The Islamia University of Bahawalpur

Department of Artificial Intelligence

SOFTWARE REQUIREMENTS SPECIFICATION

(SRS DOCUMENT)

for

<Lungs Disease Pneumonia Detection Using Deep Learning AI >

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Revision History

Name	Date	Reason for changes	Version
MUNEER IQBAL Muhammad Ashraf Aqsa Rasheed	15-01-2024	This document contains introductory lines regarding my project. It will contain the scope of the project that is being developed. Scope of the project will be explained on the basis of requirements (functional or non-functional) are related to project that will be developed. Our project requirements use case diagram use case description.	1.0

Application Evaluation History

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

Supervised by

<Mr Mubeen Shehroz>

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,

1.1 Purpose

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 beextrasevere 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.

1.2 Scope

Artificial intelligence and machine 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 Overall description

2.1 Product perspective

This product prospective is to immediate detection of lung disease pneumonia. It can detect the Pneumonia in an any person body using the X-ray of that person. The persons do not know which kind of disease they facing. This model can help to knowing about the disease which they face. The key words of this product are Lung disease detection, deep learning, CNN, Neural network, preprocessing techniques.

Persons who suffer from emphysema have compromised air sacs in the lungs. Over time, the inner sacs in the lungs weaken and tear, resulting in larger air spaces rather than small individual ones. Emphysema can go undetected for many years. Pleural thickening is a chronic condition wherein scar tissue thickens the pleural lung tissue, commonly known as pleura. For doctors, classifying chest X-ray abnormalities of these many kinds of lung diseases is a time-consuming operation; as a result, various algorithms have been proposed to effectively accomplish this work. Over the years, computer-aided diagnostic tools have been developed to capture significant information of X-rays to assist doctors in acquiring a thorough knowledge of the X-ray. On the other hand, such CAD system may not have reached a considerable degree of importance for making diagnoses in X-rays. As a result, their role has been confined to providing visualizing functionality to clinicians to aid in decision-making.

2.2 Operating environment

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.

2.3 Design and implementation constraints

- 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.
- User interface will be for interaction

