

A Survey of Medical Image Analysis of Infectious Diseases using Deep Learning

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Abstract

In this study several papers were studied on the application of deep learning in medical image processing. Corona Virus and Tuberculosis were selected as case study of infectious diseases because they are chest diseases that can be easily identified from X – ray and CT scan images. Several deep learning applications for detection and recognition of Corona Virus and Tuberculosis from X – ray and CT scan images were discussed. Different datasets were discussed for both Chest X-ray and CT scan images. Deep learning models were measured based on the accuracies and sizes of training data. Medical Image analysis is affordable and reliable and will increase accuracies of Covid-19 and Tuberculosis detection.

Keywords: Covid-19, TB, CXR, CT SCAN, EAI, CNN, DNN

1. Introduction

Medical Image Analysis is a process of pre-processing, processing, segmentation, post processing, and classification of images to extract meaningful information for health purposes. Deep learning Neural Network is a multi-layer neural network that shows promising result in recognizing patterns, and prediction in medical field. Large datasets are used to train Deep learning models. The trained network can classify image, identify presence or absence of a feature, segment image, and find specific features. (Mall et al., 2023)

Medical imaging particularly CT scan and X-ray, is frequently employed in conjunction with RT-PCR test to enhance diagnostic certainty. Seppanen et al. (2023) stated that driven by the effectiveness of computer aided diagnosis (CAD) in different medical fields most especially for diagnosis purpose, researchers investigated the utilization of CAD to enhance COVID-19 detection through the processing of medical images. Several observations further support this approach, including the fact that X-rays are widely accessible, cost-effective, and portable, reducing the risk of virus transmission. Additionally, medical imaging can simultaneously detect other respiratory and pathological diseases with a relatively high degree of accuracy. Notably, COVID-19 is characterized by hazy grey areas spread across the lungs, which help distinguish it from other respiratory diseases. However, its visual patterns often resemble those of other viral and bacterial pneumonia, highlighting the value of computer-aided detection (CAD) or chest computed tomography (CCT) techniques for COVID-19 diagnosis. Furthermore, artificial intelligence (AI)-based tools are recognized for their potential to ease the workload on radiology services by accelerating the

interpretation of findings and assisting radiologists in preparing detailed diagnostic reports. (Seppanen et al., 2023).

2. Related Works

Deep learning is used in medical analysis of tuberculosis and corona virus. According to Xie et al., (2023), modern medicine has seen significant advancements in medical imaging techniques, including computed tomography, X-rays, and magnetic resonance imaging. Deep learning mimics the way the human brain processes information to make precise decision and teaches a system to process inputs through multiple layers, assisting in data prediction and classification (Bhattacharya et al., 2020). Deep learning methods have been increasingly successful in rapidly, accurately, and automatically detecting lung diseases using chest radiological images (Sharma et al., 2023). Compared to traditional detection methods, these techniques offer advantages such as shorter detection times, ease of operation, and relatively lower costs (Xie et al., 2023). Infectious diseases are communicable diseases that are transmitted from one person to another. These infectious diseases are caused by pathogenic microorganisms such as fungi, virus, bacteria or parasites. Transmission of this infectious disease can be through air, water, body contact or vectors like insects. Understanding the nature of infectious diseases is very essential for effective prevention, diagnosis and treatment. This survey is limited to Corona Virus (COVID-19) and Tuberculosis as case study of infectious diseases that are detected in the Lungs. Corona Virus and Tuberculosis were selected as the infectious because they are chest diseases that can be easily identified from X – ray and CT scan images. Several deep learning applications for detection and recognition of Corona Virus and Tuberculosis from X – ray and CT scan images were discussed. Corona virus as the name implies is caused by a group of viruses. In city of Wuhan, China, a number of patients were infected with the coronavirus disease (coronavirus disease 2019, covid-19) during the last days of 2019. Since then, covid-19 being contagious has spread around the world affecting people in different ways. The common symptoms developed by the infected patients include fever, fatigue and dry cough. Other symptoms may include aches and pains, nasal congestion, runny nose, sore throat and diarrhoea (Albahri et Al., 2020). Covid-19 spread very fast and due to this reason, a huge number of infections were reported daily, leading to overload of intensive care units and delay in obtaining timely accurate diagnosis (Beddiar et Al., 2023). One of the major ways of contacting the disease is touching a contaminated surface with the hands and touching the face i.e. nose, mouth and eyes with the affected hands several efforts by scientist to come up with a relevant treatment has been in vain. Hence a major way to prevent infection is to observe personal hygiene by using sanitizers, disinfecting surfaces and covering the face with a mask (Nabavi et Al., 2021). Another way is the early detection of infected persons and isolation from people (Daniel et Al., 2022). The emergence of COVID-19 has affected human health by attacking the respiratory system, thereby claiming the lives of many people all over the world (Daniela et al., 2022).

