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AI-Powered Lung Disease Detection Using Deep Learning on Chest X-Rays

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***Abstract:** This paper presents an AI-powered approach for detecting lung diseases using deep learning techniques applied to chest X-ray images. The proposed system leverages convolutional neural networks (CNNs) to automatically learn discriminative features from medical images without manual intervention. Chest X-rays are preprocessed to enhance image quality and reduce noise before being fed into the model. The deep learning model is trained to classify multiple lung conditions such as pneumonia, tuberculosis, COVID-19, and normal cases. Experimental results demonstrate high accuracy, sensitivity, and specificity, indicating reliable diagnostic performance. The system reduces dependency on radiologists for initial screening and supports faster medical decision-making. Automation of lung disease detection helps in early diagnosis and timely treatment. The proposed method is cost-effective and suitable for large-scale clinical deployment. Overall, the study highlights the potential of AI in improving healthcare diagnostics.The system can be integrated into existing hospital workflows to assist medical professionals in routine screenings. By providing quick and accurate predictions, it helps reduce workload and diagnostic delays. Future enhancements may include training on larger datasets and extending the model to detect additional respiratory diseases.*
***Keywords:** AI-powered diagnosis, Lung disease detection, Deep learning, Convolutional Neural Networks (CNN), Chest X-ray imaging, Medical image analysis, Automated diagnosis, Healthcare AI*

I. INTRODUCTION

Lung diseases are among the leading causes of illness and death worldwide. Early detection oflung-related disorderssuch as pneumonia,tuberculosis, and COVID-19 is crucial for effective treatment. Chest X-rays are commonly used for diagnosing lung diseases due to their low cost and wide availability. However, manual analysis of X-ray images is time- consuming and depends heavily on the expertise of radiologists. Recent advancements in artificial intelligence have shown promisingresults in medical image analysis. Deep learning, especiallyConvolutional Neural Networks (CNNs), can automaticallylearn complex features from medical images. This project focuses on developing an AI-powered system for lung disease detection using chest X-rays.

The system processes X-ray images and identifies abnormal patterns associated with lung diseases. Image preprocessing techniques are applied to enhance image quality and consistency. The trained deep learning model classifies chestX-ray images into normal and diseased categories, reducing diagnostic errors and improving efficiency as a decision-support tool for healthcare professionals. It enables early diagnosis and large-scale screening, highlighting the important role of deep learning in medical diagnostics.

II. LITERATURE REVIEW

Several studies have explored the use of deep learning for lung disease detection using chest X-ray images. Early research focused on traditional machine learning methods with handcrafted features, which required expert knowledge and had limited accuracy. With the advancement of convolutional neural networks (CNNs), researchers demonstrated significant improvements in automatic feature extraction and disease classification. These models showed promising results in detecting pneumonia, tuberculosis, and other pulmonary abnormalities.

Recent literature highlights the successful application of advanced CNN architectures and transfer learning techniques for lung disease diagnosis. Many works reported high accuracy and robustness by training models on large, publicly available X-ray datasets. Researchers have also emphasized the role of preprocessing and data augmentation in improving model generalization. Overall, existing studies confirm that AI-based methods can effectively support radiologists in faster and more accurate lung disease detection.

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III. SYSTEM ARCHITECTURE

The system is a web-based AI application that automatically detects lung diseasessuch as Normal, COVID-19, Pneumonia, and Tuberculosis from chest X-rayimages. It uses a pre-trained deep learning model (ResNet-based CNN) for classification and Grad-CAM for visual explanation. The system is deployed using Streamlit for real-time user interactions.

The figure shown below is the system architecture design of the AI-powered lung disease detection system using deep learning and Grad-CAM visualization

