DETECTION AND SEGMENTATION OF PNEUMONIA IN MEDICAL IMAGES USING CONVOLUTIONAL NEURAL NETWORK

PROJECT PRESENTATION

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Introduction to Medical Issue

What is Pneumonia?

- Pneumonia is a lung infection caused by fungi, bacteria, or viruses.
- Affects one or both lungs, causing inflammation in the alveoli (air sacs).
- Alveoli fill with fluid or pus, making breathing difficult.

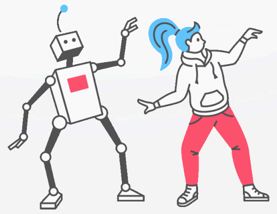
Main Causes: Bacteria & Viruses

General Symptoms: Chest pain, Fever, Cough & Trouble breathing

How is Pneumonia Detected?

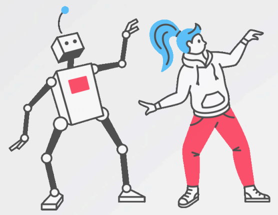
- **Traditional Methods:**
  - Chest X-ray (most common imaging technique)
  - Blood or sputum culture (to identify the cause)
  - Complete Blood Count (CBC) (to check for signs of infection)
  - Advanced lab tests (for complicated cases).
- **Our Approach:** Using Deep Learning with Chest X-ray images to detect pneumonia efficiently and accurately.

Why Use Deep Learning for Pneumonia Detection?



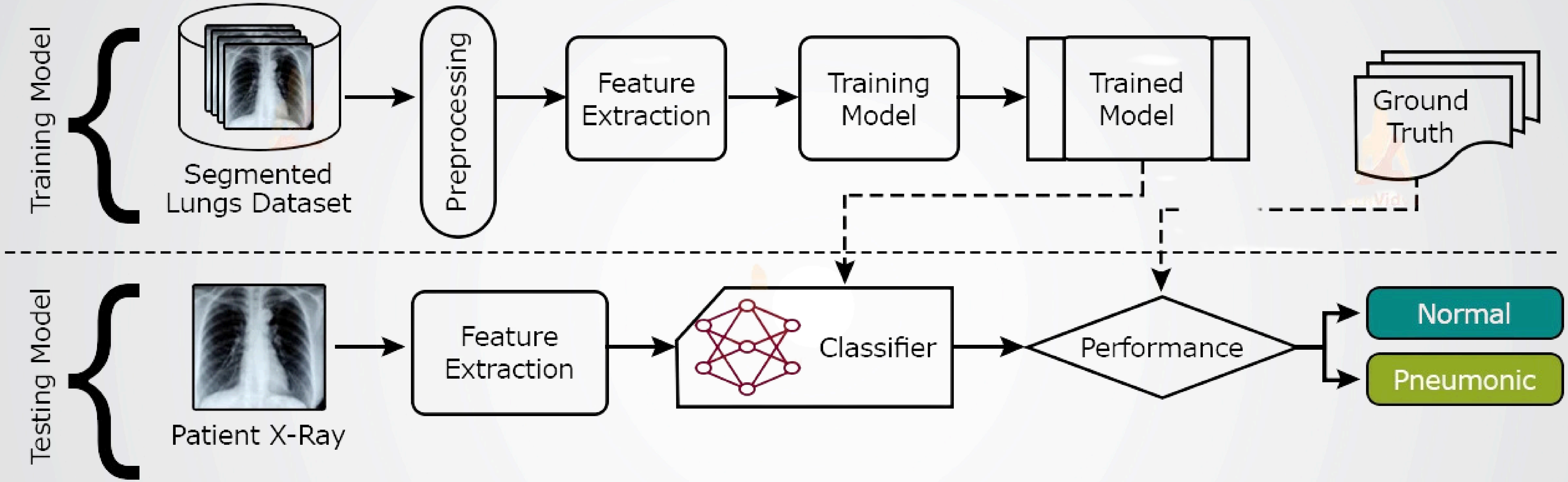
- Efficient Analysis
- High Accuracy
- Cost-effective

Problem Statement



- **Manual Diagnosis Issues:** Traditional X-ray diagnosis is slow, subjective, and prone to human error, especially under high workloads.
- **Public Health Impact:** Delayed or inaccurate diagnosis can lead to severe complications or increased mortality in pneumonia patients.
- **Need for Automation:** Automated tools can provide real-time, consistent, and accurate diagnostic results, reducing dependence on radiologists.
- **Deep Learning Potential:** CNNs are well-suited for image classification tasks and can efficiently learn patterns in medical X-rays.
- **Objective:** Develop a CNN-based model to classify chest X-rays as NORMAL or PNEUMONIA.
- **Outcome:** Enhance healthcare efficiency and accessibility, particularly in resource-limited regions.

