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SCHOOL OF ELECTRICAL and COMPUTER ENGINEERING

Automated Lung Tuberculosis Detection Using Chest Radiograph Images Based on CNN – RNN Approach

By

Addis Meshesha

Advisor: Dr. Sreenivas Nune

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Approved and signed by board of Examiners:

	Name	Signature	Date
Dean, School of Electrical and Computer Engineering	Dr.Bisrat Derebssa	____________	___________
Advisor	Dr.Sreenivas Nune	____________	___________
External Examiner	_______________	___________	__________
Internal Examiner	________________	____________	___________

Declaration

I, the under signed, declare that this research is my original work and has not been presented for a degree in any other university, and that any source of material used for the research have been acknowledged.

Declared by:

Name	Signature	Date
Addis Meshesha	___________	___________

Approved by

Name	Signature	Date
Dr. Sreenivas Nune	___________	__________

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ABSTRACT

In the prevailing era, automated identification of diseases becomes a vital for medical technology due to a rapid increase of human population in different parts of the globe. A framework of automated diseases detection based image processing is important to assist radiologists and doctors in the diagnosis/screening of disease and provides more accurate, enhanced diagnosis time, and decrease the mortality rate. Lung tuberculosis has been a severe threat in the current time and it is spreading globally. In order to ameliorate this serious problem, employing an automated detection, identification and diagnosis system will be helpful to enhance the diagnosis speed of this disease and imped it from being spread globally. Many Lung tuberculosis patients in Low and Middle-Income countries die each year due to mistakenly interpret in diagnosis. Developing Accurate Computer-Aided Diagnosis system is helpful for doctors and radiologists to interpret Chest radiograph of a lung tuberculosis patients. Chest radiograph is the most widely used technical tool in medical diagnosis for identification of Lung tuberculosis. However, the interpretations of Chest radiograph might vary from one individual to another**.** Using correct and early diagnosis imaging technique, the survival rate of the patients with lung tuberculosis is significantly raised.

The proposed method has four major components: preprocessing, lung segmentation, feature extraction and classification. In preprocessing, image quality is enhanced using Gaussian filter and adaptive histogram equalization techniques. Gaussian filter is done for noise avoidance and adaptive histogram equalization is done for image contrast. The output gained from this preprocessed image taken as an input and were performed by thresholding, morphological and Active counter model which used to focus on the lung region or regions of the gained results. The output from this lung segmentation integrated with feature extraction and classification by applying Xception and LSTM architecture. Xception deep convolutional neural network model is a very important model in our thesis to extract the feature of the whole input image (data). And finally LSTM outputs the decision that whether image is TB positive or TB negative. The performance of the proposed computer-assisted diagnostic system for lung TB detection achieves accuracy (86%), precision (90.35%), Recall (85.10%), F1-score (87.65%).

Keywords: Chest Radiograph, ACM, Thresholding and Morphological Operator, LSTM and Xception-Net

This Thesis is dedicated to

My Beloved Elder Brother

Gugsa Meshesha Yimam

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List of Acronyms

ACM: Active Contour Model

ADM: Adaptive Moment Estimation

AHE: Adaptive Histogram Equalization

CAD: Computer Assisted (Aided) Diagnosis

CNN: Convolutional Neural network

CT: Computer Tomography

DNN: Deep Neural Network

FP: False Positive

FN: False Negative

GPU: Graphical processing Unit

LSTM: Long Short Term Memory

NN: Neural Network

RNN: Recurrent Neural Network

RELU: Rectified Linear Unit

SGD: Stochastic Gradient Decent

TP: True Positive

TN: True Negative

1D: 1 Dimensional

2D: 2 Dimensional

CHAPTER ONE

INTRODUCTION

1.1. Background

Breathing is the basic requirement of being alive, and all the human body organs that directly or indirectly take part in the breathing process are part of the respiratory system. The Lungs are the most important part of organ in human body, and responsible for supplying oxygen to blood [1].The region of lungs are divided by fields/areas named as lobes. The left lung side of lung anatomy consists of two lobes, and smaller than anatomy of right lung side, which has three lobes. Lung Tuberculosis (TB or TBC) is a common and a highly lung infection diseases which kills millions of people each year. A global report from World Health Organization (WHO) in 2018 [2], indicated that 10 million people were infected with tuberculosis bacteria, and 1.4 million died from the disease ((including 208000 people with HIV positive).The majority of (87%) active tuberculosis bacteria case population occurred in thirty countries with high tuberculosis diseases loads. Eight countries assess for two thirds of amount, with in India leading chart, followed by Indonesia, Bangladesh, and Nigeria and South Africa region. While TB mainly affects 5.6 million men in their most productive years, infectious disease burden among women and children is also high and rising dramatically. The cases associated with the disease are diverse and leads to a complex pathological changes in the organs like the lungs. The complexity and diversity in the lung tuberculosis disease patterns are recorded.

Lung tuberculosis is a disease which is caused by the Tubercle bacillus or Mycobacterium tuberculosis. It mostly affects the lung but also can cause problems outside the lungs regions. This lung disease transmits through the air, when humans with active TB cough, sneeze, or otherwise expel mycobacterium infectious bacteria. Symptoms of this disease is coughing, weight loss, blood, cough that persists for more than a week, fatigue and tiredness, fever for all human body, night sweats, lack of breath, chest pain etc. The death rates of tuberculosis patients are huge amount when there is improper treatment and detection, medical drug treatment with antibiotics can improves the chances of survival of the patients.

In tuberculosis detection, two ways are relevant based on screening and humans initiated path way. The first path is patient initiated where improved awareness of the diseases symptoms among humans can increase early detection and the second one is the screening path way ,where cost effective screening mechanism are required to be accurately done in patients. In the screening process, medical imaging method plays a vital role. The development of the current CAD medical imaging techniques screening mechanism with algorithms for lung tuberculosis detection plays importance role as the reduction in incidence of lung tuberculosis and its degrading in turn to decreases the poverty and improves /enhances healthcare outcomes for people those who live in low income countries. Chest X-rays (chest radiograph) are significance in non-invasive examining and diagnosis tools.

Chest Radiographs are essential part of any radiological procedures for Tuberculosis [3][4][5], among screening mechanism like : microbiological sputum smears microscopy, skin tests and blood test, biosensor tests etc. A potential screening system for tuberculosis detection on chest radiograph is a greater towards more powerful tuberculosis diagnostics. However, due to the huge amount of patients and lack of skilled medical technologist, there is large rate of human fault in analyzing chest radiographs and thus mostly remain unreported cases. Due to the use of CAD system can provide a great help in poor and developing countries where the numbers of patients is huge and medical health services cannot be provided properly. This system also provides medical image processing techniques to improve, segment and detect CXR images of tuberculosis patients to further examine a diagnosis, identifying whether the patient is tuberculosis infected or not infected based on the Chest Radiograph image readings. The rapid advancement in computer system capabilities, image processing algorithms of artificial intelligence techniques and deep learning encouraged the research /thesis and development of computer-assisted tuberculosis diagnosis system. The system aims to assist medical technologist and improve and enhances the accuracy of clinical diagnosis. Structure of the lung is shown in Figure 1.1

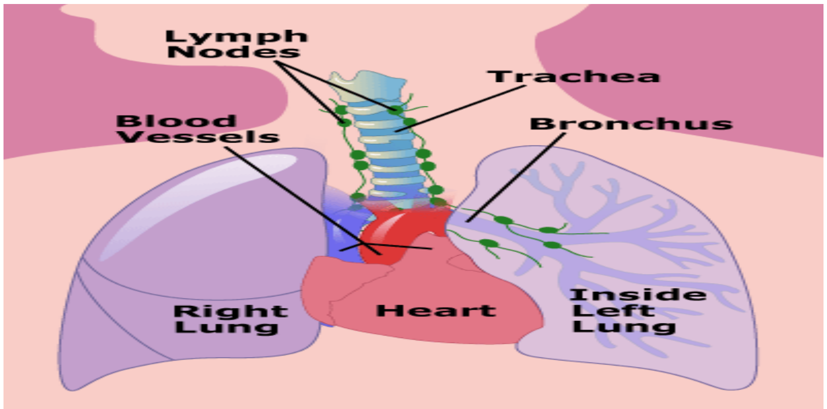


Figure 1.1 structure of lung [1]

1.2. Motivation

Among many of other killer bacterial infectious diseases, lung tuberculosis is the leading cause of death in the world, and also a common deadly case lung infectious disease which affects the lung part of the human body. Basically, in many part of developing and developed countries more than 95% of lung tuberculosis diseases rapidly spread globally [6]. Tuberculosis disease is a common and a highly lung bacterial infection which kills millions of people each year due to lack of highly treatment and fault in diagnosis case. There is necessary to innovate with technical approaches to diagnosing case abnormality chest radiograph images from normal in medical application using CAD system. The advancement technique of deep learning with CAD has significant role to make examining the process better efficient and effective method. The radiologist benefit from the deep learning method with CAD for screening or detecting lung tuberculosis based on chest radiograph (CXR) images. A deep learning solution to interpret chest radiograph (CXR) for presence of lung tuberculosis in a cost-effective manner would expand to reach or address of early detection and highly proper treatment of lung tuberculosis diseases in low and middle income countries.

1.3. Statement of the problem

Lung tuberculosis is a deadliest bacterial infectious disease and serious health problem to the world population and remains a major health constraint to humans, particularly for those who live in Low and middle-income countries. The manually annotating method of Lung tuberculosis is Fatigue & distraction, tedious, time consuming, highly subjective errors and impractical, limited visualization system and inadequate training and experience in today medical imaging diagnosis where the large amount of medical images are taken for a single patient. However due to huge amount of patients and lack of skilled medical technologist or radiologists, there is a high rate of human faults/errors to analyzing the chest -radiograph for lung tuberculosis those many patient cases remaining under un reported cases. Therefore to solve the problem, this thesis/research is aim to develop computer assisted diagnosis system for automatic lung tuberculosis detection from chest radiograph using deep leaning over existing proposed approach. These can be help in under low and middle income countries where the number of tuberculosis patients is large or huge, and medical health services cannot be provided properly. The research questions that should be answered at the end of this work are:

Research Questions:

1. Can we improve the accuracy of TB detection in chest radiograph images using CNN stacked with RNN over CNN model?
2. What is the impact of lung segmentation to enhance computational speed of the system?

