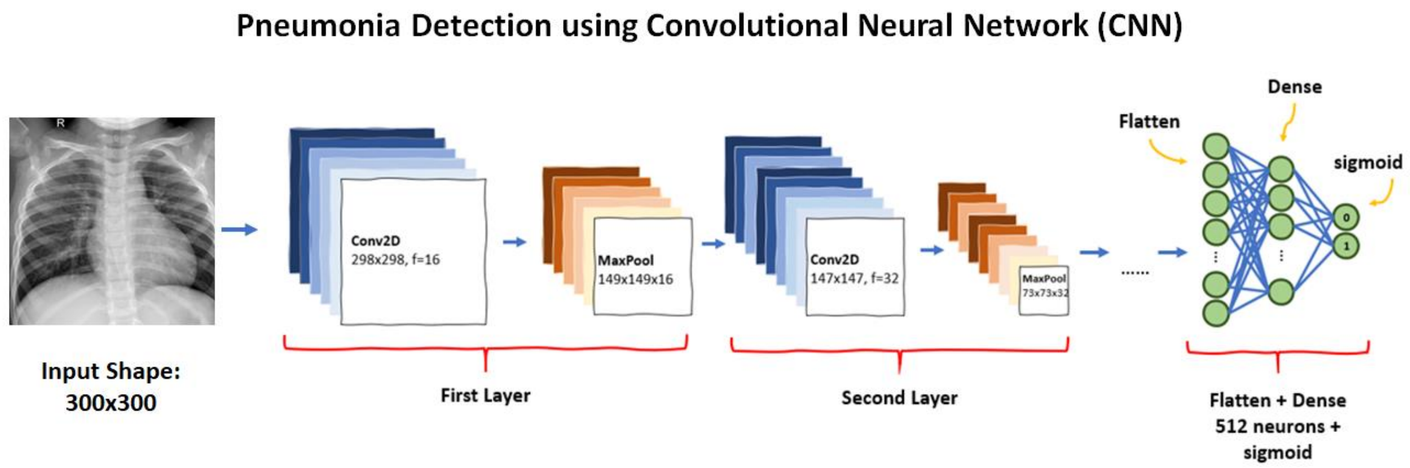
- **Class Diagram**



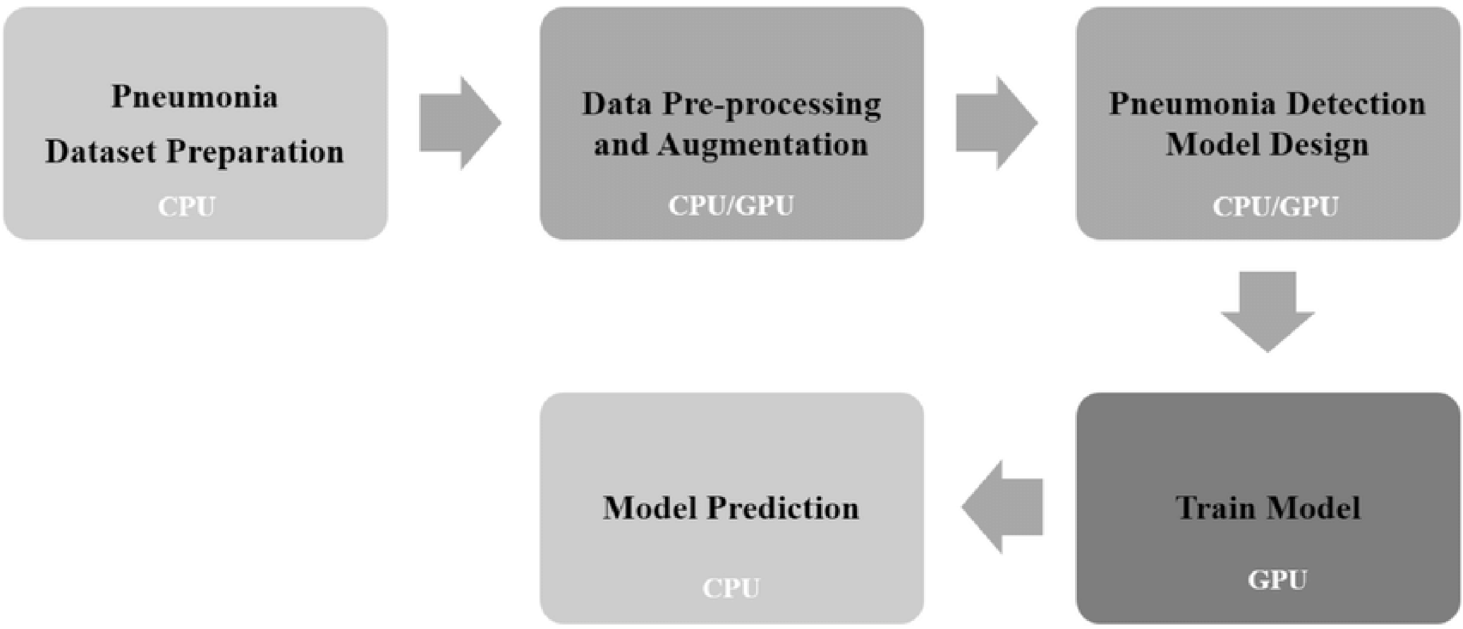
- **Sequence Diagram**



- **State Transition Diagram**



- **Data Flow Diagram**



5 Data design

We are designing this project for those persons who faces lungs disease difficulties. A CNN based trained model is used which will take x-ray as a input and detects that the person is pneumonia affected or not.
We will use an Android Application which capture the live picture of x-ray and the model will detect that it is pneumonia affect or not. A user interface Application developed. Both the local or cloud space can be used. In local host the system will operate locally and in cloud the system will operate through internet.
It can work on every android phone efficiently.

- The Language we are using in our project is Python.

- The Model we will use CNN.
- The library Tensor Flow is used.
- An android application is used which is developed in flutter.
- Cloud or local database should be used
- User interface will be for interaction

5.1 Data dictionary

Functional requirements describe the specific functionalities or features that a system must have to meet the needs of its users and stakeholders. These requirements define what the system is supposed to do. Here are some examples of functional requirements for a pneumonia detection system:

User Authentication:

The system should have a user authentication mechanism to ensure that only authorized healthcare professionals can access patient data and system functionalities.

Image Upload:

Users should be able to upload chest X-ray images for analysis by the system.

Image Preprocessing:

The system must preprocess uploaded images to ensure uniformity in dimensions, handle noise, and normalize pixel values.

Pneumonia Detection:

The system should use the trained CNN model to analyze uploaded images and provide a binary classification indicating the presence or absence of pneumonia.

Confidence Level Display:

For each detection, the system should display a confidence level or probability score to indicate the model's certainty in its prediction.

