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AI-Driven Detection of COVID-19 and Pneumonia on Chest X-Rays

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Abstract -In the era of rapid digital transformation and amidst the unprecedented challenges posed by the COVID-19 pandemic, the imperative for accurate and efficient disease diagnosis has never been more pressing. This study delves into the realm of automated detection of two critical respiratory illnesses, COVID-19 and pneumonia, employing a sophisticated approach that integrates the utilization of three distinct models: a custom model developed in-house, Xception, and DenseNet121. Using CNNs, widely recognized for their exceptional capabilities in pattern recognition within medical images, our research endeavors to give a thorough evaluation of each model's performance. Through meticulous experimentation and rigorous comparative analysis, we aim to elucidate not only the strengths and limitations of these models but also their potential for practical deployment in clinical settings. By juxtaposing the outcomes derived from our custom model with those from the established architectures of Exception50 and DenseNet, we seek to offer a nuanced understanding of their respective efficacies in disease detection. Moreover, this study aspires to contribute substantively to the ongoing discourse in medical image analysis, with the overarching goal of facilitating the methodologies to enhance disease detection accuracy and ultimately improve patient care outcomes amidst the challenges posed by respiratory illnesses such as COVID-19 and pneumonia.

***Key Words*:** X-ray Detection, Pneumonia Detection, DeepLearning, Image Analysis, Medical Imaging

1.INTRODUCTION

The new coronavirus disease (COVID-19), commonly referred to as coronavirus illness, is spreading rapidly around the world, but the route of infection is still unknown. The virus generally causes few or no symptoms, but in 2% to 8% of cases it can cause pneumonia, which progresses rapidly and is often fatal. In part, this is due to the unique challenges posed by SARS-CoV-2 infection, including: B. Peak infectivity at or just before the onset of symptoms, and the physiology of an unclear multiorgan pathway with prominent features and lethality in the lungs, precise mortality rates, prevalence, etc. The transmission dynamics are still not completely understood. Lack of experienced medical professionals and necessary protective equipment, in addition to unequal access to point-of-care diagnostic methods like RT-PCR (reverse transcription-polymerase chain reaction), have led to rapid adoption in healthcare systems. It's a burden. In the world. There are still issues with rapid RT-PCR tests, including: B. Significant false negative rates, processing delays, variability in testing procedures, and sensitivity as low as 60-70% in some cases.

A test called computed tomography (CT) provides progressive physiological insight that helps detect and clarify the various stages of disease progression. Although it remains difficult to quickly diagnose COVID-19, front-line radiologists have identified typical symptoms such as round opacities, enlarged vessels within the infiltrate, ground-glass opacities around the lungs, and then their further consolidation. reported an almost characteristic structure of infection, accompanied by various signs. It is a sign of a serious, progressive disease. Artificial intelligence (AI) technologies have the potential to help with diagnostic imaging and characterization of coronavirus disease (COVID-19) given the rapidly increasing number of new and suspected cases. there is. CT provides rapid and transparent insight into this process, and deep learning on large-scale global CT data finds reproducible and automated biomarkers to measure and classify COVID-19 infections. Previous single-center studies have demonstrated that artificial intelligence (AI) can detect and even distinguish COVID-19 from community-acquired pneumonia. Here we show that while our robust model can achieve up to 90% cure rates in separate test populations and maintain high specificity in pneumonia independent of COVID-19 infection, it also We show that good generalizability can be demonstrated across settings.

2.LITERATURE SURVEY

Here is a survey of pertinent literature techniques. It outlines the several methods that were employed. The brief information about the referred research papers is explained in this section.

In Paper[1], the researchers offer a computational framework that counts the interviewee's communication-related performance and provides performance feedback based on the analysis of multimodal data like voice and facial expressions.

In Paper[2], the researchers discuss the pressing need to use technology to help diagnose COVID-19 patients in the midst of the pandemic in 2020. The research assesses the potential of cutting-edge pre-trained convolutional neural networks (CNNs) to identify sick individuals from chest X-ray pictures. The experimental results show good classification performance, with the best-performing models achieving a precision of up to 95%. Transfer learning is used to minimize the small sample size. This demonstrates how CNN-based methods can help diagnose COVID-19 accurately and quickly, providing important information for preventing similar outbreaks in the future.

