YZV303(2)E/BLG561E Deep Learning Project Proposal Explainable AI with Deep Learning Models for Pneumonia Detection in Chest X-rays

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I. Project Description

Pneumonia remains an important global health issue, with millions of deaths a year, especially in low-resource settings. A fast and precise diagnosis is crucial to avoiding dire consequences but manual detection of chest X-rays could delay or misdiagnosis caused by human error, limited expertise etc. Various deep learning models have shown their potential in automating diagnostic tasks with high accuracy in image-based medical applications.

Nevertheless, their clinical applicability is still limited due to the non-transparent behaviours of these models. Due to lack of clarity in the rationales behind their predictions, these systems are unable to convince the trust of medical professionals and patients which is an important obstacle for deployment into practical use in healthcare environment.

II. Problem Definition

This project responds to that important necessity of having adquate explainable deep learning models in the area of medical imaging. The main objective is to create a deep learning framework for detection of pneumonia from chest X-ray images and apply explainability measures on relevant layers of different models for interpretability and trustworthiness. Integrating approaches like Grad-CAM and SHAP, the project seeks to deliver explainable predictions in a way to help healthcare professionals verify and have confidence in the results of model predictions.

Proposed system will provide proof-of-concept for explainable AI applications that can create a trade-off between performance and interpretability resulting in the increased acceptability of AI tools in everyday clinical settings, enhancing diagnosis confidence through human-AI partnerships. By implementing explainable artificial intelligence, this method helps to mitigate biases in automated diagnostic systems and serves as a more interpretable and controllable approach for diagnosis.

III. Dataset

Chest X-rays will be derived from public-domain repositories e.g NIH Chest X-Ray Dataset For diversity of patient demographics and imaging conditions, a subset will be selected.

A. Specifications

For variety, the dataset will consist of chest X-ray images that have been harnessed from readily-available sources such as NIH Chest X-Ray Dataset and Kaggle. These outside sources are to be additional to the custom-curated dataset in order to amass a more complete and diverse dataset. For increasing robustness, pre-processing and augmentation techniques including rotation, flipping, scaling and normalization will be used. Resizing images to a common resolution so that we can train our model on it.

B. Data Collection Process

The images will be collected from public datasets and preprocessed like so:

- Duplicate images and incomplete data entries will be removed.
- Images will be resized and normalized to standardize pixel intensity distribution.
- Augmentation methods like flipping, rotation and cropping will be used to make the dataset bigger and more reliable.

The dataset will comply with ethical guidelines, including KVKK compliance, ensuring that no personally identifiable information is collected or used. Metadata (e.g., patient demographics) will be anonymized, and all processing steps will be documented for transparency.

IV. Methodology

A. Models

Various Convolutional Neural Network (CNN) architectures will be utilized for feature extraction, classification and seg-

mentation in the project. We have chosen each of the following architectures for tackling different aspects on pneumonia detection and explainability:

- **ResNet Family**: Suspending the vanishing of gradients by using a deep residual network that allows increasing depth without degrading performance. Because of the trade off made for both accuracy and efficiency, it is well suited for most medical imaging tasks.
- **VGG-16 Architechture**: It is a simple but effective CNN architecture with homogeneous layer structures, making it effective for extracting hierarchical features from medical images.
- **EfficientNet Family**: A scalable and computationally efficient model that optimizes accuracy and resource usage, ideal for scenarios where training time and resources are limited.
- **U-Net**: A convolutional neural networks architecture for image segmentation pixel-wise localization of pneumonia-affected lung regions This is vital towards producing explainable outputs by exposing areas of infection in X-ray images.
- **Custom CNN**: A lightweight and modular architecture that was created to establish a baseline for experimentation, as well as rapid prototyping.

B. Training Strategy

Models will be built on top of PyTorch, trained with binary cross-entropy loss function and SGD or ADAM optimizer. The training will encompass the following:

- Experimenting with varying learning rates and batch sizes to determine the optimal training configuration.
- Using early stopping and learning rate schedulers to avoid overfitting and converge better.
- Cross-validating to see how well the model will generalize to unseen data.

Various metrics used to evaluate the models will be as mentioned:

- Classification performance in terms of accuracy, precision, recall, and F1-score.
- Quantitative assessment of model explanations, with explainability metrics like fidelity and human interpretability scores.

To ensure transparency and interpretability, Grad-CAM will be carried out for visualizing what parts of the chest X-ray was involved in making the predictions by the model.

REFERENCES

[1] Siddiqi R, Javaid S. Deep Learning for Pneumonia Detection in Chest X-ray Images: A Comprehensive Survey. J Imaging. 2024 Jul 23;10(8):176. doi: 10.3390/jimaging10080176. PMID: 39194965; PMCID: PMC11355845.

[2] Jain DK, Singh T, Saurabh P, Bisen D, Sahu N, Mishra J, Rahman H. Deep Learning-Aided Automated Pneumonia Detection and Classification Using CXR Scans. Comput Intell Neurosci. 2022 Aug 4;2022:7474304. doi: 10.1155/2022/7474304. PMID: 35936981; PMCID: PMC9351538.

[3] Hasan, M.R., Ullah, S.M., & Rabiul Islam, S.M. (2024). Recent Advancement of Deep Learning Techniques for Pneumonia Prediction from Chest X-Ray Image. Medical Reports.

[4] Sharma, S., & Guleria, K. (2023). A deep learning based model for the detection of pneumonia from chest X-ray images using VGG-16 and neural networks. Procedia Computer Science, 218, 357-366.