About Pneumonia Detection Project



- In this Project, we will detect Pneumonia using Deep Learning. We will create a model that will classify whether the patient is normal or suffering from pneumonia by looking at Chest X-ray images. The algorithm or the model which we will create should be extremely accurate because the lives of people are at stake.

Dataset Overview

- **Source:** The dataset used is the **Kaggle** Chest X-Ray Images Dataset. It is already splitted into train, test, & val.
- **Content:** Includes labeled chest X-ray images classified as NORMAL or PNEUMONIA.

- **Training Data: NORMAL:** 1,341 & **PNEUMONIA:** 3,875
- **Validation Data: NORMAL:** 8 & **PNEUMONIA:** 8
- **Test Data: NORMAL:** 234 & **PNEUMONIA:** 390

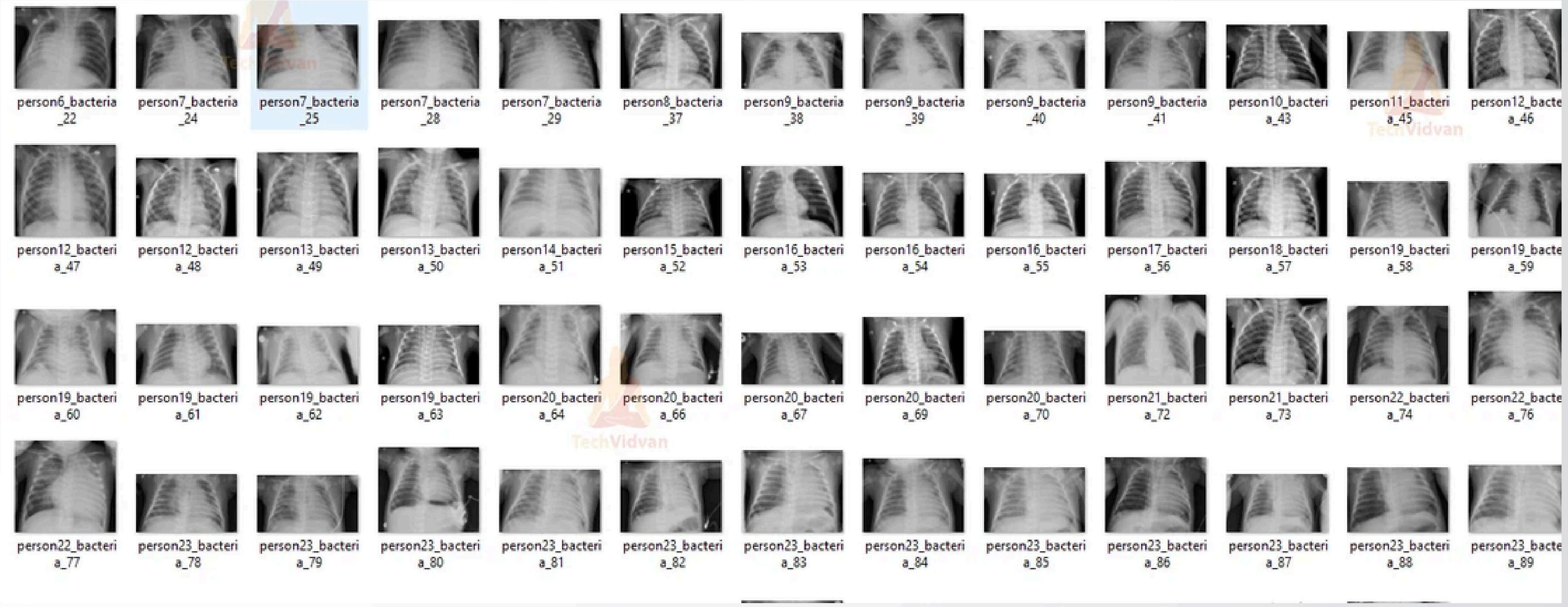
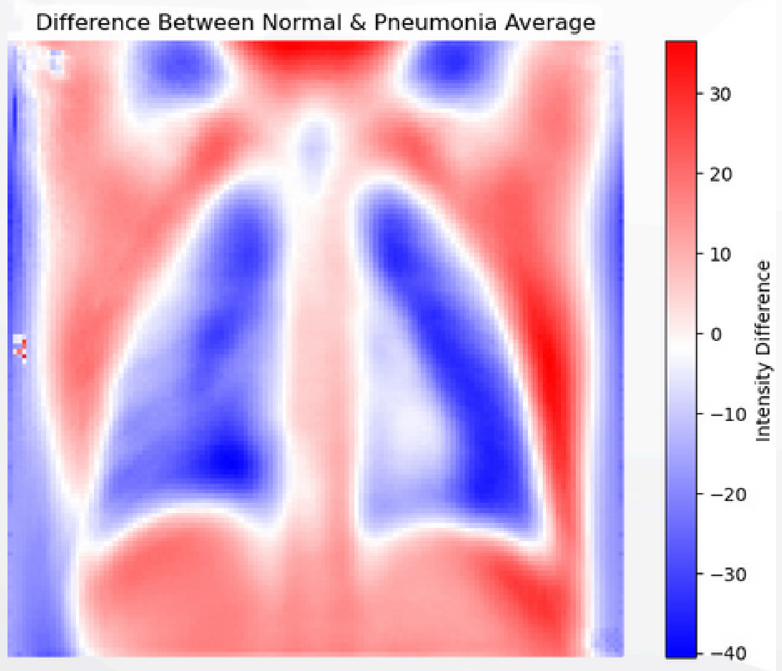


