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Chest Disease Detection Using Deep Learning System: A Review

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Abstract- Healthcare industry serves as a major sector of economy of every country. It is a well-defined practice that started several years ago. As the time passed the improvement in healthcare sector has touched the new edges and of course technology has always played a very important role in it. Each and every phase of the healthcare development has different issue with them. When it comes to the prehistoric era, when medications were not yet created, healing with herbs and other natural resources was a lengthy process that may take years to complete. Now-a-days with advancement of machines and technology although the time involved in treatment has decreased but the problem arises to store data and records of several patients, records, treatments and many more. This review paper work focuses on the detection of several chest diseases including lymphoma disease. As we realize that chest diseases are so regular now-a-days, it's basic to successfully predict and analyze them. The study's dataset of several chest x-ray pictures was analyzed. Images from people with a total of fourteen different types of chest disorders—including atelectasis, consolidation, infiltration, and pneumothorax—as well as a class dubbed "No findings" if the condition was undetected—were included in the study. Consequently, the classification report states that the VGG-19 model is the most effective deep and federated transfer-learning model.

Index Terms—Chest Diseases, Deep Learning, X-Ray, Lymphoma

I. INTRODUCTION

A wide variety of medical disorders affecting the organs and tissues inside the chest cavity is referred to as chest disease, sometimes called chest disease or lung disease. The heart, lungs, esophagus, diaphragm, chest wall, and other related structures are the main structures affected by these disorders. The etiology, symptoms and severity of chest disease can vary widely. There are several other chest conditions that should test the creativity and tenacity of forward-thinking physicians. Conditions affecting many organs and tissues in the chest provide a broad enough category and a sufficiently complicated set of problems to fully engage the skills and knowledge of the medical professionals involved. When studied as related things, one can more easily achieve competence and efficiency in managing these conditions. Chest disorders can only be diagnosed and treated with an interconnected understanding of each problem due to the close anatomical and functional links between the organs that may be affected [1]. Diagnosis and treatment of chest disorders usually requires a complete medical examination, this consists of a physical examination, imaging studies (such CT or X-rays), lung function tests, and occasionally biopsies or laboratory blood tests. Various treatment options are available for each disease, including medication, lifestyle changes, breathing exercises, surgery, and additional procedures.

Doctors use various diagnostic techniques known as "chest detection methods" to detect and evaluate diseases that affect organs and tissues located in the chest cavity, such as the heart and lungs. These techniques often use different types of medical imaging that offer precise visual details about the inner workings of the chest area, such as radiography, Computed Tomography scans, and MRIs. PFTs, or pulmonary function tests, assess lung function, while EKGs, or electrocardiograms, monitor the heart's electrical impulses. In addition, more sophisticated diagnostic methods such as cardiac catheterization and bronchoscopy may be used in certain situations. Blood tests, sputum analysis and biopsies can help diagnose underlying disorders.

Artificial intelligence (AI) is increasingly being implemented in chest disease detection techniques as a powerful tool to improve speed and accuracy. AI-driven algorithms are able to accurately evaluate medical images, including Computed Tomography (CT) scans and X-rays, helping in the early detection of abnormalities or diseases. In addition, using patient information along with disease history, neural network models can aid in risk assessment by predicting the possibility of specific chest-related diseases.

II. RELATED WORK

Muhammad Umair Ali et al. (2023) [2] developed a 19-layer convolutional neural network (CNN) model to identify chest infections in X-ray scans during the COVID-19 outbreak. The model, which was optimized using stochastic gradient descent and momentum, achieved impressive classification accuracies of 98.85% in binary classification and 97% in four-class subclassification. The model also demonstrated a 98.5% accuracy rate on a fresh dataset. The model required significantly less training time than other pretrained models, making it an invaluable asset for medical professionals in clinical endeavors. This technology holds the promise of improving diagnostic processes and patient care in respiratory medicine.