1.4. Objectives of the Thesis

The general and specific objectives of this thesis work are outlined in the following:

1.4.1. General Objectives

The general objective of this study is to develop detection system for lung tuberculosis using Chest -Radiograph images based on deep learning technique.

1.4.2. Specific Objectives

The specific objectives are:

- To select and examining the preprocessing technique
- To select and examining lung segmentation method
- To evaluate precision, recall and f1_score
- To test and evaluate the accuracy of the detection method using input Chest - Radiograph images.

1.5. Significance of the Study

Lung tuberculosis is potentially life threatening diseases than other type of bacterial infectious diseases. Because in low resource setting, the high cost examinations and lack of skilled experts hinder patients from receiving the service. In this regarding to automate lung tuberculosis detection system should effectively address many of potential significant. In lung tuberculosis screening mechanism, it needs the examination of a large amount of medical images objectively in less amount of time than current setting screening driven technical approaches which are subjectivity of radiologist decision based on CAD system. The proposed CAD system is necessary for diagnostic assists and can reduce or decrease the workload of physicians, thereby considering costs effective manner inside medical or clinical applications. The work in this thesis is comprised of good medical image analysis algorithm design and development with potentially significant in clinical and medical applications which should contribute to the existing CAD method problems. The method improves the existing proposed system of automatic lung tuberculosis patients by enabling or aided workload of physicians to provide their full confidence or appropriate medication for early detection and proper treatment of the tuberculosis diseases in short period of time. Besides, the thesis work is significance because it helps to understand the difficulties in screening chest x-rays (to detect abnormalities) and proposes a framework that makes it simpler to reduce the medical technologist's decision-making as a second opinion.

1.6. Contributions of the Thesis

The importance of doing the proposed frame work is to effectively address the challenges that are facing the problem of tuberculosis detection by the use of the state of the art approach. The state of the art approach is using Gaussian and AHE for preprocessing and thresholding, Morphological operation and Active contour model for lung segmentation technique purpose. The proposed approach also involves an Xception convolutional network model for feature extraction technique, which is helpful to feeding the LSTM recurrent neural network model for classification and then detection of the presence of Lung TB effects in the image.

1.7. Scope and Limitations

1.7.1. Scope of the Thesis

This thesis work is focuses on designing and implementing automated lung tuberculosis detection with chest radiograph images. This approach framework proposed solution should have to be detect lung tuberculosis images using deep learning algorithms integrated with AHE, Gaussian preprocessing technique and thresholding, morphological and active contour lung segmentation approach. Due to the machine's limited computational capability, we cannot use large number of images with large number of depth wise separable convolutional blocks in deep leaning approach. The proposed approach was tested on a labeled dataset provided by the USNLM of Montgomery and the Shenzhen dataset. However, the training and testing case of chest radiography image (CXR) was incorporated in the design and implementation framework.

1.7.2. Limitation of the Thesis

The dataset used in this thesis are two publicly available lung TB dataset which are: 3D Montgomery County and Shenzhen chest radiograph (chest x-ray medical images). However, in this work, we cannot use CT (Computer Tomography) scan medical image to design and implement our proposed model.

1.8 .Methodology

To conduct this thesis or research work, the methodologies that are presented below will be important to develop detection system for lung tuberculosis using Chest -Radiograph images based on deep learning technique.

1.8.1. Literature Review

The goal of this section is to give a literature review of some of the latest research/thesis works that are closely relating with automatic lung tuberculosis detection with computer assisted diagnosis. Before starting actual work, a deep study was made in the literature written on the area of Lung tuberculosis detection to have a clear description and understanding about our research work. Different research work previously (existing work) written on lung tuberculosis have to be reviewed to clearly understand the various methods medical tool and approaches about automatic Lung tuberculosis detection system.

1.8.2. Data Collection

In our proposed framework, we have used two public available datasets which are Montgomery and Shenzhen data set. The Montgomery county dataset comprises 138 CXR images consisting of 80 normal images and 58 abnormal (TB) images, and also Shenzhen dataset has 662 images consisting of 326 normal and 336 abnormal cases. Therefore, the data set comprises a total number of 800 images are collected.

1.8.3. System Design and Implementation

Our designing and implementing the proposed model architecture is based on combining with two deep learning techniques which are deep convolutional neural network architecture (Xception) and deep recurrent neural network architecture (LSTM). Beside to this, in image preprocessing stage, AHE and Gaussian used to improve the quality of the chest radiograph images. In the other part of the proposed lung region segmentation, the proposed operators active contour, morphological, and thresholding techniques are used to minimize the search space or reduce ROI by segmenting the lung region image. The design and implementation of our proposed approach also based on different hyper parameter configuration and their values like activation function, learning rate, regularization (dropout) etc. The proposed models are implemented and tested in Python programming language using Tensor Flow backend and Keras library.

1.8.4. Experimental Result Evaluation and Conclusion

For evaluation of the design and implemented model, we will use four performance metrics like precision, Recall, f1-score and accuracy with confusion matrix on our proposed approach to clearly point out the accuracy measures of the proposed models. The experimental data set were obtained from the data set of USNLM challenge using two public available dataset which are the service of health department at Montgomery county and Guangdong medical college, Shenzhen china.

1.9. Thesis Outline

The rest of this thesis documentation should be organized in the following way. The second chapter presents the theoretical back ground, and basic concepts that are related with lung tuberculosis, Xception, LSTM, thresholding, morphological, active contour, data preprocessing, CAD system etc. In this chapter we also elaborated theoretical concepts of the existing CAD system such as: data preprocessing, lung segmentation, feature extraction and classification. For deep overview/understand of our thesis domain are explained in this work. The third chapter is Literature review part that discusses about Literature related to this research work, and are reviewed based on different proposed approaches and techniques. Chapter four presents detailed description of the proposed frame work, design and model architecture (Xception &LSTM) section of the work. In Chapter five, implementing and designing the proposed system (method) architecture and experimental results. Discussion on part of the experimental results reveals how the results are interpreted using the image acquisition based on our proposed methodologies. Finally, Chapter six presented future work and the conclusion.

CHAPTER TWO

THEORETICAL BACKGROUND

2.1. Introduction

This chapter of the work points the theoretical background and concepts that are related with automated lung tuberculosis detection for biomedical image diagnosis. We try to present and elaborate different researches focusing on this study/area, beside this the theoretical concept of the method, medical tool and algorithms are also discussed to implement/design each stage of the system.

2.2. Tuberculosis Disease

Among many of other killer infectious diseases, tuberculosis is the leading cause of death in the world, and a common deadly lung infectious disease which affects the lung regions of the human beings. Basically, in many developing and developed countries more than 95% of Tuberculosis diseases rapidly spread globally. Tuberculosis disease mainly attacks the lung region, but can also attacks any other parts of the human body through transmission of air-borne. It is a common and highly lung infection diseases which kills millions of world population each year due to lack of highly treatment and fault in diagnosis case [58].

Now a days, the clinical screening of tuberculosis is carried out manually by microbiologist through microscopy to examining tubercle bacilli in sputum for lung tuberculosis, or/and in tissue section for extra-pulmonary tuberculosis. Clearly, manual screening is till, time consuming, labor-intensive, tedious, very highly subjective, impractical, the accurate and correct diagnoses depend on experience of the microbiologist. With a huge amount of deaths (biggest mortality rate) worldwide, quick and correct diagnosis which facilitates highly treatment is vital to control tuberculosis. Therefore, early detection of lung tuberculosis has the potential to come up with their limitations with computer assisted diagnosis system.

2.2.1. Lung Tuberculosis Symptom and Tests

Lung Tuberculosis is one of the lung disorders and rapidly spread diseases through the air when people who have active tuberculosis in their lung region cough, sneeze, or otherwise expel infectious bacteria, and it is extremely risky operation to handle, and rapidly spreading and duplicating the human body and shown symptoms [7].

Symptoms are highly revealing, the disturbs /attacks to lung region of human body. Symptoms of this lung disease is coughing blood, weight loss, cough that may happens last for more than two or three weeks, fatigue and weakness or tiredness, fever, night sweats, difficult to breath, chest pain, loss of appetite and even talks, tiny droplets that comprises the germs are released, and it can be inhaled by anyone. The germs inhaled by the nose and mouth reach the windpipe and the splitting air tubes that lead to the lung regions. The germs also rapidly spread from the initial location in the lung regions to other section of the human body.

To detect lung tuberculosis disease examination or screening of the lungs by stethoscope examines crackles. Thus image medical technology tests like Chest X-ray, Bronchoscopy, Open lung biopsy, skin tests, blood tests, smear microscopy tests etc. Among the aforementioned tests, for our research work emphasis is based on chest x-rays are also named as chest-radiographs; x-rays are a form of medical radiology that can penetrate the human body to form image or pictures.

2.2.1.1. Chest Radiographs

Medical imaging also implies the art of creating visual representations ,radiograph interpreting of the interior of a body of humans for clinical image analysis, and medical service intervention. Chest radiographs demonstrate pleural effusion, consolidation (infiltrate), nodules, lesion, and other features of lung tuberculosis [59][60][61].

<u>Pleural effusion</u>: When there is an abnormality present the pleural become evident. A pleural effusion is fluid that collects in the pleural space. Depending on the patient's position, fluid collects in the lower region of the chest. If the patient is standing when the X-ray is obtained, fluid will surround the lung base. A pleural effusion layers along the posterior aspect of the chest cavity while a patient is supine, making it difficult to spot on a chest X-ray.