Fig: Dataset Sample



The **heatmap** shows intensity differences between NORMAL and PNEUMONIA chest X-rays: *white* indicates no difference, *red* highlights pneumonia features *(e.g., lung opacity)*, and *blue* emphasizes normal lung structures.

Data Preprocessing

- **Resizing:** All images were resized to 150x150 pixels for *uniformity* in input dimensions to simplifies preprocessing and allows the model to process all data consistently.
- **Normalization:** Pixel values were scaled to the range [0, 1] to stabilize training and improve convergence by dividing the original values (0-255) by 255. It ensures all pixel values are *within* a uniform *range*.
- **Data Augmentation:** Random shear, zoom, and horizontal flips were applied. It artificially introduces diversity into the training dataset by applying random transformations.
- **Tools Used:** Keras's *ImageDataGenerator* dynamically handled resizing, normalization, and augmentation during training.
- **Class Imbalance Handling:** Class weights were used to account for the *imbalance* between unbalanced samples. Assigned higher weights to the minority class (NORMAL) and higher to majority (PNEUMONIA).

```
train_datagen = ImageDataGenerator(
    rescale=1.0 / 255,  # Normalize pixel values to [0, 1]
    shear_range=0.2,  # Random shear transformations
    zoom_range=0.2,  # Random zoom transformations
    horizontal_flip=True  # Random horizontal flipping
```

Model Building

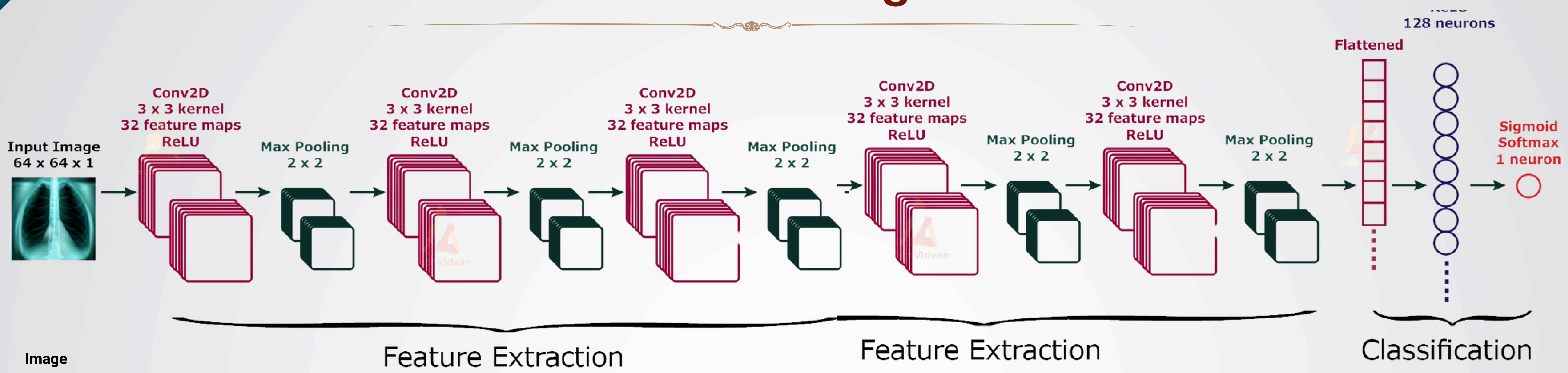


Fig: CNN Model Architecture

Input Layer: Defines the input shape for processing image data.