Al-Sheikh M.H. et al. (2023) [3] developed a novel automated system for detecting multiple lung diseases using X-Ray and CT scans. The system uses a fusion of deep learning models and a convolutional neural network (CNN) and image enhancement to improve image classification accuracy. The pre-processing stage involves an innovative image enhancement algorithm that enhances visual quality and diagnostic utility of images. The classification stage uses a custom CNN architecture and pre-trained CNN models AlexNet and VGG16Net. The system's efficacy was evaluated using publicly available image datasets, achieving high levels of classification accuracy, sensitivity, and specificity. The study highlights the benefits of incorporating an image enhancement model in the processing pipeline and suggests potential for significant improvements in diagnostic accuracy and patient care in pulmonary medicine.

Chaudhary et al. (2019) [4] pioneered a significant breakthrough in medical imaging by creating a deep convolutional neural network (CNN) specifically tailored for the analysis of chest diseases. This network was trained on the comprehensive Chest X-Ray 14 dataset, which is a collection of radiographic images that represent a range of chest pathologies. The deep CNN developed by the research team was able to distinguish between various chest conditions with an impressive average accuracy rate of 89.77%. Such a level of accuracy underscores the potential of deep learning in assisting and augmenting the diagnostic process in clinical settings, providing a tool that can reliably classify diseases from chest X-rays, potentially reducing diagnostic times and improving patient outcomes.

Pan et al. (2020) [5] ventured into the application of deep learning for the opportunistic screening of osteoporosis during lung cancer assessments. Utilizing low-dose chest computed tomography scans, their system went beyond the detection of pulmonary abnormalities. It precisely segmented vertebral bodies, computed mean CT numbers, and related these values to bone mineral densities, offering a dual-purpose screening process. The system’s robust segmentation and labeling, coupled with its ability to accurately predict bone mineral densities, illustrated its dual capabilities and potential as a tool for both osteoporosis screening and lung cancer detection, showcasing the multifaceted utility of deep learning in healthcare diagnostics.

In their study, Kalmady et al. (2017) [6] investigated the efficiency of transfer learning by leveraging fine-tuned features extracted from customized deep neural architectures along with the implementation of specific ensemble learning algorithms. Their research aimed to evaluate the transfer learning impact on performance enhancement. Comparative analysis with previous experiments revealed a substantial improvement in performance when utilizing fine-tuned features derived from a customized deep neural network for transfer learning tasks.

In their research, Syrykh et al. (2020) [7] introduced a novel deep learning framework tailored for the analysis of hematoxylin and eosin-stained slides, with a specific focus on detecting follicular lymphoma (FL) and incorporating a confidence estimation mechanism. The study utilized Bayesian neural networks (BNN) for training, validation, and testing purposes, employing whole-slide images depicting lymph nodes affected by FL alongside those depicting follicular hyperplasia. This comprehensive approach aimed to enhance the reliability as well as accuracy of FL detection in histopathological images.

Pathak, Y. et al. (2022) [8] explored the utilization of Deep Transfer Learning (DTL) to develop a classification model for identifying COVID-19 infected patients, addressing the urgent need for accurate diagnostic tools during the pandemic. The study employed a 10-fold cross-validation method to mitigate overfitting and partitioned the dataset into 60% for training and 40% for testing, with an additional 10% of the training data dedicated to validation. The experimental outcomes highlighted the efficiency of the proposed DTL-based COVID-19 classification model, showcasing higher training and testing accuracies of 96.2264% and 93.0189%, respectively, when compared to traditional supervised learning models. The model's performance indicates its potential as a substitute for traditional COVID-19 testing kits, offering a quicker, dependable, and economical diagnostic option. Moreover, the paper highlights opportunities for future research in creating a novel, lighter deep learning model to improve network efficiency further. It also acknowledges the potential of exploring optimal hyper-parameter selection, proposing the utilization of advanced algorithms like the genetic algorithm, non-dominated sorting genetic algorithm-III, parallel Strength Pareto Evolutionary Algorithm-II, and memetic differential evolution for hyper-parameter tuning in upcoming versions of the model.