Infiltrate abnormalities: Infiltrate abnormalities indicate to the filling of the small airways and alveoli with dense material. It is important to realize that consolidation does not always imply infection, and the small airways may be fill with material other than pus (such as in pneumonia), such as fluid, swelling.

Nodule abnormalities: a chest X-ray reveals bilateral opacities of multinodular in the lower and middle zones, with nodules of different sizes.

Cavity lesion: darkened area in the lung parenchyma, with or without uneven edges, surrounded by a region of airspace infiltrates, nodular or reticular densities, or both. The lucent area's surrounding walls can be substantial or thin. Calcification can form in the vicinity of a cavity.

Hilar lymphadenopathy abnormalities: bronchi, Vessels, and lymph nodes make up the hilar. Lung abnormalities of these features are reflected on a chest X-ray by a change in size, position and/or density. The following figure shows features of lung tuberculosis and tuberculosis negative on chest radiograph.

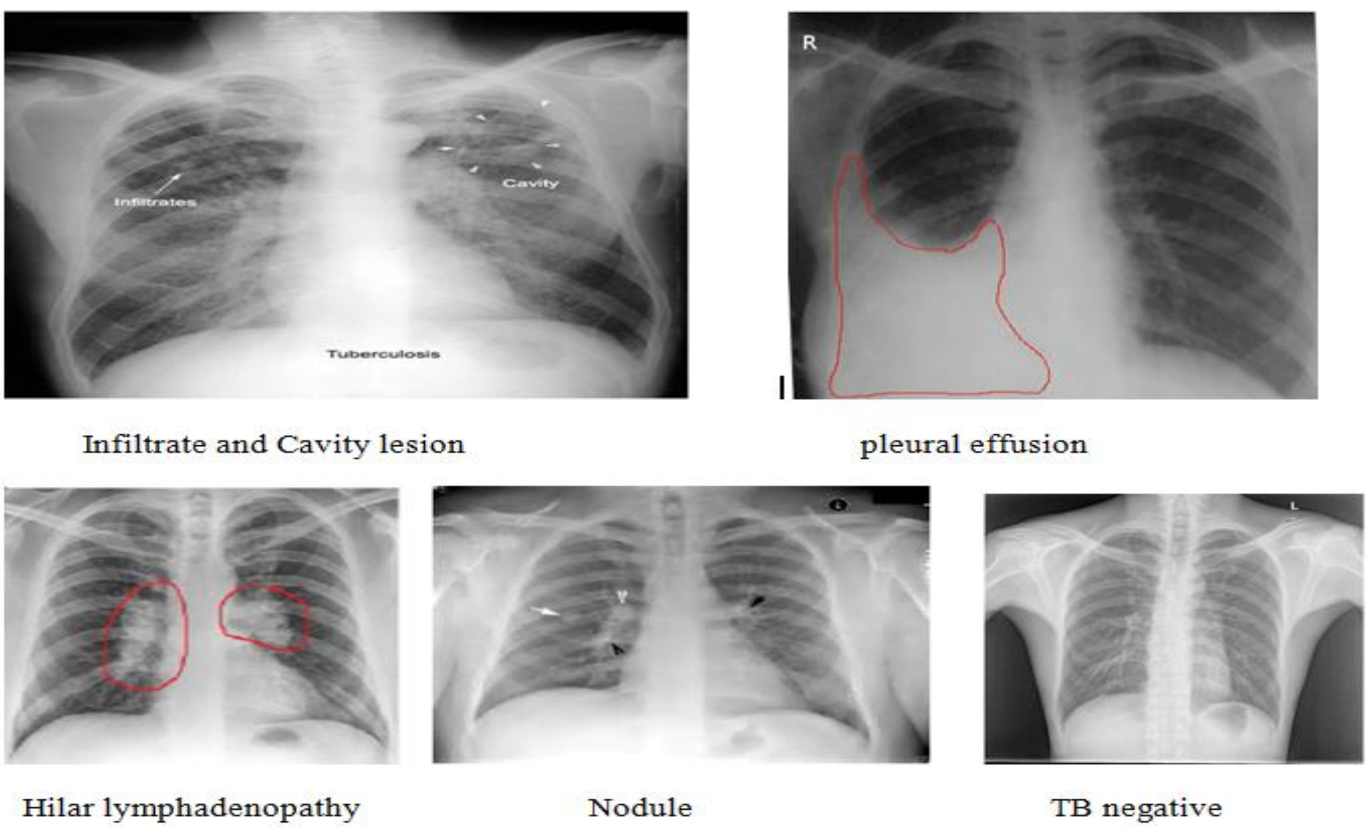


Figure 2.1 Radiological characteristics of lung tuberculosis on chest radiograph images

In the figure 2.1, the radiograph plays to reveal internal structures hidden by the skin and bones, as well as to adequate diagnose disease using technical approaches. Medical image analysis technical approaches have significance role in various medical applications. It is used to analyzing and solving medical problems by using different medical image analysis techniques to detect relevant and hidden information or knowledge from any medical images. The image plays crucial role in aiding or assisting treatment and diagnose for medical technologist, and it can also be important in education domain for medical health care students, these can great help to their studies. In recent years, progressively in medical image technologies, would be created a by huge amount in digital images [8]. The analysis of medical images representation and interpretation is a vital role, and is the part of computer vision but interpreting of chest radiograph in image processing is very challenging i.e., it might be happened the false it interpretation [9].

The analysis of medical images representation and interpretation is also provides visual examinations ,radiograph interpreting of the interior of a body of humans for medical image analysis, and medical service processing. Its significance role in several medical applications and also it is used to analyzing and solving medical problems by using different medical image analysis techniques to detect relevant and hidden information or knowledge from any medical images.

Chest radiograph is the very important screening Medical imaging techniques for huge amount of people and it can diagnose active lung TB with in cost effective and reasonable amount of time. It is a medical x-ray imaging that contains different type of rays but x-ray is a form of radiograph [62]. Implementation of image acquisition for example radiography is help in the medical imaging research field such as biomedical engineering, computer science and medical physics.

Large amount of lung tuberculosis patients with tuberculosis infections needs to be chest X-rayed and screen for active tuberculosis to ensure diagnosis and a proper treatment of their infections. Taking Standard Chest X-rays (CXRs) is an in easiest way to diagnose or screening for the presence of tuberculosis. The ultimate goal of screening mechanism is to identify or differentiating each and everything that is or should be related to a patient having tuberculosis infectious infection disease. For this reason, a Computer-aided diagnostic system (CAD) helps to detect Tuberculosis infections using chest X-ray. These systems have the potential to promote the tuberculosis detection error risk rate and also it's depending on the medical radiologists and medical technologist. The potential method of computer assisted-diagnosis technique is essential to support medical radiologist in evaluating, interpreting and analyzing the Chest radiography medical scan images.

2.3. Computer-Assisted Diagnosis System

Information is determined by images or pictures. Images are one of the most vital or important task of conveying information in the area or field of computer vision and realizing information obtained/getting from images. Medical image processing is a process where input image is medical image. It is processed to obtain the experimental resulting output image, and the output is medical image. Medical image modalities are used to analyze or interpretation of the human body. In medical image, interpretation of the output images can carried out advanced medical image processing methods that significant role in visual interpretation, and also improves medical image analysis methods that can provide automated, properties and multiple transformations could be essential in order to extract the data of interest from digital image, and hierarchy in the image processing stage.

Computer-assisted diagnosis system based on image processing is used to assist the doctors and radiologists in the visual interpretation of the images in a relatively short period of time. CAD result is capable to help the medical technologist can screening and provide proper treatment based on the subjective judgment of the medical health services. It is becoming one of the most important research fields in medical imaging and has been the inspiration for important advances in many application including medical image processing, machine learning, and clinical systems. Medical technologist or medical radiologist can promote computer-aided diagnostic techniques for the practical decision of the lung diseases pertaining to liver, lungs, kidneys, heart etc. Advancement use of CAD systems could help better to improve or enhance the detection accuracy and reducing human burden in screening and accurate and correct diagnosis, particularly in low income countries regions that lack of sufficient radiological resources. Therefore, in prevailing era computer aided diagnosis systems (CADs) are extremely used to assist doctors or medical technologist during the process of decision making in identifying or differentiating active tuberculosis diseases. It is also potentially decreasing the efforts of medical radiologists as second opinion and minimizing or reducing the negative numbers in diagnosis case and false positive rate.

2.4. Image Pre-processing

Preprocessing of an image is a technique used to improve its quality and interpretability. It plays a great role in medical image analysis, and it makes the classification processes more effective and accurate. The main aim of thus processing stage is to improve the quality of the image and critical improve the important image features and reducing the undesired ones. The image preprocessing method have been included in normalization, image resizing, image noise removing and enhances image the quality and produces an image in which minutiae could be correctly detected. Therefore it is very important role to preprocess it before screening the diseases.

2.4.1. Adaptive Histogram Equalization and Gaussian filter Preprocessing technique

AHE image contrast enhancement method is a computer medical image processing technique used for improving or enhancing the contrast of medical images before processing the data. It is different from the normal HE technical approaches because of HE implies only single histogram but in case of AHE approaches generates various histograms that corresponding to different area of the image, and the method that it can redistributes the intensity values of the medical image. The Ordinary histogram equalization of the method uses the similar transformation derived can from the medical image histogram to transformation from all pixels. This AHE works very well when the distribution intensity value of the pixel is the same or similar throughout the image. However, when the digital image contains regions and can contrast those image regions would not be enhanced sufficiently, because of importantly darker or lighter than most of the images. AHE is the very important approach by transforming the pixel each value with in the derived transformation function that can outperforms neighboring regions. Each and every pixel is will be transformed using the histogram of squared surrounding the intensity pixels. The technical approach has the ability to handling the level of contrast enhancement in the medical output.