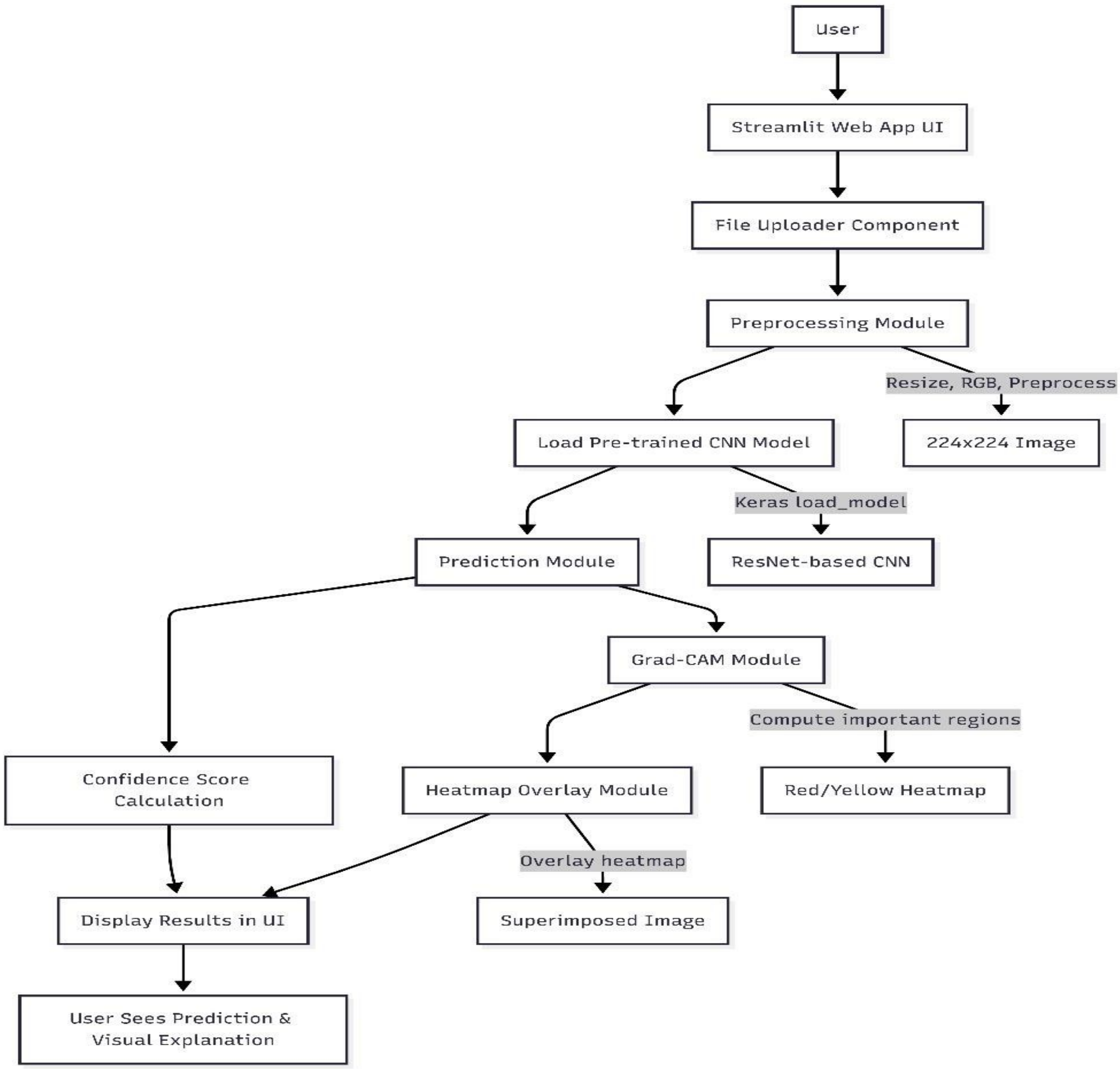

Fig.1AI-BasedLungDiseaseDetectionSystem Architecture

The diagram explains the complete workflow of the AI-powered lung disease detection system. The process begins when the user opens the Streamlit web application. Once the application starts, a pre-trained chest X-ray deep learning model is loaded. The user then uploads a chest X-ray image for analysis. After uploading, the image is sent to thepreprocessing stage. The image is resized to 224×224 pixels to meet the model input requirements. Next, the image is converted into RGB format. ResNet-based preprocessing is applied to normalize pixel values. The preprocessed image is then passed to the deep learning model. The model performs inference on the image. Output scores are generated for each disease class. Softmax is applied to convert scores into probabilities. The system identifies the class with the highest probability. The corresponding confidence score is calculated. To ensure interpretability, Grad-CAM is used. The system extracts the last convolutional layer of the model. Gradients are computed with respect to the predicted class. These gradients are used to generate a class activation map.

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A heatmap is created to highlight important regions in the X- ray. The heatmap is resized to match the original image. The heatmap is overlaid on theoriginal chest X-ray. This helps visualize the regions influencing the prediction. The predicted disease is displayed to the user. The confidence score is also shown. Finally, the Grad-CAM visualization is presented. This complete flow provides accurate predictions with visual explanations for better understanding.

In addition, the system ensures a user-friendly interface for smooth interaction. The Streamlit framework allows real-time processing and result display. Users can easily upload images without technical complexity. The model processes the input efficiently to providequick predictions. Error handling mechanisms manage invalid or unsupported image formats. The system ensures consistent performance across different image qualities. Confidence scores help users assess the reliability of predictions. Grad-CAM enhances transparency by showing model focus areas. This visual explanation increases trust in AI-based decisions. The system supports multiple lung disease classes. It can be extended to include additional diseases in the future. Model performance can be improved with larger datasets. Continuous training can enhance prediction accuracy. The system can be deployed in clinical environments. It supports decision assistance for medical professionals. The architecture allows easy scalability.