In Paper[3], the authors delve into the urgent need for accurate diagnostic methods for COVID-19 amidst its rapid global spread and high mortality rates. While RT-PCR techniques offer some diagnostic capabilities, chest CT scans and X-ray images exhibit higher sensitivity levels. Using machine learning techniques on various imaging modalities has become a viable strategy for precise COVID-19 diagnostic estimation. The study assesses the diagnostic effectiveness of machine learning and deep learning approaches applied to chest X-ray pictures and CT scans by thoroughly reviewing previous research in the field. The range of accuracy shown by the results, from 76% to over 99%, highlights the promise of ML and DL techniques for clinical COVID-19 diagnosis.

The authors of Paper[4] examine deep learning techniques for evaluating chest X-ray pictures in order to help in COVID-19 screening and diagnosis.. By leveraging publicly available datasets, they develop tailored models to detect viral pneumonia cases associated with COVID-19. The study suggests simple health indicators that can be used to estimate infection status and forecast patient outcomes. The results of the experiments show that deep learning models can be trained for COVID-19 screening, and that the generated detection models can successfully diagnose infected patients. Furthermore, by merging synthetic and actual health data in simulated patient scenarios, it is shown that the recommended health indicators are effective.

In Paper [5], it addresses the urgent need for rapid and accurate COVID-19 screening methods due to the challenges associated with RT-PCR testing. Leveraging chest X-ray (CXR) scans as a potential alternative, the study proposes a deep learning method using an AlexNet model. The model has been trained to classify multiple conditions, such as normal CXR scans, bacterial pneumonia, non-COVID-19 viral pneumonia, and COVID-19 pneumonia. High levels of accuracy, sensitivity, and specificity are shown in the results across a range of categorization scenarios, underscoring the promise of deep learning for thorough COVID-19 diagnosis from CXR pictures.

The use of deep learning for identifying COVID-19 pneumonia in thoracic radiographs and differentiating it from bacterial pneumonia is shown in Paper [6]. Transfer learning (TL) is used to improve model performance in light of the limited availability of COVID-19 X-ray samples. TL makes use of pretrained networks using enormous scale datasets of images or data-rich sources such as radiographs of bacterial and viral pneumonia. As compared to models trained without TL, experimental data show that the TL technique considerably increases COVID-19 classification accuracy in chest X-ray pictures. This demonstrates how TL may be used to create precise automated diagnosis models for COVID-19 pneumonia identification even in the absence of sufficient training data.

In Paper[7], In order to categorize chest X-ray pictures into COVID-19, pneumonia, and normal categories, it offers image classifiers that use Dense Convolutional Networks and transfer learning. The study increases classification accuracy by optimizing pretrained networks, using a twofold transfer learning strategy, and maintaining output neurons. Layer-wise Relevance Propagation (LRP) produces heatmaps that improve the interpretability of models. Notwithstanding the need for more clinical validation, the results demonstrate encouraging accuracy gains, suggesting the possibility of AI-assisted chest X-rays for COVID-19 diagnosis.

In Paper[8], the study uses chest X-ray images to automatically diagnose and classify COVID-19 pneumonia using an optimal Deep Learning (DL) method. With VGG16 transfer learning, the study surpasses existing approaches in the literature with a classification accuracy of 95.63% using a publicly available dataset. The suggested method, which calls for additional correlation with clinical data, appears to have promise for enhancing the effectiveness and precision of COVID-19 diagnosis.

The study presented in Paper[9] uses chest X-ray pictures to identify the site of pneumonia and evaluate how serious it is using a deep learning network. The research trains and tests the model on a dataset of 4668 X-ray pictures, with an additional 1500 X-ray images for testing, using data from the RSNA Pneumonia detection challenge on Kaggle. On the train set, the first model achieves a mean average precision (mAP) of 0.90, and on the test set, it reaches 0.89. In order to create a highly precise deep learning approach for determining the severity percentage in chest X-ray pictures with pneumonia present, the study aims to enhance current approaches.

In Paper[10], In an effort to improve patient care, the study presents a frontal chest X-ray image-based intensity scoring prediction technique for COVID-19 pneumonia. The model training procedure is based on retrospectively rated photos by blinded experts from an open COVID-19 database. The model's low mean absolute error (MAE) in predicting the degree of lung involvement and opacity scores is demonstrated by the results.

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These findings suggest the potential utility of the model in escalating or de-escalating care and monitoring treatment efficacy, particularly in intensive care units (ICUs). The availability of code, labels, and data online facilitates further research in this area.

3.PROPOSED SYSTEM

The system is built and designed in a way which can predict diseases such as Covid-19 and Pneumonia using human X-Rays as input to it in the form of images.