III. TYPES OF CHEST DISEASES

In recent years, the escalation of certain phenomena such as atmospheric pollution, the spread of diseases, and persistent smoking behaviors has significantly heightened the risk factors associated with chest disorders, leading to millions of individuals worldwide being diagnosed with a chest illness annually [9]. The array of chest diseases outlined in the provided diagram encapsulates a spectrum of respiratory conditions, each with its distinct pathology and clinical significance. Pneumonia is an ailment that causes inflammation in the lungs' air sacs, which can result in fluid- or pus-filled sacs. When there is a complete or partial failure of a lung or section of a lung, developing when the alveoli within become deflated is referred as Atelectasis. Pleural diseases encompass various conditions that affect the pleural space, including pleuritis and pleural effusion Consolidation occurs when lung tissue becomes filled with liquid instead of air, often due to pneumonia. Infiltration is a broad term that refers to the accumulation of substances in the lung that shouldn't be there. When air or gas is present in the space between the lungs and the chest wall, the lung collapses (pneumothorax) [10].

Edema in the chest typically involves fluid accumulation in the interstitial spaces of the lungs, known as pulmonary edema. Emphysema, a type of COPD, is characterized by damage to the alveoli in the lungs. Fibrosis of the lungs results in scarred and stiffened lung tissue, leading to severe respiratory issues. Effusion is the escape of fluid into a bodily cavity, and in the context of chest diseases, it often refers to pleural effusion, where fluid gathers in the pleural space. Cardiomegaly indicates an enlarged heart, often a sign of heart disease or high blood pressure [11]. A nodule is a small growth or lump of tissue within the lung, often seen on an X-ray or CT scan. Lastly, a mass in the chest could represent a variety of benign or malignant conditions and requires further investigation to determine its nature. Each of these diseases presents unique challenges in diagnosis and treatment, reflecting the complexity and critical nature of respiratory healthcare.

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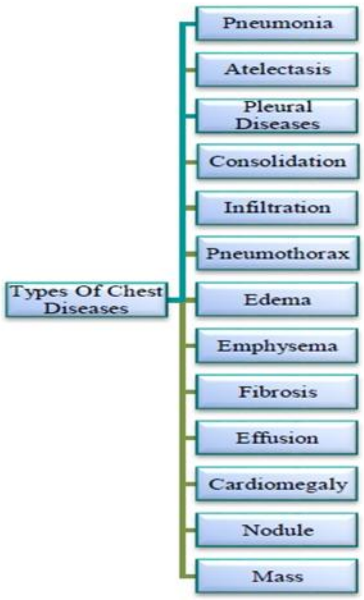

Figure 1: Types of Chest Diseases

Pneumonia: A common lung infection called pneumonia causes the alveoli of the affected person to fill with fluid and take on the appearance of clouds. Bacterial& Viral are two forms of pneumonia. However, patterns on the image of the x-ray are strikingly similar. For clinicians, determining the precise identity and level of infection remains a difficulty [12].

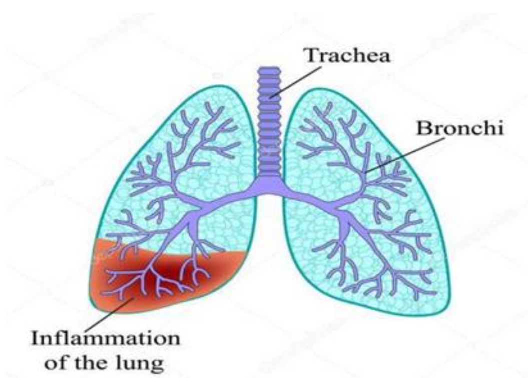

Figure 2: Pneumonia

Atelectasis: Atelectasis is a medical condition characterized by the collapse of lung tissue, primarily caused by factors such as the blockage of air passages, specifically the bronchus or bronchioles, or external pressure exerted on the lung.

Atelectasis and Bronchoscopy: Atelectasis is a lung tissue collapse due to airway obstruction or external pressure. It often involves fluid accumulation in lung spaces, often seen post-surgery or in hospitalized patients. It complicates guided bronchoscopy by hindering lung visualization, increasing pneumothorax risk, and causing misleading imaging results. Lack of specialized ventilation protocol can lead to atelectasis and ghosting artifacts in CT and CBCT scans [13].

