Medical Image Analysis On Chest X-ray Using Deep Learning

Aditya Paliwal
dept. of Computer Science & Engineering
Acropolis Institute of Technology & Research, Indore
adityapaliwal20434@acropolis.in

Aeshna Jain
dept. of Computer Science & Engineering
Acropolis Institute of Technology & Research, Indore
aeshnaj525@gmail.com

Bhavik Sharma
dept of Computer Science & Engineering
Acropolis Institute of Technology & Research, Indore
bhaviksharma20111@acropolis.in

Devendra Singh Pawar
dept. of Computer Science & Engineering
Acropolis Institute of Technology & Research, Indore
devendrasinghp80@gmail.com

***Abstract*— Pulmonary infections, alsoreferred to as lung infections, are among the most widespread medical conditions worldwide. They encompass a variety of types, spanning from acute tochronic ailments. This research paper is dedicated to diagnosing pulmonary infections such as pneumonia,Empyema, and COVID-19. It centers on training different CNN models to analyze Chest X-ray images and categorize them into three classes: COVID-19, Normal, and Pneumonia. Three models—ResNet50V2, DenseNet121, and a custom CNN model—are employed for evaluation and accurate results analysis. The paper also addresses challenges arising from unbalanced datasets and strategies to enhance model accuracy. With a total of 1104 images for training and 1288 for testing across the three classes, early detection of pulmonary diseases is crucial for timely treatment and infection prevention.**

Keywords—CNN, Deep learning, Resnet50v2, Chest X-ray

I. Introduction

Chest X-ray imaging plays a crucial role in diagnosing respiratory diseases, including COVID-19and pneumonia. These diseases pose significant health risks and can lead to severe complications if notdiagnosed and treated promptly. The global COVID-19 pandemic of 2020-2021 starkly illustrated the urgent need for accurate and timely detection methods to combat infectious respiratory diseases. Pneumonia,a common respiratory infection, is caused by variouspathogens, including bacteria, viruses, and fungi. While some cases of pneumonia are mild and resolve with treatment, severe pneumonia can lead to respiratory failure and even death, particularly in vulnerable populations such as the elderly and immunocompromised individuals.

The importance of chest X-ray imaging in the diagnosis of COVID-19 and pneumonia cannot be overstated. Chest X-rays provide detailed images of the lungs, allowing healthcare professionals to identify characteristic patterns associated with these respiratory diseases. However, interpreting chest X- rays accurately requires specialized expertise, and theprocess can be time-consuming, especially duringoutbreaks when healthcare resources are strained.

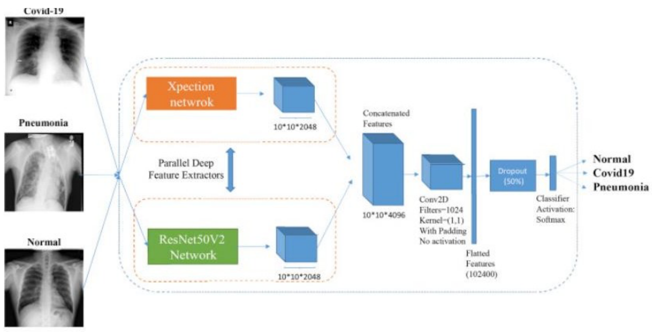
In this project, we present a Deep learning-based system designed to analyse chest X-rayimages and classify them into three categories:COVID-19, pneumonia, or normal. By harnessing the power of pre-trained DLmodels, our system aims to assist healthcare providers in the early detection and management of respiratory diseases,potentially saving lives and reducing the burden on healthcare infrastructure.

II. Objectives

- Develop a machine learning-based system capable of accurately classifying chest X-ray images as COVID-19 positive, pneumonia positive, or normal.
- Train the ML model on a diverse dataset of annotated chest X-ray images to ensure robust performance across different patient demographics and imaging conditions.
- Implement a user-friendly interface for healthcare professionals to upload X-ray images and receive rapid diagnostic results.
- Validate the performance of the ML model through rigorous testing and evaluation against ground truth labels provided byradiologists and medical experts.
- Optimize the system for real-time processing to facilitate timely diagnosis and treatmentdecisions in clinical settings.
- Ensure compliance with regulatory standards and ethical guidelines governing the use of ML algorithms in medical diagnostics.