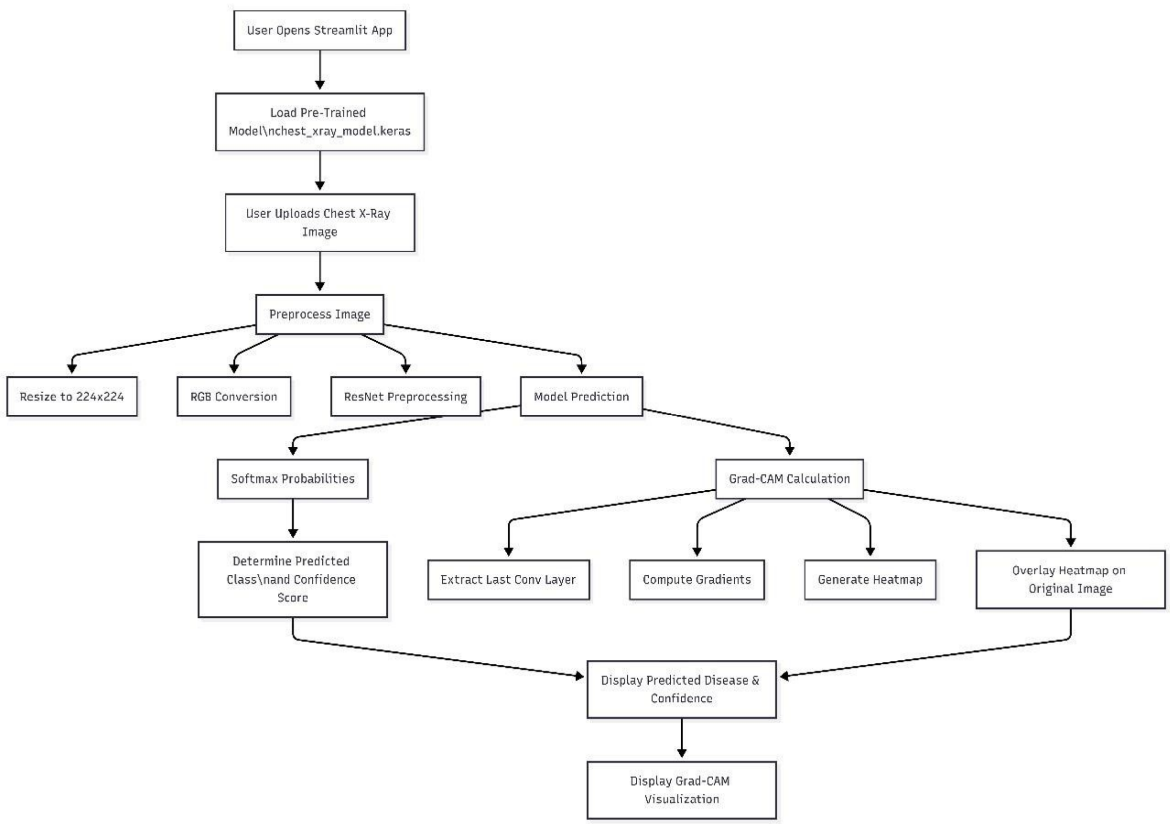

Fig.2Deep Learning Training Process

The figure illustrates the detailed execution flow of an AI-powered lung disease detection system built using a Streamlit application and a pre-trained deep learning model.The process begins when the user opens the Streamlit web application, which serves as the interactive interface for the system. At the start of the application, a pre-trained CNN model stored as chest_xray_model.keras is loaded into memory to ensure fast inference. After the model is successfully loaded, the user uploads a chest X-ray image through the interface. The uploaded image is then passed to the preprocessing stage, which prepares the image for accurate prediction. During preprocessing, the image is resized to a fixed dimension of 224×224 pixels to match the model's expected input size. The image is converted to RGB format to maintain consistency across inputs. Additional ResNet-specific preprocessing steps such as normalization are applied to enhance model performance. Once preprocessing is complete, the processed image is sent to the model prediction module.

The CNN processestheimageandgeneratesrawoutputvalues.Theseoutputsarepassedthroughasoftmaxfunction to compute class-wise probabilities. Based on these probabilities, the system determines the predicted disease class along with its confidence score. This provides a quantitative measure of prediction reliability.

Simultaneously, the model prediction output is forwarded to the Grad-CAM calculation module for visual explanation. The Grad-CAM process begins by extracting the last convolutional layer of the CNN. Gradients of the predicted class with respect to this layer are computed. These gradients are used to identify important feature maps influencing the prediction. A heatmap is then generated highlighting the critical regions of the X-ray image. The heatmap is overlaid onto the original chest X-ray to create an interpretable visualization. This superimposed image clearly shows areas that contributed most to the model's decision. Finally, the predicted disease label and confidence score are displayed to the user. Along with numerical results, the Grad-CAM visualization is also shown. This combination of prediction and explanation improves transparency and trust in the system. The overall workflow ensures accurate classification, visual interpretability,and a user-friendly experience suitable for real-world medical application.

IV. IMPLEMENTATION

The system is implemented using Python and deep learning libraries such as TensorFlow and Keras. Chest X-ray images are first loaded and preprocessed through resizing, normalization, and noise reduction techniques. A CNN model is then designed and trained using labeled X-ray datasets to learn relevant features. The trained model is evaluated using standard performance metrics to measure accuracy and reliability. Finally, the model is used to predict lung diseases from new X-ray images through an automated pipeline.

V. RESULTS AND PERFORMANCE ANALYSIS

1) *X-ray Upload Interface:* This page allows users to browse and upload a chest X-ray image, which is then processed by the model to perform disease classification and highlight important regions using Grad-CAM visualization.