The biomedical image could be containing some noise; and then it makes sense to reducing (minimizing) the image noise on the preprocessing data image. The color information in images produced by medical health services. It is generally undesirable the medical image by product during data images or image acquisition. Filtering technical approach for enhancing an image and in filters are mostly used to decreasing frequencies in the image (high) or low frequencies in the images i.e. smoothing the image to improving detected the edges of medical image[10]. The most popular filtering technique of in image processing application, such as mean filter, median filter Gaussian filter and 2 dimensional cleaner**.** However, the Gaussian filter is a smoothing filter and which used to filter images with remove detail and noise than other filtering technique. In Gaussian noise, each pixel in the image will be changed from its original value.

2.5. Lung Image Segmentation

Medical image processing is the help of computer system to outperform processing the image on the digital images. Image segmentation is an important and challenging process of image processing. It is dividing or partitioning an input image in to its constituent regions or categories, which correspond to different objects or parts of objects. The process which is between image feature extraction technique and image preprocessing stage in image processing is Lung image Segmentation. The main aim of image segmentation is to transform the digital image into something that is more meaningful and easiest way to analyze the image. Each pixel assigning a label to the image so that Pixel having same label show similar(same) characteristics and properties [11].Segmentation of lung form Chest radiograph image is the major challenging work due to heterogeneity in lung region and similar densities in pulmonary structures such as arteries, veins etc. An important stage to reduce the search space is segmentation on chest images in medical application.

In general, image segmentation problem comprises of two tasks/methods; object recognition and object delineation methods. Object recognition is the way of determined the locations of the target objects on the image whereas object delineation is drawing of the object’s spatial object extent and composition of the image. Accurate and correct image lung segmentation greater improvement of the feature extraction, classification and quantification of defects within region of the lungs. When lung segmentation not to correctly or accurately outline the medical image borders of the lungs, findings the might missed or findings the outside of the lung image might be has been included in the image analysis.

2.5.1. Thresholding and Morphological Operations

Image lung segmentation by thresholding technical approach is the easier methods and convenient way to outperform lung region, and the very powerful segmentation techniques. This proposed method partitioning or dividing the data image pixels with respect to their intensity level, and it is used to over images having lighter objects on dark background. Threshold is important in discriminating foreground data image from the background. Based on the preprocessing image, selecting and choosing an adequate threshold value (T), and the gray level image data can be converted to binary image. The binary image should contain all of the necessary information about the shape and position of the objects of interest or foreground. The importance of obtaining first a binary image is reduce the complexity of the image data and simplifies easiest way to the process of classification and recognition. The crucial way to convert a gray-level image in to a binary image is to select and choosing one threshold value T,then all the values of gray level image below thus threshold T and showed as zero and T will be one.

Morphological operations elaborate range of image biomedical processing method or techniques that deal with the shape of features images or morphology operators in an image. Morphological operations, e.g. morphological dilation, erosion, morphological opening and closing, are important role in surface of operator the metrology and dimensional operator metrology [12]. More accurately; it is the process of allocating a label to each and every pixel in data image such that pixels with same or similar label share certain visual characteristics. The main objective /goal of using morphological operations operator is to remove the imperfections in the structure of the image processing of the data image. The morphological operation operators use a small set of matrix structure named as structuring element. The shape and size morphological operation of the structuring element has significant impact on the final result. Structuring elements are a sub image or very small sets in matrix form used to interact with the image to be probed. It helps us to define some arbitrary neighborhood structures. The binary structuring element of the morphological operator is comprised/consists of zeros and ones i.e., all the binary structuring elements have the values. The ones of the binary structuring element could be define the neighborhood of the binary structuring element. The precise and accurate details would be obtained by choosing the very suitable binary structuring element. Morphological operations are significant role in many medical applications. To list some significant role that they are vital role in hole filling the image, boundary extraction of target objects, extraction targeted objects of connected components structure, thickening and thinning. The structuring element plays a very significance role in morphological operations. It is the size and shape of morph local operator feature of the structuring element morphological operations that can decides the output. The emphasis of the structuring element is to be given to its shape and size. Dilation is an operation which modifies morphological operator that increases pixels to the boundary image pixels. Erosion component of an image with a binary structuring element causes the object boundary image pixels to shrink in size. Opening component of morphological operation opens up gap between the target objects can connected by a thin hole bridge of pixels values whereas morphological closing operation operators fills the thin or small holes in the regions keeping initial of the region sizes and shapes.

2.5.2. Active Contour Model

The most widely used for analysis of medical image segmentation image in medical application is active contour model. The purpose of operator active contour model is locating the image boundary of clear border of the image. Those contour models can be navigated by energy function based on image segmentation analysis.

The very powerful significant technique for image segmentation, and is important to segment the borders or extract border of lung accurately is active contour model [13]. As the active contour is defined as an energy minimization of spline, it deforms itself to minimize the energy function. The energy function is designed for the contour to converge toward the boundary of the target or image. The terms active contour in the energy function are named as internal energy and external energy. The function is estimated for internal and external forces, which is capable of finding the accuracy of Region of interest. Due to the internal and external forces created within the image the contour is moved near to the target by an iterative process. For each iteration of the process, a new location is searched among neighboring pixels. A contour moves to a pixel that has lower energy contour of obtained initial lung areas is assumed as initial contour. External energy function is designed to capture desired image features and image energy or push the contours near to the region of interest whereas internal energy is shape energy and prevent outlier points, smooth image. Therefore, the energy function is estimated for internal and external forces, which is capable of finding the accuracy of region of interest.

2.6. Feature Extraction Techniques

Feature extraction is the major important steps for reducing the dimensionality of pattern recognition and bio medical image analysis. It uses an algorithms and methods to isolate detection of several desired portions or shapes (features) of a given image [14]. A feature is ranging of discriminative information extracted from a digital image which provides more detailed understanding of the image. When the given medical input medical image of the algorithm is very large for controlling, it suspicious for being redundant, and then images transformed in to reduced group of features (features vector)[15]. Transforming the medical input image into the group of features is referred to as feature extraction. If the features extracted are carefully chosen, it is expected to that the features set will extract the very important relevant information from the input medical image in order to outperform the desired task using this decreased representation instead of the full size input data.

In image Features, if the properties of the objects of interest are selected carefully, the representatives of the large amount of relevant information of the image have to offer for complete properties of an object of interest. Feature extraction method analyzes objects and images to extract the most eminent features that are representative of the various classes of the objects/images. Features are used as inputs to classification stage that assign to the class that they represent. In this context, the aim of feature extraction is to decrease the input image data by measuring certain characteristics, or features, that differentiate one input pattern from another pattern. Data present in an image are very complex and very high dimensional, it is important task to extract the informative feature from an image for object recognition and detection. The extracted features perform as the basis for classification stages.

In learning algorithm, Feature Extraction implies with the first set of consistent input data and develops the borrowed values also referred to as features, and expected for being descriptive analysis and non-redundant, simplifies the consequent learning values and observable steps. The reduction of the data and the machine's efforts in building variable combinations (features) facilitate the speed of learning and generalization steps in the machine learning process. It is mainly associated with decreased dimensionality [16][17]. The area of machine learning approach that can dramatic admission in the prevailing era, with rise of Artificial Neural Network. One of the most vital forms of ANN architecture is that of the deep Neural Network (CNN).Deep learning is a class of machine learning approach or algorithms that helps multiple feature extraction map layers to highly hierarchical level of extract higher level features from the medical raw input data image. In this section of the algorithm gives the impact of the stage feature extraction that used in a Deep learning based technique named as Convolutional Neural Network. The powerful or potency learning capability of deep Convolutional Neural Network is mostly used for complex feature extraction stages that can automatically learning feature representations from the input medical data.

2.6.1. Deep Learning Algorithm

Deep learning is originated from Artificial Neural Network, which uses complex layers to progressively extract high level feature and transformation from the raw input data image in order to obtain hierarchical representations learning [22]. The concept of Deep Learning comes from the study or field of Artificial Neural Network, which contains more hidden layers node is a Deep Learning model structure. Information is takes place in each layer and the output of one layer used as an input to the other layer, and the first node layer is known as an input layer, while the last layer is an output layer. Currently, it is applied in many areas like computer vision, face recognition, natural language processing, audio recognition, social network filtering where its various model architectures like deep belief networks ,deep neural networks and, other recurrent neural networks have produced results which are comparable to the human experts. Computer vision is the area or the field which uses theoretical concepts and algorithmic basis to perform the detailed analysis, feature extraction and critical understanding of important information from medical images. The advancement of deep learning in the area or the field of computer vision is deep Convolutional Neural Networks algorithms and it is a form of artificial neural network.

Artificial neural network is the way in which an information of human brain processing pattern, artificial representation of millions of human nerve cells, and a distributed hierarchical node that is inspired by way of biological agent of human nervous system (such as the human nerve system) operates [18]. Each neuron as nervous cell (human nerve cell) takes inputs from many other neurons in the first layer and outperforms the required processing on the input. The result of each neuron contained, is passed on to many other neurons in the other preceding layer. ANNs are mainly handles of a huge number of interconnected communication nodes (referred to as human nerve cells) of which work twist in Artificial distributed fashion to collectively learn to representation from the input in order to optimize its output [19][20][21]. The presence of impressive artificial neural network that can succeed at those perceptual, cognitive and control tasks in which human beings are successfully proofs by human brain. Basically, the propagation method of artificial neural network can operate by two mechanisms which are backward and forward direction. In Artificial neural network propagation method, forward propagation is the information of neural network transfer from one way points towards to input to output map. On the other hand, the reverse propagation of forward artificial neural network is backward approach. It can process only the neural backwards direction.