The system takes input as the image applies different operations on it to convert the images into desired specs and then analyzes which different models to get its best accurate predictions.

Below are some of the models we used and tested.

CNN Model

Convolutional neural networks are a particular kind of deep learning algorithm that function well for tasks involving image recognition and classification (CNN). CNNs are designed to easily and adaptively learn a spatial hierarchy of features from input images. These are inspired by the structure of the animal visual cortex.

Xception model

The Xception (Extreme Inception) model is a deep convolutional neural network architecture. You can load a pre-trained version of the network trained on over 1 million images from the ImageNet database. This allows the model to use the dataset according to its previous training to obtain results.

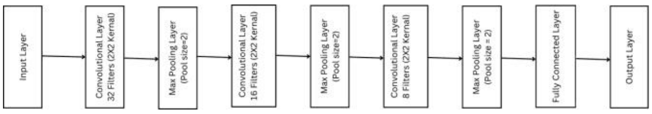
DenseNet121 Model

The DenseNet121 model is a variant of the DenseNet (Densely Connected Convolutional Network) architecture. The characteristic of DenseNet is its highly interconnected layers, in which all levels are connected to all other layers in a feed-forward manner. In very deep networks, this dense connectivity structure improves gradient flow, makes feature reuse easier, and helps solve the vanishing-gradient issue. A particular version of the DenseNet architecture with 121 layers is called DenseNet121. It has demonstrated state-of-the-art performance on a variety of picture classification tasks after being pretrained on the ImageNet dataset.

The results and accuracy of each model is given in the paper further in performance evaluation.

4.METHODOLOGY

1. The flow of our system thoroughly goes like :Data Collection : We collected data from different sources such as Kaggle which was in the form of images of diseases such as Covid-19, Pneumonia, and Normal Human X-Rays.
2. Data Cleaning and Processing : After the collection of data we then sorted the data into different categories and resized the data images into the desired format and pixels.
3. Training the Models : For the models we used in the system we tried models such as CNN, Xception, and Densenet which were trained on the data we prepared earlier and then they were compared with each other to get what goes best for the system and is more accurate.



4. Testing : The trained models were then tested with some random data samples to check if the model was working in the right fashion and giving accurate results. (The results for them are mentioned in Performance Evaluation).

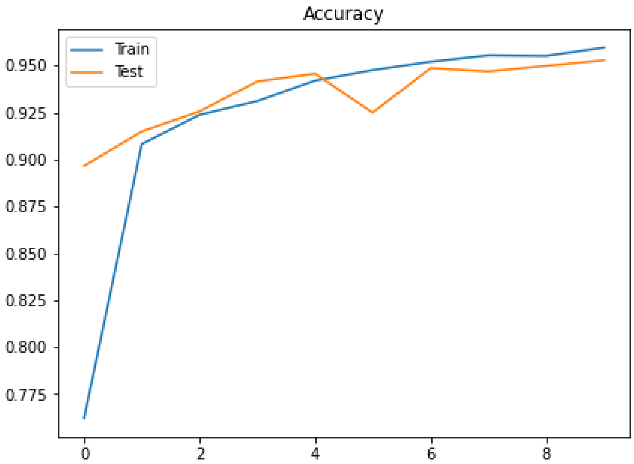
5.PERFORMANCE EVALUATION

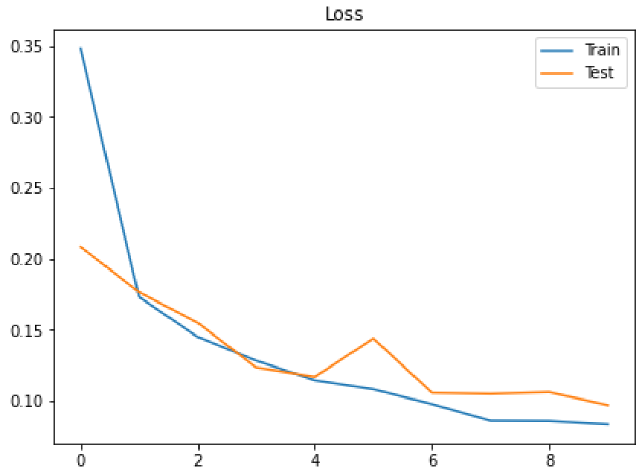
In our research we have trained two transfer learning models that are XceptionNet and DenseNet121 and a Custom trained CNN model.

The Metrics used for the proprietary trained CNN model are loss:- 'Binary CrossEntropy',optimizer :- Adam, Epochs:- 10.