Convolutional Blocks:

Block 1:
- Low-level features (edges, textures).
- Layers: 2 Conv2D (16 filters), MaxPool2D for down-sampling.

Block 2:
- Intermediate features with stabilization.
- Layers: 2 SeparableConv2D (32 filters), BatchNormalization, MaxPool2D.

Block 3:
- Higher-level features extraction.

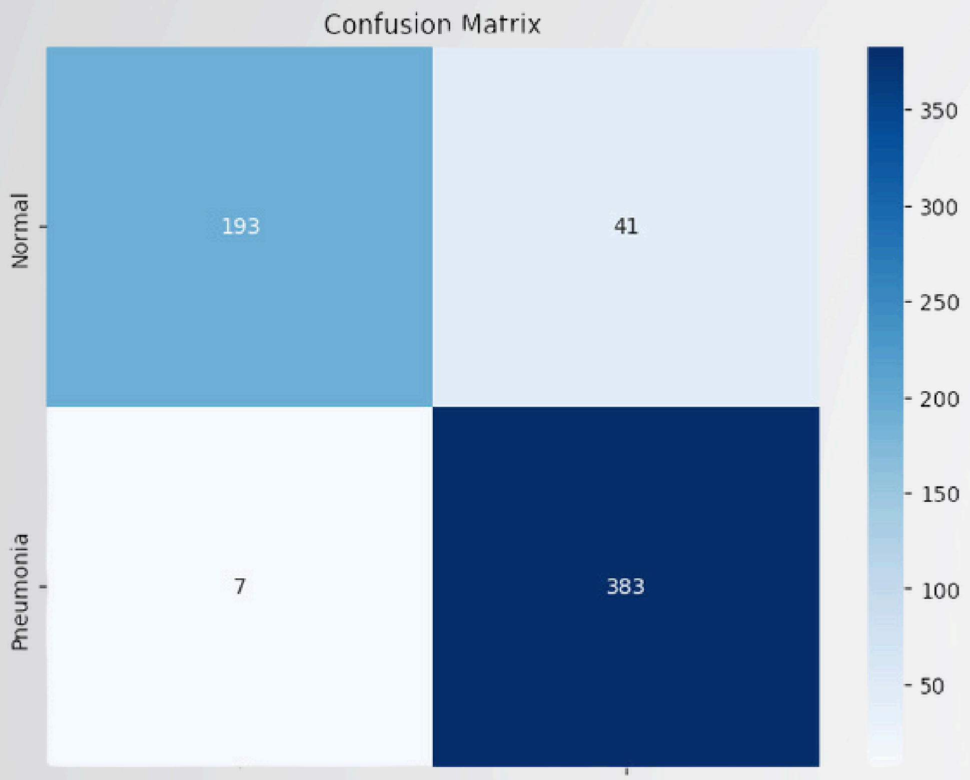
Block 4:
- Advanced features with dropout for regularization.
- Layers: 2 SeparableConv2D (128 filters/kernals), BatchNormalization, MaxPool2D, Dropout (rate=0.2).

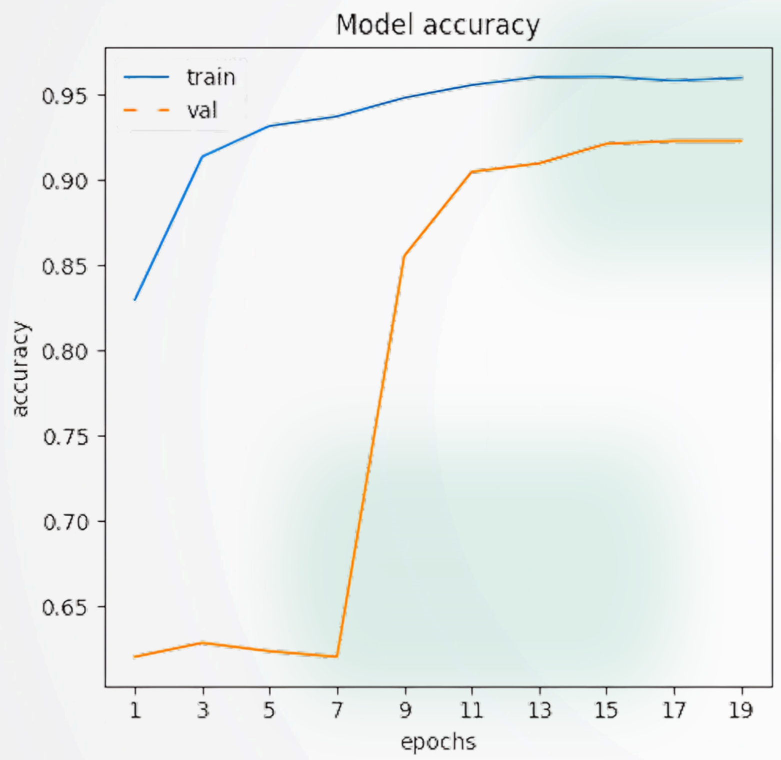
Block 5:
- Abstract features for classification with added regularization.
- Fully Connected Layers: Combines features for decision-making with heavy regularization.

