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A COMPREHENSIVE REVIEW OF DEEP LEARNING APPLICATIONS IN DIAGNOSING PULMONARY DISEASES USING CHEST X-RAYS AND CHEST CT SCANS

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ABSTRACT

Pulmonary syndromes such as lung cancer, pneumonia, chronic obstructive pulmonary sickness (COPD), and interstitial lung disease (ILD) are major health concerns across the world. An accurate and fast diagnosis is critical for the optimal treatment and management of many disorders. Traditional diagnostic approaches, which rely heavily on radiologists' interpretations of chest X-rays and CT scans, are frequently unreliable and inefficient. This research article presents a thorough overview of recent advances in the use of deep lmodels to diagnose lung illnesses using chest X-rays and chest CT images. The paper emphasizes the potential of deep learning to improve diagnostic accuracy, expedite the diagnostic procedure, and aid in early diagnosis and illness progression monitoring. Integrating deep learning with medical imaging has the latent to meaningly augment patient outcomes and maximize healthcare resources. The survey examines major findings from previous studies, ongoing difficulties, and potential future research areas to enhance the field of pulmonary disease diagnosis.

KEYWORDS

Pulmonary diseases, deep learning, chest imaging, diagnostic accuracy, medical AI

INTRODUCTION

Pulmonary disorders are among the primary causes of morbidity and death globally, placing a huge burden on healthcare systems and affecting millions of people each year. Lung cancer, pneumonia, chronic obstructive pulmonary disease (COPD), and interstitial lung disorders (ILD) all require prompt and correct diagnosis in order to be treated and managed effectively. Traditional diagnostic approaches, which rely significantly on radiologists' knowledge to interpret chest X-rays and computed tomography (CT) images, are frequently variable and inefficient. The growing complexity and amount of medical imaging data necessitates the creation of more dependable and automated diagnostic systems.

In recent years, deep learning, a subcategory of artificial intelligence (AI), has developed as a strong implementation for medical picture interpretation. Deep learning models, remarkably convolutional neural networks (CNNs) and its derivatives, partake performed well in a variety of image identification and classification applications. The application of these models to chest imaging has the latent to renovate pulmonary illness diagnosis by delivering consistent, exact, and timely interpretations of imaging data.

Because of their ubiquitous availability and inexpensive cost, chest X-rays are often employed as the first-line imaging modality for screening and diagnosing a variety of lung disorders. However, the low resolution and two-dimensional nature of X-rays can hide important features. Chest CT scans, on the other hand, produce three-dimensional, high-resolution images that reveal more information about lung anatomy and pathology. The integration of deep learning models with various imaging modalities has the potential to improve the diagnostic process by automating abnormality identification and classification, hence assisting radiologists and enhancing clinical decisions.

The advantages of using deep learning models in chest imaging are numerous. These models can interpret large volumes of imaging data with great precision, lowering diagnostic time and boosting throughput in clinical settings. They can also assist in detecting subtle patterns and early indicators of disease that the human eye may overlook, resulting in earlier intervention and improved patient outcomes. Furthermore, deep learning models can standardize diagnostic criteria, reducing interobserver variability and ensuring that diagnostic recommendations are used consistently.

This study presents a comprehensive overview of the recent status of deep models applications for diagnosing lung illnesses utilizing chest X-rays and chest CT images. It investigates advances in model creation, assesses their performance, and analyzes their incorporation into clinical workflow. The review focuses on the field's tremendous progress, remaining problems, and future research objectives. By investigating the influence of deep learning on pulmonary illness detection, this research hopes to contribute to the continuing efforts to use AI to improve healthcare delivery and patient care.

The combination of deep learning and chest imaging shows potential for revolutionizing pulmonary disease diagnoses. However, certain hurdles must be overcome in order to fully fulfil its potential. These include the necessity for large, annotated datasets to train robust models, the creation of models that can generalize across varied populations and imaging equipment, and the easy and reliable integration of AI technologies into existing clinical processes. Ethical issues, such as protecting patient privacy and eliminating biases in AI algorithms, are also essential for the effective implementation of these technologies in healthcare settings.

