PROJECT ABSTRACT

Tuberculosis Detection using Chest X-Rays

DenseNet121 transfer-learning classifier that flags TB manifestations in chest X-rays, trained on Shenzhen and cross-tested on Montgomery County data — delivered as a built-to-order student project (research prototype, not a medical device).

01. Title

Tuberculosis Detection using Chest X-Rays

02. Introduction / Background

Tuberculosis remains among the top infectious killers globally, and chest X-rays are the frontline screening tool where sputum testing is slow or unavailable. Reading screening films for TB patterns — apical nodules, cavitation, fibrotic streaking — requires trained radiologists who are in short supply in high-burden regions. The U.S. National Library of Medicine released two public chest X-ray collections for exactly this research (Shenzhen and Montgomery County), making TB detection a classic, well-scoped student deep-learning project. This build fine-tunes DenseNet121 on these sets with honest cross-institution evaluation. Medical-prototype disclaimer: this project is an academic prototype and is not a diagnostic or clinical device. It requires oversight by qualified medical professionals and is never a substitute for clinical diagnosis.

03. Problem Statement

TB screening programs generate far more chest films than available radiologists can read, so cases wait and infectious patients go undetected. A model trained on one hospital's data often degrades on another's — the central practical problem. The project builds a TB classifier and evaluates it across institutions (Shenzhen <-> Montgomery), documenting the generalization gap openly rather than reporting only in-distribution scores.

04. Objectives

- Fine-tune DenseNet121 (ImageNet backbone) on the Shenzhen TB X-ray set (662 CXRs: 336 TB / 326 normal) for TB-vs-normal classification.
- Evaluate cross-institution on the Montgomery County set (138 CXRs: 58 TB / 80 normal), with a design target of ~0.85+ AUC in-distribution.
- Implement a lung-segmentation pre-step (U-Net masks) so the classifier sees lung ROIs rather than raw films.

- Build a demo app with classifier, attention map and cross-dataset comparison views.
- Deliver the complete student kit: source code, trained weights, report, PPT and viva Q&A document.

05. Proposed Methodology

The system has four stages. (1) Preprocessing: PNG/DICOM load, U-Net lung segmentation and ROI cropping, CLAHE contrast enhancement, resize to 512x512, ImageNet normalization. (2) Training: DenseNet121 with a dropout + sigmoid head, class-weighted binary cross-entropy, AdamW optimizer, two-phase unfreezing (head first, then deeper dense blocks), augmentation with small rotations, flips and elastic distortion. (3) Evaluation: patient-level splits plus the honest cross-institution protocol — train on Shenzhen, test on Montgomery and vice versa — reporting AUC, sensitivity at 90% specificity and F1. (4) Demo: the web app shows predictions with attention overlays and a comparison view of both datasets.

06. System Architecture / Working

Chest X-ray -> U-Net lung mask -> crop to lung ROI -> CLAHE -> resize 512x512 -> DenseNet121 (fine-tuned) -> global average pooling -> dropout -> sigmoid -> P(TB). Grad-CAM-style attention from the final dense block is upsampled and overlaid on the radiograph so reviewers can see which regions (typically the upper lobes) drove the decision. A pattern checklist annotates the radiographic findings shown in the demo.

07. Hardware / Software Requirements

- Python 3.10, PyTorch (torchvision DenseNet121), OpenCV, NumPy, pandas
- scikit-learn (metrics, splits), Matplotlib/Seaborn (curves, ROC)
- Flask demo web app (classifier + attention + dataset comparison views)
- GPU recommended for training (512x512 inputs); 12 GB RAM suggested

08. Expected Outcomes

A trained TB classifier with a design target of ~0.85+ AUC in-distribution and documented cross-institution scores, a working demo with attention overlays, ROC and sensitivity-at-fixed-specificity analysis in the report, and full documentation. All figures are measured in the buyer's own training run. The system is an educational research prototype, not a diagnostic device.

09. Applications

- Teaching material for transfer learning, domain shift and medical-image evaluation protocols
- Demonstration of cross-institution generalization testing

- Prototype screening-triage interface for radiology training (non-clinical)
- Reference build for other chest X-ray screening tasks

10. Future Scope

- Multi-class TB manifestation typing (cavitation, effusion, miliary)
- TB-consistent ROI segmentation with weak localizations (U-Net)
- Ensembling across Shenzhen + Montgomery + Belarus TB sets
- Integration with sputum-test workflows (clinical-grade extension, requires certification)