In backward ANN propagation, ANN is a very effective technique to update the weight of neural network parameter and computationally adequate to fix propagation errors. A hidden layer is a layer in which multiple connection between input map and output layers in Artificial neural network where neurons (nodes) take in a composed of weighted inputs and produce an output through tanh, sigmoid, relu etc. It is a portion of any Artificial neural network in which human can reveals the types of operation that towards on the human brain information process. We can evaluate loss or errors when we update weight based on back propagation approach in artificial neural network.

Activation function is the most significant role of any artificial neural network (ANN) algorithm. Without activation functions in artificial neural network, the network may be complicated mode as linearly. It is also capability to network converges in some points, and activation might impede artificial neural network from point of converging location. Activation function for non-linearity is used in hidden layer by using mainly neuron function as logistic or sigmoid, relu; tanh etc. The above mentioned the major activation functions are an element of multiple or numerous hidden layer for activation functions. And then we will elaborate below in briefly.

<u>ReLU (Rectified Linear Unit) function</u>: Relu activation function is one of the major common neuron activation functions and it improves, enhance learning speed based on converging and classification problems in CNN application. Its main significance is that it removing and resolves vanishing gradient problem and lower amount of computation time and expensive than hyperbolic tangent and sigmoid. ReLu activations function in the range of probability of x<0, gradient decent will be 0 whereas, which the weights could not gained updating during descent. That means, those nonlinear function which go up into that function could ends responding to variations in input map (easily whereas gradient point is zero, nothing changes).

$$R(x) = \begin{cases} x & x \geq 0 \\ 0 & x \leq 0 \end{cases} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Therefore, ReLu is an important and most effective activation function of non-linearity compared to other major activation function, and all disadvantages like Vanishing Gradient Problem issue is totally removed by using this activation function.

<u>Sigmoid function</u>: Logistic or sigmoid activation function is used for neural network to classify the probability of an output map.it is the function of non-linearity activation function,non decreasing or increasing (monotonic function) and differentiable based on continuity and also fixed output as range of probability and deeper network layer. Logistic layer is better and easy for classification problems. It has smooth, saturate and kills gradient with respect input layer. But still the drawback of this activation function of non-linearity is vanishing gradient problem. Because the location of the output map is not centered at zero. Sigmoid function is better to make adjusting the gradients use up on different way of directions. Therefore the range of the probability is 0 <output < 1, and it makes optimization very difficult. This takes very huge amount of computation in hidden layer of artificial neural network.

$$S(x) = \frac{1}{1+ e^{-x}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

<u>Hyperbolic tangent function or Tanh function</u>: Hyperbolic tangent function or Tanh activation function in neural network is commonly named as zero centered function. This activation function is same with logistic (sigmoid) activation structure. The activation function tanh used to feed the flow values in to the neural network. Although, the function range values between -1 to +1. When we considering the function act as the negative values, clearly the minimum range function in sigmoid or logistic are 0 values and the minimum range function in tanh is -1. The difference between the activation function tanh and sigmoid is that the range of the Activation function of tanh is larger than sigmoid. But the remaining functionality of the network is similar as the sigmoid function based on the feed-forward neural network. The following figure 2.2 shows graphical illustrations of sigmoid, tanh, relu activation function in neural network.

$$\text{Tanh}(x) = \frac{2}{1+e^{-2x}} - 1 \qquad (3)$$

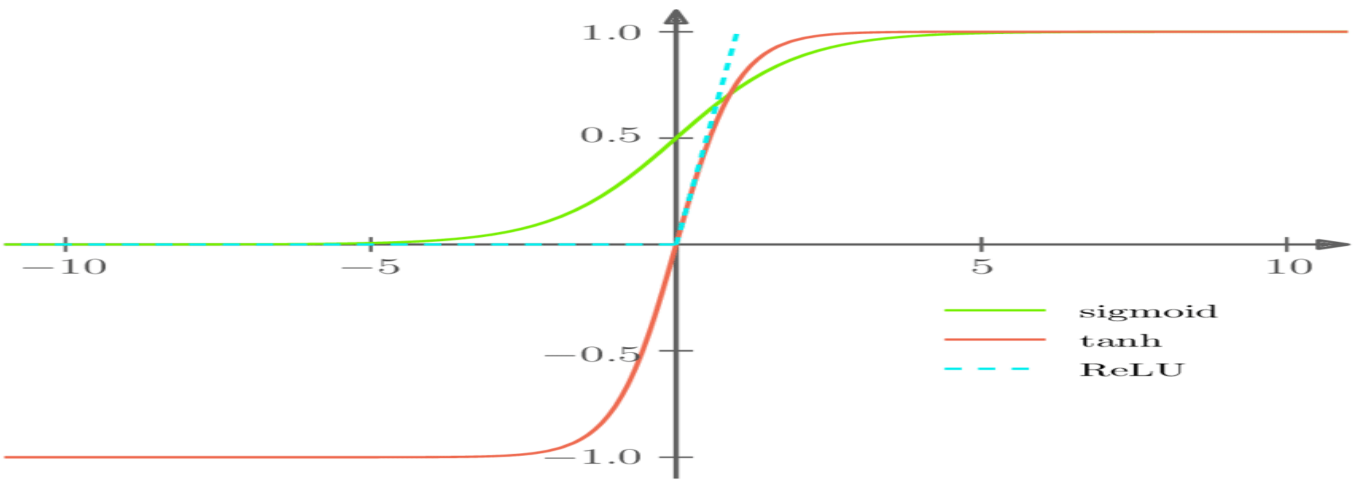


Figure 2.2 some non-linearity activation function in neural network

In NN, Activation function is an important role non linearity function of the artificial neural network because it is able to outperform a deep complex network and critical neural network based on sigmoid, relu,tanh function feed values into the network.

2.6.1.1. Convolutional Neural Network Algorithm

Convolutional neural network is family of deep structured learning and feed -forward artificial neural network. In convolutional neural network, the information flow takes place only in one direction from their inputs to outputs. Convolutional neural network techniques widely used for a variety of fields such as natural language processing, pattern recognition, Image Classification, Object Detection, Video Processing and face Recognition etc. The potency or the powerful learning capability of Convolutional neural network is mostly useful for deep feature extraction stages that can automatically learn hierarchical representations from the input medical data. The Convolutional neural layers convolve the first layer of input and pass it's the result output to the last layer. The convolve input image feature pass to its output map to the other layer is convolutional neural layers. The main advantage CNN has over other algorithms is that it can automatically detect the features which are essential for classification without teaching the model throughout. The deep CNN algorithms follow the network parameter architecture which is reveals in the following Fig. 2.3. First the input data is taken on which we can outperforms perform the operations. Convolution and Pooling are performed on input image along with different number fully connected layers. We get output while performing class classification. Figure 2 .3 shows pattern or network architecture of deep CNN.

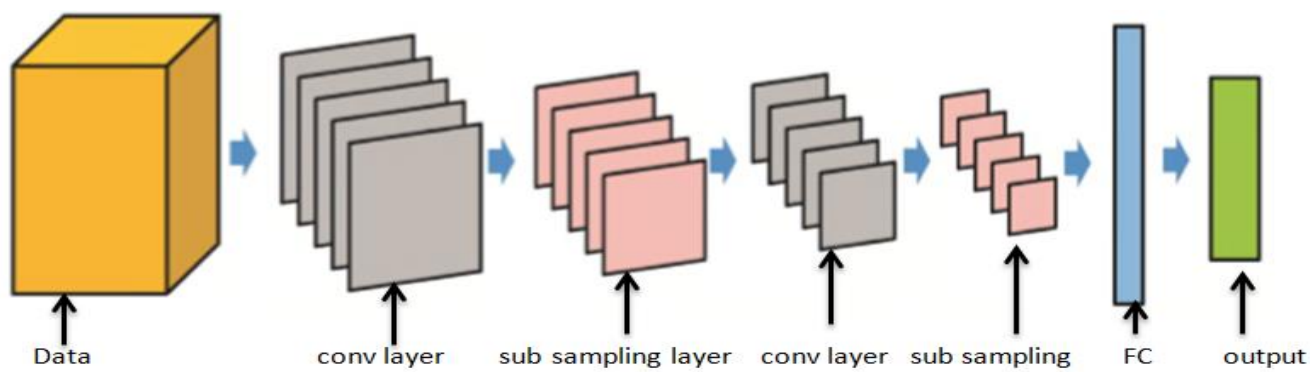


Figure 2.3 Architecture or network of deep convolutional neural network algorithm [17]

2.6.1.2. Input Layer

In put layer is the first component of deep convolutional neural network algorithm, and the pixel and size of input image is feed into the deep network architecture. It is a three dimensional image of pixels or RGB or gray scale image.

2.6.1.3. Convolution Layers

In Convolutional component layers, convolutional in case of CNN is used to extract features maps or convolve feature from the input data image. It is comprises order of deep convolutional kernels (every neuron act as a kernel). These kernels are associated with a smaller size of area with comparison to the input image known as a receptive field. It works by departing the medical image into very small size of blocks (receptive fields) and convolving with a specific set of weights (multiplying elements of the filter with the corresponding receptive field elements).