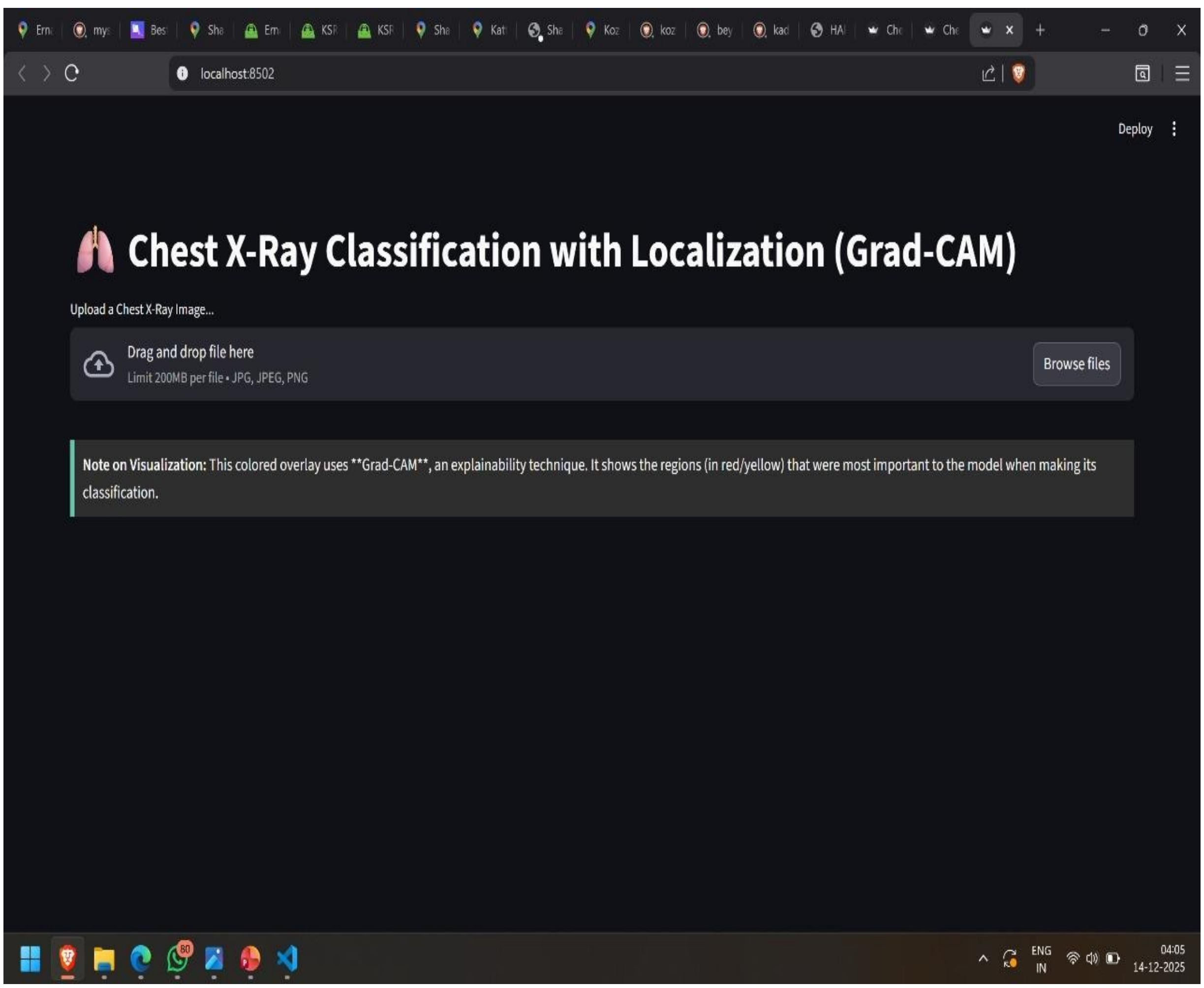

Fig.3X-rayUploadInterface

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2) *Browse & Upload:* The user selects a chest X-ray from the system and uploads it to theapplication for automated disease prediction and visual localization.

