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DL Proposal

Deep Learning-Based Detection of COVID-19 from Chest X-Ray Images using CNNs

I. Motivation and Objective

The Covid-19 pandemic has placed an unprecedented strain on healthcare systems worldwide, emphasizing the need for rapid, accessible diagnostic tools. The lungs are vital organs in the human respiratory system, and any viral or bacterial infections that target them can quickly escalate into severe respiratory failure, resulting in both severe short term and long term complications. Chest X-rays are an effective method in detecting lung abnormalities and assisting physicians in assessing the severity of infections. However, relying solely on doctor-driven diagnoses introduces several challenges. The doctor-to-patient ratio is often unfavorable in low income regions, leading to delayed or missed diagnoses. Moreover, diagnoses based purely on physician experience and training can introduce bias and inconsistency across regions. The overwhelming influx of patients that present with distress in the lungs further compounds these issues, leading to clinician fatigue and decreased diagnostic accuracy. These challenges highlight the urgent need for computer-aided diagnosticians systems capable of providing timely and reliable assessments within the healthcare system.

Manual interpretation of X-ray images is time-consuming and subject to inter-observer variability. This project aims to bridge this gap by leveraging convolutional neural networks (CNNs) to automate the classification of chest X-rays into 3 categories: Covid-19, pneumonia, or normal. This study will involve preprocessing and balancing the dataset to ensure robust model training, evaluating model performance using standard metrics to identify the most effective CNN architecture, and implementing explainability techniques to visualize model focus regions.

By developing an accurate and interpretable deep learning model, this project seeks to support health care practitioners in rapid COVID-19 screening and other respiratory infections, ultimately contributing to the growing field of AI-assisted medical diagnosis.

II. Related Works

Given the still prominent impact of COVID-19 in society, there is a plethora of research into COVID-19, particularly studying alternative approaches to diagnosis. With inspiration from previous clinical use of deep learning image classification models to diagnose Pneumonia from chest X-rays, research in this process has expanded to COVID-19, showing much promise in this regard. Still, difficulty differentiating COVID-19 from other lung related ailments like Pneumonia has prevented system-wide use of image analysis for COVID-19 diagnosis, as additional research both corroborating and improving on previous findings across more datasets is still necessary.

One study, which focused solely on diagnosing COVID-19 was conducted by Akter et al., which trained 11 different types of pre-trained CNN models, settling on the MobileNetV2 model for advanced hypertuning. In the end, their model which implemented MobileNetV2 with RMSProp optimization achieved very impressive classification results, with an accuracy of 98%, a specificity of 97% and a sensitivity of 98% [1]. This project corroborated findings by Apostolopoulos et al. which also found their best results using a slightly different format of a MobileNetV2, implementing Transfer Learning and adjusting layer parameters for their CNN model. This model was also evaluated on images normalized to a lower resolution than Akter et al., normalizing images to a size 200 x 266 compared to 299 x 299 [1 2]. Even with the reduced resolution, results from this study were very similar to the prior, with an accuracy of 97.4%, specificity of 97.09%, and a sensitivity of 99.1%.

One drawback of these models is that they were trained on two class datasets, distinguishing between healthy individuals and those with confirmed COVID-19. A much more difficult task has been distinguishing between COVID-19 and other respiratory ailments, particularly Pneumonia, a disease with very similar symptoms and pulmonary impact to COVID-19. For this reason, chest X-Rays are rarely utilized alone in clinical practice to diagnose COVID-19, requiring other forms of COVID-19 testing to confirm any case. The current gold standard for COVID-19 diagnosis is the reverse transcription-polymerase chain reaction (RT-PCR) test, which carries its own drawbacks including being expensive, very time time dependent for accurate results and consuming to return, and difficult to attain in many communities [3]

Lamouadene et al. aimed to fill this gap with their research, using a CNN architecture with transfer learning. Their best model used a ResNet-18 structure, achieving an accuracy of 86.2%, a sensitivity of 83.5%, and a precision of 81.3% [4]. This model performed well enough to show promise in continuing the pursuit of a model which can distinguish COVID-19 for multiclass problems, but also shows space for refinement to improve model's ability to distinguish COVID-19 from Pneumonia in patients who have an unknown classification at the time of

[1] Akter S, Shamrat FMJM, Chakraborty S, Karim A, Azam S. COVID-19 Detection Using Deep Learning Algorithm on Chest X-ray Images. Biology (Basel). 2021 Nov 13;10(11):1174. doi: 10.3390/biology10111174. PMID: 34827167; PMCID: PMC8614951.

[2] Apostolopoulos ID, Mpesiana TA. Covid-19: automatic detection from X-ray images utilizing transfer learning with convolutional neural networks. Phys Eng Sci Med. 2020 Jun;43(2):635-640. doi: 10.1007/s13246-020-00865-4. Epub 2020 Apr 3. PMID: 32524445; PMCID: PMC7118364.

