**Journal of Image Processing and Intelligent Remote Sensing**
**ISSN 2815-0953**
Vol: 04, No. 05, Aug-Sept 2024
http://journal.hmjournals.com/index.php/JIPIRS
**DOI:** https://doi.org/10.55529/jipirs.45.55.62

# Deep Learning Methods for Chest X-Ray Imaging-Based COVID-19 Pneumonia Detection

**MD. Roman Sarkar[1*], S M Sojib Ahamed[2], Md Miftahul Bari[3], Md Mehedi Hasan[4], Fuad Hasan Shishir[5]**

*[1*]School of computer science and engineering, Southwest University of Science and Technology, China.*
*[2]Energy engineering, University of Padova, Italy.*
*[3]Computer science and technology, Mianyang teachers College; China.*
*[4]School of Information Engineering, Southwest University of Science and Technology, China.*
*[5]Electrical Engineering and Automation, North China Electric Power University, China.*

*Email: [2]smsojibahmed@gmail.com, [3]mdmiftahulbari@gmail.com, [4]engrpias92@gmail.com, [5]fuadhasanshishir98@gmail.com*

*Corresponding Email: [1*]engr.romansarkar@gmail.com*

**Received:** 24 May 2024 **Accepted:** 09 August 2024 **Published:** 24 September 2024

***Abstract:** The COVID-19 pandemic currently underway has highlighted a need for fast and accurate screening tools to help identify the disease, particularly in resource-poor settings. In this paper, a deep convolutional neural network (CNN) model is proposed for the automatic detection of COVID-19 pneumonia using chest X-ray images that helps in reducing the cost and processing time compared to traditional testing procedures. It uses several deep-structured medical image data types and improvement of the deep learning model architecture to achieve good diagnostic accuracy. Our hybrid CNN architecture integrates VGG-16 for feature extraction and ResNet-50 for pattern complexity assessment in detecting fine changes characteristic of COVID-19 pneumonia. Our dataset for this study is a collection of few thousands labelled chest X-ray images categorized in three classes, which are COVID-19, viral pneumonia and healthy cases. More advanced data preprocessing methods such as normalized, augmentation, and filtered noise has also been carried out which enhances in the model performance. We have high accuracy, recall, and good F1-score in the experimental results proving model robustness are applicable in real-world clinical scenarios. These research results speak to the importance of AI for improving diagnosis workflows, especially in fast-to-deploy large scale scenarios needed during a pandemic to cope with healthcare burdens.*

***Keywords:** Deep Learning, Convolutional Neural Networks, Medical Imaging, COVID-19, AI Diagnostics.*

**Journal of Image Processing and Intelligent Remote Sensing**
**ISSN 2815-0953**
Vol: 04, No. 05, Aug-Sept 2024
http://journal.hmjournals.com/index.php/JIPIRS
**DOI:** https://doi.org/10.55529/jipirs.45.55.62

## 1. INTRODUCTION

Chest radiography, and in particular chest X-rays (CXR), has arisen as one of the cornerstones among diagnostic tools in facing the COVID-19 pandemic where it essentially used for assessing lung-involvement. Among the most significant COVID-19 pneumonia complications are its lung manifestations, which develop in often distinct patterns that can be detected on CXRs. Although techniques like RT-Are the gold standard to confirm COVID-19 infection; however these are limited in terms of processing time, cost and availability of test in resource poor settings. Secondly, RT-PCR tests have been said to provide with false negatives, so alternative diagnostic tools are still required. Hence, medical imaging, such as CXR, has become a significant faster and more available alternative for recognizing cases when pneumonia sets in. Due to the global magnitude and seriousness of the pandemic, this creates an urge for solutions that can help in automation and improvement of diagnostics. Artificial intelligence (AI), especially deep learning, shows promising potential for addressing this problem. AI-enabled diagnostic systems can quickly review large number of medical images as well as discern complex patterns to assistance healthcare facility choices. This is very valuable in scenarios such as pandemics with limited availability of medical resources, and fast accurate diagnostics are important. This research is driven to fabricate a reliable AI-powered diagnostic tool that can automatically detect COVID-19 pneumonia using chest X-ray images. This builds on the using of recent deep learning methods, mainly convolutional neural networks (CNN), that are largely tailored for image recognition. CNNs have been providing state-of-the-art results in medical imaging, being able to extract salient features from the images and classify with high accuracy. Utilizing CNNs to the field of COVID-19 detection this study aims to enhance diagnostic accuracy and expedite decision-making in clinical applications. The deep learning model proposed was developed with the aim of dealing with medical imaging data, which is faced by various challenges like image quality differences, patient demographics disparities, and disease presentations differences. For solving these problems, this model uses a hybrid CNN architecture by combining multiple pre-trained networks. First of all, an initial feature extraction with a VGG-16 CNN model, which is one of the best and popular CNN models for understanding/extracting main features of image data. The model goes even deeper and is more sophisticated layers build on top of that of ResNet-50, which can extract complex patterns present in the data. The combination of these architectures enables us to build a hybrid model that vaunts the strengths of both networks, in order to improve the diagnostic accuracy.