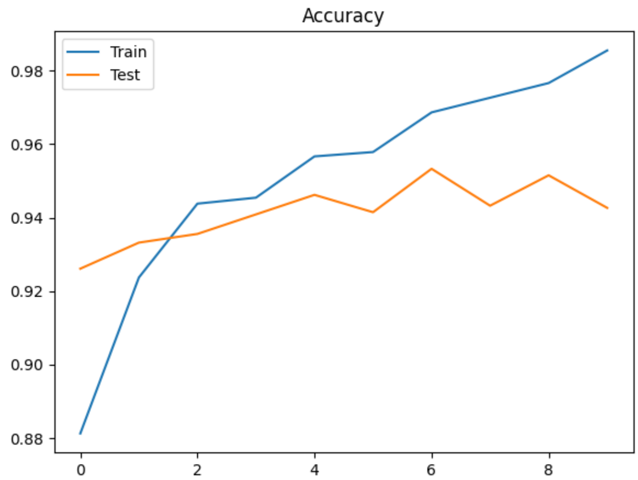
The metrics for the XceptionNet and enseNet121 model are the same loss:- 'Binary CrossEntropy',Optimizer:- Adam, Epochs:- 10.

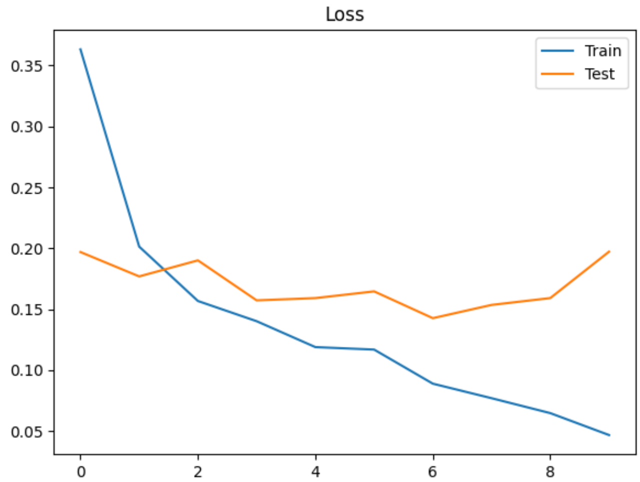
- Custom Trained Model (CNN):-
  - Loss:- 0.0835
  - Accuracy:- 0.9595
  - Validation_Accuracy:- 0.9527
  - Validation_Loss:- 0.0970



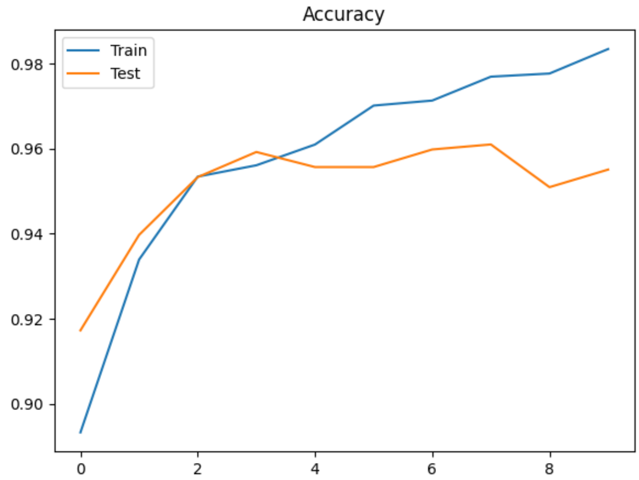


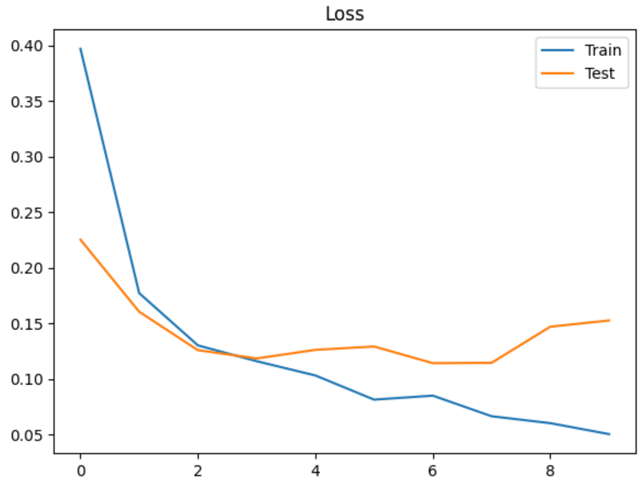
- XceptionNet:-
    - Loss:- 0.0405
    - Accuracy:- 0.9870
    - Validation_Accuracy:- 0.9427
    - Validation_Loss:- 0.1972