III. Study of Existing System

During the research, there were many researches already done but no established apps or websites are there that can predict diseases out of Chest-X-Ray. A survey on existing research is done which uses Xception model and Resnet50V2 model combined to offer accuracy of 91.4% for all 3 classes. The Architecture for the same is shown below.



IV. Scope

- The scope encompasses optimization efforts to ensure the system can deliver timely diagnostic results suitable for integration into clinical workflows.
- Enable patient education and empowerment by providing tools for self-assessment and early disease recognition, facilitating proactive measures before seeking medicalconsultation.
- Promote patient advocacy and informed decision-making by equipping individuals with knowledge to navigate healthcare interactions confidently and critically evaluatemedical advice.
- By using this system, users Support educational initiatives by offering a valuable learning resource for students and medical professionals to study and understand respiratory diseases through real-world chest X-ray examples, fostering enhanced diagnostic skills and medical education.

V. Design and Use cases

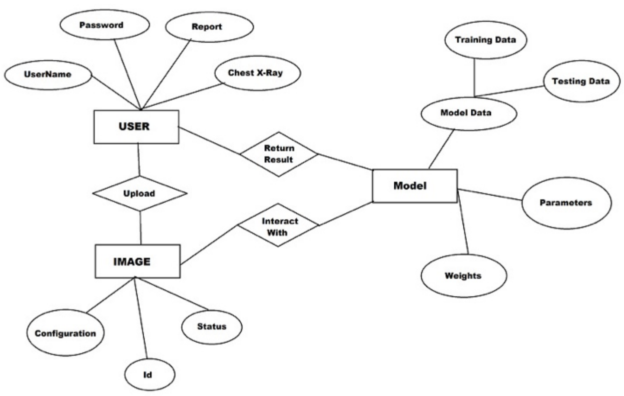


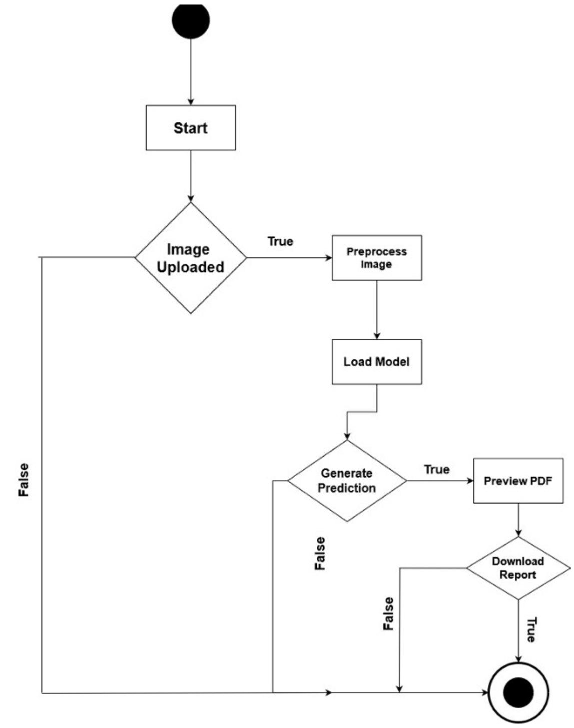
Fig.1 Entity-relationship Diagram

1. *ERD:*

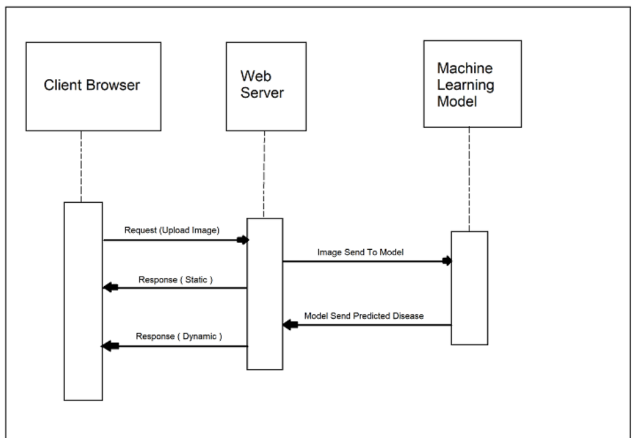
ER diagram consists of 3 entities – User, Imageand Model. User has its attributes like username, password and chest-x-ray imageand model has its attributes – model data,weights, and parameters. The last entity image consists of three attributes its configuration, Idand status.

