A Comprehensive Review of Machine Learning Techniques for Pneumonia Detection from Chest X-ray Images

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Abstract - Pneumonia, a significant contributor to global respiratory illnesses, demands prompt diagnosis for successful treatment. Chest X-rays, being widely accessible and cost-effective, serve as the primary imaging modality for pneumonia detection. However, manual interpretation of chest X-rays is subjective and susceptible to errors due to the often subtle and diverse visual indicators of pneumonia. This study delves into the potential of deep learning, a subfield of artificial intelligence, to automate pneumonia detection utilizing chest X-ray images. By leveraging the well-established VGG-16 model, a convolutional neural network architecture renowned for its image recognition capabilities, the study aims to develop a robust and accurate classification system. This system, if successful, has the potential to alleviate the burden on healthcare professionals by assisting in the timely and efficient detection of pneumonia, ultimately contributing to improved patient outcomes.

***Key Words*:** Deep Learning, VGG16, CNN, Pneumonia, Chest X-rays .

1.INTRODUCTION

Pneumonia, an inflammation of the lung tissue, affects millions globally, causing significant morbidity and mortality. Early and accurate diagnosis is crucial for optimizing treatment outcomes and minimizing complications. Chest X-rays, a standard imaging modality, play a vital role in pneumonia detection. However, manual interpretation can be subjective and prone to errors due to the subtle and diverse nature of pneumonia presentations.

Deep learning, particularly Convolutional Neural Networks (CNNs), have demonstrated remarkable potential in medical image analysis tasks. This paper investigates the application of VGG-16, a pre-trained deep learning model, for automated pneumonia detection in chest X-ray images. By leveraging pre-learned features from a large dataset, the VGG-16 model can potentially identify pneumonia patterns with high accuracy and efficiency, overcoming the limitations of manual interpretation.

This study aims to develop a robust and accurate deep learning system for pneumonia detection using chest X-ray images. The paper will detail the methodology, including image pre-processing techniques to enhance the data, transfer learning from the pre-trained VGG-16 model, and fine-tuning the model for the specific task of pneumonia classification. Furthermore, it will discuss the evaluation metrics employed to assess the performance of the proposed system and its potential contributions to the field of medical image analysis and automated pneumonia diagnosis.

2. LITERATURE SURVEY

In [1] author addresses the crucial issue of pneumonia diagnosis, particularly its impact on children under 5 and adults over 65, by employing convolutional neural networks (CNNs) on chest X-ray datasets. Their focus is on achieving binary classification to distinguish pneumonia-affected from unaffected cases. By optimizing CNN architectures for minimal loss and maximum accuracy, they aim to provide a valuable diagnostic tool for medical practitioners, capable of identifying various pneumonia types solely from chest X-rays.

In [2] Researchers studied pneumonia detection using chest X-rays, focusing on its prevalence in developing countries due to limited resources. Early diagnosis is crucial, but interpreting X-rays can be challenging. To address data limitations, they employed deep learning techniques, specifically Convolutional Neural Networks (CNNs) with transfer learning methods like VGG16 and CovXNet. Additionally, Long Short-Term Memory (LSTM) networks were used to assess the future intensity of the pandemic. The proposed approach, using CNNs and transfer learning, achieved good accuracy in detecting pneumonia from chest X-rays. This research highlights the potential of deep learning in overcoming data scarcity and improving pneumonia diagnosis, emphasizing the need for further development in this field.

In [3] Author proposes a novel framework that utilizes Deep Convolutional Generative Adversarial Networks (DCGAN), a type of AI, to generate synthetic "pneumonia" images. This balances the data and allows for more effective training of the model. Additionally, they combine this with "Random Under-Sampling" to further address the imbalance. To improve detection accuracy, the framework leverages transfer learning on established deep learning models like ResNet-50. This research offers a promising approach to improve pneumonia detection by addressing data imbalance and leveraging advanced AI techniques. However, further evaluation is needed to confirm the effectiveness of these specific methods in this context.

In [4] author used Deep Learning (DL) for pneumonia detection in chest X-rays, addressing the high global mortality rate,

especially in children. Highlighting DL's advantages like automatic feature extraction and improved performance, the authors applied the PRISMA method to systematically review 57 relevant studies. It explores various DL techniques like convolutional neural networks, evaluating their effectiveness and limitations. It emphasizes the potential of DL in early pneumonia diagnosis and proposes avenues for further research.

In [5] The authors propose a hybrid deep learning model combining VGG16, VGG19, CNN, and MobileNet networks to analyse chest X-rays. This model aims to improve accuracy compared to existing methods. The trained model utilizes convolutional layers, pooling, and dense layers for feature extraction and prediction. Data augmentation techniques like flipping, cropping, and rotations are employed to enhance the training data and prevent overfitting. This approach shows promising results in efficiently detecting pneumonia using chest X-ray images, potentially aiding early diagnosis and treatment.