LITERATURE SURVEY OF DEEP MODELS IN LUNG DISEASE IDENTIFICATION & CLASSIFICATION

The authors[1] conducted a research in which numerous lung illnesses were detected using the Neural Network algorithms. The dataset utilized here is the ChestX-ray14 dataset, which includes several lung illnesses. The suggested fine-tuned MobileLungNetV2 model is used for the investigation. X-ray pictures since the dataset are pre-processed by means of CLAHE to improve contrast. A Gaussian filter is used to denoise photographs, along with data augmentation approaches. Pre-processed pictures were input into transfer learning models, which achieved 91.6% accuracy in diagnosing cuts on Chest X-ray images. One of the principal datasets of anterior-view pulmonary X-ray scan data is ChestX-ray14. 112,120 bilateral thoracic X-ray data were included in this investigation from the dataset. The ChestX-ray14 dataset includes data from 30805 distinct patients over 14 illness classes and one normal class. The typical class is tagged "No finding". Natural Language Processing was used to classify the datasets based on the accompanying data's radiological reports. The transfer learning MobileNetV2 model outperforms previous algorithms for predicting lung lesions.

Rapid development in emerging nations has led to worrisome increases in air pollution, raising public health concerns. This study intends to investigate how air pollution impacts infirmary calls for breathing ailments, namely Acute Respiratory Infections (ARI). We collected information on case hospice calls, air effluence, and climatic indicators between March 2018 and October 2021. The diurnal air effluence and outpatient visits for ARI were analyzed by the authors using eight machine learning algorithms (five layers). Five cross-fold confirmations were used in the examination. This study provides insight into the advancement of risk prediction machine learning algorithms, which might be applied to forecast analytics for a range of illnesses besides acute respiratory infections (ARI), such as heart disease and other respiratory disorders[2].

With the mounting quantity of lung cancer patients, computer-aided diagnosis (CAD) is increasingly important for automatic picture identification. Pulmonary nodules are a form of lung abnormality that can be diagnosed early in a patient's life utilizing computer-assisted diagnosis (CAD). The current lung CT image categorization approach is less effective for early cancer diagnosis and takes longer to process. We introduce a new strategy for classifying lung CT images that improves processing speed and accuracy. Our lung cancer classification system combines Gabor filters, an upgraded Deep Belief Network (E-DBN), and various classification algorithms. The authors[3] suggested a model that uses a support vector machine and an E-DBN to identify lung CT images and enhance performance metrics. The suggested methodologies are tested and assessed on the LIDC-IDRI and LUNA-16 datasets.

Lung cancer is an incurable disease that has a high death rate. Patients' lives can be saved by lung cancer when detected early and staged appropriately. Using image processing, biomarker-based methods, and machine automation, medical professionals face difficulties in correctly and quickly identifying lung cancer. The Lung Image Database Consortium and Image Database Resource Initiative (LIDC-IDRI) were used by the authors[4] to extract images from CT scans. Lung cancer is traditionally diagnosed with manual CT scans. A hybrid neural network (CCDCHNN) was used by the scientists to provide a novel method for the primary and precise detection of cancer cells. The pre-processed dataset offers the required analytical inputs. CNN and RNN are used to train training samples, and both methods are used to analyze test data. The ultimate result is predicted by combining the projected outputs of CNN and RNN. Until the maximum threshold is reached, the exact procedure is repeated. Enhancements to the hidden layer weights lead to better optimal results.

The study's objective is to identify malicious lung nodules on CT scans and categorize lung cancer according to strictness. This training used state-of-the-art Deep Learning (DL) algorithms to identify cancerous nodules. The practical difficulty also lies in exchanging data with hospitals around the globe while maintaining their privacy. Additionally, the biggest challenges in exercise a universal deep learning classical are establishing a collective model and protecting confidentiality. In this post, it was explained how to create a global deep learning model with tiny quantities of data from several hospitals using blockchain-based Federated Learning (FL)[5]. To address variability, the first step is to standardize data from multiple institutions utilizing various CT scanners. The authors classified lung cancer patients in local mode using CapsNets. We came up with a method to use FL and blockchain technology together to anonymously train a global model. We used data from actual lung cancer patients for testing purposes. LUNA 16, Kaggle Data Science Bowl (KDSB), the Cancer Imaging Archive (CIA), and local data were some of the datasets used to train and evaluate the proposed method.