2. *Activity diagram:*

Activity diagram represents the flow ofprocess. In this project information flows from user and pass on to two modules. If user feedsin images then flow divert towards object detection module and if user feeds in text then regression module becomes active. At the endboth modules integrate and gives out the predicted price.



Sequence Diagram:



3. Sequence Diagram

VI. Project Description

This project is a medical image analysis system designed to examine pulmonary diseases using chest X-rays and categorize them into three classes:Covid19, Pneumonia, and Normal Lungs. Users can register and upload their chest X-rays to receive a detailed report. Since chest X-rays exhibit subtle variations across different diseases, it's imperative to develop a system capable of identifying unique patterns and alerting users of specific ailments. To detect such abnormalities, this project employs deep learning techniques to train the system on a dataset comprising chest X-ray images of individuals with Covid19, pneumonia, and those without any such diseases. The system generates reports outlining symptoms, causes, treatment options, and preventive measures before users consult a healthcare professional.

VII. Methodology

1. Requirement Analysis:

Pulmonary Infections are one of the deadliestinfections as we have seen during pandemic. Covid19 is one of the pulmonary diseases andto prevent its spread this system needsfollowing hardware and software requirements:

- *Hardware requirements:*
  - Operating system (used Windows 10)
  - GPU
- *Software Requirements:*
  - Pythonn
  - TensorflowKeras
  - Scikit learn,
  - numpy, pandas
  - OpenCv
  - matplotlib
  - Network Connection

2. Data Collection:

We have taken a dataset from Kaggle known as Chest X-ray (Covid-19 & Pneumonia) by Prashant Patel. The sources for authors are:

1. https://github.com/ieee8023/covid-chestxray-dataset
2. https://www.kaggle.com/paultimothymooney/chest-xray-pneumonia
3. https://github.com/agchung

The Dataset contains two directory – train andtest and both folders contains 3 subfolders – Covid19, Pneumonia and Normal. This entiredataset contains 6432 x-ray images and test data have 20% of total images.

3. Technology Analysis:

In the quest to diagnose lung infections, grayscale Chest X-rays serve as essential diagnostic tools, with deep learning techniques employed to detect patterns that differentiate between various diseases. Grayscale Chest X-rays provide invaluable insights into pulmonary conditions, yet interpreting them accurately poses a significant challenge due to their nuanced nature. This project undertook a comprehensive exploration, evaluating three distinct models: ResNet50V2, DenseNet121, and a custom CNN, assessing their efficacy in analyzing the aforementioned images. Notably, ResNet50V2 emerged as the frontrunner, consistently delivering superior performance and precise results across thedataset.

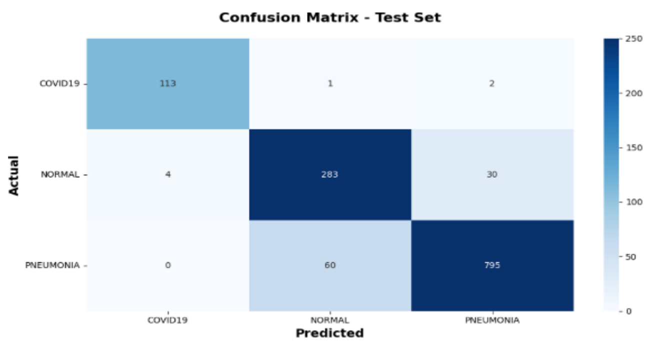
4. Design Flow:

The flow of data in this system starts from feeding in a chest-X-ray. The system accepts the image and done some pre-processing to make it in accordance of the input given to themodel. This image then interacts with the model where trained model find patterns and based on its learning it classifies the Chest-X-ray into one of the defined classes. The systemtakes result from the model and gives theresult along with the symptoms, causes and preventive measures to the user.

