# Lung Disease Classification from Chest X-Ray Images

Using Deep Ensemble CNNs and a Python Streamlit Interface

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# Project Overview

## ⚠ The Problem

Radiologists face an increasing workload, leading to fatigue and potential diagnostic errors. Manual analysis of Chest X-rays (CXRs) is time-consuming and subjective.

## ◎ The Objective

To build an **end-to-end AI system** that provides:

**Automated "Second Opinion":** High-accuracy multi-class classification.

**Interactive Tool:** A user-friendly web interface for real-time diagnosis.

**Comprehensive Reporting:** Automated generation of medical-grade PDF reports.

## Target Classes

Bacterial Pneumonia  COVID-19  Tuberculosis

Viral Pneumonia  Normal

## Key Technologies

Python  PyTorch  Streamlit  Pandas

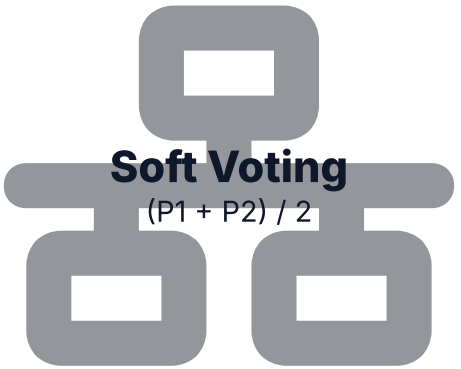
# Methodology: Deep Ensemble Learning

We employed Transfer Learning using three diverse architectures pre-trained on ImageNet. The final predictor is a **Top-2 Soft-Voting Ensemble**.

**DenseNet121**
Feature Reuse, 6.96M Params

**EfficientNet-B0**
Compound Scaling, 4.01M Params

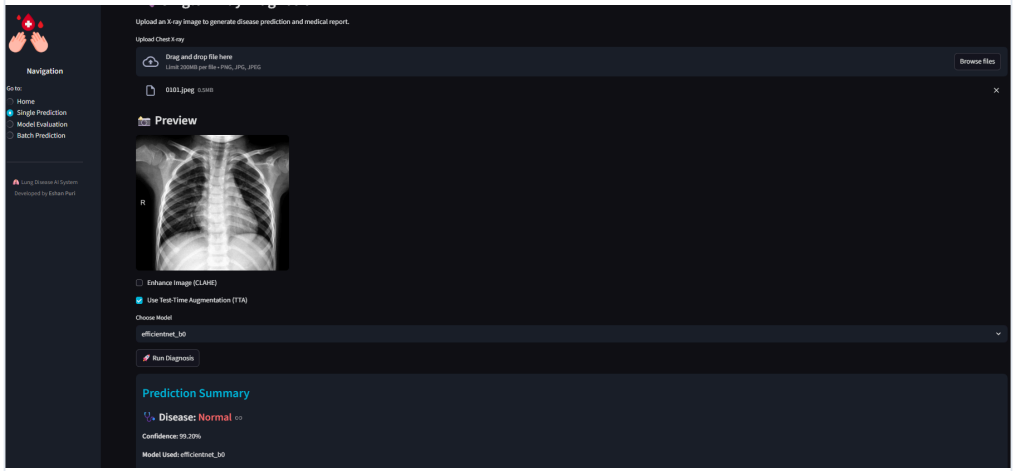
**ResNet50**
Residual Learning, 23.5M Params




## Why Ensemble?

Combines the probabilities of the two best models (DenseNet + EfficientNet) to reduce variance and improve robustness.

# User Interface: Single Prediction




## Key Features

- **Real-time Inference:** Immediate feedback upon image upload.
- **Advanced Options:**
  - *Enhance Image (CLAHE):* For improving contrast in low-quality X-rays.
  - *Test-Time Augmentation (TTA):* Averages predictions of original and flipped images for reliability.
- **Visual Confidence:** Clear display of the predicted class (e.g., "Normal") and confidence score (99.20%).

> **Observation:** The interface abstracts complex model parameters, presenting only clinically relevant data.