Lung cancer (LC) is still a top cause of mortality globally. Early detection is crucial to save innocent lives. CT scans are a main imaging modality used to diagnose lung cancer. However, manual CT scan analysis is time-consuming, error-prone, and inaccurate. Computational technologies, such as machine learning and deep learning, can progress the accurateness of identifying malignant and non-cancerous CT images. The authors[6] introduced Lung-EffNet, a new transfer learning-based predictor for lung cancer categorization. Lung-EffNet builds on the EfficientNet design and adds top layers to the classification head. The trials are based on the "IQ-OTH/NCCD" benchmark dataset, which categorizes lung cancer patients as benign, malignant, or normal based on their cancer status. Numerous data growth approaches were used to address class imbalance and biases. EfficientNetB1-based Lung-EffNet beats other CNNs in accuracy and efficiency.

Octad pre-trained convolutional neural networks (CNNs) were used by the authors[7] to classify COVID-19, pneumonia, pneumothorax, tuberculosis, and normal images from a chest X-ray dataset. There are two phases to the categorizing process. CNNs are proficient using the Adam optimizer throughout the training phase, with a mini-batch size of 32 and a maximum epoch of 30. During the classification stage, diseases are categorized using trained networks. The dataset is scaled, enhanced, and color-preprocessed during each phase. Alexnet, Darknet-19, Darknet-53, Densenet-201, Googlenet, InceptionResnetV2, MobilenetV2, and Resnet-18 are the eight pre-trained CNNs that we used. In the end, we determined that this was the best way to categorize lung conditions. The suggested strategy outperforms current state-of-the-art approaches. Our suggested study might help physicians quickly diagnose and treat lung issues, leading to improved recovery.

The authors[8] offer an innovative technique for detecting lung cancer. Data collection begins with downloading two benchmark datasets including attribute information from several individuals' health records. Features were extracted using two basic techniques: "Principal Component Analysis (PCA)" and "t-Distributed Stochastic Neighbor Embedding (t-SNE)." Deep features are obtained from the "pooling layer of Convolutional Neural Network (CNN)". The BF-SSA algorithm, also acknowledged as optimum feature selection, is used to choose relevant features. In many domains, this hybrid optimization method works wonders for efficiently searching the search space and optimizing feature selection. High Ranking Deep Ensemble Learning (HR-DEL) is functional to five different kinds of uncovering models during the prediction stage. The anticipated output is determined by the highest rating of all classifiers combined. The classification results are compared to the performance of several methods.

Worldwide, lung cancer is a severe threat to life, hence early detection is critical. This study found four forms of lung cancer. The authors[9] used the Kaggle chest CT-scan image collection for adenocarcinoma, large cell carcinoma, squamous cell carcinoma, and normal cell. A novel Deep Learning (DL)-based strategy for identifying lung cancer illness was developed by totalling layers to the innovative DenseNet framework and altering the

DenseNet201 model. The best features retrieved by DenseNet201 were picked by means of two feature selection algorithms, and these features were then applied to a number of machine learning models. This study shows how computer technology and machine learning approaches can advance the accuracy of a CT scan-based lung cancer diagnosis.

The authors[10] want to extract texture descriptors from X-rays of COVID-19 patients' lungs and use them in frameworks to evaluate patients appropriately. Experiments with separate texture descriptors and integration were undertaken to integrate new properties into the suggested models. These frameworks will be compared to traditional ML models for COVID-19 diagnosis. Combining texture descriptors with additional conventional characteristics improves algorithmic prediction power, according to the results. Combining diverse texture characteristics improves accuracy for identifying and diagnosing COVID-19.