Tuberculosis is an infectious disease that affects the lungs. It is ranked as the second most dangerous infectious disease after Covid-19. Tuberculosis can easily be misdiagnosed due to poor radiological image or less competent doctors especially in rural areas (Sharma et al., 2023). Molecular techniques like quantitative real-time reverse transcription polymerase chain reaction (RRT-PCR), along with other methods such as serological tests and viral throat swab analysis, are widely used and highly significant for detecting COVID-19. Nevertheless, numerous studies have demonstrated that chest X-rays and computed

tomography (CT) scans are crucial in identifying abnormalities associated with various lung diseases, including COVID-19 (Albahri et al., 2020).

In a study by Moghaddam & Ghavipour (2022), while RT-PCR serves as a primary method for diagnosis of COVID-19, its sensitivity is quite low. Consequently, even if a patient receives a negative result, it doesn't completely rule out the possibility of having COVID-19.

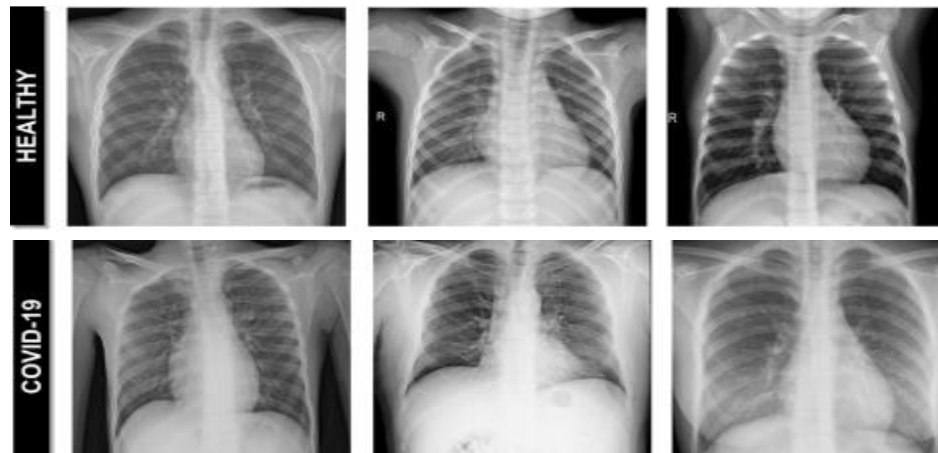
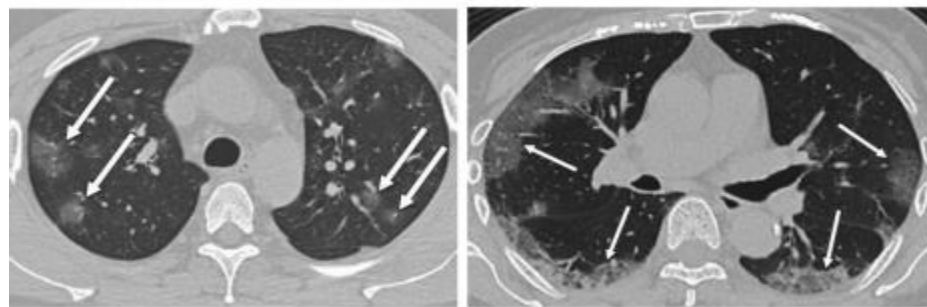


Figure 1: Representative examples of X-ray images. Row 1 showing X-ray images from a healthy patient and row 2 of a patient with COVID-19 (Ortega, 2021).