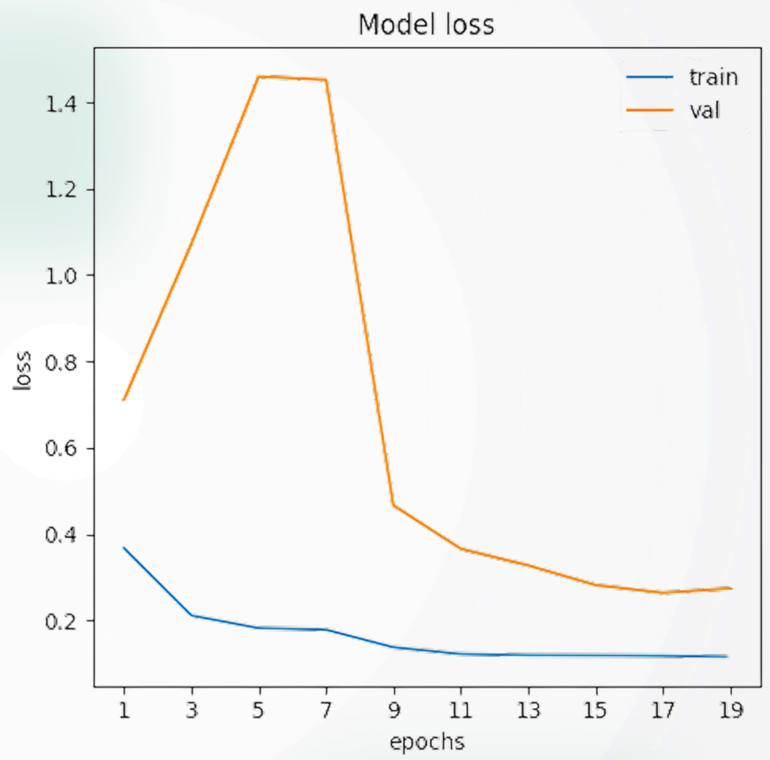
Output Layer:
- Sigmoid Activation: Outputs probability for binary classification
- Maps predictions to [0, 1].

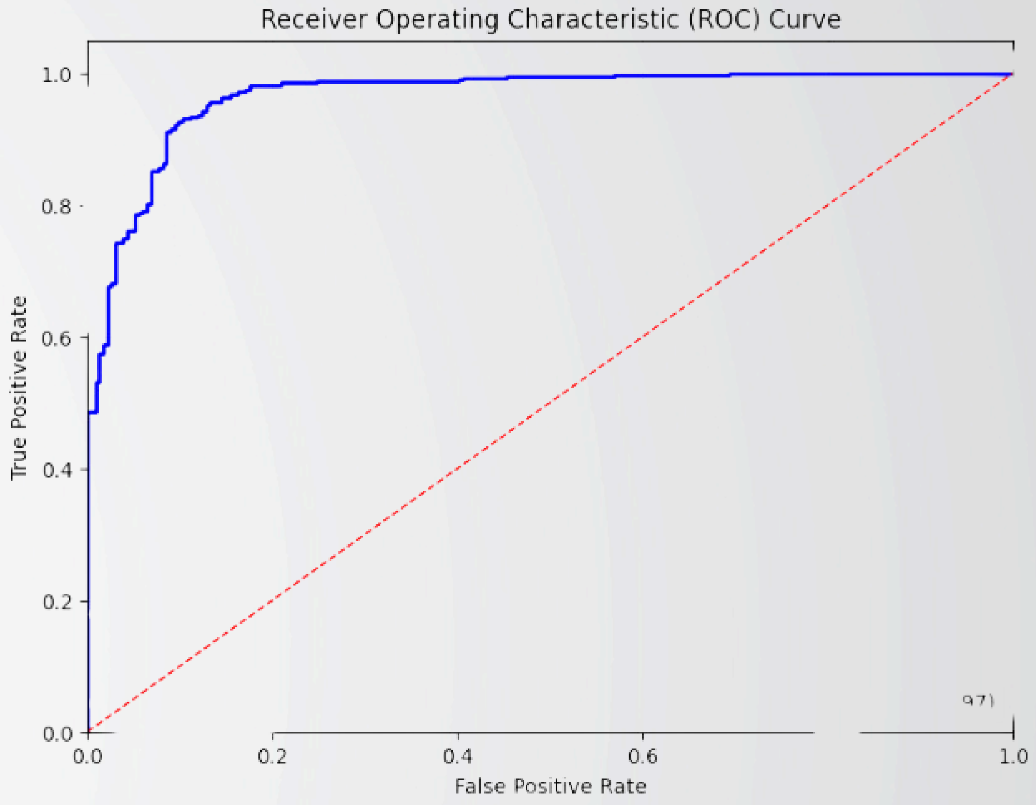
- Conv2D: Detects features like lung edges or abnormalities.
- MaxPooling: Focuses on prominent patterns, like signs of infection or inflammation