Deep learning systems have demonstrated amazing ability for detecting and classifying lung illnesses. They help and speed up the diagnosing procedure, saving time for medical professionals proposed by the Authors[11]. To meet the DL requirements, enormous CXR pictures of 3615 COVID-19, 6012 lung opacity, 5870 pneumonia, 20,000 lung cancer, 1400 tuberculosis, and 10,192 normal images were reduced, normalized, and randomly split. We used a pre-trained VGG19 model for classification, three CNN blocks for feature extraction, and a fully connected network for the final phase. The experimental conclusions established that our suggested VGG19 + CNN outperformed previous research. The proposed technique improved recital, permitting healthcare experts to analyze and treat patients more swiftly and efficiently.

The authors[12] offer an approach that employs transfer learning using the EfficientNet-B4 architecture, with a pre-trained model, to enhance classification performance on a large dataset of lung X-rays. The use of explainable artificial intelligence (XAI), especially Grad-CAM, enhances model interpretability by offering insights into the neural network's decision-making process, revealing the critical elements and activation areas that influence multi-disease classifications. The end product is a strong multi-disease classification system with an impressive 96% reliability and visuals that highlight crucial spots in X-ray images.

The Authors resolution of this article is to illustrate the usefulness of deep learning architectures in lung disease detection utilizing CXR pictures. The results revealed that several pre-trained networks, such as ResNet, VGG, and DenseNet, are the most often utilized CNN designs and would result in a significant improvement in sensitivity and accuracy. Recent research indicates that combining deep networks with a strong machine learning classifier can beat deep learning systems that depend only on fully connected neural networks as their classifier. Finally, this systematic review discusses the limits of the prevailing literature as fine as prospective forthcoming research possibilities in CXR pictures utilizing deep learning architectures[13].

The combination of SVM and CNN for multi-class RSs classification is the author's main focus. Additionally, the VGG16 model was enhanced with a two-layer CNN model by transfer learning, and the classification outcomes were contrasted with those of Softmax and SVM. 294 patients provided the dataset for this study, which was gathered by clinical professionals. Several classifiers were built during the classification phase, including CNN-Softmax, CNN-SVM, VGG16-CNN-Softmax, and VGG16-CNN-SVM with 10-fold cross validation. The design also included a two-layer CNN and an SVM. Furthermore, the dataset was subjected to cutting-edge models (DenseNet 201, VGG16, InceptionV3, ResNet 101, and VGG16-CNN-KNN)[14].

Authors[15] automated COVID-19 identification utilizing chest CT-scan pictures might minimize the clinician's workload and save thousands of lives. This research provides a deep learning-based technique with chest CT scan images to create a robust system for automated COVID-19 screening. This work automates COVID-19 screening using a publicly available CT-scan image dataset, two pre-trained deep learning models (DLMs), MobileNetV2 and DarkNet19, and a newly built lightweight DLM. Tenfold holdout validation is the method used to train, validate, and test DLMs. More CT scans can be used to test the proposed framework. To demonstrate the effectiveness of the research, replication results utilizing the widely available COVID-19 CT scan image dataset are provided.

Lung diseases mostly impact the lining of the lungs, causing problems with breathing, obstruction of airways, and exhalation. Early diagnosis of lung problems, including COVID-19, pneumonia, fibrosis, and tuberculosis, is challenging because of limited test kits and imaging modalities available. A major benefit for critically ill patients admitted to intensive care units (ICUs) is that chest X-rays can identify the rapid progression of lung disease. A novel framework for lung illness prediction is created, which uses a hybrid bidirectional Long-Short-Term Memory (BiDLSTM)-Mask Region-Based Convolutional Neural Network (Mask-RCNN) model to enhance clinician decision-making. Three publicly accessible lung disease datasets are used to evaluate the efficacy of the suggested methodology: the National Institute of Health Chest X-ray Dataset, which includes pictures of patients with infected lung disease, the Tuberculosis (TB) Chest X-ray Database, and the COVID-19 radiography dataset[16].