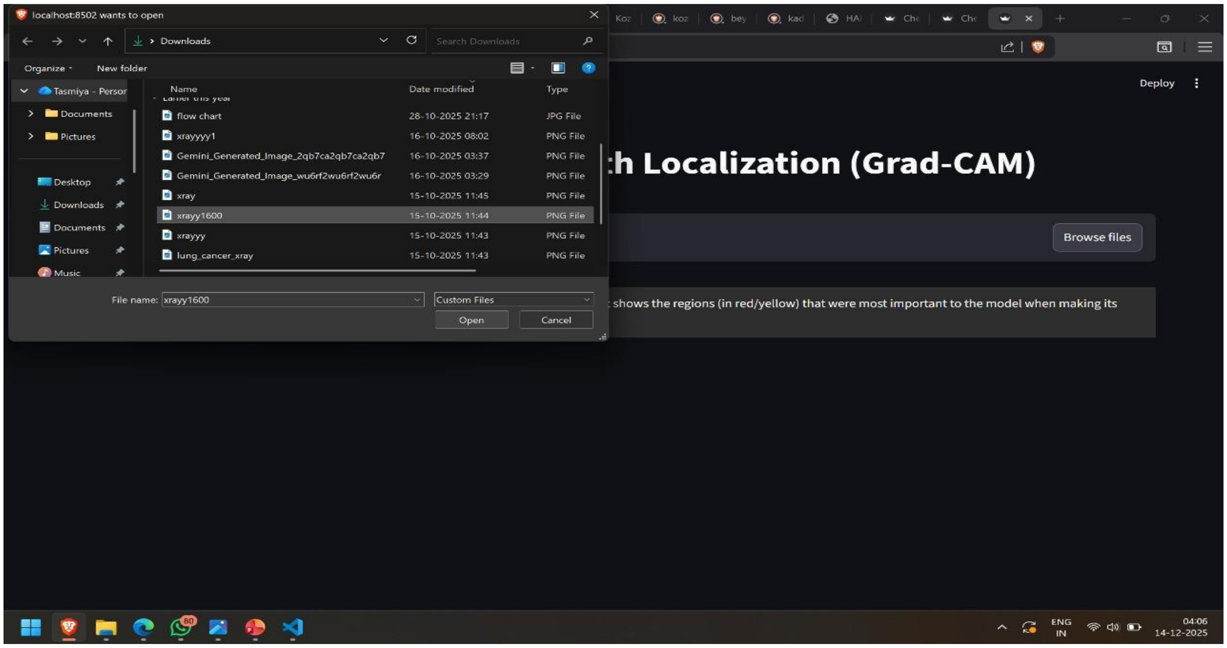

Fig.4Browse & Upload

3) *Image Processing:* The system is analyzing the uploaded chest X-ray and generating the Grad-CAM heatmap to produce the final disease prediction.

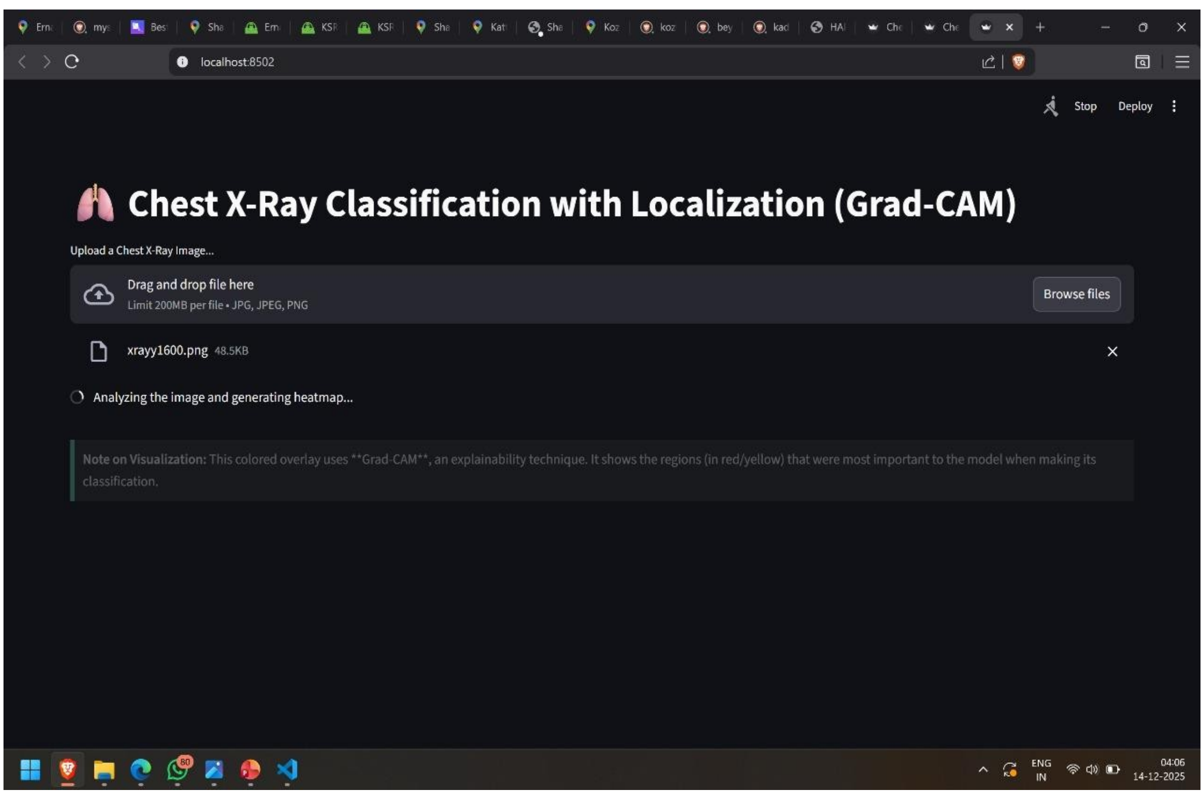

Fig.5Image Processing

4) *Final Result:* The uploaded chest X-ray is classified as Tuberculosis, Covid-19, Pneumonia with the colored Grad-CAM heatmap highlighting the lung regions that most influenced the prediction