(c) COVID-19 CT scan image 1

(d) COVID-19 CT scan image 2

Figure 2: CT scan images of covid 19 patients (Bhattacharya et al., 2020)

Moghaddam & Ghavipour (2022) stated that using CT and chest X-ray images for an accurate diagnosis of COVID-19 relies on the Radiological expertise as some radiologist might fail to interpret the results of the images accurately thereby resulting in diminished sensitivity. The use of AI and ML model together with radiological images will enable a more accurate diagnosis of the disease at an early stage thereby ensuring availability of treatment. (Piran et al., 2020). The recent advancement of machine learning techniques most especially deep learning and this technique in medical image processing scientist and doctors aim to enhance the precision of COVID-19 diagnosis by implementing deep learning techniques on chest medical imaging. These methods hold the potential to offer decision support for clinicians, thereby reducing the occurrence of medical errors (Moghaddam & Ghavipour, 2022).

3. Methodology

Deep neural networks (DNNs) are a specialized subset of machine learning (ML) that uses multilayered neural network architectures. These networks are inspired by the way the human brain processes large volumes of data during training. DNNs refine their performance through repeated tasks, with deeper layers enabling progressive learning and improved results over time. Typically, DNN architectures include numerous, often broad, layers connecting the input and output, with some modern implementations surpassing 1,200 layers and containing over 16 million neurons. Each layer comprises neurons modeled after biological neurons, activated through linear or non-linear functions such as the hyperbolic tangent or sigmoid. Specific layers play distinct roles depending on the architecture. For example, convolutional layers, named for the convolution operations they perform using filters, are responsible for feature extraction. Many unique DNN architectures exist, each tailored for specific tasks. DNNs have proven highly effective in enhancing pattern recognition in medical imaging across various anatomical regions and organs, such as the brain, kidneys, lungs, liver, bones, and more. These models facilitate accurate and automated analysis of medical images, supporting diagnosis, treatment planning, and disease monitoring. The hierarchical analysis of medical images using DNNs involves several stages. At the base, various imaging modalities—such as MRI, CT, PET, ultrasound, and X-rays—provide diverse data for training. These modalities capture unique anatomical or physiological details, which are essential for the network's learning process. Training involves large datasets of labeled images and employs optimization techniques like backpropagation and gradient descent, enabling the model to identify patterns and features relevant to specific tasks. After training DNNs can analyse medical images, classify and detect abnormalities (Mall et al., 2023)

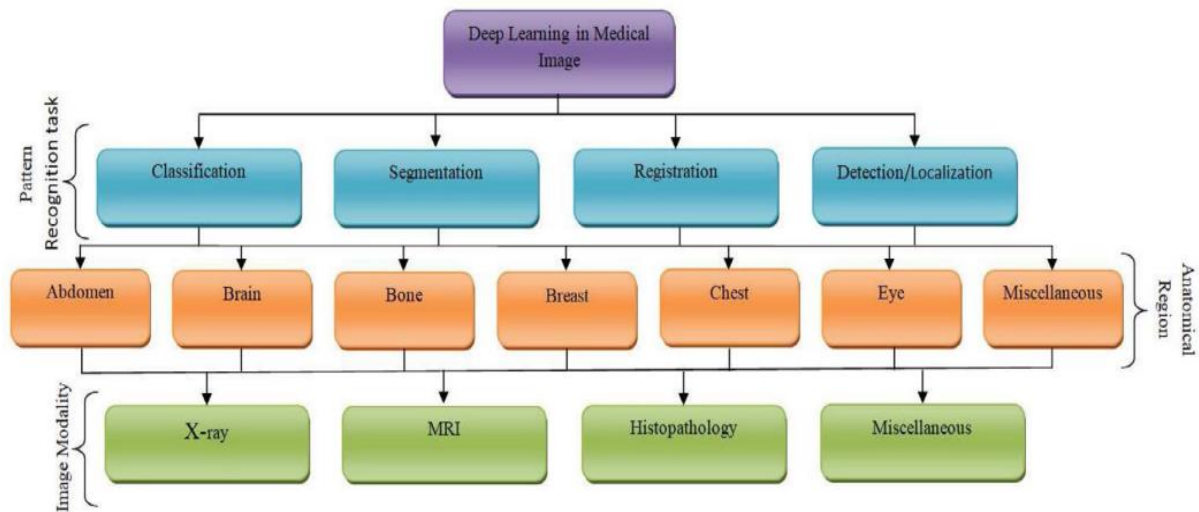


Figure 3: Application of Deep Learning in Medical Field (Mall et al., 2023)