[3] Islam R, Tarique M. Chest X-Ray Images to Differentiate COVID-19 from Pneumonia with Artificial Intelligence Techniques. Int J Biomed Imaging. 2022 Dec 22;2022:5318447. doi: 10.1155/2022/5318447. PMID: 36588667; PMCID: PMC9800093.

[4] Hajar Lamouadene, Majid EL Kassaoui, Mourad El Yadari, Abdallah El Kenz, Abdelilah Benyoussef, Amine El Moutaouakil, Omar Mounkachi, Detection of COVID-19, lung opacity, and viral pneumonia via X-ray using machine learning and deep learning, Computers in Biology and Medicine, Volume 191, 2025, 110131, ISSN 0010-4825, https://doi.org/10.1016/j.compbiomed.2025.110131.

X-Ray. Our project aims to continue this research, testing other CNN architectures to further distinguish X-Ray images of healthy, COVID-19 infected and Pneumonia infected lungs.

III. Proposed Work

This project will focus on developing a CNN capable of accurately classifying chest X-ray images into three diagnostic categories: COVID-19, Pneumonia, and Normal. The dataset obtained from *Kaggle* will be divided into training, validation, and testing subsets to ensure unbiased evaluation of the final model. Images will be preprocessed through normalization, resizing, and augmentation techniques, including rotation, flipping, and contrast adjustment to enhance model generalization. An initial baseline CNN architecture will be developed, consisting of multiple convolutional and pooling layers followed by fully connected dense layers and finally, a final softmax classifier. Transfer learning will then be explored using pretrained models to leverage pre-learned feature representations and improve classification performance.

Model performance will be evaluated using standard classification metrics including accuracy, precision, recall, F1-score, and confusion matrices. To ensure robust model validation, k-fold cross-validation may be employed to assess generalizability across subsets of the data. Explainability will play a critical role in evaluating model interpretability. Visualizing regions of interest that contribute most to the model's decision making process and comparing those to medical clinicians' regions of interest will allow us to assess whether the model is truly making accurately informed decisions. Success will be defined by achieving high predictive accuracy, strong generalization on unseen data, and interpretable visual explanations consistent with clinical reasoning.

The novelty of this project lies in combining CNN architectures with explainable AI techniques to create an interpretable and efficient diagnostic framework for chest X-ray classification. The architectural design can be conceptualized as a multi stage pipeline: Data processing, responsible for normalization and augmentation; Feature Extraction, where convolutional layers capture spatial and structural lung patterns; Classification, where dense layers assign class probabilities; and Visualization and Evaluation, which generate visualization maps and compute performance metrics. The integration of explainability into the model architecture represents a meaningful advancement toward trustworthy AI in medical imaging, bridging the gap between high-performance prediction and clinical interpretability.

IV. Plan of Action

Given that we will be training and tuning CNN architectures, it will be necessary to utilize software with access to GPU resources. Due to the availability of GPU in Google Colab Pro, which is free for students we will be utilizing that platform for our model development and training. Python coding will be used, particularly leveraging the TensorFlow library to test pre-trained architectures including but not limited to MobileNetV2, ResNet-18, and DenseNet121, which have been pretrained on ImageNet. Applying the Keras API on top of TensorFlow will allow us to easily integrate Transfer Learning into our models both to potentially improve our model performance and allow for seamless feature extraction. These libraries along with Sci-Kit Learn will be utilized for evaluating results and comparing performance across features. To visualize results Grad-CAM will be used for CNN focus areas, while Matplotlib and Seaborn can apply feature mapping and basic metric curves across our models. The schedule for implementation will be as follows.

- 11/3/2025 - Have dataset cleaned and normalized to proper specs relative to each model architecture
- 11/10/2025 - Complete baseline CNN architecture
- 11/17/2025 - Implement pretrained models and transfer learning approaches for comparison
- 11/24/2025 - Have model tuning completed and evaluated to begin drawing conclusions
- 12/1/2025 - Complete all visualizations and begin drafting demo and paper
- 12/8/2025 - Submit demo and be prepared to present
- 12/15/2025 - Submit final paper

V. Evaluation and Testing Methods

Model performance will be evaluated using a combination of quantitative metrics and qualitative interpretability analyses, as outlined above. While overall accuracy provides a general indication of performance, it may not be the most informative metric for this application due to potential class imbalance in the dataset. Instead, precision, recall, and f1 measure will be prioritized. In a healthcare context, recall (i.e. sensitivity) is particularly critical, as false negatives can have severe public health implications. Misclassifying a positive patient as healthy can lead to further development of the virus and put the patient's safety at risk, along with the potential release of patients to spread the virus to others. However, precision will still be monitored to minimize false positives that could lead to an increase in patient anxiety, unnecessary isolation of patients, or unnecessary treatment which can cause viral immunity to antibiotics within individuals. Testing will involve unseen data from the reserved test subset to ensure unbiased generalization. In addition to these quantitative methods, explainable AI will be used to qualitatively assess whether the model's focus relations align with clinically relevant lung structures. Together, these evaluations and testing methods will ensure that the final model is not only accurate but also reliable, interpretable, and ethically suited for medical decision support.

VI. Bibliography

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