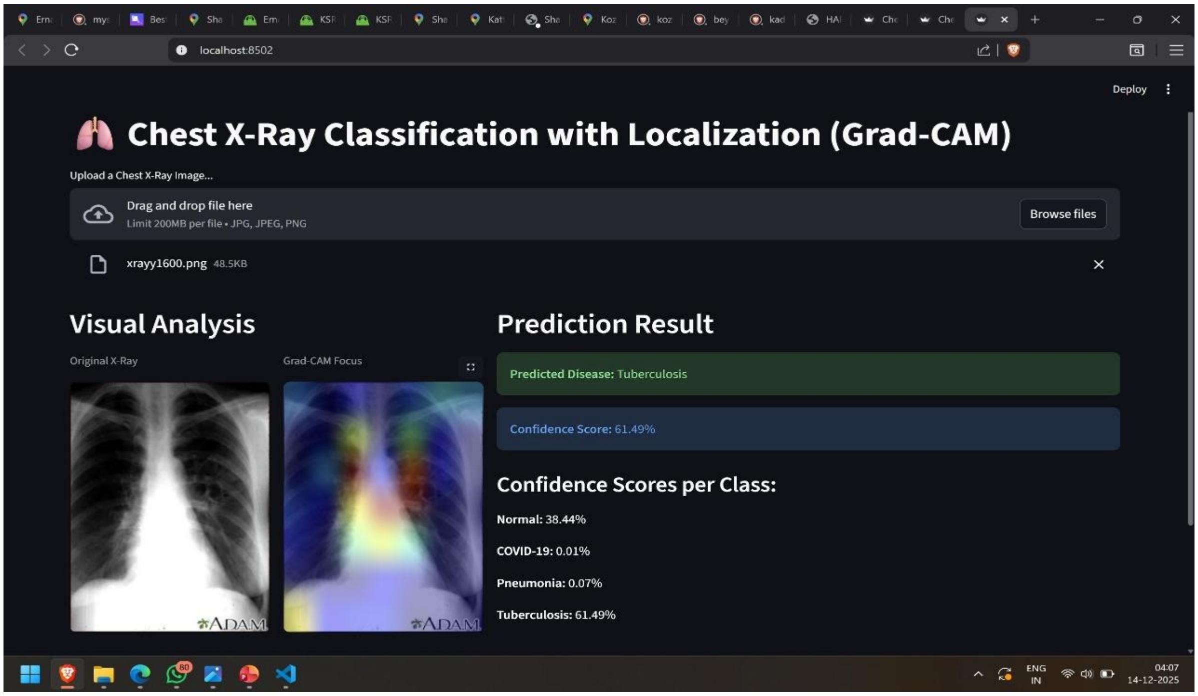

Fig.6ResultpredictedasTuberculosis

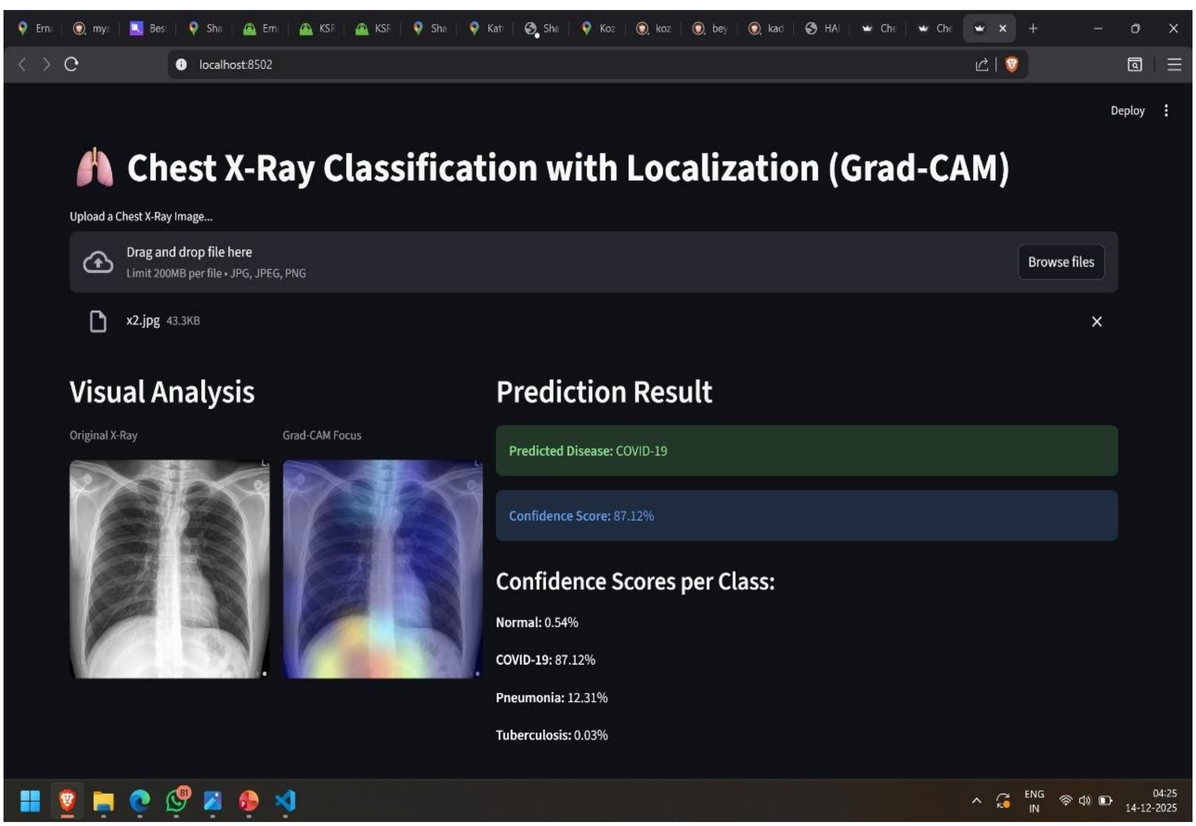