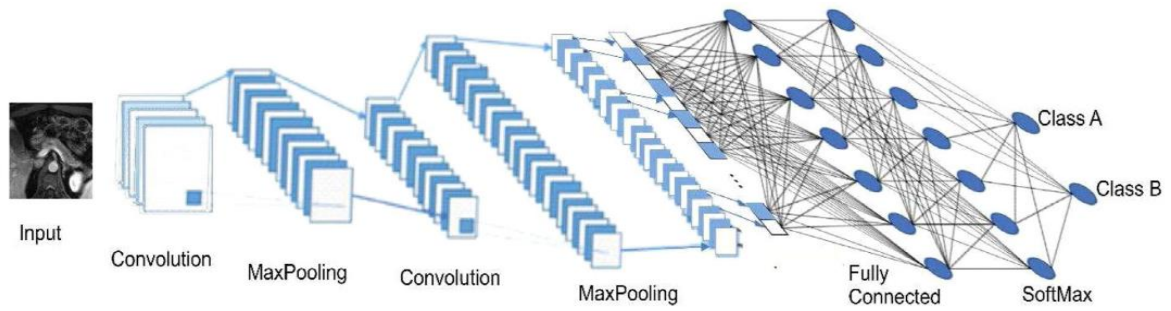


Figure 4: Convolutional Neural Network Architecture (Mall et al., 2023)

There is need for machine interpretation to reduce errors caused by manual observation and conditions such as poor radiological image. The application of deep learning algorithm in medical image analysis has improved drastically over the traditional medical image analysis. Sharma et al., (2023) used classification and segmentation techniques on chest X-ray images, and deep learning algorithm to train datasets collected from Montgomery County and Shenzhen Hospital. They also use Gradient-weighted Class Activation Mapping (Grad-CAM) heat maps for visualization of infected areas of the lungs.

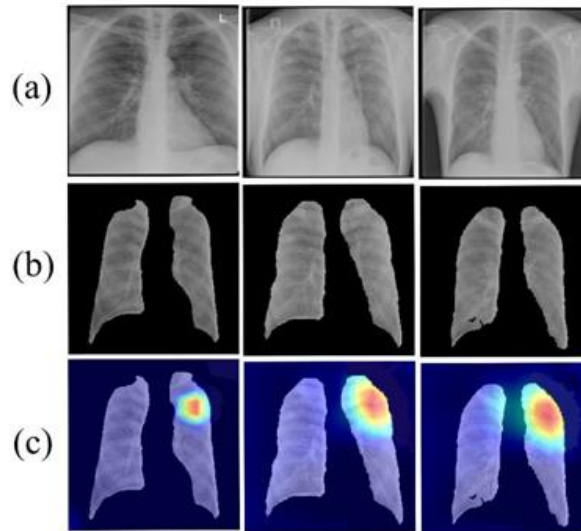


Figure 5: (a) CXR image (b) Segmented image (c) Heat Map showing affected areas (Sharma et al, 2023)