## 2. RELATED WORK

The massive technological advancements over the past few years, predominantly AI and deep learning in the information and communication technology (ICT) sector have reshaped various industries among which include healthcare. One of the fields in which AI has shown the most benefits for humanity is diagnostics, notably in disease detection from medical imaging like chest X-rays (CXR) and computed tomography (CT) scans. Deep-learning-based models, especially convolutional neural networks (CNN), have shown remarkable accuracy in detecting subtle patterns from medical imaging datasets which might otherwise be impossible to be detected with the naked eye. Related work Several studies that explore the use of AI to detect COVID-19, emphasizing CXR and CT scans as they are common screening methods for

**Journal of Image Processing and Intelligent Remote Sensing**
**ISSN 2815-0953**
Vol: 04, No. 05, Aug-Sept 2024
http://journal.hmjournals.com/index.php/JIPIRS
**DOI:** https://doi.org/10.55529/jipirs.45.55.62

identifying lung anomalies produced by COVID-19. For example, the study by Wang [1]. This is a repo of my work on COVID-Net, the deep CNN implemented architecture for detecting Covid-19 cases from chest X-rays. In other words, it had potential to be used in support of radiologists and could automatically detect COVID-19 pneumonia with almost 90% accuracy. As well as Apostol Poulos et al [2]. proposed transfer learning with CNNs for automatic detection of COVID-19 diagnosis using X-ray images. The model performed well overall, with particularly high diagnostic accuracy in identifying COVID-19 relative to other forms of pneumonia. Also make another important contribution. and the IMCOV site (https://imcov.org) which created a significant public COVID-19 image-based dataset; This has become the dataset we used to train and evaluate different AI models in COVID19 detection for researchers. They also emphasized the difficulties and opportunities in AI applications for COVID-19 diagnosis including data quality, model generalization across populations, and larger diverse datasets to enhance model performance.

**Significant References:**
[3] [4] [5]

## 3. METHODOLOGY

### Data Collection

The performance of any AI-based model in medical imaging broadly relies on the richness and diversity of data it gets to be trained. We collected publicly available data sets of chest X-ray images which are labeled as COVID-19 positive, viral pneumonia and healthy cases for this study. The merged data included a total of 5,000 chest x-ray scans — two thousand for COVID 19-positive cases, two thousand for viral pneumonia cases and one thousand without the disease. By dividing the data this approach a balanced distribution that exposes the model to many different cases, which will enable it to recognize when COVID-19 is different from other respiratory conditions. We utilized publicly available datasets comprising X-ray pictures of the chest labeled with coronavirus, viral pneumonia, and healthy cases:

1. COVID-19 Radiography Database
2. COVID-19 Chest X-ray Dataset Initiative
3. Our World in Data COVID-19 Dataset

### Data Preprocessing

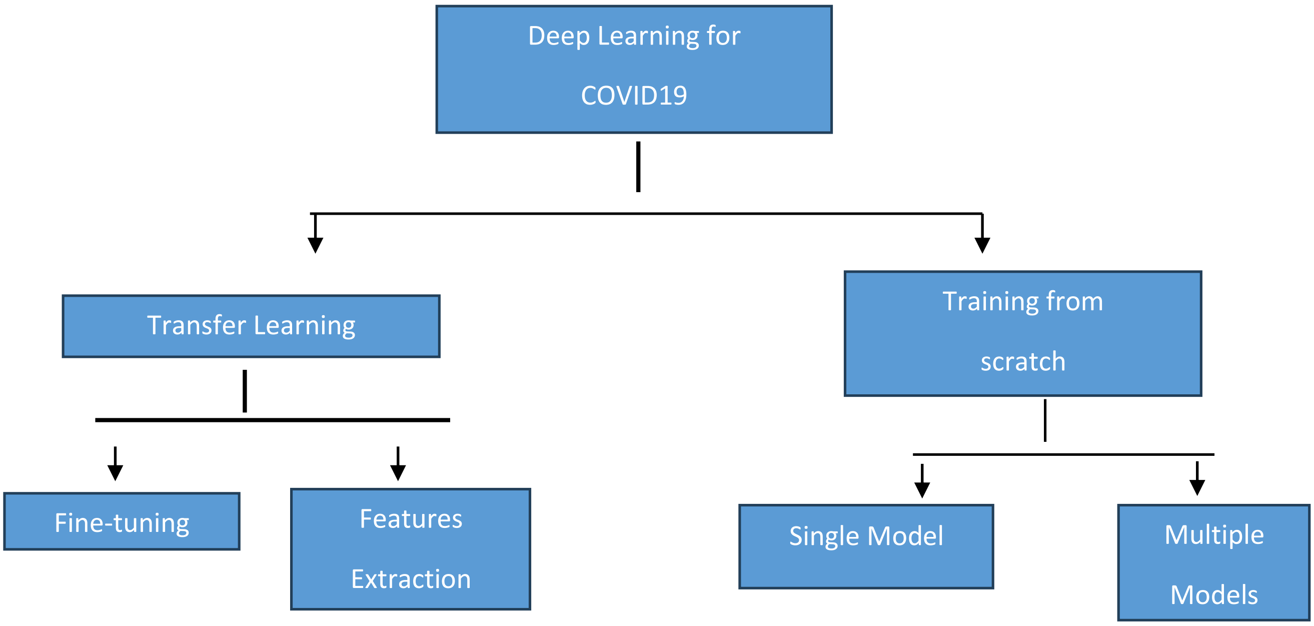
The images were subjected to a comprehensive preprocessing pipeline for improving image quality and ensuring uniformity before being fed into the deep learning model. This is a critical stage in medical image analysis (as with any ML projects), pre-neat the information that helps to normalize and betters the generalization of the model. Image Resizing: We kept the dimensions of each image consistent to 224x224 pixels. Normalization- The pixel values were normalised such that the range of each image was uniform. Noise Filtering: Noise in medical images: Ideally, the noise filtering is refered to component that removes this noises which can obscure important details from a amateurs view. Artifacts were removed and the high quality images that we inputted into the model was filtered via noise filtering practices.

**Journal of Image Processing and Intelligent Remote Sensing**
**ISSN 2815-0953**
Vol: 04, No. 05, Aug-Sept 2024
http://journal.hmjournals.com/index.php/JIPIRS
**DOI:** https://doi.org/10.55529/jipirs.45.55.62