Patient Data Management:

The system should allow healthcare professionals to input and manage patient information, including medical history and previous X-ray results.

Notification System:

In case of a high probability of pneumonia detection, the system should notify healthcare professionals for further review and action.

Audit Trail:

The system should maintain an audit trail of all user activities, including image uploads, model predictions, and user logins, for accountability and traceability.

Performance Metrics:

Provide metrics such as sensitivity, specificity, and accuracy to assess the performance of the pneumonia detection model.

Integration with Existing Systems:

If applicable, the system should integrate with existing healthcare information systems to streamline data flow and ensure interoperability.

User Feedback Mechanism:

Implement a mechanism for users to provide feedback on model predictions, helping to improve the system over time.
Security Measures:

Implement encryption protocols to ensure the security and privacy of patient data during transmission and storage.
System Logging:

Maintain logs of system events, errors, and warnings to facilitate troubleshooting and system maintenance.
User Roles and Permissions:

Define different user roles (e.g., admin, healthcare professional) with corresponding permissions to access and modify specific functionalities within the system.
Localization Support:

If applicable, provide support for multiple languages to cater to a diverse user base.
Functional requirements should be detailed, specific, and testable to ensure that the development team can implement and verify them effectively. These requirements form the basis for system design, development, and testing.

Cloud support:

The cloud support is used to host the model at cloud space. The model needs space for his working. The model is accessed through internet.

6 Algorithm & Implementation

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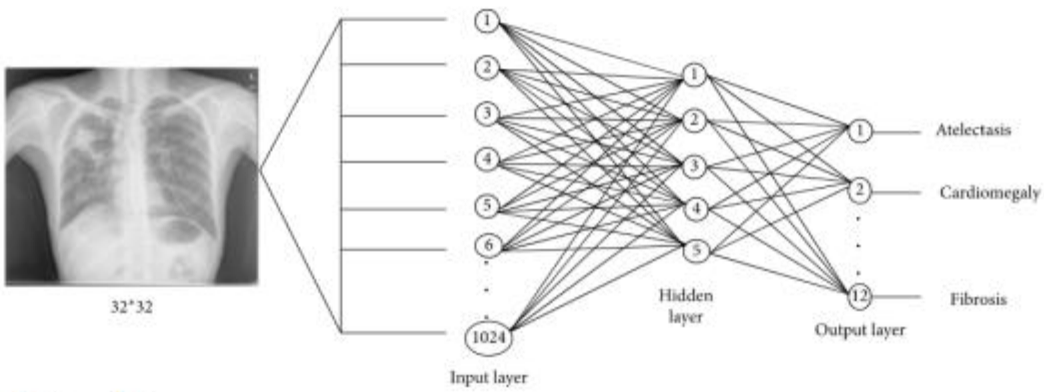

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7 Software requirements traceability matrix