5. Model Selection and Research:

To initiate our research, we began by creatinga new dataset derived from the existing one. This initial step was crucial due to the high instability of the data, characterized by uneven distribution in image proportions. Specifically, we encountered a disparity where only 460 images were available for theCovid category, while the Pneumonia and Normal categories had over 2000 images each.To address this imbalance, we organized the data into new training and testing directories, ensuring a more equitable distribution across categories.

Our research focused on evaluating three distinct models: ResNet50V2, DenseNet121, and a custom CNN. Among these models, ResNet50V2 emerged as the top performer, achieving an impressive accuracy rate of 92.6%. DenseNet121 followed closely with anaccuracy of 89.6%, while the custom CNN model exhibited a lower accuracy of 67%.Employing Transfer Learning, we utilized the ResNet50V2 model with its base layers frozen and modifications made to the last dense layerto adapt it to our dataset. The Softmax activation function was employed to facilitate convergence of the neural network and classify inputs into one of the three classes.



The accompanying figure illustrates the confusion matrix for the ResNet50V2 model, providing a clear representation of its performance across all cases

Above image shows true positive cases for 113 images of covid and 0 false negative for covid-pneumonia and similarly true positive for normal cases are 283 and for Pneumonia are 795 which are far greater than the false negative cases of corresponding classes.

The parameters used are tabulated below:

Training Parameters	ResNet50V2	DenseNet121
Learning Rate	1e-4	1e-2
Batch Size	32	32
Optimizer	Adam	Adam
Loss Function	Categorical CrossEntropy	Categorical CrossEntropy
Epochs	10	40
Horizontal/Vertical flipping	true	true
Zoom Range	0.1	0.1
Rotation Range	20	20
Width/Height Shiftin	0.1	0.1
Shear Range	0.1	0.1
Re-scaling	1.0/255	1.0/255
Validation Split	0.2	0.2
Min Delta	0.0001	0.0001

Modifying the last layer with 256 neurons in Dense Layer and Relu as activation function. Dropout and Global Average Pooling layers are also used after and before the dense layer respectively to prevent themodel from overfitting.

VIII. Expected Outcome

We anticipate that our research efforts will yield significant insights into the classification of pulmonary diseases using deep learningtechniques applied to chest X-ray images. By addressing the data imbalance through the creation of a new dataset and leveraging advanced models such as ResNet50V2 and DenseNet121, we expect to achieve high levels of accuracy in disease classification.

IX. Conclusion

In conclusion, our project focused on the development of a medical image analysis system for diagnosing pulmonary diseases using chest X-ray images. We addressed the challenge of data imbalance by creating a newdataset and explored the effectiveness of three deep learning models: ResNet50V2,DenseNet121, and a custom CNN. Our research findings revealed that ResNet50V2 emerged as the top-performing model, achieving an impressive accuracy rate of 92.6%. DenseNet121 followed closely behind with an accuracy of 89.6%, while the custom CNN model exhibited a lower accuracy of 67%. These results highlight the efficacy of Transfer Learning in fine-tuning pretrained models for specific datasets, enabling accuratedisease classification.

Through our efforts, we have demonstrated the potential of deep learning techniques in enhancing the diagnosis of pulmonary diseases, such as Covid19, Pneumonia, and Normal Lungs, using chest X-ray images. By providing clinicians with a reliable tool for early detection and management of these conditions, our project contributes to improving patient care and outcomes in the field of respiratory medicine

References

- https://arxiv.org/ftp/arxiv/papers/2110/2110.06512.pdf
- A Review of Recent Advances in Deep Learning Models for Chest Disease Detection Using Radiography by Adnane Ait Nasser ORCID and Moulay A. Akhloufi
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9135545/
- Multi-Label Chest X-Ray Classification via Deep LearningAravind Sasidharan Pillaiorcid University of Illinois Urbana-Champaign, Champaign, IL, USA.Anirudh Kaushal, Achyut Shankar, House Price Prediction Using Machine Learning, 2021.