# User Interface: Batch Processing

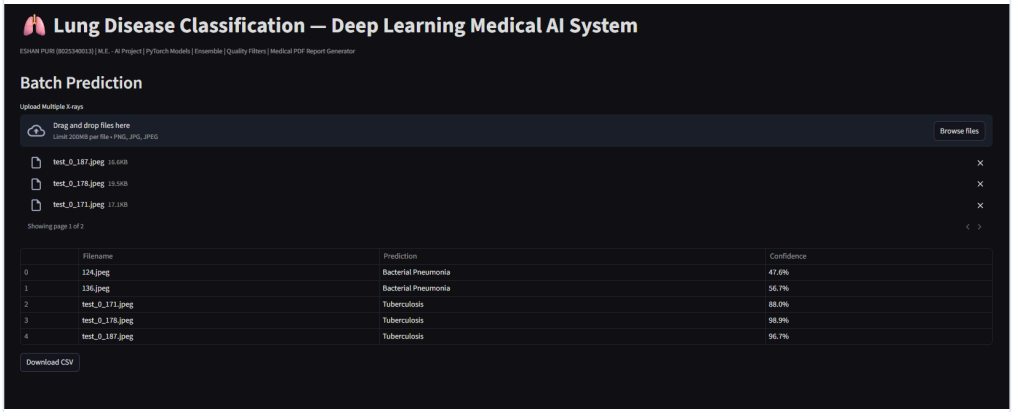
## Simulating Clinical Workflow

Radiologists often need to screen multiple patients rapidly. The **Batch Prediction** module addresses this need.

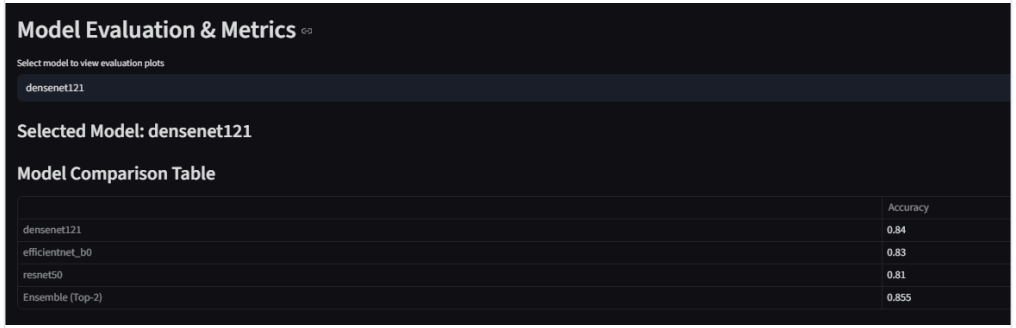
**Bulk Upload:** Supports drag-and-drop for multiple files simultaneously.

**Tabular Results:** Displays Filename, Prediction, and Confidence in a structured table.

**Data Export:** Includes a "Download CSV" feature for offline record-keeping and analysis.




# User Interface: Evaluation & Metrics




### Transparency & Trust

Black-box AI is a barrier to medical adoption. This module provides transparency by exposing performance metrics directly in the app.

- **Dynamic Selection:** Users can select different models (DenseNet, EfficientNet, Ensemble) to compare performance.
- **Live Comparison Table:**
  Ensemble (Top-2): **0.855**
  EfficientNet-B0: **0.83**
  ResNet50: **0.81**
- **Visual Validation:** Displays Confusion Matrices and ROC curves dynamically.