- DenseNet121:-
    - Loss:- 0.0552
    - Accuracy:- 0.9803
    - Validation_Accuracy:- 0.9551
    - Validation_Loss:-0.1526



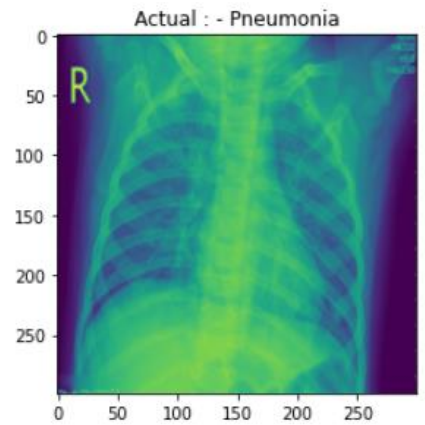


The testing of all the models are depicted in the further section of the performance evaluation.

A different image of a chest X-ray is used for model testing instead of the training dataset.

The testing of each model is given below:-

1. Custom Trained (CNN):-

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1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 289ms/step
Accuracy: - 0.9692073464393616
Predicted: -  PNEUMONIA
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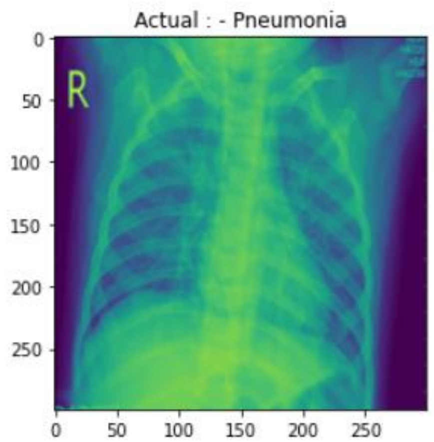
2. XceptionNet:-

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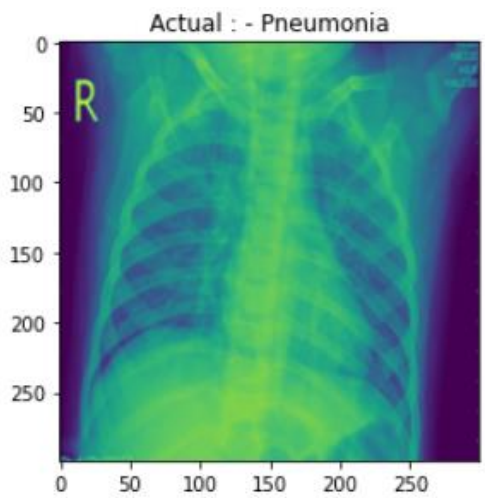
1/1 ━━━━━━━━━━━━━━━━━━━━ 2s 2s/step
Accuracy: - 0.9999308586120605
Predicted: -  PNEUMONIA
```

3. DenseNet121:-

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1/1 ━━━━━━━━━━━━━━━━━━━━ 6s 6s/step
Accuracy: - 0.9992960691452026
Predicted: -  PNEUMONIA
```

Consequently, it is evident that the transfer learning model has higher accuracy than the custom trained model. In transfer learning, we can increase the accuracy of CNN by changing the number of epochs and learning rate. As per the research analysis of all 3 models, we can state that XceptionNet has the highest accuracy amongst all.

6. CONCLUSION

We have successfully achieved our objective of developing a deep learning technique for the detection of COVID-19 and pneumonia diseases. Utilizing Convolutional Neural Networks (CNN), renowned for their efficacy in image analysis and processing, our model underwent comprehensive testing with various types of images sourced from COVID, pneumonia, and normal datasets. Demonstrating an impressive accuracy rate of 95.425%, our model holds potential for diverse medical development applications, aiming to bridge the gap between treatment and patients. Engaging in this project has provided us with invaluable learning experiences, guiding us through the multifaceted phases of project development and offering profound insights into the intricacies of developing medical software. The challenges encountered throughout the project journey have fostered a deeper understanding of professional software design practices and instilled in us a sense of accomplishment and excitement akin to that of industry developers. This project has served as a pivotal moment in our journey, illuminating the path towards proficient software development and enriching our understanding of the complexities inherent in medical software projects.

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