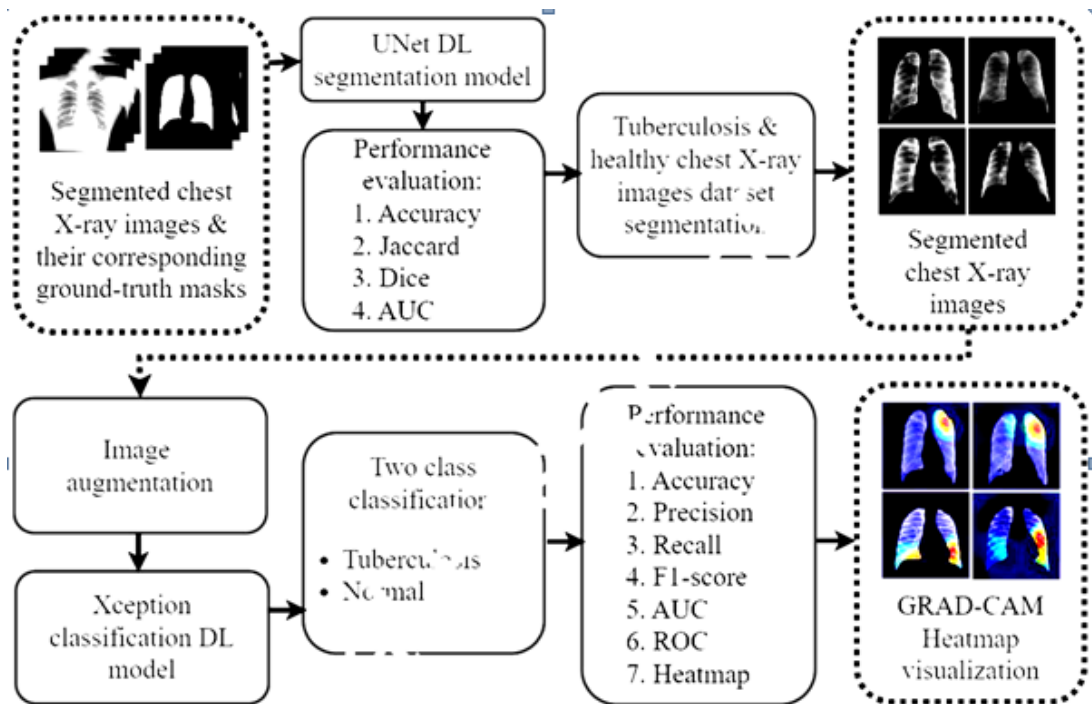


Figure 6: Methodology (Sharma et al, 2023)

Ejiyi et al. (2024) proposed ResNet fused External Attention Network (ResFEANet) to classify Chest X-ray images. It has 97.59% accuracy in classifying positive and negative Tuberculosis. Due to limited number of trained radiologist for interpreting CXR images the need for an automated system for reading and interpreting CXR images is required.

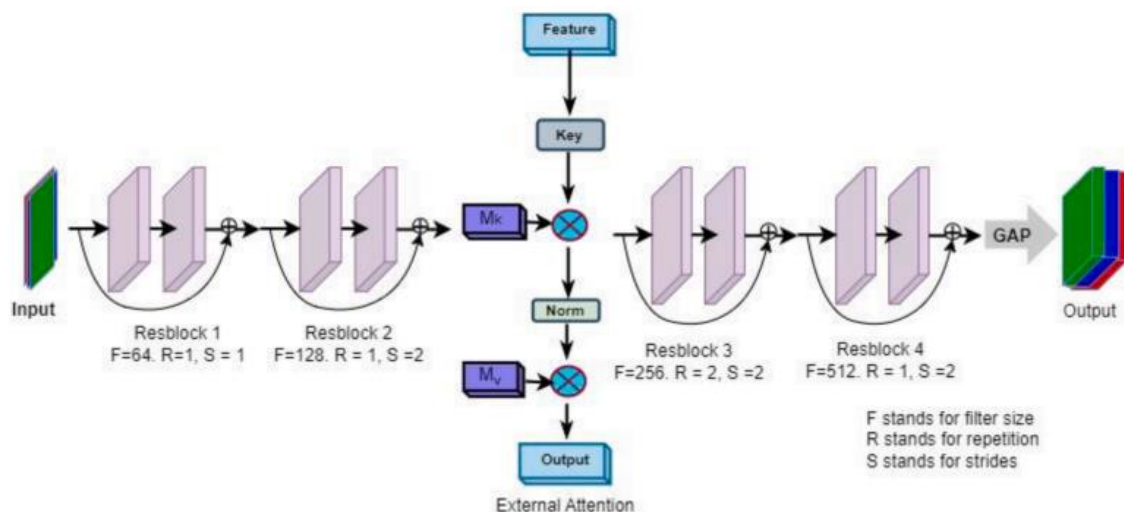


Figure7: ResFEANet Architecture (Ejiyi et al., 2024)

(Bhandari et al, 2022) also proposed deep learning approach to predict COVID-19, Pneumonia, and Tuberculosis using CXR. The proposed system also used Explainable Artificial Intelligence (EAI) for drawing conclusion which can be used by medical doctors.