# Error Analysis: Confusion Matrix

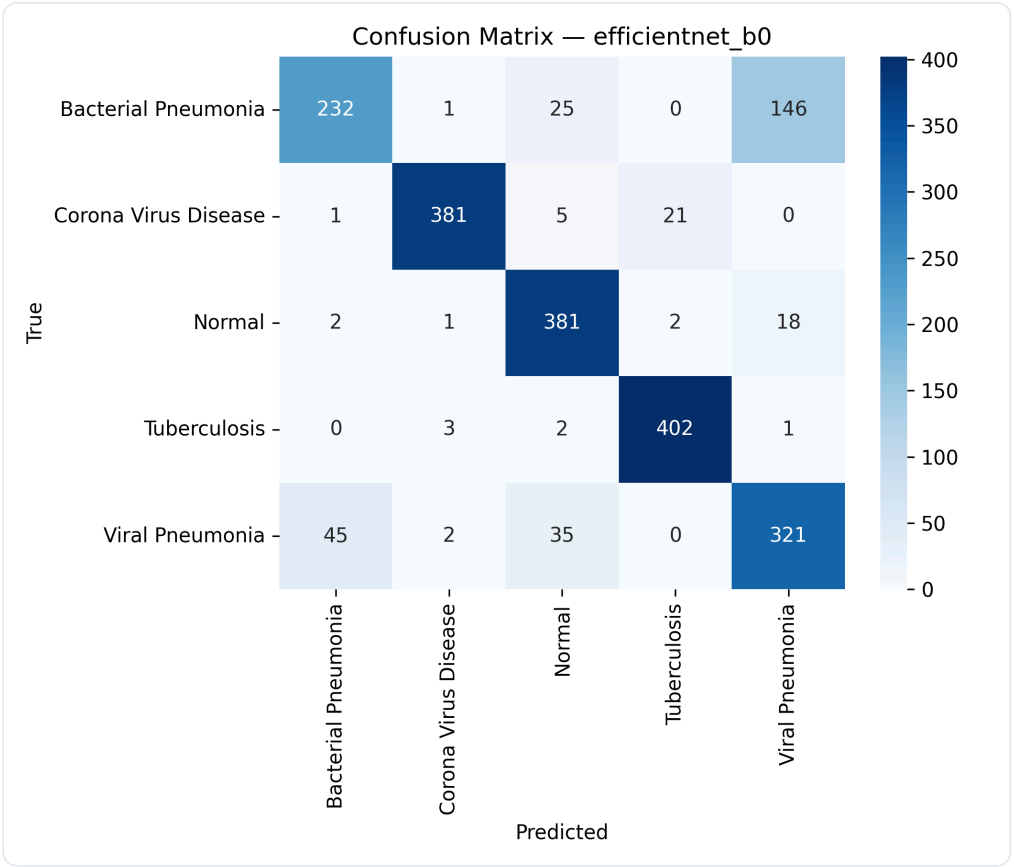
## Performance Breakdown

The confusion matrix for **EfficientNet-B0** reveals critical insights into the model's behavior.

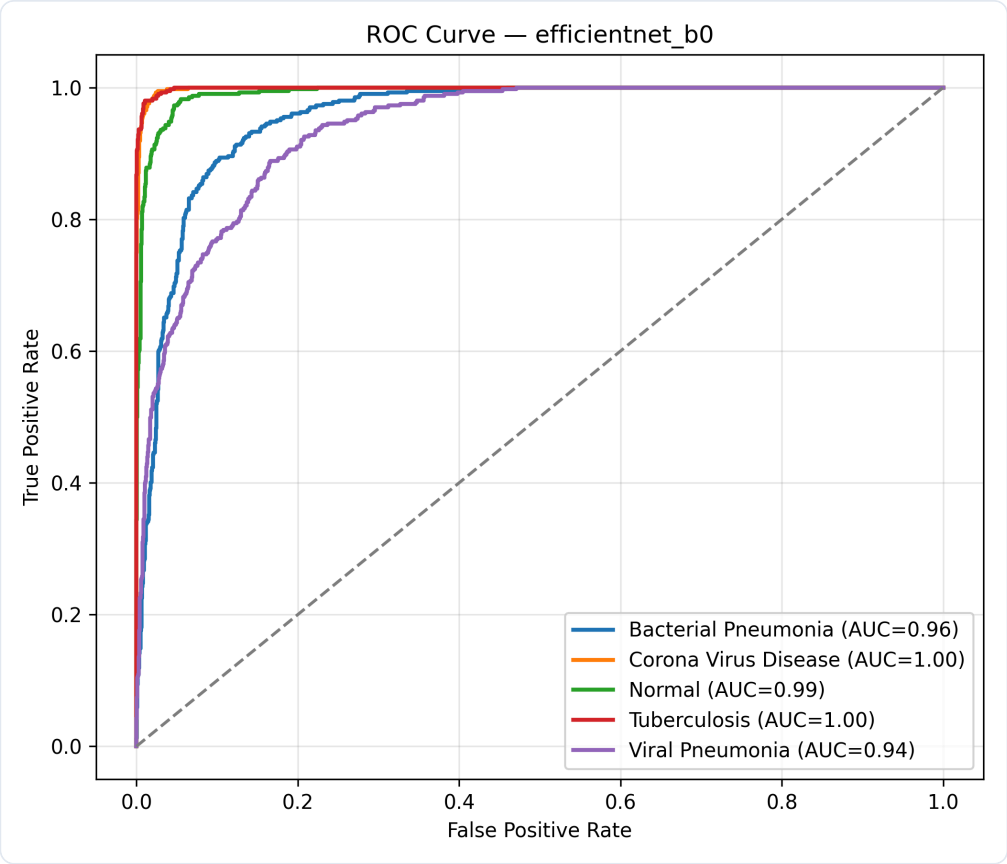
> **The "Viral-Bacterial" Challenge**
> The most significant error source is distinguishing between **Bacterial** and **Viral Pneumonia**.