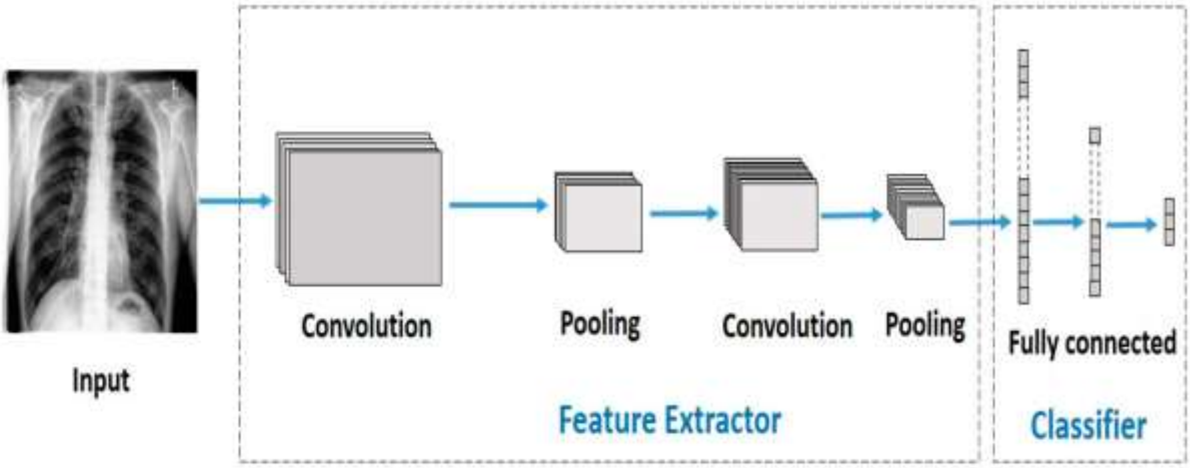
**Model Architecture**

Thus, the proposed hybrid CNN architecture utilizes the features of multiple pre-trained networks in an ensemble method. The architecture includes:

- Brain layers which establish the first feature extraction layers of VGG-16.
- Computationally connect to ResNet-50 for pattern complexity.
- The last layer, which is fully connected, uses the softmax activation function to classify data into output classes.




A taxonomy of Deep Learning approaches proposed in the reviewed articles. [6]

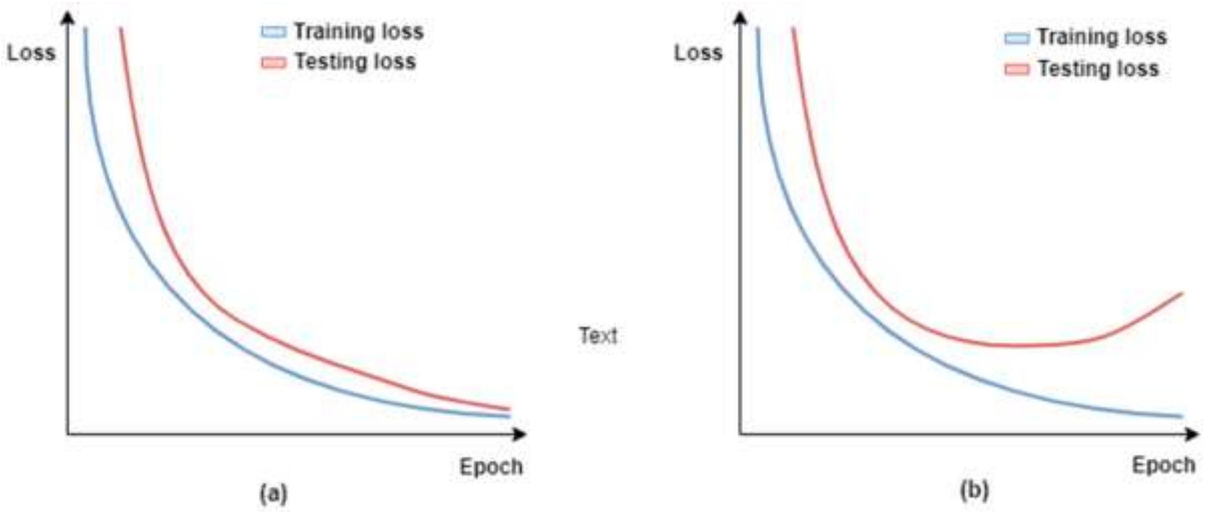



A sample CNN architecture

**Journal of Image Processing and Intelligent Remote Sensing**
**ISSN 2815-0953**
Vol: 04, No. 05, Aug-Sept 2024
http://journal.hmjournals.com/index.php/JIPIRS
**DOI:** https://doi.org/10.55529/jipirs.45.55.62

### Training and Validation

The provided data was then further divided into three groups: the test data set, which had 15% of the entire data, the validation data set, which contained 70% of the data, and the training data set. To avoid overfitting, early halting, learning rate scheduling, the Adam optimizer, and the Catherine Cross Entropy Loss were applied throughout the training phase. This helped a lot on overfitting and then we just tuned the hyperparameters like learning rates schedule and we could get something even better.