In [6] The research explores different methods to achieve benchmark results, including using the Mask R-CNN model with image augmentation and exploring YOLOv3 for potential future improvement. While the AP-PA model and the CLAHE filter proved less effective, YOLOv3 shows promise with further development. This research suggests that CNNs with transfer learning have the potential to be an accurate and efficient tool for pneumonia detection, even with limitations in computational resources.

In [7] This research proposes a novel method for pneumonia detection using ensemble learning with deep learning models. It combines three pre-trained CNNs (MobileNet, DenseNet, and Vision Transformer) to improve accuracy. The models are fine-tuned on a pneumonia dataset after pre-training on the larger ImageNet dataset. The ensemble method combines their predictions to achieve an accuracy of 93.91%, outperforming other methods. This approach shows promise for improving the accuracy of pneumonia diagnosis from chest X-ray images.

In [8] The authors claim their VGG16 with NN approach outperforms alternatives like VGG16 with other classifiers (SVM, KNN, Random Forest, Naive Bayes) on both datasets. It highlights the potential of deep learning, particularly VGG16 with NN, for accurate and efficient pneumonia detection. The VGG16 model achieved high accuracy on two CXR datasets: 92.15% for the first (characteristics not specified) and 95.4% for the second (including pneumonia, normal, and COVID-19 images). Other evaluation metrics like recall, precision, and F1-score also show promising results.

In [9] This study explores using Quaternion Convolutional Neural Networks (QCNN), a type of AI, for detecting pneumonia in chest X-rays. Pneumonia is a lung infection causing inflammation. The research highlights the need for Computer-Aided Detection Diagnosis (CAD) tools to assist radiologists in interpreting X-rays accurately. QCNNs differ from traditional CNNs by treating colour channels as a whole, improving feature extraction for classification. The researchers trained a QCNN model on a large chest X-ray dataset, achieving good accuracy (93.75%) and highlighting the potential of QCNNs compared to other methods. This suggests QCNNs could automate pneumonia detection, reducing workload on radiologists and enhancing diagnosis reliability.

In [10] author introduced the MDEV model, which combines four pre-trained deep learning models through transfer learning.
Tested on a dataset of over 5,800 images, MDEV outperformed other methods, achieving high accuracy and recall. Notably, the model required minimal data pre-processing, making it efficient. The study emphasizes the advantages of transfer learning, ensemble approaches, and reduced data pre-processing for pneumonia detection. However, limitations exist. The model relies on a smaller dataset, potentially affecting its generalizability. Resource constraints restrict further exploration of models, and the model's interpretability and sensitivity to image variations pose challenges.

In [11] This study addresses the challenge of detecting pneumonia, a life-threatening lung infection, especially in children. Traditional methods relying on chest X-rays and radiologists are time-consuming and require expertise. To overcome these limitations, the authors propose a fast and automatic method using a deep learning architecture called MobileNet. The trained model achieves impressive accuracy (over 94%) while remaining computationally efficient and faster than existing methods. This research highlights the potential of deep learning to improve pneumonia detection accuracy and speed, potentially saving lives, particularly among children.

In [12] This research proposes a novel deep learning model (DCNN) for efficient and accurate pneumonia diagnosis using chest X-rays. It aims to address the limitations of human-assisted analysis, such as cost and limited access to experts, by offering an automated and precise alternative. The model, comprising 52 convolutional layers and trained on a chest X-ray dataset, achieves a high validation accuracy of 96.09%. However, its complexity raises concerns about overfitting and computational demands, potentially limiting its use in resource-constrained settings.

In [13] authors propose an automatic method using multichannel Convolutional Neural Networks (CNNs), a type of deep learning, to analyse X-rays and detect pneumonia. The method involves pre-processing steps like image cropping and edge detection (using the Canny method) to extract relevant features from the X-rays. This pre-processed data is then fed into the CNN for analysis. Tested on a large chest X-ray dataset, the method shows promising results for automatic pneumonia diagnosis. This research offers a potentially valuable tool for improving accessibility and efficiency in pneumonia diagnosis, especially in areas with limited healthcare resources.

In [14] The proposed deep learning-based model shows potential for efficient pneumonia detection in chest X-ray images, which can aid in early diagnosis and treatment of the disease. The use of Convolutional Neural Networks (CNN) allows for automatic diagnosis of pneumonia in X-ray images, reducing the need for manual interpretation and potentially improving accuracy. The inclusion of a dropout layer among the convolutional layers of the network contributes to quicker

convergence during training and better accuracy in validation and prediction.

In [15] author proposes a computerized diagnostic system for pneumonia detection using Convolutional Neural Networks (CNNs). It highlights the limitations of subjective interpretation by radiologists in chest X-ray diagnosis and the potential of deep learning to improve accuracy and efficiency. The system is based on a CNN model trained on a dataset of chest radiographs. The model extracts features from X-rays to classify them as pneumonia or non-pneumonia.