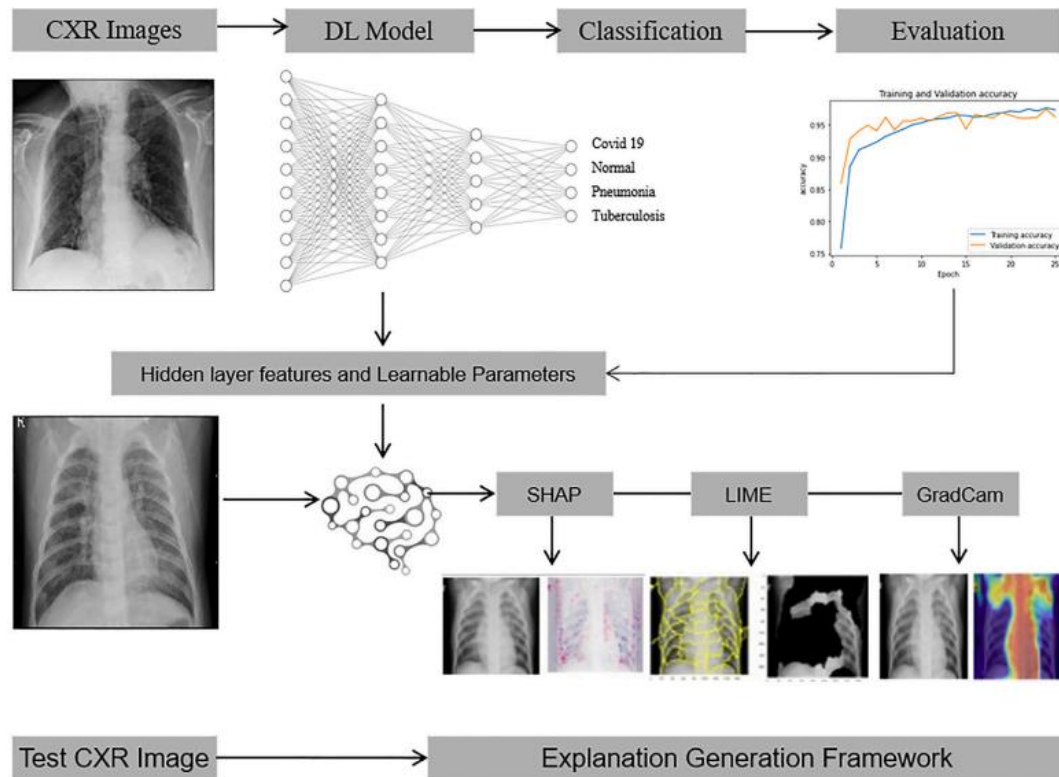


Figure 8: Deep Learning Approach for detecting COVID-19, Tuberculosis and Pneumonia (Bhandari et al., 2022)

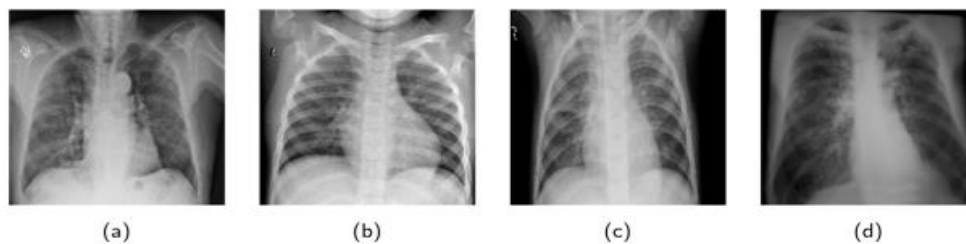


Figure 9: (a) COVID - 19 (b) Normal (c) Pneumonia (d) Tuberculosis (Bhandari et al, 2023)

According to Sathitratanaheewin et al. (2020), deep learning model trained from dataset of one population may not have the same diagnostic performance in another population. Chest X-Ray (CXR) dataset for Tuberculosis was used to train Deep Convolutional Neural Network (DCNN). Bhandari et al. (2022) also proposed deep learning approach to predict COVID-19, Pneumonia, and Tuberculosis using CXR. The proposed system also used Explainable Artificial Intelligence (EAI) for drawing conclusion which can be used by medical doctors.

Wang et al. (2023) used segmentation techniques for CT images to detect pneumonia, pulmonary nodule and tuberculosis. The Generative Self-Supervised Adversarial Learning (GSAL) architecture was employed for the end-to-end segmentation of pneumonia, lung nodules, and tuberculosis lesions, utilizing multi center datasets. This approach demonstrated superior performance compared to nnUnet in detecting pneumonia, pulmonary nodules, and tuberculosis lesions.

