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Detection and Classification of Pneumonia Using Explainable AI

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Abstract - Pneumonia continues to pose a significant public health threat, particularly among vulnerable populations such as children, the elderly, and individuals with compromised immune systems. Early and accurate diagnosis is critical for effective treatment and the prevention of severe complications. While chest X-rays are a standard diagnostic tool, their interpretation is often subjective and reliant on the expertise of radiologists, leading to potential delays and inconsistencies. To address these challenges, this study presents a deep learning-based model augmented with explainable artificial intelligence (XAI) for the automated detection of pneumonia in chest radiographs. The proposed system integrates interpretability techniques—Grad-CAM, LIME, and SHAP—to provide visual explanations of the model's decision-making process. By highlighting the specific regions of interest that contribute to the diagnosis, the system enhances transparency, fosters trust among medical professionals, and supports clinical decision-making. The model achieved high accuracy in detecting pneumonia and demonstrated practical utility in clinical settings, offering a reliable and interpretable solution to improve diagnostic workflows.

Key Words: – pneumonia, chest X-ray, deep learning, convolutional neural network, Grad-CAM, VGG-19

1. INTRODUCTION

Pneumonia is a leading global health concern, especially among children under five and the elderly, contributing to over 800,000 deaths annually according to the WHO. Timely and accurate diagnosis is vital, yet many regions face shortages of skilled radiologists and diagnostic tools, leading to delayed or missed diagnoses. Chest X-rays are commonly used for detecting pneumonia, but manual interpretation is time-consuming and often inconsistent. Recent advances in artificial intelligence, particularly deep learning, have shown promise in automating medical image analysis. This study presents a deep learning-based pneumonia detection system using the VGG-19 model for classifying chest X-rays as normal or pneumonia-positive. Preprocessing through normalization improves model consistency, while Grad-CAM is employed to enhance interpretability by highlighting key image regions influencing predictions. The proposed system combines diagnostic accuracy with explainability, offering a practical solution for aiding clinicians, especially in resource-limited settings.

2. LITERATURE SURVEY

Recent advances in deep learning have greatly enhanced automated pneumonia detection from chest X-rays. CheXNet by Rajpurkar et al. [1], built on DenseNet-121, matched radiologist-level performance. Kermany et al. [2] used transfer learning with InceptionV3 on pediatric X-rays, achieving high accuracy and releasing a widely used benchmark dataset. Wang et al. [3] introduced ChestX-ray8, enabling multi-label disease detection with CNNs on a large scale. Rajaraman et al. [4] found VGG-19 to be both accurate and efficient for pneumonia detection, especially in low-resource settings. To improve interpretability, Selvaraju et al. [5] introduced Grad-CAM, a visualization method that highlights key image regions influencing predictions. Rahman et al. [6] combined CNNs and Grad-CAM for detecting both pneumonia and COVID-19, emphasizing the importance of explainable AI in clinical adoption.

3. PROBLEM STATEMENT

Diagnosing pneumonia from chest X-rays is challenging due to subtle and overlapping features, often leading to errors. While deep learning models offer high accuracy, their lack of interpretability limits clinical trust. There is a need for an AI solution that combines accurate detection with explainable insights to support reliable clinical decisions.

4. EXISTNG SYSTEM

Deep learning models such as CheXNet (DenseNet-121) and InceptionV3 have demonstrated high accuracy in pneumonia detection from chest X-rays, using large datasets like ChestX-ray14 and ChestX-ray8. VGG-19 is also widely used due to its balance of accuracy and computational efficiency. However, most of these models operate as black boxes, lacking interpretability. Visualization methods like Grad-CAM have been developed to improve understanding of model predictions by highlighting important image regions.

5. PROPOSED SYSTEM

The aim of this project is to develop an automated system for the early detection of pneumonia from chest X-ray images using deep learning techniques. The system leverages a fine-tuned VGG-19 Convolutional Neural Network (CNN) to classify chest X-rays into two categories: Normal or Pneumonia. The proposed pipeline consists of the following stages:

- Data Preprocessing and Normalization
- Transfer Learning with VGG-19
- Binary Classification
- Visual Explainability using Grad-CAM

The system begins with chest X-ray images sourced from an open dataset. Images are preprocessed by resizing, normalizing pixel values, and converting to RGB if needed.

A pretrained **VGG-19 model** is fine-tuned through **transfer learning**, replacing its top layers with custom dense layers for binary classification. The model is trained using **binary cross-entropy loss** and optimized with the **Adam optimizer**.

For interpretability, **Grad-CAM** is used to generate heatmaps that highlight lung regions influencing the model's predictions, adding transparency to the diagnosis process.

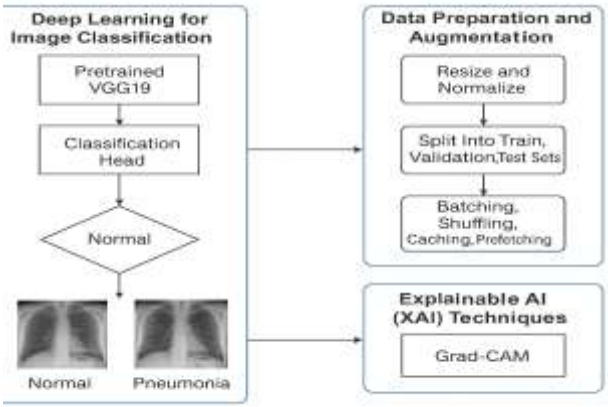

Figure-1: Architectural Overview

6. SOFTWARE REQUIREMENTS

Python: Used for data preprocessing, model training, and evaluation**.**

Keras/TensorFlow: Framework for building and training the VGG-19 CNN.