Consolidation: Consolidation Diagnosis is Filling of pulmonary airspaces with substances like pus or fluid, Symptoms include coughing, dyspnea, chest pain, wheezing, and hemoptysis. The diagnosis involves physical examination and chest imaging. The location of consolidation can indicate cause. Treatment and prognosis depend on underlying condition and patient's overall health

Infiltrative Disease: Infiltrative Diseases and Their Impact on CardiomyopathySarcoidosis and Langerhans cell histiocytosis can form a sellar mass, enlarging the pituitary stalk. Tuberculomas affecting the sellar region can arise from systemic infection or independently. These conditions primarily impact the hypothalamus and infundibulum, causing diabetes insipidus. Infiltrative sarcoidosis of the hypothalamic-pituitary unit is common in individuals with central nervous system sarcoidosis. Infiltrative cardiomyopathies are cardiac diseases characterized by abnormal substance deposition within myocardial tissue [14]. Diagnosis relies on high clinical suspicion and confirmatory evidence obtained through endomyocardial biopsy, echocardiography, and cardiac magnetic resonance imaging.

Pleural Disease: Pleural disease is a diverse population with a variety of symptoms. Pleural effusions are common in most patients, causing discomfort, dyspnea, coughing, and lower quality of life [15]. Pleural metastases have a poor prognosis, with pleural implant resection and intrathoracic hyperthermic chemotherapeutic infusion potentially improving survival. Pleural biopsies obtained during medical thoracoscopy are a reliable diagnostic technique. Medical thoracoscopy is currently used for pleurodesis and implantation of an indwelling pleural catheter (IPC) as therapeutic procedures.

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Pulmonary Edema
Pulmonary edema is caused by an imbalance between fluid formation and clearance in lung tissue. It results from fluid leaks into the lung interstitium and alveoli, disrupting gas exchange and pulmonary ventilation.

Mass: Masses are abnormal tissue growths in or on the body, varying in size and size. They can occur in any part of the body, including the brain, lungs, liver, breasts, muscles, and bones. Types of masses include benign (non-cancerous growths like lipomas, fibromas, and hemangiomas), malignant (cancerous growths like carcinomas, sarcomas, and lymphomas), and cystic (enclosed pockets of tissue filled with fluid, pus, air). Treatment options include observation, surgery, radiation therapy or chemotherapy, targeted therapy and immunotherapy. Mass presence can indicate various conditions, from benign to life-threatening, making timely medical evaluation crucial.

IV. CHEST DISEASE DETECTION

Chest disorders are some of the deadliest illnesses in the world; CORONA, lung cancer, and tuberculosis (TB), pneumonia, are just a few conditions that claim many lives every day. Reports published by WHO says that millions of personslose their lives each year due to thoracic disorders leading to high mortality rate. Life can be saved if these disorders are detected early. Radiologists may encounter difficulties when interpreting CXR pictures for a variety of reasons, including low resolution, a lack of experience, and similarities between clinical symptoms. To support radiologists in making decisions, deep learning and machine learning algorithms has proposed CAD systems. ML techniques have grown traction in the last decade for identifying and categorizing abnormalities in medical imaging, with multiple studies demonstrating their enhanced accuracy. Medical image analysis has extensively utilized machine learning (ML) for various applications, including organ categorization, disease identification, and classification. TB, pneumonia, edema, cardiomegaly, and COVID-19 are just a few of the illnesses that were identified and classified using machine learning algorithms [16].

Chest X-rays stand as the cornerstone of diagnostic imaging for a myriad of chest disorders, serving as the most routine and initial test to screen for conditions such as lung cancer, various respiratory infections, and influenza. As a quick, non-invasive procedure, it provides a two-dimensional snapshot of the chest cavity, giving clinicians a broad overview of the lungs, heart, and major blood vessels. This initial glimpse can be critical in the early detection of serious conditions, guiding further diagnostic steps or immediate treatment when necessary [17].

