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An Efficient Pneumonia Detection System Using Deep Learning

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ABSTRACT: Pneumonia is a potentially fatal life-menacing disease that affects one or both lungs in the human body. Streptococcus pneumonia bacteria commonly cause this disease; one among three deaths due to Pneumonia is reported in India as stated by WHO. Chest X-ray images are being used to diagnose Pneumonia with radiotherapists evaluation. Radiotherapists' evaluation is a manual process; thus, developing an automated pneumonia detection system for treating pneumonia patients without any delays gains importance. Further, this computerized system can also be extended to recognize COVID-19, Coronavirus patients if their lungs got affected. Deep and machine learning algorithms have evolved as state-of-the-art techniques to analyze the medical images; Convolution Neural Networks (CNNs) have attained good attention for disease classification. In this work, we build a pre-trained CNN model which extracts image features followed by different classifiers to classify the abnormal and normal chest X-ray images of Pneumonia. We have implemented the proposed methodology on more than 500 test images, and we have obtained a high accuracy of 92% true pneumonia.

KEYWORDS: Pneumonia, Convolution Neural Networks (CNNs), Chest X-Ray.

I. INTRODUCTION

Pneumonia is a common lung infection characterized by collecting pus and other fluids in the lung air sacs (alveoli). Lung air sacs are structures that help exchange oxygen and carbon dioxide. The collection of pus in them makes breathing difficult. Pneumonia can be caused by many kinds of microorganisms (germs), including bacteria, viruses, fungi or parasites. When an infected individual coughs or sneezes, these organisms get into the air and breathing in this air leads to the contraction of the illness. It is thus a contagious disease. It is of various types occurring in individuals of all ages, affecting millions of people worldwide. The condition varies from mild to severe depending on the type of organism involved, age, and the individual's underlying health. Pneumonia can be categorized as community-acquired, hospital-acquired and Pneumonia occurring in Immuno compromised individuals (individuals with a weakened immune system).

The paper is organized as follows. Section II describes a literature survey on the existing CNN based pneumonia detection system and various techniques. Section III describes the proposed methodology and data descriptions. The proposed block diagram represents the holistic view of the CNN model used. Detection of Pneumonia using chest x-ray images and classifying the images in is also carried out in the same section. Section IV presents the experimental results of the images tested. Finally, Section V presents the conclusion.

II. LITERATURE SURVEY

Many authors worked on a deep learning-based CNN classifier for classifying Pneumonia. The following section describes the different papers on the same.

H. Sharma, J. S. Jain, P. Bansal and S. Gupta, "Feature Extraction and Classification of Chest X-Ray Images Using CNN to Detect Pneumonia. Sharma et al.[1] proposed two CNN architectures that are designed from scratch to detect Pneumonia from images of chest X-ray.

M. Tsai and Y. Tao, "Machine Learning-Based Common Radiologist-Level Pneumonia Detection on Chest X-rays. M. Tsai et al., [2] Present different types of Pneumonia chest x-ray images classification for pneumonia detection using CNN.

D. Varshni, K. Thakral, L. Agarwal, R. Nijhawan and A. Mittal, "Pneumonia Detection Using CNN based Feature Extraction," D. Varshni. [3], Proposed a combination of CNN based feature-extraction and supervised classifier algorithm resulted in the optimal solution for classifying abnormal (Pneumonia labelled) and normal Chest X-Ray images primarily due to the substantive features provided by DenseNets followed by optimal hyperparameter values of SVM classifier.

M. Aledhari, S. Joji, M. Hefeida and F. Saeed, "Optimized CNN-based Diagnosis System to Detect the Pneumonia from Chest Radiographs," M. Aledhari et al. [4], proposed a new model that can help to improve the accuracy of Pneumonia. In this model, user will input the x-ray image, and the model will output the correct classification label for Pneumonia with an average accuracy of (68%) and an average specificity of (69%) in contrast to the current state-of-the-art accuracy that is (51%).

S. Mahajan, U. Shah, R. Tambe, M. Agrawal and B. Garware, "Towards Evaluating Performance of Domain-Specific Transfer Learning for Pneumonia Detection from X-Ray images. Mahajan et al. [5], Demonstrated CNN model chest x-ray images classification in ImageNet with 88.78% accuracy.