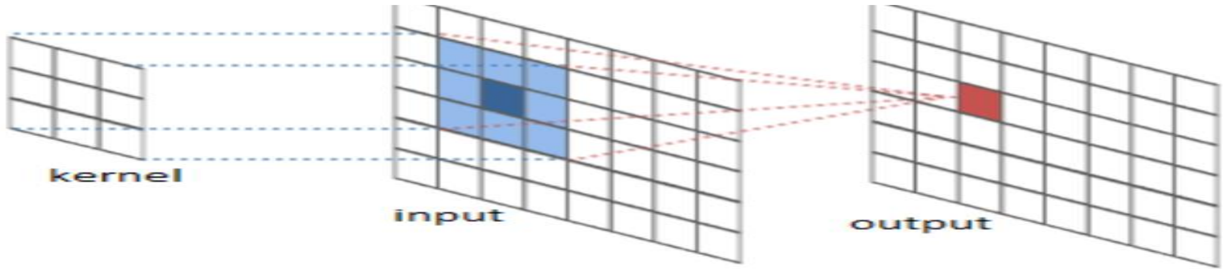


Figure 2.4 Convolution operation pattern

In the above figure 2.4 convolution operation, the features of all the last layers are convolved feature with kernels of the function of activation to outperform the output image. Each output feature result may be merging with numerous inputs. The size of medical image of the feature map (convolved feature) is controlled by hyper parameters configuration that we need to settle before feature convolution step is outperformed. Convolutional layers are also able to significantly decrease the complexity of the model architecture through the optimization of its output map. These are optimized through three hyper parameters, the depth, the stride and setting zero-padding.

Depth: The depth hyper parameter of the convolutional layer, determines the number of different neurons that process the same receptive fields which is named as the depth column, with a different set of weights. Depth hyper parameter fits or corresponds to the number or element of filters that we use for the convolution operation pattern. The filters in CNNs traverse the whole image using typical convolution operation. Because the filter size is much smaller than the image and the number of weights we need to solve for is drastically reduced. The spatial border or extent of the filters is determined by the receptive field size.

Stride: While the depth hyper parameter is determined by the total amount of input image planes to a filter, the stride will determines the step value across and down the image as the convolution is performed. It is the total number of pixels by pixels that we can slide our element filter matrix operation over the input matrix. A unit stride implies the need for introducing new depth columns for spatial regions of the image that is a unit distance apart. The stride should be chosen carefully as low stride values lead to a higher number of resolutions per each filtered image, with a high overlap in the receptive fields leading to an increased redundancy in weights.

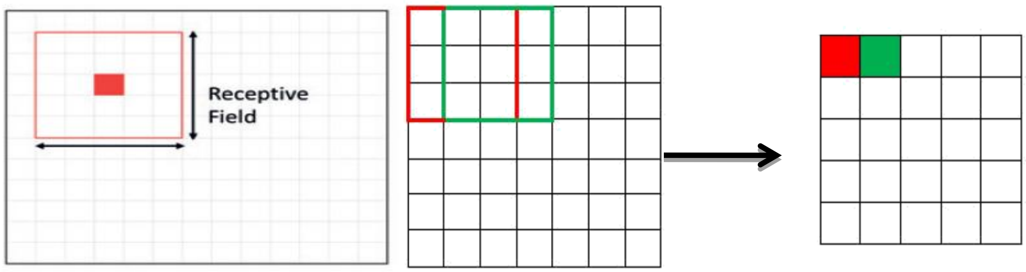
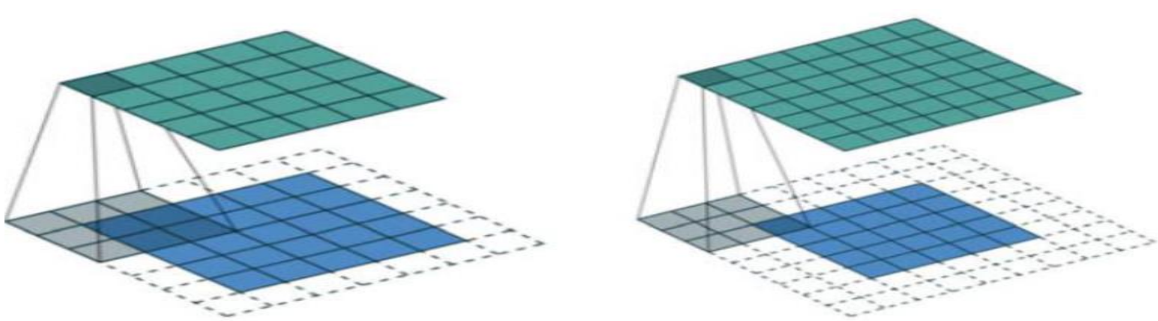


Figure 2.5 receptive field representation and effect of hyper parameter stride one [23][24]

In figure 2.5, Stride hyper parameter is the count of the stride of the slide of the convolution filter map at each and every step of the convolution to be outperformed. The default value of stride hyper parameter configuration is considered as the value 1. The large in the stride hyper parameter, the smaller is the extraction feature map. When the size of the stride parameter is high, the feature map size becomes reduced than that of the convolved input image because the data image must contain the convolution filter. In order to maintain same dimensions of image and that of feature map we need to have padding operation around the image.

<u>Zero padding</u>: Zero-padding hyper parameter is the easiest process of padding operation of the border of the input, and is an effective and efficient method to give additional control as to the dimensionality padding of the output. Padding operation of hyper parameter with a value more than zero is significance method to preserve the padding information on the borders of the image from vanishing through multiple convolutions. Sometimes, it is partially good to pad the operation of input matrix with zeros around the border image, so that we can apply the image filter to bordering elements of our input image matrix. A very nice feature map of zero padding operation hyper parameter is that it allows us to additional control the size of the feature maps.



a) Padding same operation   b) full padding operation

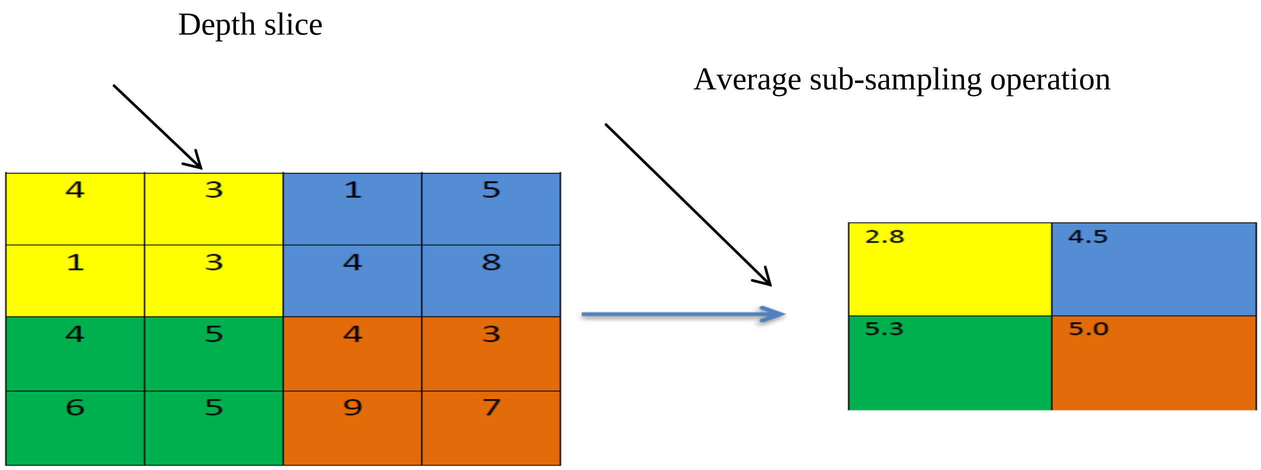
Figure 2.6 example of zero padding (full and same) operations [25]

In padding operation, same padding and full padding operational type are important to increases size of an output map and input map to similar sizes as an output map before convolve the operations.

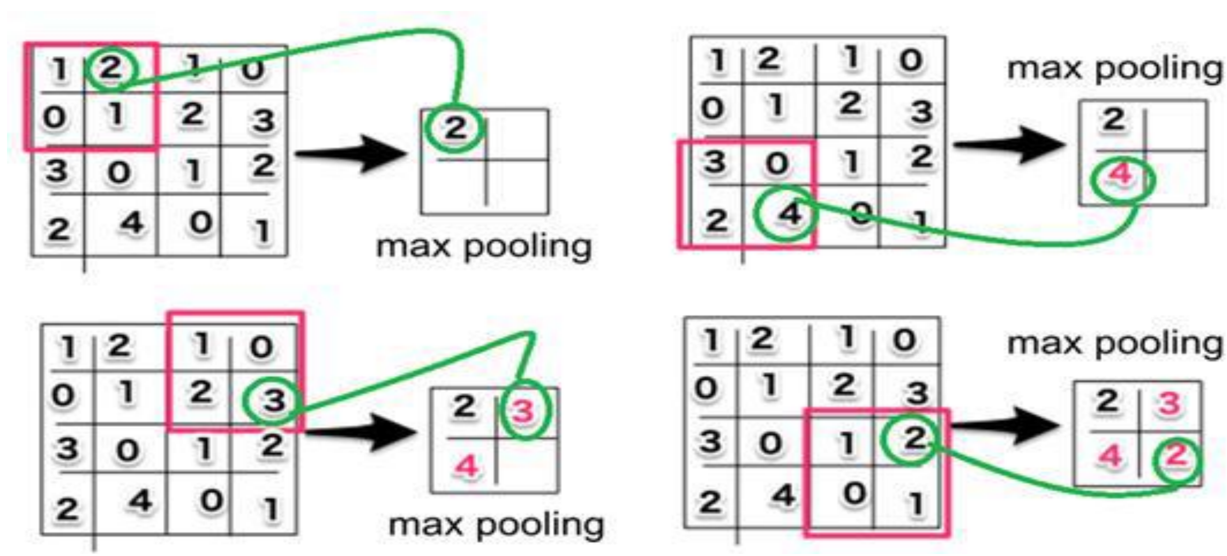
2.6.1.4. Sub Sampling Layers

Subsampling (pooling) layer reduces the dimensionality of every feature map but can give the most important information [26]. It is also reduces the number of computations required for training the network or simply running it forward during a classification. There are various ways to do subsampling layer: max subsampling and average subsampling, Sum-subsampling layer etc. In those subsampling layer cases, the input layer is departing into non-overlapping of the two-dimensional (2D) spaces. Max pooling (max sub sampling layer) extracts out the highest pixel value out of a feature whereas average subsampling layer evaluates the average pixel value that should have to be feature extracted. Average pooling (average subsampling layer) can takes the average of rectified feature map elements. Sum pooling can also imply sum of all elements in the extraction feature map. For sampling operational layer, the two vital hyper-parameters are stride and value window size.