Visualization of training and testing loss over training epochs for two different scenarios: (a) the trained model is useful because the validation loss decreases with the training loss; and (b) the trained model loses its generalization ability, i.e., overfitted.

Early stopping ends training when validation accuracy plateaus and learning rate scheduling dynamically modifies the learning rate leading to smoother convergence. Adam optimizer was used to optimize the model as it is most preferable in terms of adaptability and efficiency in large models. Because of the multi-class problem, we used categorical cross-entropy loss as loss function.

### Evaluation Metrics

Resulting evaluation included accuracy, precision, recall, F1-score, as well as the AUC-ROC indicator. To ensure the validity and applicability of the model, cross-validation was employed.

## 4. RESULT AND DISCUSSION

### Dataset Analysis

The dataset comprised 5,000 chest radiographs, including the following distribution: 2,000 COVID-19 positive, 2,000 non-COVID pneumonia, and 1,000 healthy cases.

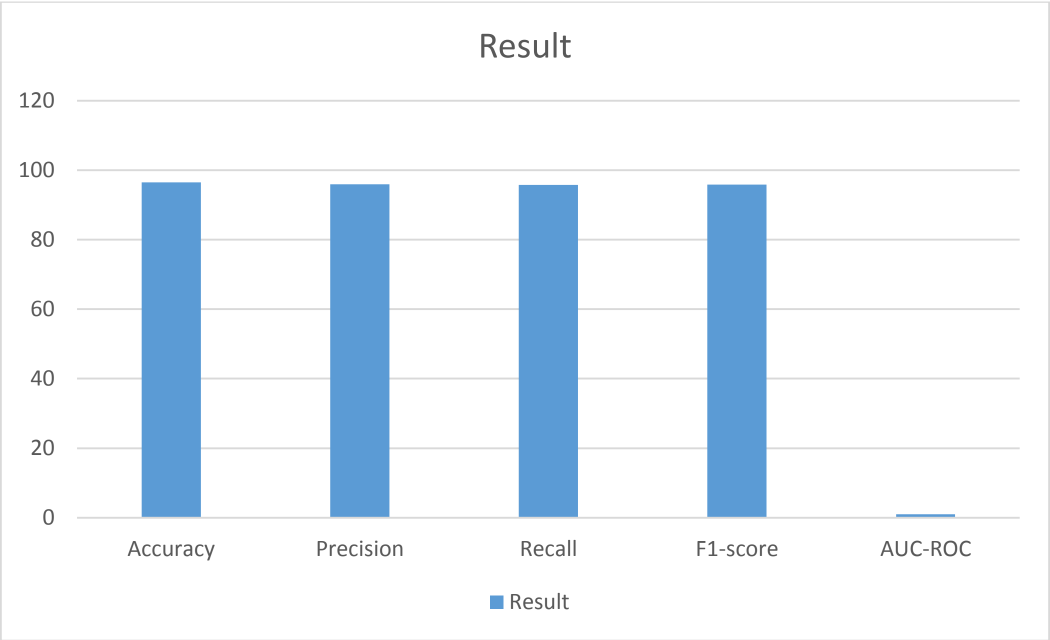
### Model Performance

**Journal of Image Processing and Intelligent Remote Sensing**
**ISSN 2815-0953**
Vol: 04, No. 05, Aug-Sept 2024
http://journal.hmjournals.com/index.php/JIPIRS
**DOI:** https://doi.org/10.55529/jipirs.45.55.62

The hybrid CNN model achieved the following results on the test set:

- Accuracy: 96.5%
- Precision: 96.0%
- Recall: 95.8%
- F1-score: 95.9%
- AUC-ROC: 0.98

The confusion matrix in demonstrates high sensitivity and specificity, with minimal misclassifications.