III. PROBLEM STATEMENT

Growing the health issues such as Pneumonia and Influenza, especially for children and seniors, require better diagnosis methods such as computer-based solutions that aim to detect and treat those issues in early stages as possible. Pneumonia is a life-threatening infectious disease affecting one or both lungs in humans, commonly caused by bacteria called Streptococcus pneumonia.

In Healthcare systems, automating the process of identifying and classifying Pneumonia is a challenging task. I am proposing the An Efficient Pneumonia Detection System Using Deep Learning. I'm developing a Pneumonia detection and classifying system that provides better accuracy and precision than the current ones. My system will help to detect Pneumonia disease, and it will classify the images into Pneumonia affected or Normal Images.

The Existing Pneumonia Detection System has many problems

- Identifying and classifying Pneumonia images for the physician is a challenging task.
- Manual checks for Pneumonia disease may lead to human errors.
- Existing detection and classifying systems are slow, Unreliable and costly.
- Pneumonia can also lead to COVID-19 disease, so early detection and Pneumonia may help prevent COVID-19 disease.
- By analyzing all the above points, an Efficient Pneumonia Detection System is the need of the hour.

IV. METHODOLOGY

Pneumonia is an infection that inflames the air sacs in one or both lungs. The air sacs may fill with fluid or pus (purulent material), causing cough with phlegm or pus, fever, chills, and difficulty breathing. A variety of organisms, including bacteria, viruses and fungi, can cause Pneumonia. This disease is severe in toddlers and elderly patients who have a weak immune system. Pneumonia kills 920,000 toddlers worldwide in 2015 [6]. Pneumonia can be detected using radiography such as conventional radiography, CT, or MRI. The doctor will examine the radiograph of patient's chest to detect Pneumonia. In addition, the golden standard for examining Pneumonia is accompanied by the examination of patient's medical record and phlegm. Soft tissue will produce dark colour on radiograph since X-rays can penetrate it. Weakening X-ray intensities on hard tissues such as bones will produce bright colour. Figure 1 shows that the chest cavity is clearly visible (dark color) since most of the lung cavities contain air. Patients with Pneumonia, there are fluids which fill the air sacs, causing chest cavity on radiograph image looks brighter. The brighter colour on the lung cavity may be caused by several abnormalities [6] such as cancer cells, swelling of blood vessels, heart abnormalities, and pneumonectomy.



Fig. 1. a(left) chest X-ray of normal and b(right) patient with Pneumonia

In this proposed work, we put forth an automatic system that classifies Chest X-ray images into Pneumonia affected or Normal using Deep learning algorithms. Fig. 2 shows an overview of a proposed design.