In the figure 2.7, the component of convolution operational layer is the same as the technical process of sub sampling or pooling layer. The only difference is that the sliding window of the minimum sub sampling operational layer is mostly 2×2 matrix, and the step is 2 sliding window steps. Therefore, this operational process should have mostly halved the extracted deep feature map of the size of the other previous layer, which to a large extent map can greatly decrease the convolution weights of neural network model parameters and this are very well for the overall speed of operations of the network training process to promote. The overall operations of sub-sampling mostly minimize or reducing the amount of parameter to be evaluated but makes the network process invariant to translations in shape, size [27]. The size of sliding window is can be specified based on the value of the stride. And also the number of parameters can avoid global sun sampling (2x2filter along with stride 2). It takes from largest amount of the pixel by pixel values of a region as shown in figure.



a) Average sub sampling operations



b) Max sub sampling operations

Figure 2.7 Average and max sub sampling operations [24][28]

2.6.1.5. Fully Connected and Global Average Pooling Layers

Fully connected layer is another components of deep convolutional network, and the layer could implies each and every of the previous layer neuron is connected to every and each neuron in other layer [19]. This layer usually used to classification network purpose. Unlike sub sampling layer, input layer, and layer convolution, fully connected layer is global layer of operation [29]. Because the significance of global average is decreasing learnable parameter, and thus operation of pooling layer is designed to reflect fully connected layer in classical deep convolutional neural network. In layer of fully connected, the weight of hidden layers should be multiplying by high feature levels. The layer of fully connected takes from the global analyzing image of the analysis of the output of the whole consecutive layers and inputs from extraction feature stages. The output map of sub sampling layers and layer of convolutional can be represented by high level features of the data. Therefore the fully connected purpose is used to the help of high feature levels for classifying the medical data image into various types of classes using image data set training.

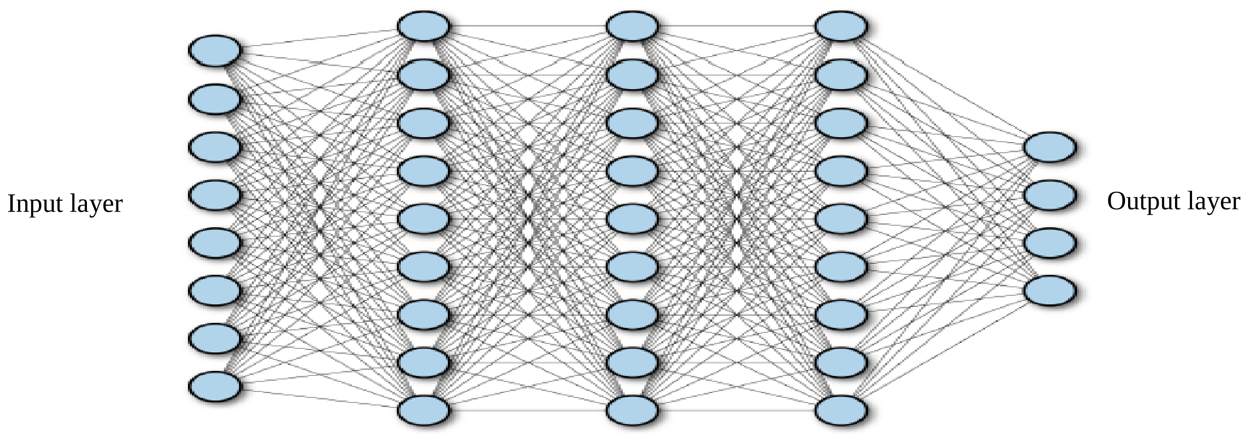


Figure 2.8 fully connected DCNN [24]

In figure 2.8, the overall operation (structure) of DNN should have two layer connections: the local feature extraction and the input layer of each or every neuron composed of connected receptive local fields of the layer of previous which is named as feature extraction layer. When the local field feature is could extracted, the positional between the relationship of the local field feature and other feature map is also determined. Another layer of feature of the map is each and every computing network layer is composed of feature map of plurality. When the each and every map feature is neuron plane, the neurons in the weight planes are equal. The advantage of the feature of map structure is non linearity activation function of deep network convolution structure and which makes the process the structure map should have in variance shift. Since the neurons feature map plane doing share weight is the same, and decrease the amount of free network parameters. Each and every layer in deep convolution network layer in followed by computing of the network layer which is evaluating the local feature average and the other extraction feature, and this unique feature extraction operation decrease the resolution.

<u>Xception Network Architecture</u>: Xception network architecture is one of the most popular deep Convolutional neural network model architecture is used in this research work.

Xception network architecture is mostly introduces a linear combination or stack of separable convolution layers or depth wise separable convolution layers with the adoption of residual connections [30].

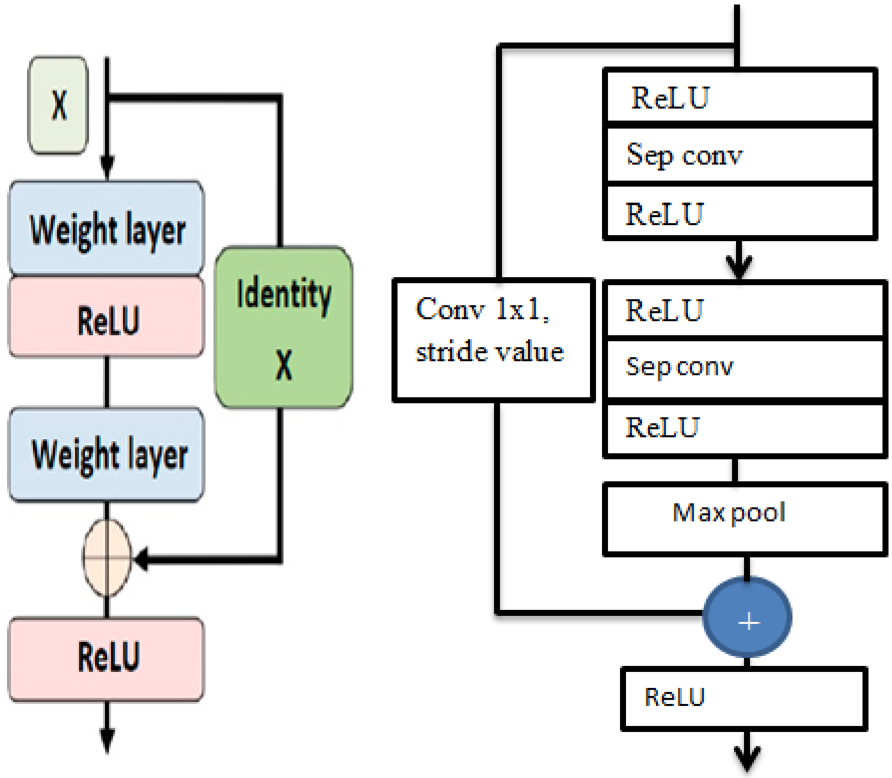


Figure 2.9 Structure of residual network and admission of residual network for Xception [31][30]

The depth-wise separable convolution is the very importance layers of Xception model architecture. These can decrease and extremely reduce the computation and the model network parameters, and which are organized in the spatial dimensions and depth dimensions of the channels.

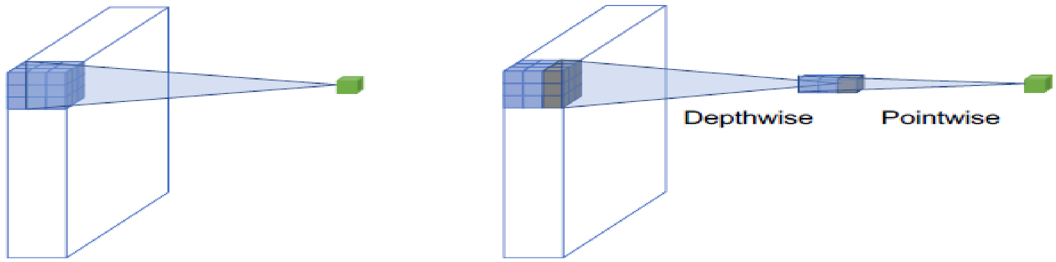


Figure 2.10 Standard convolution operation and depth wise separable (depth wise) convolution operation

In figure 2.10, the depth wise separable convolution that can departs a standard 3x3 convolution pattern into a 3 x 3 depth wise (separable) convolution and a 1 x1 pointwise operational convolution. However, the standard operational convolution can outperforms the spatial wise computations and channel-wise computation in one way step, depth wise separable convolution partitioning the computation into two steps: depth wise convolution provides one component convolutional filter per each input point wise and channel convolution is important to perform a linear stack combination of the output map of the depth wise (separable) convolution.

2.7. Classification Techniques

Images are typically considered as one of the most important task or role of conveying the information in the area of computer vision and realizing information obtained from images can be used for other tasks**.** Classification is a very crucial and vital stage which is based on feature extraction image. Image pixels could be directly used as input medical images to the standard feed-forward neural networks or class of interest to solve unique feature of medical data images in case of image classification problems[32]. In image classification problems, the critical and detailed power of features extracted are used to realize better performance classification stage. Image classification, which can be referred to as the task of categorizing images into one of constituent predefined classes, and it is the main emphasis on the overall image of the semantic judgments and basic problem in computer vision.