The authors [17] proposed that efficient COVID-19 patient testing has been essential in limiting and halting the disease's rapid international spread during the current pandemic. Patients with COVID-19 have a greater severity and fatality ratio when they have chronic pulmonary diseases.The radiographic exams that use chest X-ray images (CXI) are the subject of this study since they are becoming one of the most useful ways to assess pulmonary illnesses, such as COVID-19. Research has been done to use DL classifiers with nine CXI classes to predict lung ailments with COVID-19 cases. Deep Learning (DL) is still an excellent image classification approach and framework. Consequently, a novel CNN model (PulDi-COVID) has been suggested using the SSE algorithm to identify nine disorders using CXI (atelectasis, bacterial pneumonia, cardiomegaly, covid19, effusion, infiltration, no-finding, pneumothorax, viral pneumonia). Physicians may be able to lessen patient suffering and death by implementing the suggested SSE method in conjunction with PulDi-COVID to successfully achieve the COVID-19 quick detection requirements for a variety of lung disorders.

The human respiratory system may be significantly impacted by COVID-19 infection. Primary cataloguing is therefore a crucial task. Multiclass classification problems can be addressed with the use of quantum neural network models and quantum machine learning. For respiratory ailment detection, the quantum variational classifier may be more portable, have higher accuracy, and need less memory than standard deep and machine learning classifiers. Authors[18] offer a methodology that blends quantum classifiers and classical CNN for the detection of respiratory lung illnesses. It combines quantum classifiers with a traditional deep feature extraction method. A novel convention convolutional neural network (CCNN) deep learning classical is projected along with quantum machine learning algorithms Multi-Multi-

Single (MMS) and Multi-Single-Multi-Single (MSMS) to achieve feature extraction. Compared to other classic deep learning models, this hybrid model performs better. Furthermore, we used the IBM Q-QASM real-time quantum computer to validate our MMS and MSMS quantum classifiers.

Lung disease is a global problem. Examples comprise TB, asthma, pneumonia, fibrosis, and chronic obstructive pulmonary disease. It is essential to diagnose lung illness as soon as possible. For this purpose, a number of machine learning and image processing models have been established. Numerous well-known deep learning techniques, such as convolutional neural networks (CNN), vanilla neural networks, visual geometry group-based neural networks (VGG), and capsule networks, are utilized to predict lung sickness. When images are rotated, tilted, or in any other abnormal orientation, the basic CNN does not function well. Consequently, the authors offer a novel hybrid deep learning architecture that integrates CNN with a spatial transformer network (STN), VGG, and data augmentation[19]. VDSNet requires significantly shorter training time when only a sample dataset is used, however this comes at the expense of slightly worse validation accuracy. As a result, using the proposed VDSNet architecture, lung ailment diagnosis will be simpler for specialists and physicians.

The authors proposed that it is critical to identify cancerous cells in the lungs as soon as possible since these organs use crucial processes to release carbon dioxide and supply oxygen to the body. The application of deep learning to identify lymph node involvement on histopathology slides has drawn a lot of interest due to its potential utility in patient diagnosis and therapy. The metrics show that the projected method accomplishes better than six other deep learning algorithms: CNN Gradient Descent, VGG-16, VGG-19, Inception V3, Convolution Neural Network, and Resnet-50. Images from histology and CT scans are used to assess the proposed method. The findings of the analysis show that the accuracy of detection is increased when histopathological tissues are used for examination[20].

Healthcare image analysis performance has improved as a result of recent advances in deep learning. Since the majority of lung problems may be identified with non-invasive imaging methods, they are particularly important. Many pulmonary disease diagnosis applications, such as lung nodule classification, Covid-19, and pneumonia identification, have made use of deep learning techniques like as convolutional neural networks, convolution autoencoders, and graph convolutional networks. Due to the wide range of medical image sources that are available, such as X-rays, computed tomography scans, magnetic resonance imaging, and positron emission tomography scans, deep learning algorithms are helpful for precisely diagnosing lung illnesses. This author covers cutting-edge ways for detecting and classifying lung illnesses using deep learning and other medical imaging modalities. This paper describes a few publicly available datasets, as well as some new deep learning approaches[21].