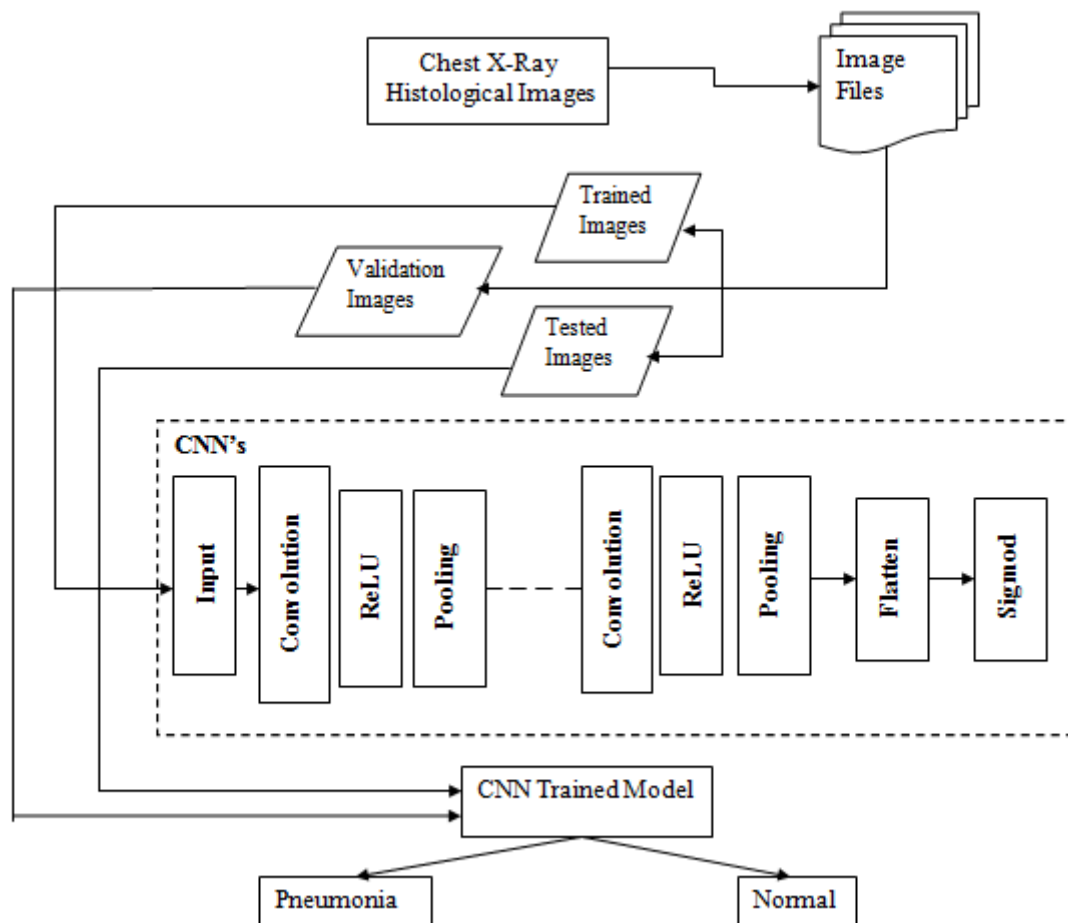


Fig. 2 Overview of the proposed system.

The proposed system has different sub-modules involved in it, Chest X-ray images were downloaded from the Kaggle data repository. We are taking Kaggle chest x-ray images as input to our proposed system. We have three categories of images training, testing and validation images. Training images are inputted into the proposed CNN model, and testing and validation images are inputted into the CNN trained model. Our proposed CNN has multiple layers, the first being the convolution layer, ReLU and Pooling layer. Flatten layer collapses data into a 1-dimensional array for inputting it into the next layer [1,2]. Our proposed model has a sigmoid function in the last layer, which classifies images into Pneumonia or Normal images. Testing and Validation data are verified in CNN trained model based on which classification takes place.

V. DATASET DESCRIPTIONS

The dataset is organized into three folders (train, test, Val) and contains subfolders for each image category (Pneumonia/Normal). There are 5,863 X-Ray images (JPEG) and two categories (Pneumonia/Normal). Chest X-ray images (anterior-posterior) were selected from retrospective cohorts of pediatric patients of one to five years old from Guangzhou Women and Children's Medical Center, Guangzhou.

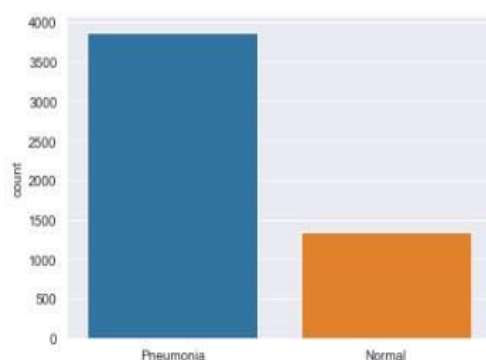


Fig 4. No. of Pneumonia and Normal images in Dataset

All chest X-ray imaging was performed as part of patients' routine clinical care. For the analysis of chest x-ray images, all chest radiographs were initially screened for quality control by removing all low quality or unreadable scans. Fig 4 show no. of patients categorized in to pneumonia and normal, two expert physicians then graded the diagnoses for the images before being cleared for training the AI system. In order to account for any grading errors, the evaluation set was also checked by a third expert.

VI. EXPERIMENTAL RESULTS

Results of deep learning models in terms of training, validation, testing accuracy and loss is discussed. Figure 5 shows Training and validation accuracy achieved here is 90.86% and Loss of the model is 0.27. Classification report for precision, recall and f1 score is also discussed. Class 0 which is Pneumonia class precision and recall is 0.93 and 0.92 respectively. For Class 1 which is Normal class precision and recall is 0.87 and 0.88 respectively. F1 score for both class 0 and class 1 is 0.93 and 0.88 respectively. Details are discussed in Fig 6.