CNN Architecture

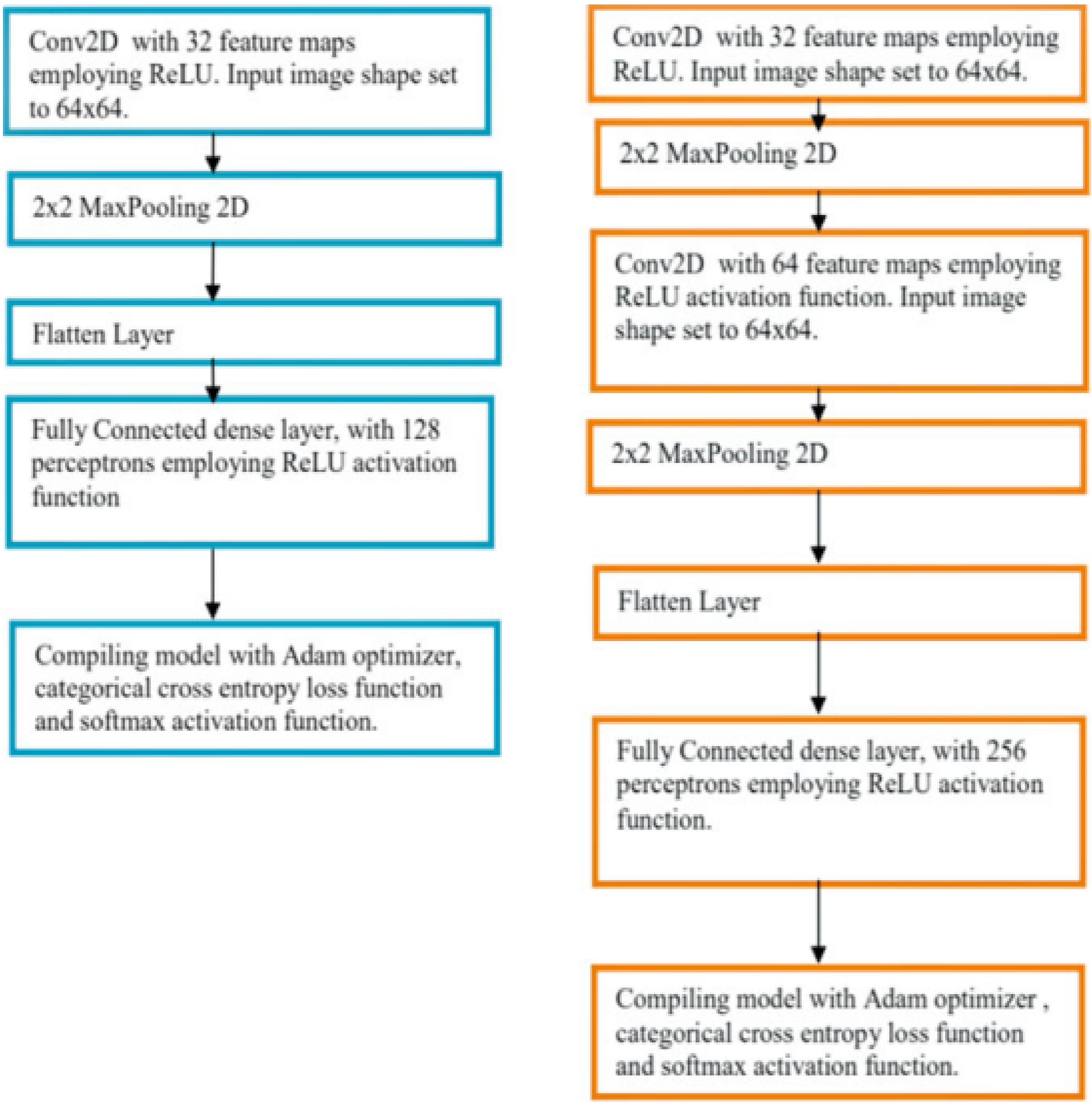
CNN models are feed-forward networks with convolutional layers, pooling layers, flattening layers and fully connected layers employing suitable activation functions. Convolutional layer. It is the building block of the CNNs. Convolution operation is done in mathematics to merge two functions. In the 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. 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.