Computed Tomography (CT) provides a significant and a detailed image for chest anatomy. With its advanced imaging capabilities, a CT scan can delineate finer structures and is particularly adept at diagnosing lung diseases and pinpointing abnormalities such as smaller lesions, nodules, or masses that might elude detection on a traditional X-ray. The ability of a CT scan to provide cross-sectional images of the body means that it can give a clearer view of the extent of a disease, which is essential for staging cancer or assessing the progression of a pulmonary condition [18].

Magnetic Resonance Imaging (MRI) is a less frequent, yet sometimes indispensable imaging modality for evaluating chest diseases. MRI's strength lies in its exceptional capacity to visualize soft tissue structures and blood vessels with high contrast and detail, and it does so without subjecting the patient to ionizing radiation. This makes MRI a particularly valuable tool for cases where detailed images of the chest wall, heart, or major vessels are needed, or for patients for whom radiation exposure is a concern [19].

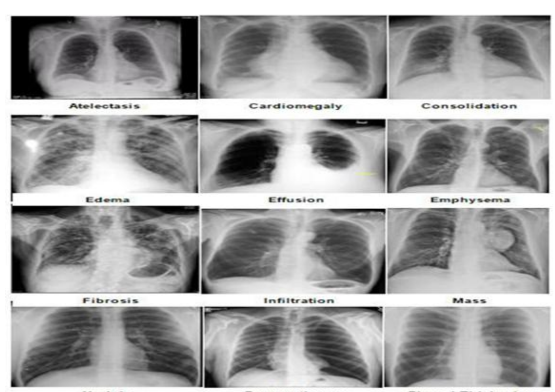

Figure 3: Different types of chest disease

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The frontier of imaging is being reshaped by incorporation of Artificial Intelligence (AI) and ML. These are being applied to revolutionize how imaging data is analyzed. AI algorithms have been developed that can swiftly and accurately sift through vast numbers of chest X-rays and CT scans, identifying patterns indicative of abnormalities that may represent disease [20]. Not only can these AI-driven methods match the accuracy of seasoned radiologists, but they can often do so with greater speed, thus potentially increasing the throughput of diagnostic imaging centres and enabling more timely interventions. This burgeoning field stands to not only augment the capabilities of radiologists but also enhance patient detection outcomes for diseases more accurately.

V. ROLE OF DEEP LEARNING TECHNIQUES MODELS IN CHEST DISEASE DETECTION

Deep Learning signifies a notable progress in disease detection, especially within the domain of machine learning. It involves training artificial intelligence systems using Artificial Neural Networks (ANN) to predict outcomes and identify patterns within data.

Deep Learning finds applications across diverse domains, including security, defense, face recognition, voice recognition, and disease detection [21]. In medical diagnosis, Deep Learning focuses on preprocessing inputs by modifying them, selecting relevant features, and resizing images to enhance data quality. This approach is particularly prevalent in medical imaging, where it extracts crucial features from input images to aid in disease diagnosis [22]. Another valuable technique in medical diagnosis is Transfer Learning or fine-tuning, which involves repurposing pre-trained models for specific tasks. These models have already been trained to recognize certain features, enabling rapid and accurate disease prediction without the need for further training. Transfer Learning finds application in medical imaging tasks such as ultrasound plane detection and lung classification diseases and various types of chest infections [23].

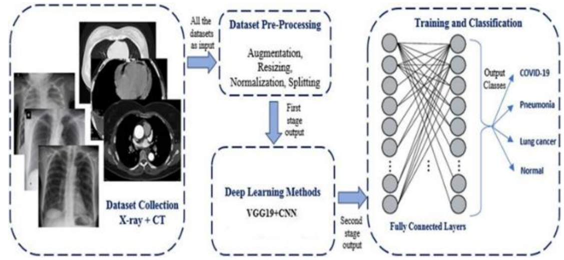

Figure 4: Deep learning models in Disease Detection

Federated Learning, a concept introduced by Google, entails the development of machine learning models capable of operating across multiple devices while safeguarding data privacy. This framework represents an advancement in artificial intelligence (AI), emphasizing the protection of user data as a fundamental principle. In Federated Learning, a globally shared model is distributed to devices for collective training, ensuring robust security protocols. Singh et al. (2020) categorize Federated Learning into three main types: vertical Federated Learning, which deals with different datasets having varying features for joint model training; Federated Transfer Learning (FTL) uses transfer learning techniques to take on new challenges by using pre-trained models for additional tasks. Horizontal or sample-based federated learning, where all devices have the same data features [24].