Authors	Research Focus	Remarks
GM. Harshvardhan et.,al [1] 2021.	Utilizing convolutional neural networks (CNNs) for binary classification of pneumonia cases in chest X-ray datasets.	Concerns about negative transfer in complex transfer learning methods, albeit with potential trade-offs in critical metrics.
Teja et.,al [2] 2023.	Utilizing deep transfer learning and convolutional neural networks (CNNs) for improved pneumonia detection in chest X-ray images.	There is a need for further improvement in pneumonia detection, as indicated by the unsatisfactory performance of existing methods.
Ali et.,al [3]2023.	Proposes a framework using Deep Convolutional Generative Adversarial Network (DCGAN) and Random Under-Sampling (RUS) techniques to manage class imbalance in chest X-ray datasets.	Need for further evaluation to assess the effectiveness of these methods specifically for pneumonia detection.
Sharma, Shagun, and Kalpna Guleria. [4] 2023.	Systematic Literature Review (SLR) exploring pneumonia detection using Deep Learning (DL) techniques.	Potential limitations in the selection process, by relying solely on parameters like impact factor and H-index.
Chandrashekhara, K. T., and M. Thungamani. [5] 2022.	Proposes a deep learning method using a convolutional neural network (CNN) to automatically detect pneumonia in chest X-rays.	Lack of interpretability: Deep learning models can be difficult to interpret, which can make it difficult to understand.
Darapaneni Narayana et.,al [6] 2021.	Utilizing deep learning techniques, specifically CNN models, for pneumonia detection in chest X-ray images, with a focus on achieving benchmark results using limited computational resources.	Challenges such as ineffective models like AP-PA and limitations in implementation, such as the requirement for a GPU with YoloV3 architecture.
Mabrouk et.,al [7] 2022.	Introducing a novel method for pneumonia detection on chest X-ray images using ensemble learning, combining MobileNet, DenseNet and Vision Transformer (VIT), convolutional neural networks (CNNs).	Potential redundancy in features learned by these models and increased computational complexity during inference due to simultaneous processing of three models.

Sharma, Shagun, and Kalpna Guleria [8] 2023.	Leveraging deep learning, specifically the VGG16 model, for early detection and classification of pneumonia using Chest X-Ray (CXR) images.	The research successfully applies VGG16 with NN for accurate pneumonia detection, showcasing improved performance compared to existing models. Challenges such as interpretability of neural network decisions and the need for large datasets for training are noted.
Singh, Sukhendra, and B. K. Tripathi [9] 2022.	Enhancing the interpretability and generalizability of Quaternion Convolutional Neural Networks (QCNN) for pneumonia detection from chest X-ray images, ensuring practical utility in diverse clinical settings.	More complex to train than traditional CNNs, Additionally, there are fewer pre-trained QCNN models compared to traditional CNNs model.
Shaikh et.,al [10] 2023.	The technology used is an ensemble of four pre-trained deep learning models: MobileNet, DenseNet-201, EfficientNet-B0, and VGG-16.	It can be computationally expensive to train and run multiple models. Additionally, it does not discuss the interpretability of the model.
Trivedi, Megha, and Abhishek Gupta. [11] 2022.	The study focuses on developing a fast and automatic pneumonia detection method using the 'MobileNet' deep learning-based architecture applied to chest X-ray images.	The training dataset used in the study was imbalanced and does not discuss the interpretability of the model.
Yi,Rong,et.,al [12] 2023.	The technology used is a Deep Convolutional Neural Network (DCNN). It is a type of artificial neural network that has been specifically designed for image recognition tasks.	The model's complexity and computational demands may hinder its deployment in resource-constrained settings.
Nahid, Abdullah-Al et.,al [13]2020.	The technology used here is a multichannel convolutional neural network (CNN).	This method is limited by the size of the dataset that the authors used to train their model.
Soundararajan et.,al [14] 2023.	The technology used is a convolutional neural network (CNN). The model uses a dropout technique in the convolutional part of the network to reduce overfitting and improve generalization.	Training CNNs can be computationally expensive, requiring significant resources such as GPUs and large amounts of memory.
Harika M et.,al [15] 2022.	The technology used is a convolutional neural network (CNN).	CNNs require a large amount of training data to be effective. In the case of pneumonia diagnosis, this data can be difficult and expensive to collect.

Table -1: Summarization of Various Authors

3. CONCLUSIONS

This study aims to contribute to the detection of pneumonia by processing the chest X-ray of the patient. By empowering healthcare professionals with accurate and timely pneumonia detection. In recent years, the application of convolutional neural networks (CNNs) in medical image analysis has garnered significant attention due to their potential to revolutionize diagnostic processes. This Paper presents a comprehensive review of literature exploring the utilization of CNNs in the realm of pneumonia detection through analysis of chest X-ray images. By synthesizing recent research findings, methodologies, and challenges associated with different approaches, it sheds light on the evolving landscape of medical image analysis and its implications for healthcare. Specifically, it delves into the intricacies of leveraging the VGG-16 model for accurate diagnosis, highlighting the advancements and limitations in current methodologies. Through this survey, it aims to provide insights into the growing significance of CNN-based approaches in medical imaging and underscore the importance of ongoing research in this field.

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