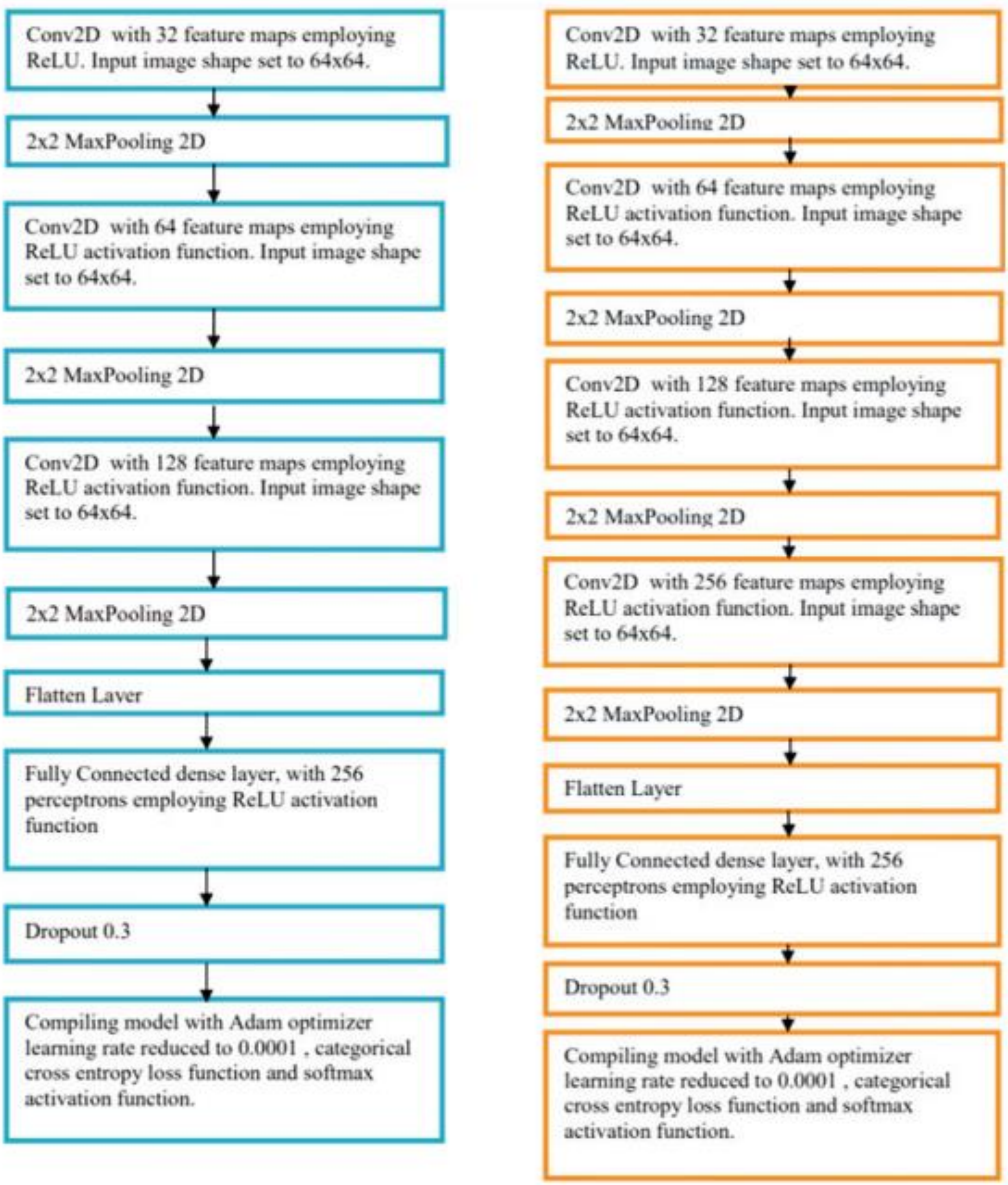
Pooling layer: Convolutional layers are followed by pooling layers. The type of pooling layer used in all four models is max-pooling layers. The max-pooling layer having a dimension of 2×2 selects the maximum pixel intensity values from the window of the image currently covered by the kernel. Max-pooling is used to down sample images, hence reducing the dimensionality and complexity of the image.

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.

Here are the images of convolutional layers which tells the whole working process of the model. There are four model layers are used.