Deep learning stands at the forefront of modern medical diagnostics, harnessing the power of complex neural network architectures to autonomously generate models that excel in the accurate prediction and classification of various diseases. This innovative approach is particularly effective in analyzing medical images to identify and diagnose a wide array of health conditions, ranging from breast cancer and liver diseases to colon cancer, brain tumors, skin cancer, lung cancer, and pneumonia. Moreover, it has proven instrumental in the rapid development of diagnostic tools for emerging threats such as COVID-19.

One of the fundamental advantages of deep learning over classical machine learning techniques lies in its ability to learn from data in a more hierarchical, abstract manner. As a deep learning network grows in depth, it constructs increasingly abstract representations of the input data. This hierarchy of complex features is not predefined but is instead learned directly from the data, with each subsequent layer building on the previous ones to refine the model's understanding.

The self-sufficient nature of feature extraction in deep learning is a key differentiator from traditional machine learning algorithms, which often require manual feature selection and are limited by the quality and comprehensiveness of these human-selected features. Deep learning algorithms circumvent this limitation by employing a series of nonlinear functions that are layered and combined in a manner that encourages the discovery of intricate patterns within the data.

These patterns, which may be imperceptible to the human eye or mind, can encapsulate critical diagnostic information, enabling the models to make predictions with a high degree of accuracy. The compounding effect of these nonlinear functions within a deep learning model results in a system that can, with sufficient training data, outperform human diagnosticians and traditional machine learning algorithms in both speed and accuracy.

In the medical field, where the stakes are life-altering and the volume of data is vast, the utilization of deep learning has the potential to revolutionize patient care. By providing healthcare professionals with highly accurate diagnostic aids, deep learning models can streamline the diagnostic process, reduce the rate of misdiagnosis, and open the door to personalized treatment plans, ultimately enhancing the efficacy of healthcare delivery.

On the other hand, transfer learning is a technique for adapting knowledge from one scenario to another. Transfer learning on a pre-trained network is usually quicker and easier than training a network from the ground up. With deep-learning-based methods, medical image processing and computer-assisted intervention challenges are increasingly being addressed [25]. Neural network architecture is commonly used to accomplish deep learning and federated learning. Deep learning-based diagnostic systems have recently been applied to develop automated methods for interpreting histopathology images. Digital microscopy can uncover unique morphological traits and increase histopathology interpretation performance when paired with deep learning algorithms [26,27]. Visual object recognition is aided by deep learning in computing. Deep learning has outperformed humans in high-level thinking and reasoning activities, indicating that it has much potential in medicine.

VI. CONCLUSION

In the past few decades, many trends have been set up in the healthcare industry, from hymns and prayers to digital systems. But every phase has a problem that was needed to be overcome. Now the latest trend and technologies are emerging as a solution for all. Implementing technologies like deep learning, machine learning has taken the healthcare industry to the next level. Data can be easily stored in a large amount over the internet and can be easily accessible whenever needed, but still, it is not the end. More new changes and developments are waiting, and the future of the healthcare industry can be brighter by implementing these new concepts.

In this review, we utilized deep learning approaches to identify chest diseases from X-ray images. Initially, we pre-processed the data by applying loading and cleansing procedures to standardize the data format. Following this, we conducted exploratory data analysis to categorize and analyses data attributes such as gender, age, and disease occurrence. Then, for every occurrence of the illness, we extracted features including area, width, perimeter, epsilon, height, and firmness. Then, in order to enhance image quality, we divided the data into training and testing sets and applied data augmentation techniques. Finally, we study a variety of deep learning models.

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