- **45** Viral cases misclassified as Bacterial.
- **25** Bacterial cases misclassified as Viral.

*Insight: This mimics human expert difficulty, as these conditions share similar radiologic features (lobular consolidation vs interstitial patterns).*




# Discriminative Power: ROC Curve




## AUC Scores

The model exhibits near-perfect separability for distinct diseases.

| Condition | AUC Score |
|---|---|
| Tuberculosis | **1.00** |
| COVID-19 | **1.00** |
| Normal | **0.99** |
| Bacterial Pneumonia | 0.96 |
| Viral Pneumonia | 0.94 |

# Automated Medical Reporting

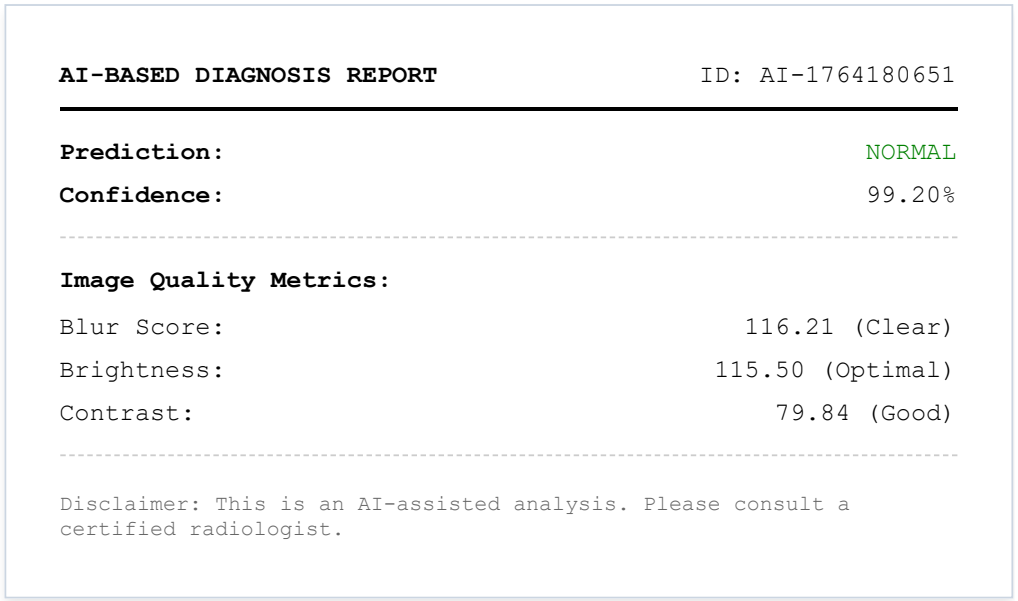
## Standardized Documentation

The system auto-generates a PDF report for every prediction, closing the loop between diagnosis and documentation.

**Patient Metadata:** Auto-generated IDs and Timestamps.

**Quality Checks:** Includes *Blur Score*, *Brightness*, and *Contrast* to ensure the X-ray was readable.

**Disclaimer:** Explicitly states this is an AI-assisted analysis, not a final diagnosis.



**AI-BASED DIAGNOSIS REPORT** ID: AI-1764180651

**Prediction:** NORMAL

**Confidence:** 99.20%

**Image Quality Metrics:**

Blur Score: 116.21 (Clear)

Brightness: 115.50 (Optimal)

Contrast: 79.84 (Good)

Disclaimer: This is an AI-assisted analysis. Please consult a certified radiologist.

# Conclusion & Impact

## Summary

This project demonstrates the power of Python in creating a **holistic medical AI solution**. By moving beyond simple model

training to full-stack deployment, we bridge the gap between research and clinical utility.

### Future Scope

- **Explainability:** Integrate Grad-CAM heatmaps into the PDF report.
- **Feedback Loop:** Allow radiologists to correct predictions to retrain the model (Active Learning).
- **New Architectures:** Experiment with Vision Transformers (ViT).

85.4%

Final Ensemble Accuracy