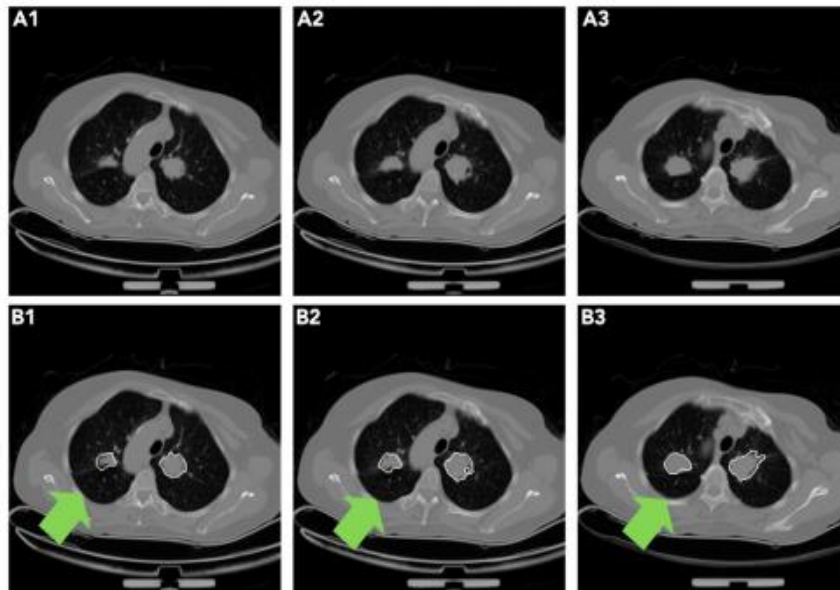


Figure 10: (a) CT Scan Image (b) Segmented COVID-19 (Wang et al., 2023)

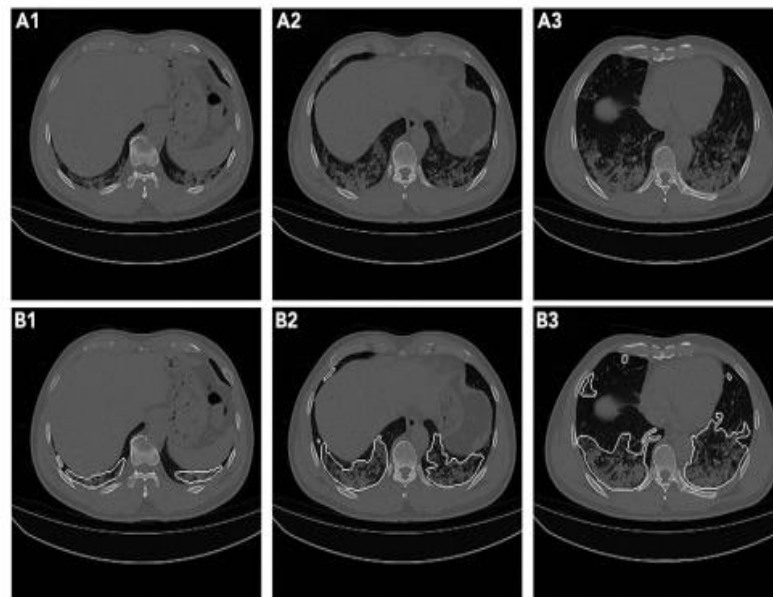


Figure 11: (a) CT Scan Image (b) Segmented Solid Nodule (Wang et al., 2023)