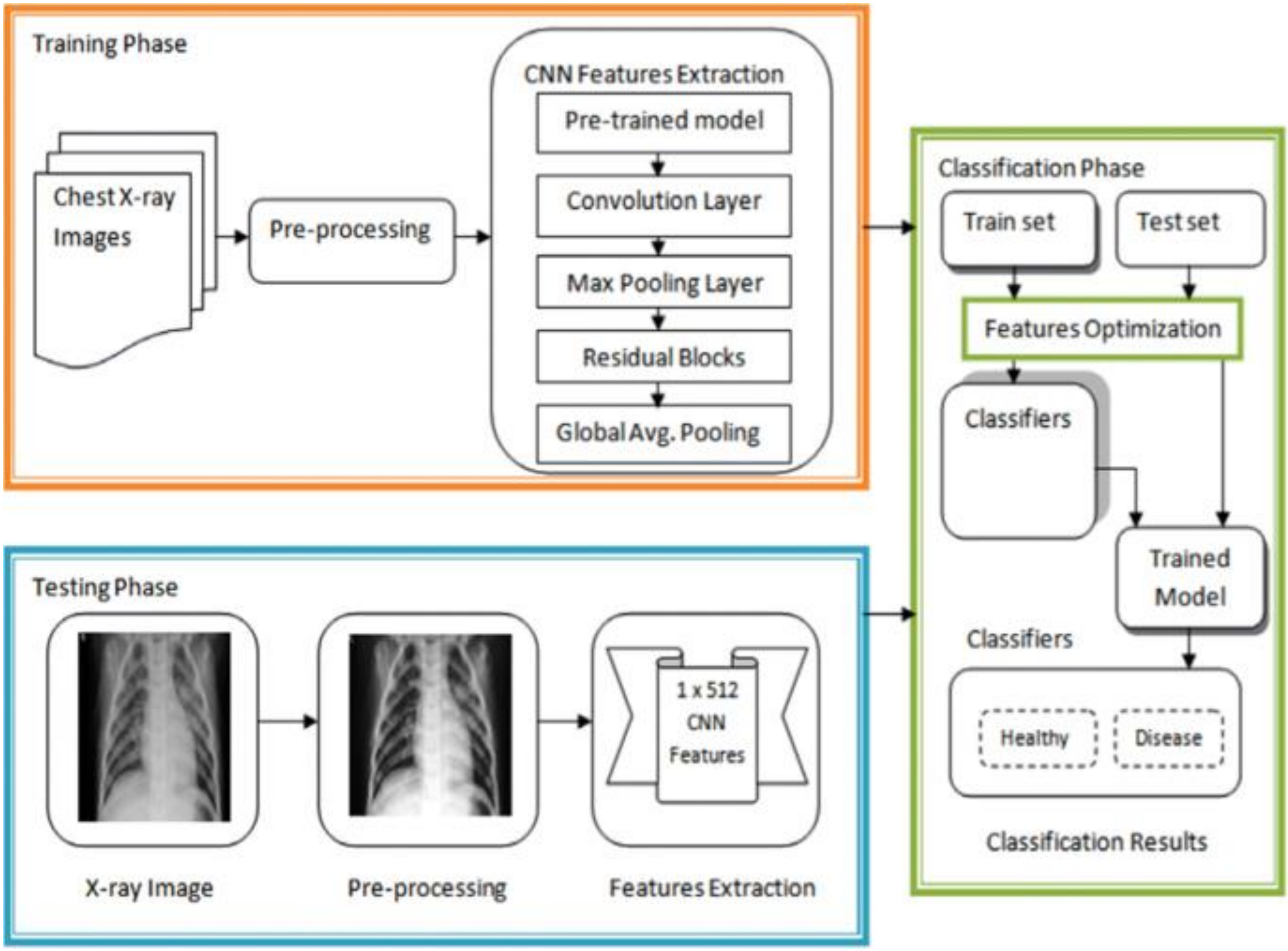
Fig(1) Algorithm of CNN Classifier model 1 (left) model 2 (right)



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

The complete working process in the flow diagram is here.