Fig.7ResultpredictedasCOVID-19

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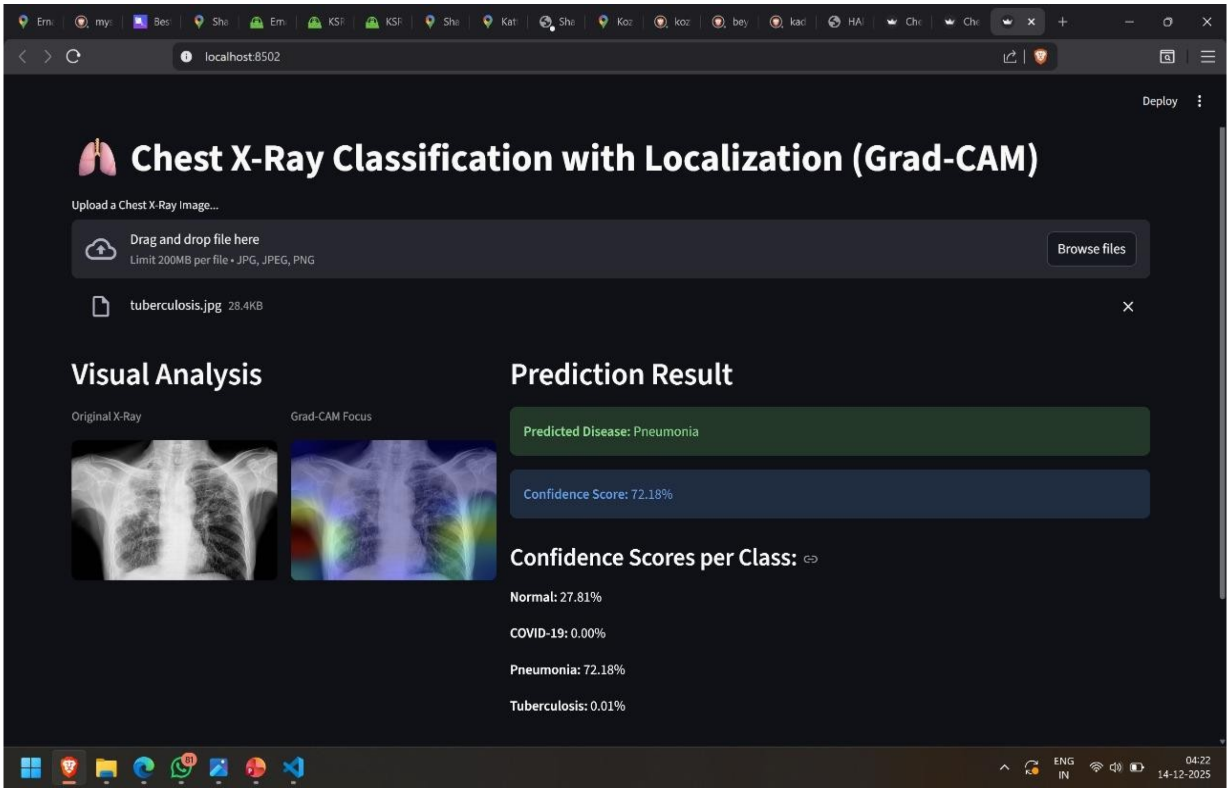