OpenCV & Matplotlib: Used for image processing and result visualization.

Grad-CAM: For explainable AI by highlighting lung regions influencing the model's prediction.

7. SCOPE OF THE PROJECT

This project focuses on developing a deep learning-based system for early and accurate detection of pneumonia from chest X-ray images. It utilizes a fine-tuned VGG-19 CNN model for binary classification (Normal vs. Pneumonia) and incorporates Grad-CAM for visual explainability, aiding clinical trust.

The system is designed to:

- Support automated, fast, and consistent diagnosis of pneumonia.
- Assist radiologists by highlighting regions of interest in X-rays.
- Be extendable to other medical imaging tasks with minimal modifications.
- Serve as a foundation for AI-powered diagnostic tools in healthcare settings.

8. RESULT

The fine-tuned **VGG-19 model** demonstrated strong generalization on unseen test data for binary classification. **Grad-CAM visualizations** confirmed that the model accurately focused on relevant lung regions, enhancing the **trustworthiness and interpretability** of its predictions. Additionally, the model exhibited **high recall**, indicating strong sensitivity—an essential characteristic in medical diagnostics to minimize missed pneumonia cases.

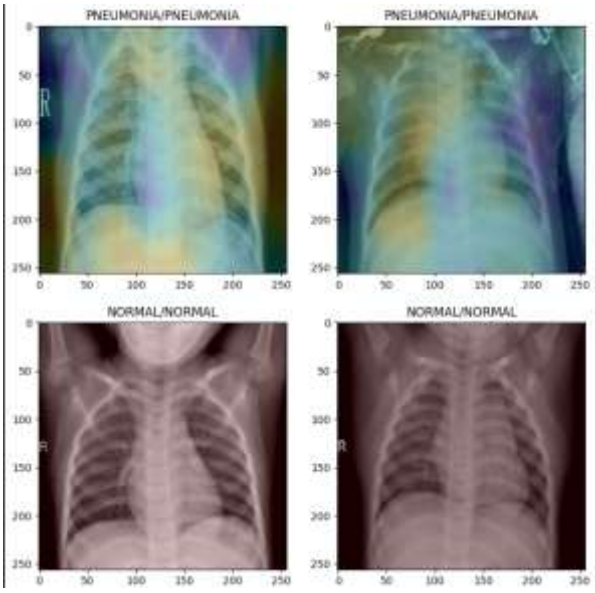

Figure-2: Photo depicting model prediction

The image above presents Grad-CAM visualizations for chest X-ray predictions.

In the **top row**, pneumonia cases are shown, where the model accurately focuses on hazy lung regions indicative of infection.

In the **bottom row**, normal cases are displayed, with minimal or no heatmap activations in the lung areas, confirming correct classifications.

These visualizations demonstrate that the **VGG-19 model** consistently attends to **clinically relevant regions**, supporting the reliability of its diagnostic decisions.

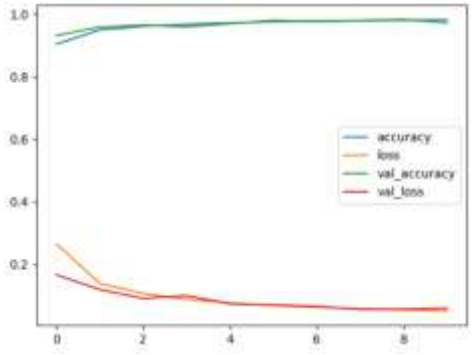

Figure-3: Training and Validation Performance

9. FUTURE SCOPE

Future work will focus on two key areas: the development of an AI-powered chatbot system and a predictive recovery estimation model. The chatbot will serve as an intelligent virtual assistant, offering real-time support for pneumonia-related queries, including symptom checking, medication adherence, recovery tips, mental health support, and appointment scheduling. With advanced natural language processing capabilities, it will understand various languages and improve over time through machine learning, enhancing accessibility and easing the burden on healthcare providers. Additionally, a predictive analytics system will be designed to estimate patient recovery progress by analyzing clinical data such as vital signs, lab results, radiology reports, and treatment adherence. This model will enable early identification of abnormal recovery patterns, support timely medical interventions, and offer patients personalized recovery timelines. Future enhancements may include integration with wearable devices and Electronic Health Records (EHRs) to facilitate continuous monitoring and more informed clinical decision-making.

10. CONCLUSION

This project demonstrates the effective use of deep learning with **explainable AI (XAI)** for pneumonia detection from chest X-rays. By integrating **VGG-19** with **Grad-CAM, SHAP, and LIME**, the system not only classifies images into **normal, viral, or bacterial pneumonia** but also provides **interpretable visual explanations**, enhancing clinical trust.

Unlike traditional black-box models, this system emphasizes **transparency, usability, and ethical AI**. The

user-friendly interface allows medical professionals to navigate and understand the model's predictions.

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