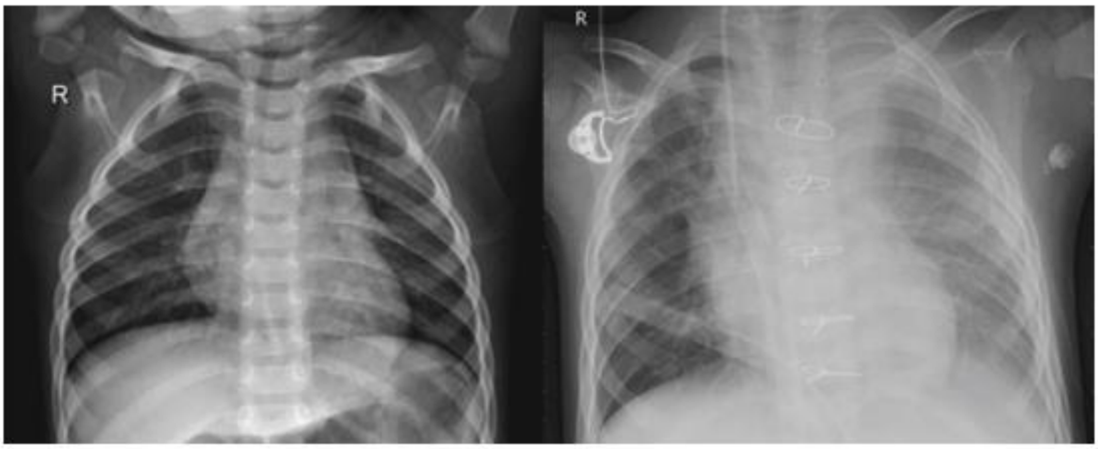
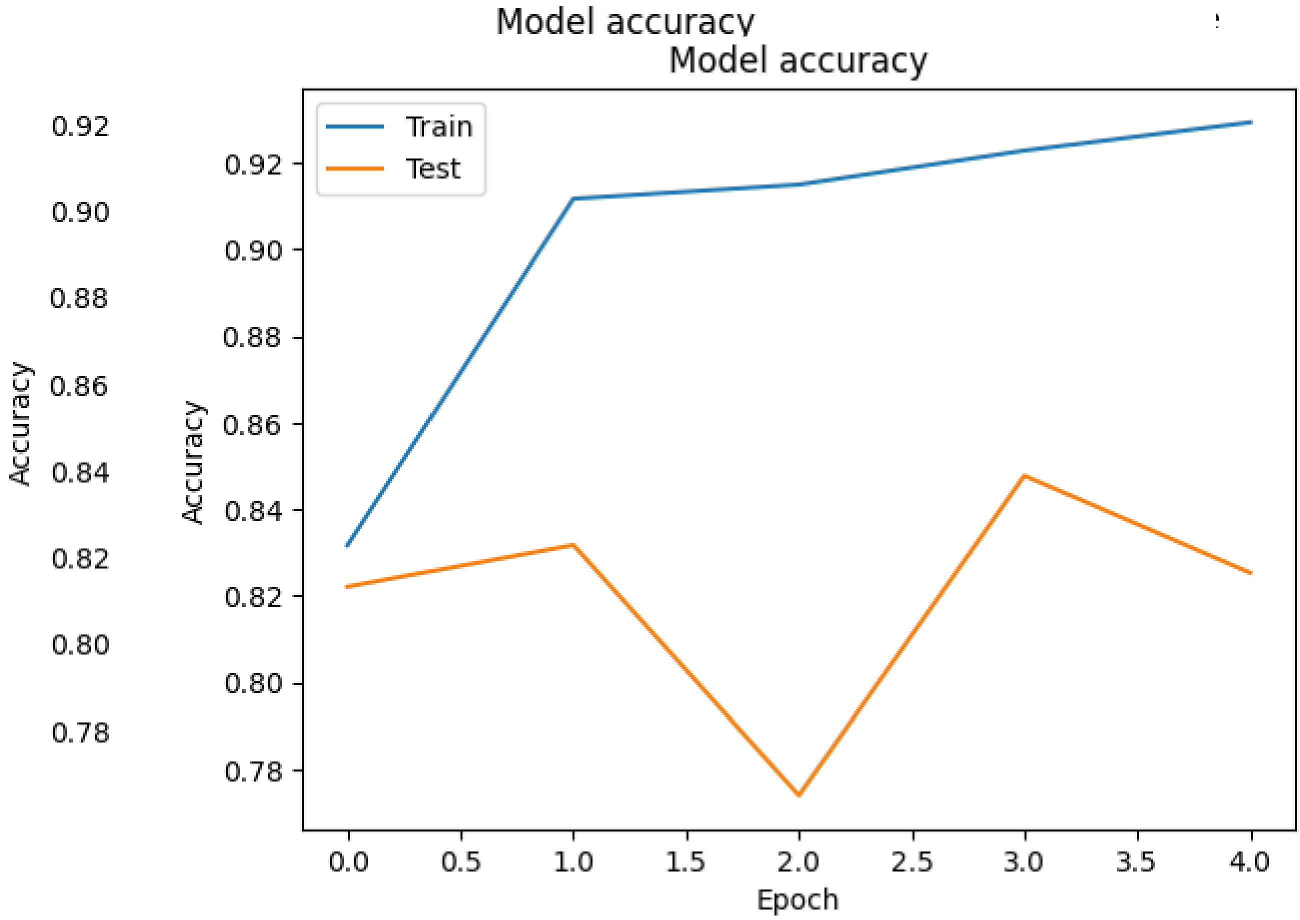