Evaluation Metrics



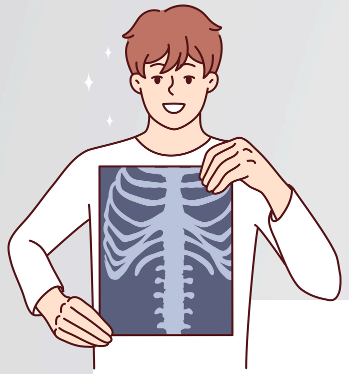


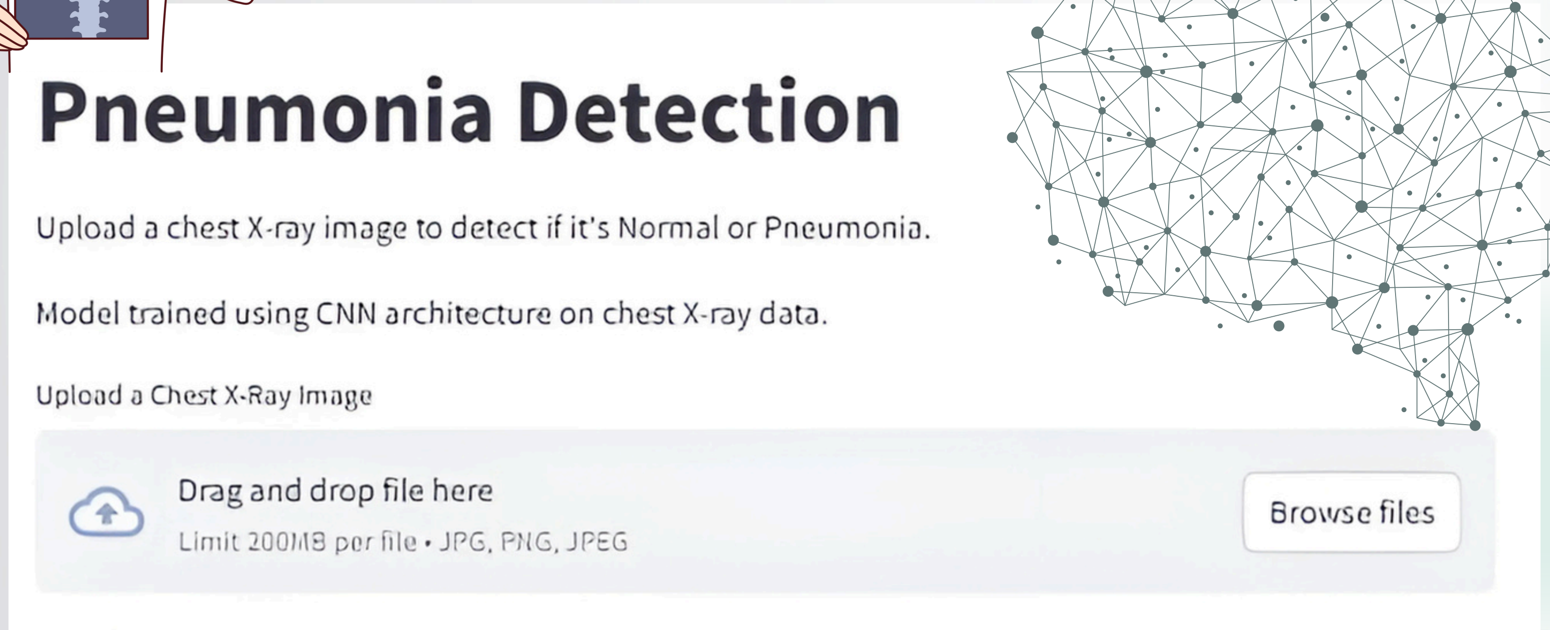


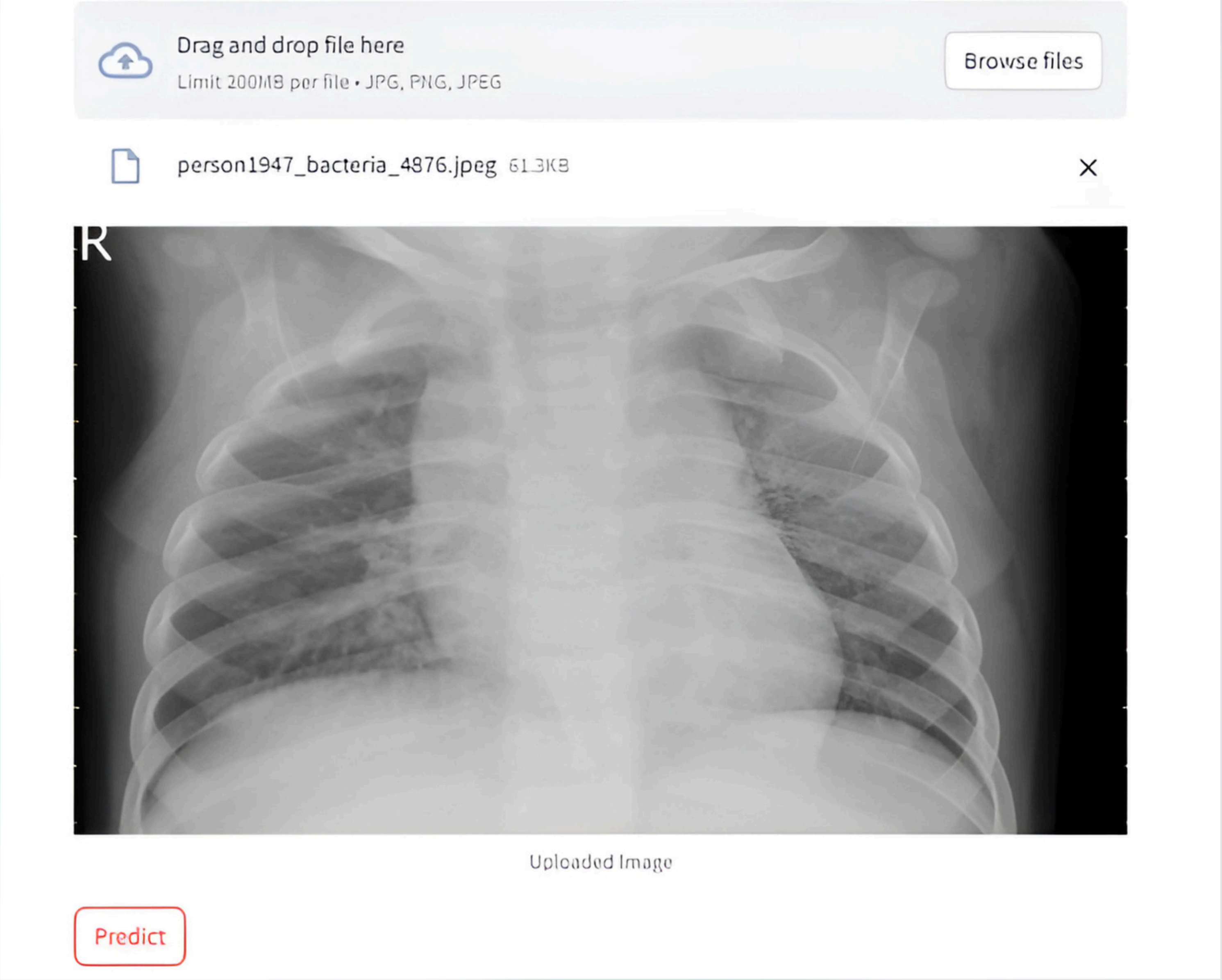


- **Accuracy:** Achieved 92.31%, indicating the model correctly classified most samples.
- **Precision:** Scored 90.33%, showing how well the model identifies pneumonia cases without false positives.
- **Recall (Sensitivity):** Reached 98.21%, highlighting the model's ability to detect most pneumonia cases/ true positives.
- **F1-Score:** Calculated as 0.94, balancing precision and recall to measure overall performance.