This author[22] focuses on detecting and classifying disorders of the respiratory system using audio samples. This study conducts a comprehensive literature analysis from 2015 to 2021 to standardize indications for detecting and identifying respiratory illnesses. The purpose is to gather, evaluate, and summarize the indications for DL in identifying, classifying, and detecting respiratory disorders. The paper aims to help professionals and specialists understand how deep learning (DL) may be used to diagnose respiratory disorders more accurately.

One of the furthermost accessible and inexpensive radiological diagnostics in clinical practice is a chest X-ray. Machine intelligence is still having difficulty identifying thoracic diseases from chest X-rays; this is because of two factors: 1) the exceedingly variable advent of lesion areas on X-rays from patients with dissimilar thoracic diseases; and 2) a lack of precise pixel-level observations by radiologists for model training. The fact that thoracic illnesses frequently arise in disease-specific areas is a challenge that cannot be addressed by current machine learning techniques. The authors [23] describe a weakly supervised deep learning system that uses max-min pooling, multi-map transfer, and squeeze-and-excitation blocks to identify concerning lesion areas on chest X-rays and classify prevalent thoracic disorders.

In many countries, chronic obstructive pulmonary disease (COPD) is the fifth and third leading cause of disability and death by 2021. Recent evaluations suggest that a deep convolutional neural network (CNN) is utilized to analyze COPD using CT images acquired by deep learning technologies. The Authors[24] highlights significant advancements in detecting and analyzing COPD utilizing image processing approaches, deep learning models, and machine learning. This research intends to provide extensive information on pulmonary disorders, including their origins and symptoms, to improve infection treatment and response time.

DATASET

The dataset utilized in the discussion involves of lung CT scans from the COVID-19 CT Segmentation.A dataset of chest CT images from COVID-19 patients, which may show lung problems. Link https://github.com/UCSD-AI4H/COVID-CT

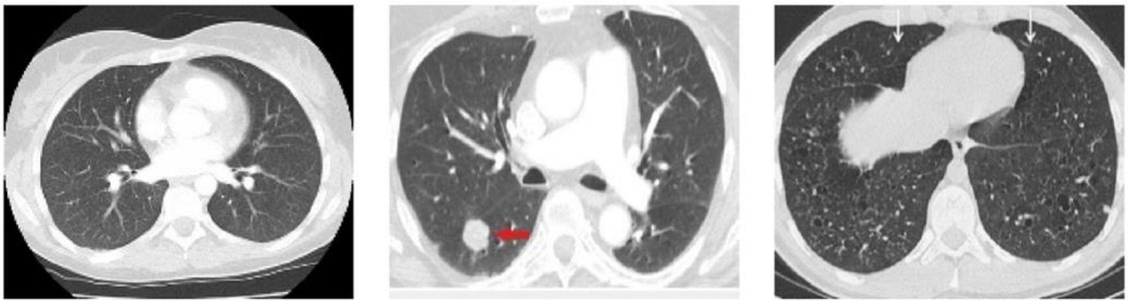

Figure 1 Lung CT images Sample from the Dataset

The collection includes chest CT scans from patients with COVID-19. These scans cover different phases of the illness and show a variety of lung abnormalities. Each CT scan has extensive markings that divide areas impacted by COVID-19. These annotations are critical for developing machine learning models that can detect and evaluate these locations.

The dataset for lungs X-ray is ChestX-ray8: Description: A large dataset of over 100,000 chest X-ray pictures annotated for up to 14 major thoracic disorders, including lung-related ailments. Link https://arxiv.org/abs/1705.02315

Figure 2 Chest X-Ray images Sample from the Dataset

The dataset includes labels for 14 common thoracic diseases images. Each image can have multiple labels, indicating the presence of one or more diseases. Using convolutional neural networks (CNNs) and other machine learning models to categorize chest X-rays into 14 pathological categories. Developing algorithms to detect and locate abnormal spots in chest X-rays.