Fig. 4 Left image depicts normal lungs and right image depicts pneumonic lungs

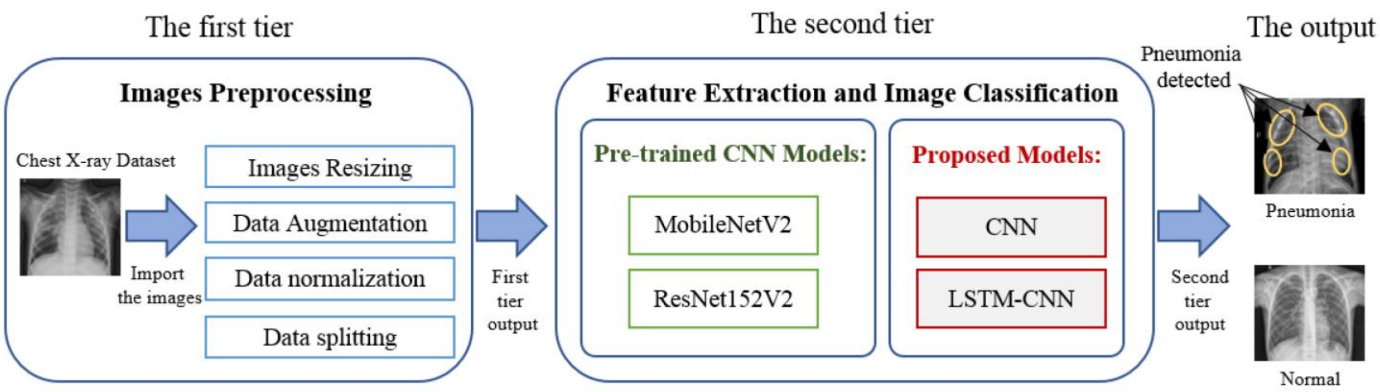
3 Requirement identifying technique

This describes the requirements identifying technique(s) which further help to derive functional requirements specification. The selection of the technique(s) will depend on the type of project. For instance,



3.1 Use case diagram

The CNN model with image augmentation accuracy is better than without image augmentation. With SVM, we got 0.92 accuracy, which is high. Logistic regression also has about 0.87 accuracy. Compare the results of models, SVM is the most efficient method.



3.2 Use case description

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 10 epochs, with training and testing batch sizes of 165 and 1, respectively. The following sub-headings further explain the above stages in depth.

Table 5 Show the detail use case template

Use Case ID:	UC-1
Use Case Name:	M USMAN
Actors:	A person who affected with lung disease
Description:	A person which is affected with pneumonia. And his respiratory system is affected. He wants to use this model to detect his disease giving his x-ray to the model.

Preconditions:	A person who affected with lungs disease can use this model.
Postconditions:	He use this model to giving his chest X-Ray to the model then the model will detect that , He is affected pneumonia or not.
Normal Flow:	1. Firstly, person need to capture his chest x-ray 2. A person which knows how to use the lungs disease detection model 3. Then this x-ray picture given to the model for pneumonia detection 4. A picture is captured by the mobile phone an android application which we developed for this project gives the facility to capture live pictures. And Also we can upload already captured image of an x ray 5. The model extracts the features from the image and then detect the disease.
Alternative Flows: **[Alternative Flow 1 – Not in Network]**	If any error occurs in the software u can contact the developers.

Business Rules	This model is available for every person. This will be available in very cheap rates. The performance of the model is so good. This can help to prevent the lungs disease.

4 Functional Requirements

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.

Table 6 Show the functional requirement template

Identifier	1234
Title	Pneumonia disease detection
Requirement	Description of requirement which may be written either from user or system perspective e.g. If written in **user perspective** The [user class or actor name] shall be able to [do something] [to some object] [qualifying conditions, response time, or quality statement]. If written in **system perspective** [optional precondition] [optional trigger event] the system shall [expected system response]
Source	Where this requirement is come from (who originate it)
Rationale	Motivation behind the requirement
Business Rule (if required)	B2B
Dependencies	Requirements ID that are dependent on this requirement
Priority	High/Medium/Low

5 Non-Functional Requirements

Non-functional requirements define the qualities or attributes that characterize how a system performs its functions. Unlike functional requirements that describe specific features, non-functional requirements focus on aspects such as performance, reliability, usability, and security. Here are some examples of non-functional requirements for a pneumonia detection system:

Performance:

Response Time: The system should provide pneumonia detection results within a maximum response time of 3 seconds.