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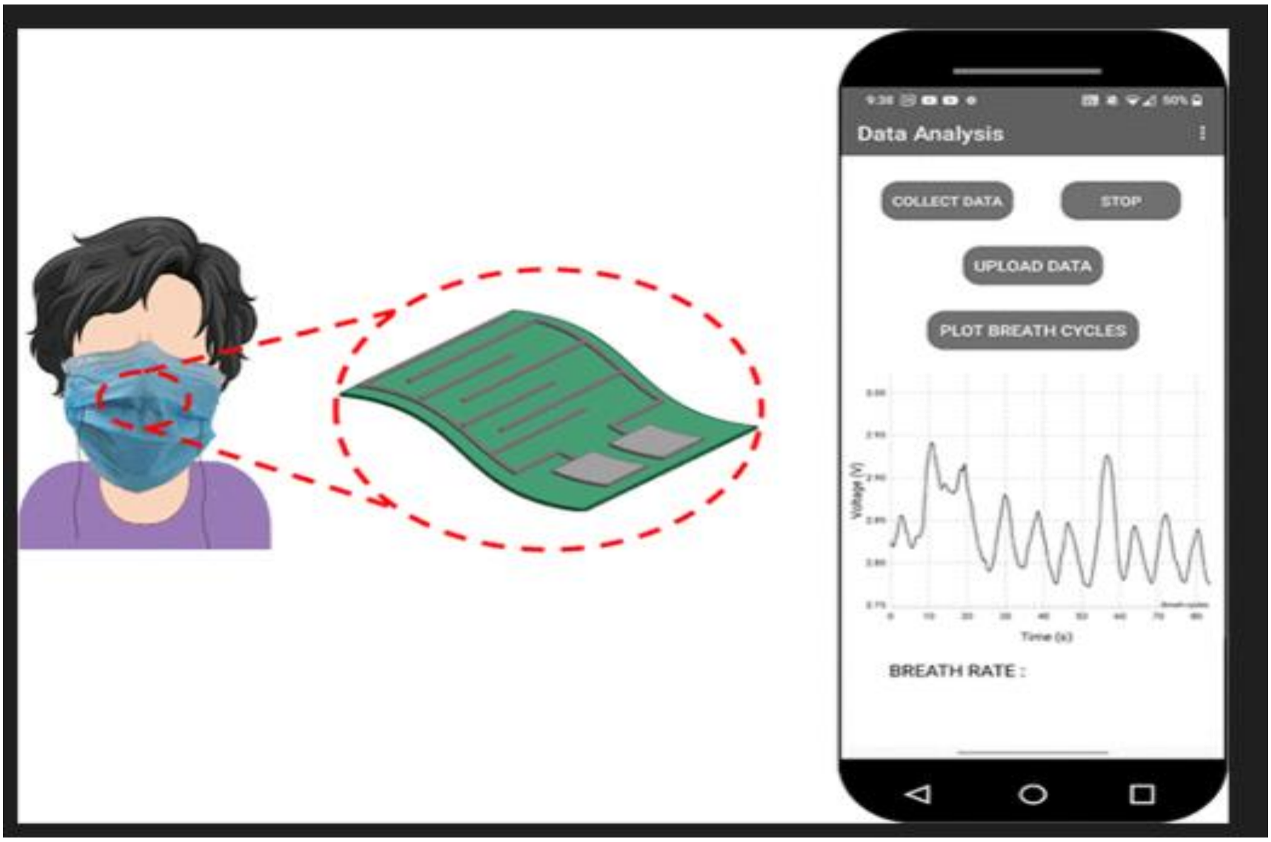
Cloud support:

The cloud support is used to host the model at cloud space. The model needs space for his working. The model is accessed through internet.

8 Human interface design

Describe the functionality of the system from the user‟s perspective. Explain how the user will be able to use your system to complete all the expected features and the feedback information that will be displayed for the user.

8.1 Screen image



8.2 Screen objects and actions

- Android application takes image as input
- Already taken image should be uploaded
- Live image can capture through camera
- After processing the image the model detects that the person pneumonia affected or not
-

Appendix I

- How to design using UML (OOP): For guidance please follow the instructions mentioned in the link: http://agilemodeling.com/artifacts/

- How and when to design ER diagrams: For guidance please follow the instructions mentioned in the link: http://people.inf.elte.hu/nikovits/DB2/Ullman_The_Complete_Book.pdf

- Data flow diagrams: For guidance please follow the instructions mentioned in the link and book:
  - http://www.agilemodeling.com/artifacts/dataFlowDiagram.htm
  - Software Engineering –A Practitioner‟s approach by Roger Pressman
- Architecture diagram: For guidance please follow the instructions mentioned in the link and book:
  - Ian Sommerville – Software Engineering 9th Edition– Chapter 6