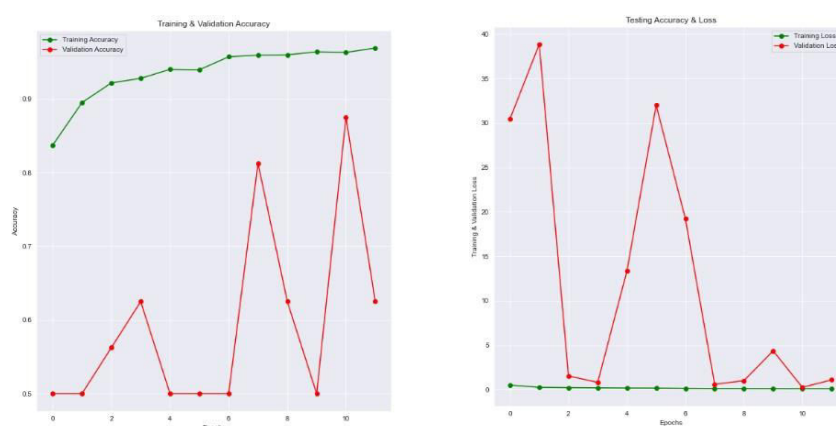


Fig 5. Training, Validation, Testing Accuracy and Loss of the model.

	precision	recall	f1-score	support
Pneumonia (Class 0)	0.93	0.92	0.93	390
Normal (Class 1)	0.87	0.88	0.88	234
accuracy			0.91	624
macro avg	0.90	0.90	0.90	624
weighted avg	0.91	0.91	0.91	624

Fig6. Classification report

Figures show CNN-based pneumonia detection results; Chest x-ray images are classified into two different classes, which are predicted and actual class. Fig.7 shows non-infected/actual x-ray images, whereas Fig 8 shows infected/predicted images.

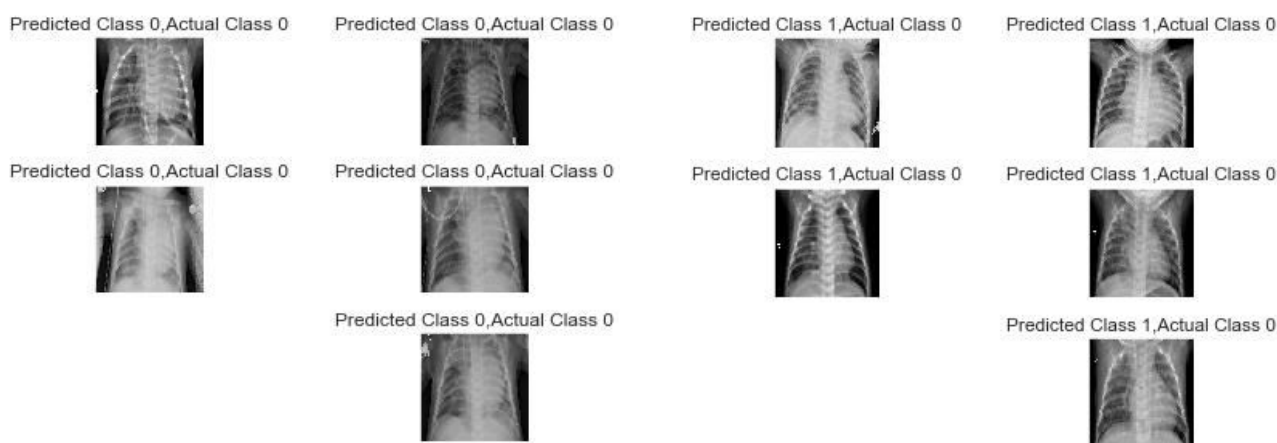


Fig. 7 Non-infected Images

Fig. 8 Infected Images

VII. CONCLUSION

In this work, we propose CNN architectures that are designed from scratch to detect Pneumonia from images of chest X-rays. We are using Convolutional Neural networks to solve a classification problem. Kaggle dataset is used as input to a proposed system. The proposed work can also be used for Covid-19 pneumonia detection techniques, which predict symptoms based on a patient's x-ray. The proposed work promises to get accurate and optimistic results in classifying Pneumonia or normal images.

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