METHODOLOGIES DISCUSSED

The workflow of the architecture is given in the Figure 3. The dataset is pre-processed and classified into training set and testing set. The ratio of classification are[60:40, 70:30, 80:20) and the results are been recorded.

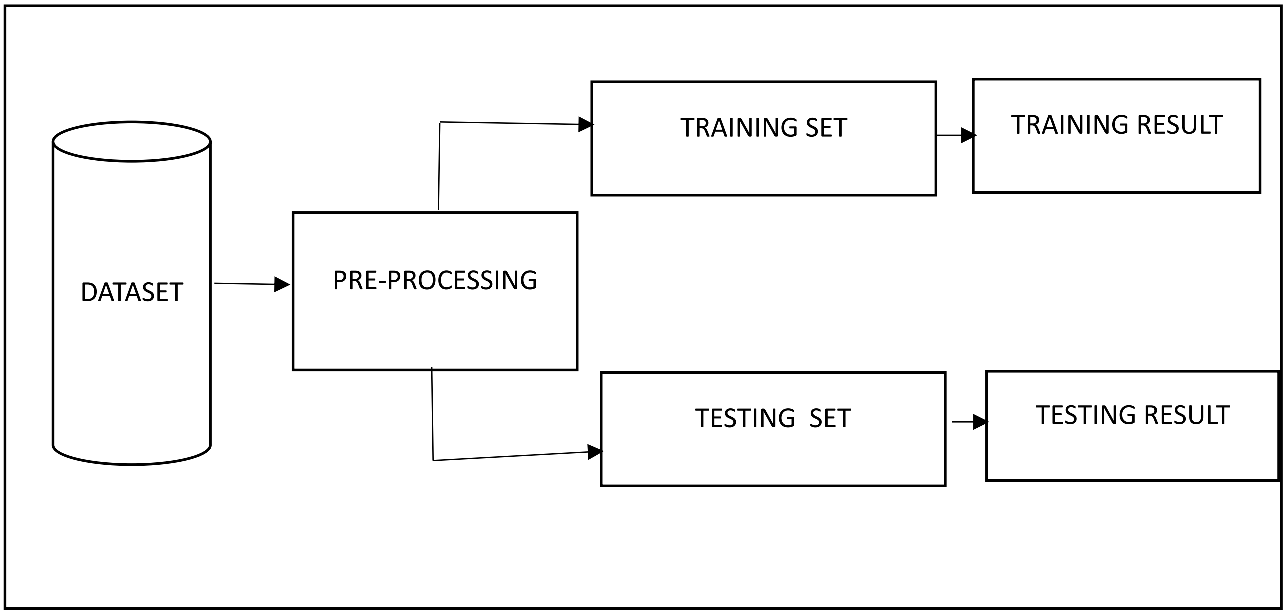

Figure 3 Workflow of the Proposed model

For the images the deep models are been trained and tested and the resulted are been verified for 20 epochs.

MODEL	ACCURACY
CNN	73
DNN	82.1
RESNET50	88.1

Table 1 Lung CT images Deep model results

The same deep models are applied for the Chest Xray images and the results are been verified for 20 epochs.

MODEL	ACCURACY
CNN	79
DNN	84
RESNET50	86

Table 1 Chest Xray images Deep model result

CONCLUSION

The combination of deep learning models and chest X-rays and CT images offers a significant leap in pulmonary illness detection. This study demonstrated the tremendous potential of deep learning to increase diagnostic accuracy, speed, and consistency, hence assisting in the diagnosis and categorization of illnesses such as lung cancer, pneumonia, COPD, and ILD. While the implementation of these models shows considerable potential, obstacles such as the requirement for big, annotated datasets, model generalization, smooth clinical integration, and ethical issues must be overcome. Continued research and collaboration between AI specialists and healthcare practitioners are critical for solving these challenges. Finally, deep learning has the potential to transform pulmonary illness diagnosis, resulting in earlier identification, improved patient outcomes, and more efficient healthcare delivery.

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