Reliability:

Throughput: The system should be able to process a minimum of 100 X-ray images per hour.

Availability: The system should be available 99.9% of the time, allowing for scheduled maintenance windows.

Fault Tolerance: In the event of a server failure, the system should continue to operate with minimal disruption, ensuring data integrity.

Scalability:

User Scalability: The system should support a minimum of 100 concurrent users.

Data Scalability: The system should be capable of handling a database size of up to 10,000 patient records.

Usability:

User Interface Consistency: The user interface should maintain a consistent design across all modules for a seamless user experience.

Training Time: Healthcare professionals should be able to use the system with minimal training, with a

maximum training time of one hour.
Security:

Data Encryption: All communication between the system components should be encrypted to ensure the confidentiality of patient data.
Access Control: The system should implement role-based access control to restrict access to sensitive functionalities based on user roles.
Maintainability:

Modifiability: The system architecture should be designed to facilitate easy modifications and updates to accommodate future enhancements.
Documentation: Comprehensive documentation should be provided for system maintenance and troubleshooting.
Compatibility:

Browser Compatibility: The system should be compatible with the latest versions of commonly used web browsers (e.g., Chrome, Firefox, Safari).
Android application: The system should be compatible with the android applictions.
Operating System Compatibility: The system should be compatible with major operating systems (e.g., Windows, Linux, macOS).
Interoperability:

Integration: The system should be capable of integrating with external systems, such as healthcare databases or electronic health record systems.
Regulatory Compliance:

HIPAA Compliance: The system must adhere to Health Insurance Portability and Accountability Act (HIPAA) regulations to ensure the privacy and security of patient information.
Performance Monitoring:

The system should include performance monitoring tools to track resource utilization, identify bottlenecks, and optimize performance.
Data Backup and Recovery:

Regular data backups should be performed, and a robust data recovery plan should be in place to minimize data loss in the event of system failures.
Non-functional requirements are crucial for ensuring the overall success and effectiveness of the system beyond its specific functionalities. They guide the development process and contribute to a system's overall quality and user satisfaction.

5.1 Usability

User Interface Consistency: The user interface should maintain a consistent design across all modules for a seamless user experience.
Training Time: Healthcare professionals should be able to use the system with minimal training, with a maximum training time of one hour.

5.2 Performance

Performance-related non-functional requirements focus on how the system performs in terms of speed, responsiveness, and scalability. Here are examples of performance-related non-functional requirements for a pneumonia detection system:

Response Time:

The system should provide initial results for pneumonia detection within a maximum response time of 3 seconds for 90% of requests.

Throughput:

The system should be able to process a minimum of 100 chest X-ray images per hour during peak usage.

Concurrency:

The system should support a minimum of 100 concurrent users without a significant degradation in performance.

Load Handling:

The system should handle a sudden surge in load, such as increased image uploads, without a substantial increase in response time. This could be specified in terms of expected load spikes or stress testing scenarios.

Scalability:

The system should scale horizontally to accommodate an increasing number of users. This could be defined in terms of the number of servers or instances that can be added to handle growing demand.

Resource Utilization:

The system should efficiently utilize hardware resources (CPU, memory, disk space) to ensure optimal performance and avoid resource bottlenecks.

Caching:

Implement caching mechanisms to reduce response time for frequently requested data, such as preprocessed images or commonly accessed patient records.

Network Latency:

The system should minimize network latency for data transfer between components, especially in scenarios where data is transmitted over a network.

Data Retrieval Time:

The time taken to retrieve patient data for analysis should not exceed a specified limit, ensuring timely access to relevant information.

Data Storage and Retrieval:

Define requirements for efficient storage and retrieval of large datasets, such as chest X-ray images and patient records.

Batch Processing Time:

If applicable, specify the maximum time allowed for batch processing tasks, such as training the machine learning model on new data.

Real-time Processing:

If real-time processing is a requirement, specify the maximum delay allowed between the acquisition of an X-ray image and the display of the detection result.

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