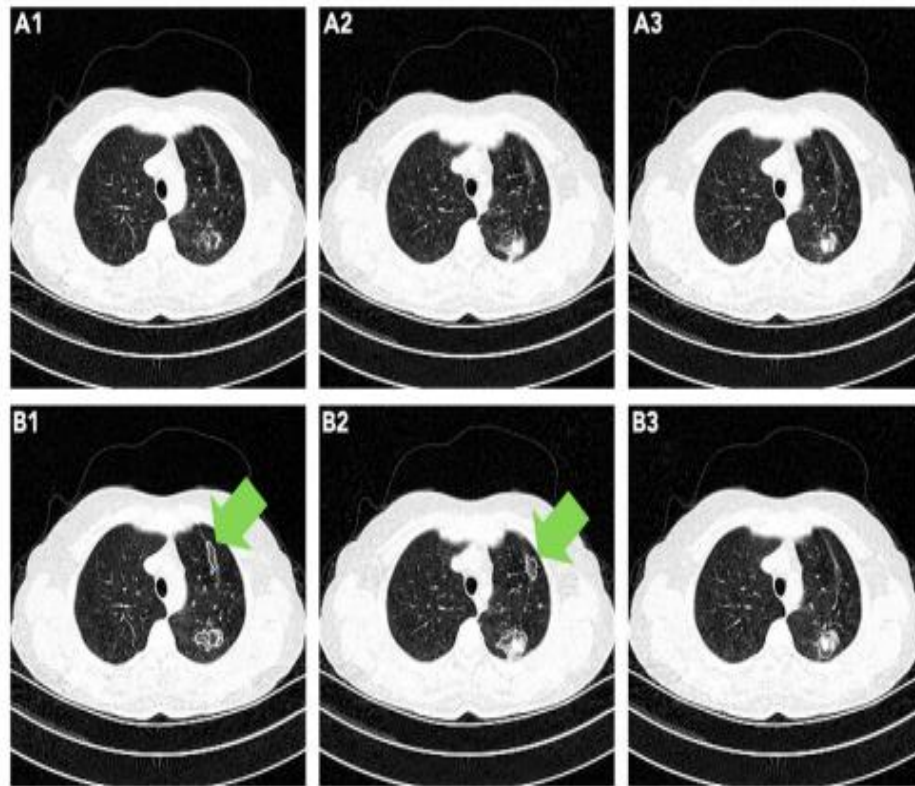


Figure 12: (a) CT scan images (b) Segmented Tuberculosis (Wang et al., 2023)

4. Results and Discussions

Table 1: Deep learning Performance (Bhandari et al, 2022)

Cases	Method	Accuracy	XAI	Source
TB = 4248 Normal = 453	Transfer learning with AlexNet and GoogleNet	85.68	No	(Liu et al, 2017)
Normal = 8851 Covid19 = 180 Pneumonia = 6054	Ensemble of Xception and ResNet50	91.40	No	(Rahimzadeh et al, 2021)
Normal = 310 Viral Pneumonia = 330 Bacteria pneumonia = 327 Covid19=284	CNN based CoroNet	89.60	No	(Khan et al, 2020)
Normal = 1583 Covid19 = 576 Pneumonia = 4273 TB =155	Custom CNN	94.53	No	(Qaqos & Kareem, 2020)
Normal = 310 Bacterial Pneumonia = 330 Viral Pneumonia = 327 Covid19 = 284	Attention based Action based VGG	85.43	No	(Sitaula & Hossain, 2021)
Normal = 1341 Covid19 = 864 Pneumonia = 1345	Inception V3 with Transfer learning	93.00	Yes	(Shastri et al, 2022)
Normal = 439 Covid19 = 435 Bacteria Pneumonia = 439 TB = 434	Transfer Learning with Resnet18	91.60	No	(Al-Timemy et al, 2021)
Normal = 1583 Covid19 = 576 Pneumonia = 4273 TB = 700	Custom CNN	95.94	Yes	(Bhandari et al., 2022)

Table 2: Lung Datasets (Mall et al., 2023)

The following are some datasets that can be used by researchers for detection related to Lung:

SN	Datasets	Source
1	Chest X-ray	https://stanfordmlgroup.github.io/competitions/
2	Chest X-ray	https://mimic-cxr.mit.edu/
3	Computed Tomography (CT) Images	http://www.imagenglab.com/
4	Lung Cancer (CT images)	https://www.kaggle.com/c/data-science-bowl-2017/
5	Lung Cancer (CT images)	https://wiki.cancerimagingarchive.net/
6	Lung Mask CT Images	https://lumic.grand-challenge.org/
7	Lung Node CT Images	https://luna16.grand-challenge.org/

5. Conclusion

The use of deep learning will revolutionized the manual interpretation of radiological images. Manual detection may lead to wrong diagnoses due to poor radiological image and lack of medical experts (radiologist). Chest X-rays are inexpensive and affordable and deep learning model can be trained to segment and classify images with high accuracies, Though CT scans give more details and are used to detect more diseases such as Lung Cancers etc. Computer Aided Diagnosis will give better diagnosis and explained results than manual interpretation which is error prone and many early symptoms maybe not detected by eyes.

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