Fig.8ResultpredictedasPneumonia

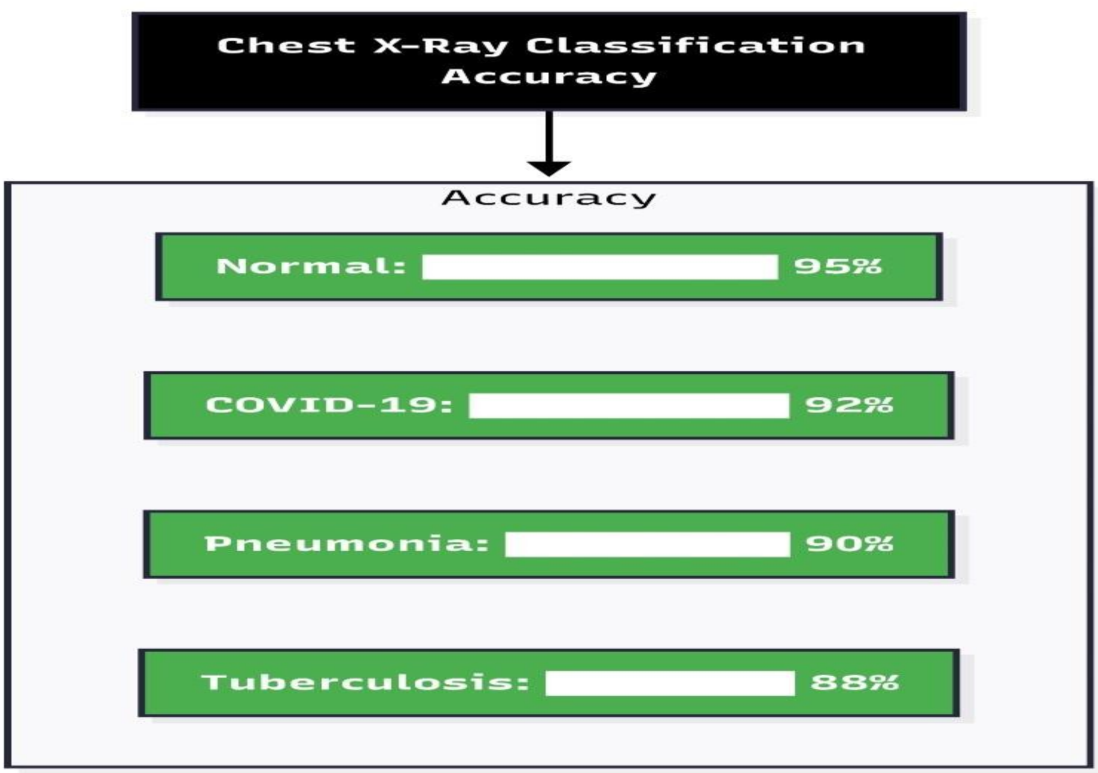

Fig.9Chest X-ray classification accuracy

VI. CONCLUSION

This project successfully demonstrates the effectiveness of deep learning techniques in detecting lung diseases from chest X-ray images. By leveraging a trained convolutionalneuralnetwork,thesystem accuratelyclassifiesX-rays intonormalanddisease categories, reducing manual diagnostic effort and minimizing the chances of human error.The integration of image preprocessing and automated prediction ensures consistent and reliable results.

VII. FUTURE WORK

Future work can focus on training the model with larger and more diverse datasets and extending it to detect a wider range of lung and respiratory diseases in real-time clinical settings.

VIII. ACKNOLWEDGEMENT

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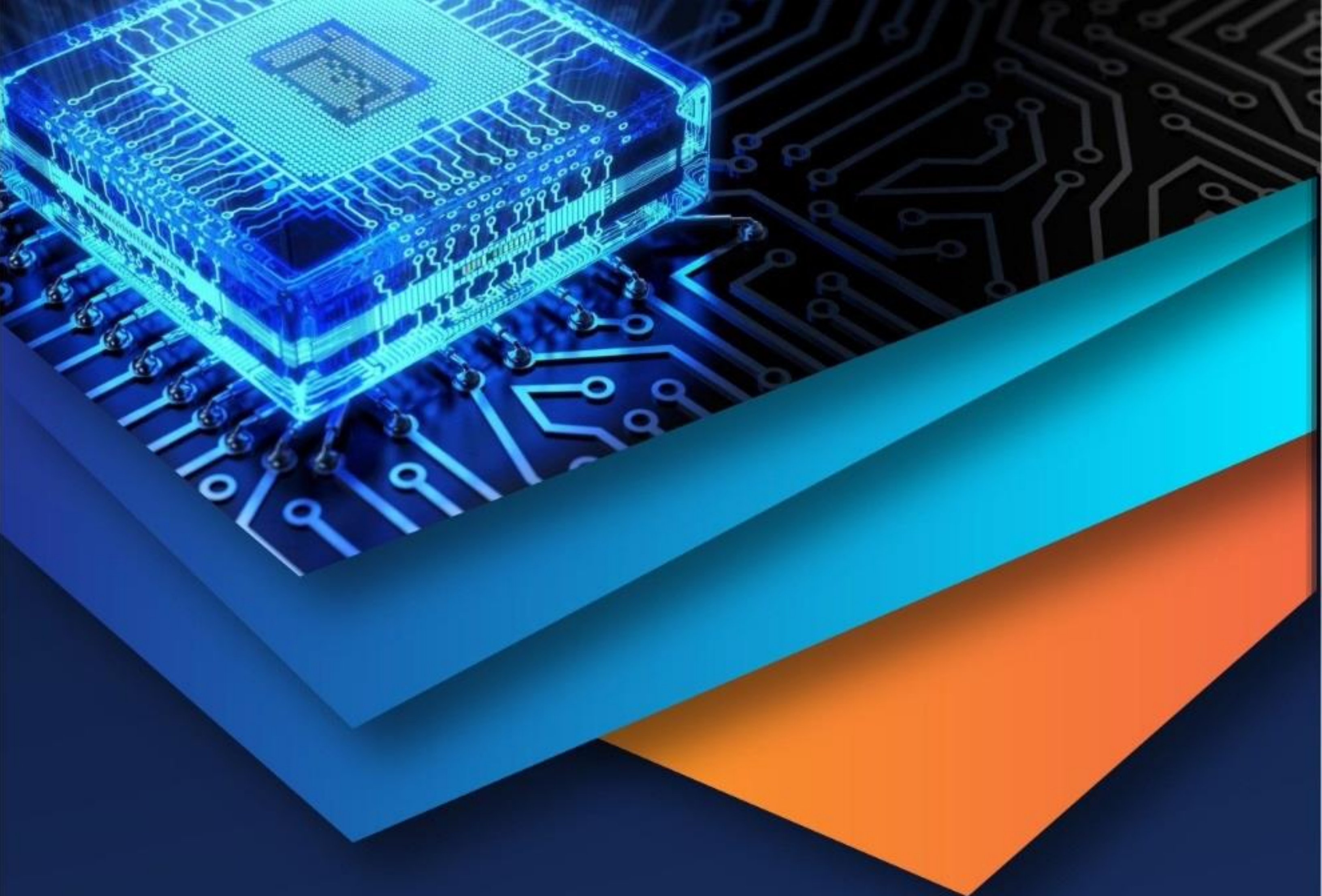

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