Project Outcome

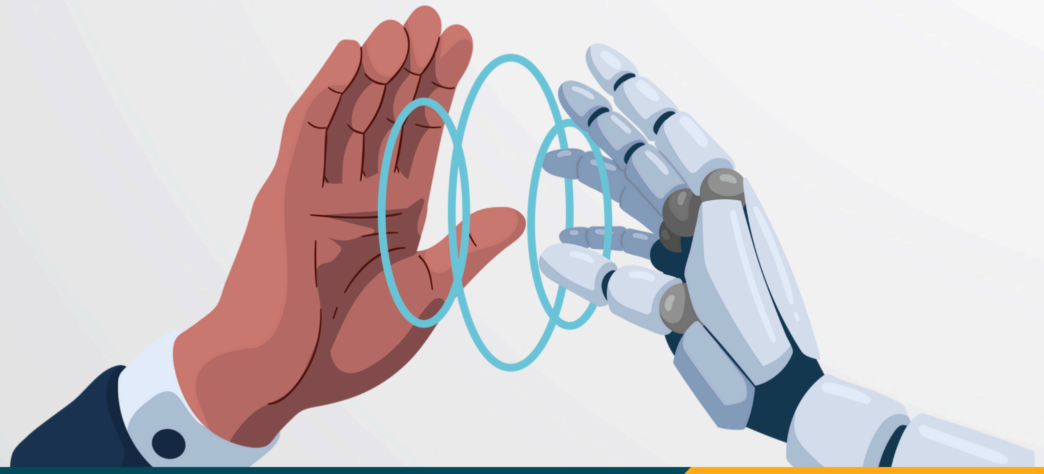






Prediction Probability for Pneumonia: 99.80%

The X-ray indicates Pneumonia.



Conclusion

- This project describes the use of deep learning algorithms using the CNN architecture to classify the dataset consisting of chest X-ray images detect the presence of pneumonia. Many pre-processing techniques are used for increasing the accuracy. As a result, by this approach gave us satisfying results. Accuracy of 92.31% for pneumonia was achieved.

Challenges of the Project

Data Quality and Availability
Imbalanced data, small size, privacy issues, and bias affecting generalization.

Model Overfitting
Mitigated with dropout, early stopping, and data augmentation (shear, zoom, flips).

Computational Requirements
High computational requirements, memory constraints, and long training times pose difficulties in model training and deployment.

Mitigation Strategies
Addressed using class weights for balance, data augmentation to expand training data, dropout for regularization, and early stopping to optimize performance.

Future Work

Expand Dataset and Diversity
Collect larger, diverse datasets from multiple sources to improve robustness and generalization.

Advanced Architectures
Incorporate architectures like ResNet or EfficientNet for improved accuracy and performance.

Integration with Diagnostics
Deploy the model into hospital radiology systems or mobile apps for real-world use.

Model Interpretability
Use Grad-CAM or saliency maps to visualize features influencing model predictions for better clinical trust.

Project Timeline & Work Allocation

Project Start

DAY 1 — Project Kickoff & Dataset Selection
- Kickoff meeting
- Dataset finalization
- Scope finalization

DAY 2 — Data Cleaning & Preprocessing
- Data cleaning
- Data Preprocessing
- Finalize preprocessing

DAY 3 — Exploratory Data Analysis (EDA)
- Data Overview and Initial Visualization
- In-Depth Data Analysis
- EDA Summary and Reporting

DAY 4 — Build CNN Architecture and Train
- Build and Deploy CNN model

DAY 5 — Evaluating Mterices
- Calculated F1 score, Accuracy, Precision, Recall

DAY 6 — Deployment
- Using Streamlit

DAY 7 — Results Analysis and Comparison
- AUC Comparison for All Models
- Final Evaluation and Decision
- Results Summary and Presentation
- Draft the Report

DAY 9 — Final Files Delivery
- Review and Finalize the Report
- Submit Final Report and Documentation

Project Completion

Legend:

- Bharat Dhungana
- Samir Bhandari
- Aravind
- Satish Kandel
- Bikash Thapa

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Team Everest

Thank You

For Your Attention

Any Queries?

We are open for discussion.

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