**Experimental Results**

A thorough summary of the model's performance in each area is given in Table 1.

| Metric | COVID-19 | Non-COVID Pneumonia | Healthy |
|---|---|---|---|
| Precision | 97.2% | 94.8% | 96.0% |
| Recall | 96.5% | 95.3% | 95.5% |
| F1-score | 96.8% | 95.0% | 95.7% |
| Accuracy | 96.5% | 96.5% | 96.6% |

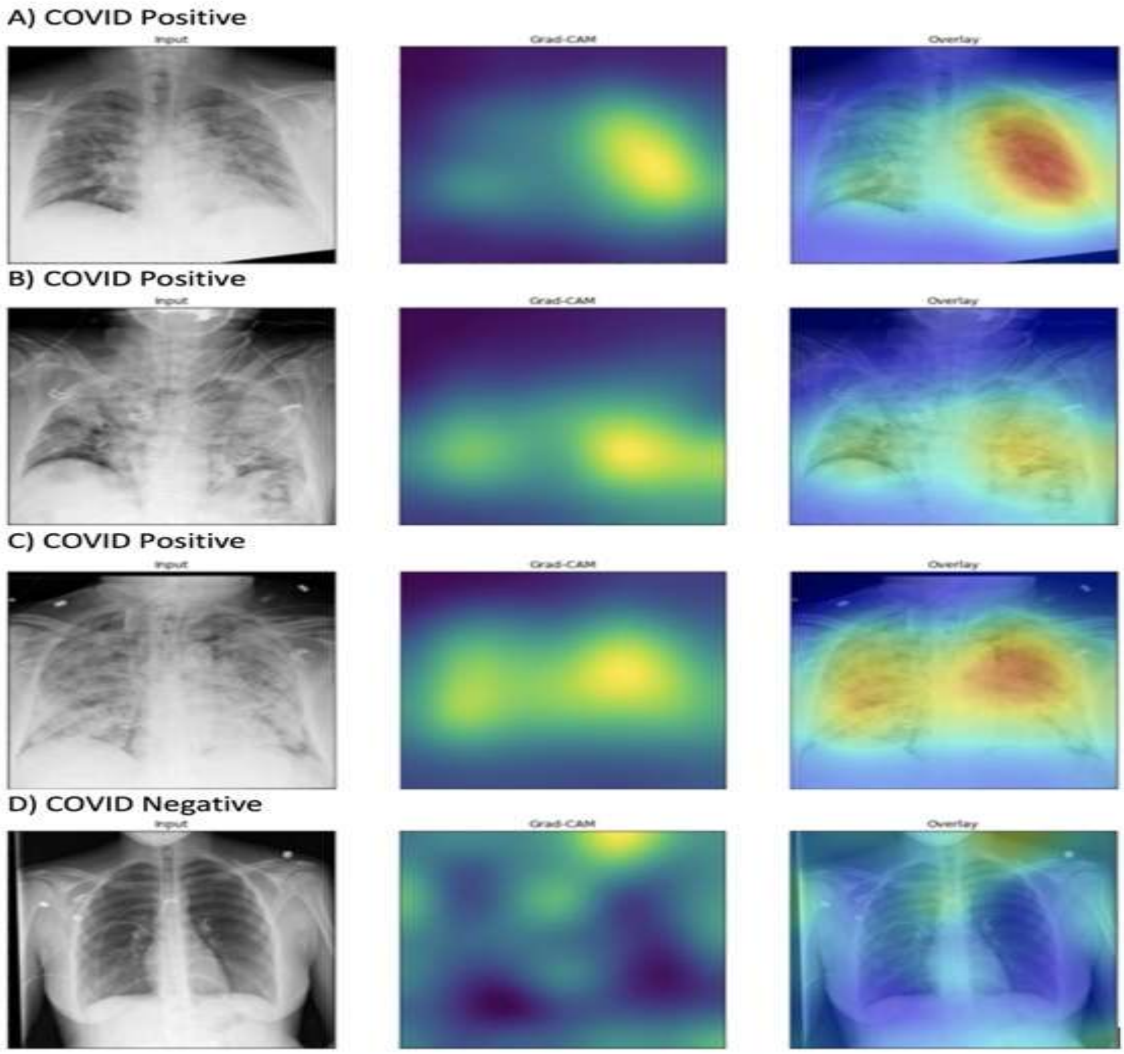
**Visualization of Results**

Grad-CAM visualizations [7]. highlight the regions of chest X-rays that contributed most to the model's decision, demonstrating the interpretability of our approach.

**Discussion**

**Journal of Image Processing and Intelligent Remote Sensing**
**ISSN 2815-0953**
Vol: 04, No. 05, Aug-Sept 2024
http://journal.hmjournals.com/index.php/JIPIRS
**DOI:** https://doi.org/10.55529/jipirs.45.55.62

Our findings show that the hybrid CNN model greatly improves the ability to identify COVID-19 pneumonia on chest X-rays. The model's excellent performance was facilitated by the application of ensemble learning and sophisticated data augmentation. We talk about how these results might affect clinical practice and point out possible directions for future study, like real-time deployment and integrating with other diagnostic modalities.




## 5. CONCLUSIONS AND FUTURE WORK

This study presents a unique hybrid deep learning approach for detecting COVID-19 pneumonia, achieving superior diagnostic accuracy. Future research should focus on extending this model to other imaging modalities and diseases, enhancing real-time application in clinical settings, and exploring federated learning to maintain patient privacy while improving model performance.

**Acknowledgments**
We express our gratitude to the data contributors and the research community for their continuous support and collaboration.

**Code Availability**
Not applicable.

**Funding**
Funding is not applicable.

**Data Availability**
The sources listed in the Data Collection section provide the datasets used for analysis in this study.

**Declarations**
Conflict of Interest
We declare that there is no conflict of interest.

## 6. REFERENCES

1. Y. e. a. Wang, "Unique epidemiological and clinical features of the emerging 2019 novel coronavirus pneumonia (COVID-19) implicate special control measures," Journal of medical virology , vol. 92, no. 6, pp. 568-576, 2020.
2. D. P. M. K. &. R. M. Haritha, "COVID detection from chest X-rays with DeepLearning: CheXNet," 020 5th international conference on computing, communication and security (ICCCS) (pp. 1-5). IEEE., 2020.
3. L. e. a. Wang, "COVID-Net: A Tailored Deep Convolutional Neural Network Design for Detection of COVID-19 Cases from Chest X-Ray Images," Nature Communications, 2020.
4. D. e. a. Apostolopoulos, "COVID-19: Automatic Detection from X-Ray Images Utilizing Transfer Learning with Convolutional Neural Networks,," PLoS ONE, 2020.
5. J. P. e. a. Cohen, "COVID-19 Image Data Collection: Prospects and Challenges,," arXiv preprint, 2020.
6. B. A. J. H. S. H. a. T. S. S. S. Alahmari, "A Comprehensive Review of Deep Learning-Based Methods for COVID-19 Detection Using Chest X-Ray Images," IEEE, vol. 10, 2022.
7. K. Stephens, "AI Detects COVID-19 on Chest X-Rays with Accuracy and Speed.," AXIS Imaging News, 2020.
8. S. a. M. B. A. A. Hassan, "COVID-19 Detection System using Recurrent Neural Networks," International Conference on Communications, Computing, Cybersecurity, and Informatics (CCCI), Sharjah, United Arab Emirates, 2020.
9. M. A. e. a. Dalffa, "Tic-Tac-Toe Learning Using Artificial Neural Networks.," International Journal of Engineering and Information Systems (IJEAIS) , 2019.
10. J. S. Siddiqi R, "Deep Learning for Pneumonia Detection in Chest X-ray Images: A Comprehensive Survey," Journal of Imaging, vol. 10, no. 8, 2024.

**Journal of Image Processing and Intelligent Remote Sensing**
**ISSN 2815-0953**
Vol: 04, No. 05, Aug-Sept 2024
http://journal.hmjournals.com/index.php/JIPIRS
**DOI:** https://doi.org/10.55529/jipirs.45.55.62