2.7.1. Recurrent Neural Network

Recurrent neural network is the major type of artificial neural network while connections between hierarchical or computational nodes form directed network along temporal sequences. The Recurrent neural network is very appropriate model for processing temporal information [33]. There is a direct cyclic connection between the units of RNN that can store its internal hidden state and thus help to model of the dynamic temporal behavior. The hidden states in RNN stores information from previous states creating a memory for a network. The fundamental architecture comprises of three types of neuron layers: input, hidden, and output layer nodes. In Recurrent neural networks, the network can flow from input layer to output layers and strictly in a feedback direction. The connection of the hidden layers is a very significance feature of RNN. The input layer nodes and the other layer of hidden nodes are connected with each other, and the hidden layer is output to the output layer. The node output information returns to the hidden layer node again, and it can even include the hidden layer adjacent nodes to each other. The cyclical connections are important in handling the sequential prediction of outputs, where the current output is not only dependent on the current input but also the previous outputs. The LSTM and GRU (gated Recurrent Unit) models are used in a recurrent neural network. To manage the memorization process, both models are benefit to a gating mechanism. A GRU and an LSTM differ in that a GRU has GRU gates (update gates and reset), whereas an LSTM has three LSTM type gates (output, forget and input gates). Larger sequences and a larger dataset make LSTM more effective. However, GRU due to have a lower memory limits.

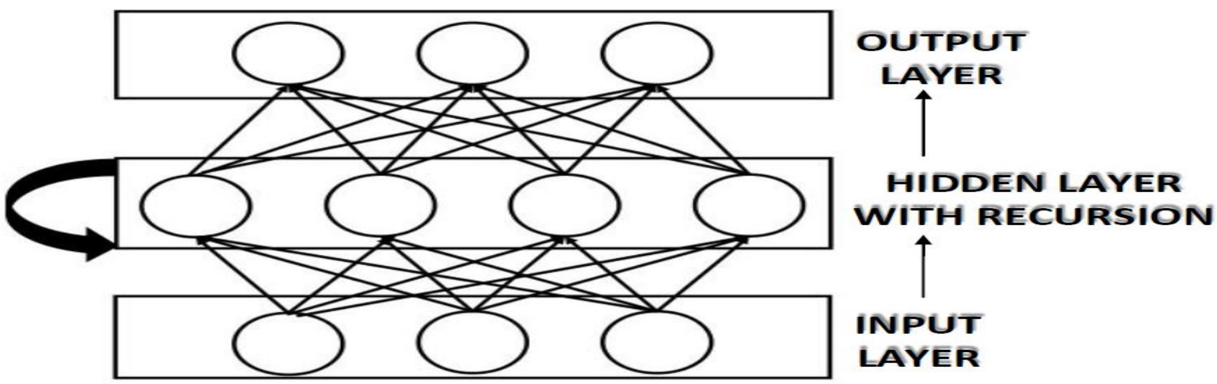


Figure 2.11 structure of Recurrent Neural network [34]

2.7.1.1. LSTM Model Architecture

Long short-term memory mode architecture is a very important type of an artificial recurrent neural network model architecture, and used in the area/field of deep learning and unlike feed forward artificial neural networks, it has backward connection. LSTM has cyclic connections and is an extended model of RNN through three types of gates namely an input gate, output gate and forget gate. It learns neural network of the long terms dependencies in temporal direction sequences or temporal sequences of dimension with these gates. LSTM is simply to optimize rather than other RNN model because these gates enable the input features to propagate through the hidden layer without effecting the output. It can also capable to sufficiently address with vanishing gradient problem because of this it frees up the memory locations in a temporal sequences of dimension cases.

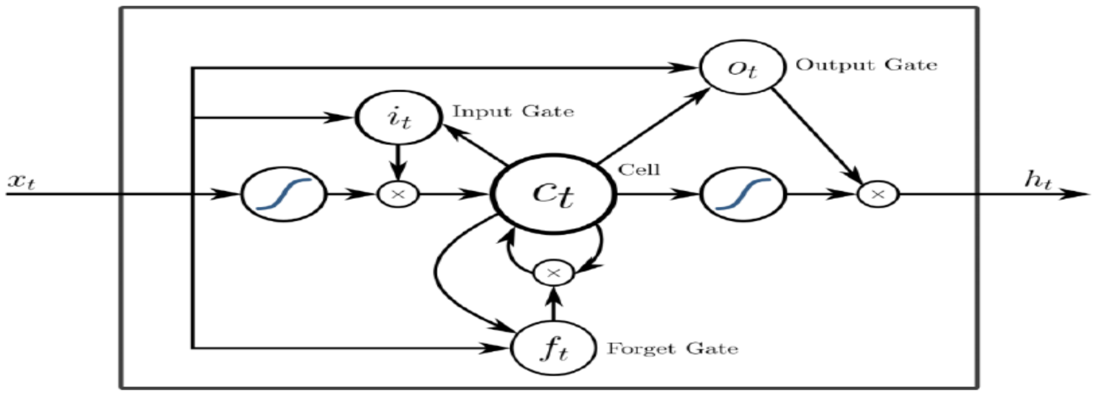


Figure 2.12 structure of LSTM model architecture memory cell

In figure 2.12, LSTM is a special and improvement of RNN structure which is structure of memory blocks in the recurrent of node hidden layer. The LSTM memory blocks comprises the memory cells along with self-connections accumulate the temporal sequence of the network architecture, besides to this, the very special multiplicative units are gates to handle the signal flow of information. The only difference between the model LSTM architecture and RNN approach is that it adds a structure of the processor to examine whether the information is important or not. The structure of that processor is named as memory cell. Input gate: can scales signal flow of input activations into cell and Output gate: this can gate flow of cell activations into the rest of the memory network. Finally, Forget gate: controls the internal state of the memory cell before increasing it as the first input to the memory cell with the back ward connection of the memory cell. Therefore resetting the cell's memory or adaptively forgetting. LSTM address vanishing gradient problems and has long-range dependencies that can make LSTM more accurately other than RNNs (recurrent neural network). From mathematical and the graphical illustration, it is reveals that the output of LSTM is dependent on the parameters, input x(t) and the feed-back connection internal state h(t-1) and h(t),weights(wo,wi,wf), bias(bo,bi,bf).The mathematical and Graphical illustration of the input multiplicative gate i(t) handling the flow of activation of input into the cell memory. The equation of i(t) given as:

$$i(t) = L(Wi(h(t-1),x(t)) + bi) \quad \text{.......................} (1)$$

Graphical illustration of the output gate o(t) controls the output flow of cell activations into the rest of the network given by:

$$O(t) = L(Wo(h(t - 1), x(t)) + bo) \quad \text{.......................} 2)$$

mathematical and Graphical illustration of the forget gate f(t) performs the internal part state of the memory cell before increasing it as input to the memory cell along with the self-recurrent(feedback) connection of the memory cell, therefore resetting the memory cell's memory or adaptively forgetting. From the equation f(t) is the forget gate which will select which part of memory is going to be passed to next step. The output of f(t) is a number between the value 0 and 1 (when choosing sigmoid as L(.)).Where L(.) is the activation function for input, output and forget gates, which is normally chosen as the sigmoid activation function. The equation of f (t) is given by:

$$f(t) = L(Wf\,(h(t-1), x(t)) + bf) \quad (3)$$

2.8. Optimizers for Deep Learning

Optimization is usually updating the weights that to make small the loss function. In deep networks, loss reduction is done by changing the hyper parameters configuration of the network. The Loss function seems to direct the gradient optimizer in the right direction put forwards to the global minimum.

The gradient descent method is easily to implement and most common optimization batch gradient decent method that minimize loss by updates iteratively the learnable parameter [35][36]. It used to improve optimization technique for several variants objective functions and modify to the hyper parameter configuration of the training algorithm, and further to increase the training process as per the requirement of model architecture. The idea of this method is that variables update iteratively in the direction of the gradients of the objective function. The update is performed to progressively converge based on speed to the optimal value of the objective function from the given data. It can converge at a slower speed if the variable is closer to the optimal solution, and more careful update iterations need to be outperformed.

In deep learning era, various optimizers used for the gradient decent optimization techniques include SGD, RmsProp and Adam optimizer etc. SGD optimizes an objective function iteratively and is regarded as a stochastic approximation of gradient descent optimization. SGD decreases the update time for dealing with huge amount of data and removes a certain amount or number of computational redundancy. It calculates the estimate of the gradient from a randomly selected subset of the data whereas in gradient descent, this is calculated for the entire dataset. Each parameter update is computed over a mini-batch. It uses a constant learning rate and the data is randomly shuffled prior to each epoch of training. When we training deep neural network large scale data set SGD has difficulties to address serious problem like timely needed and ill-condoning. This optimizer also very difficult to parallelize using GPUs. RmsProp is also a method of optimization in which learning rate is adapted for each of the parameter. It divides the learning rate using the running average of the magnitudes of recent gradients for a weight, restricts oscillations in vertical direction. It is a very important optimizer and it can deal with stochastic objectives making it applicable to minibatch learning.Basically; RMSProp happens the peak level during the training in deeper network and worse in training case.

Adam is one of the most important and most effective used optimization algorithms in context of deep learning approaches for other type of optimizer gradient algorithm [37]. It has advantages to require a little tuning for the hyper parameter in terms learning rate. And also this optimizer is straightforward to implement and computationally efficient as well as a little memory requirements for the network.

2.9. Dropout Method for Deep Learning Algorithms

A dropout map is the most effective regularization method, and applied to increase the performance by disable specific number of neurons in each layer randomly during training case.
In other ways, dropout technique can be used to reduce the influence of individual number of neurons during each layer which helps the network to generalize well and also in improve the accuracy of the result. Drop-out network with the similar size of the specific number of neurons in previous layer is initialized randomly to mark the off or on state of the network structure corresponding neuron at the beginning of each iterating train case [38]. The neurons with off state of the corresponding network are then rejecting from the network during the training case iteration, by disabling specific number of neurons of the signal backward propagation error of the neuron and the activation signal of forward propagation purpose. Overfitting and under fitting examples are shown in figure 2.13.

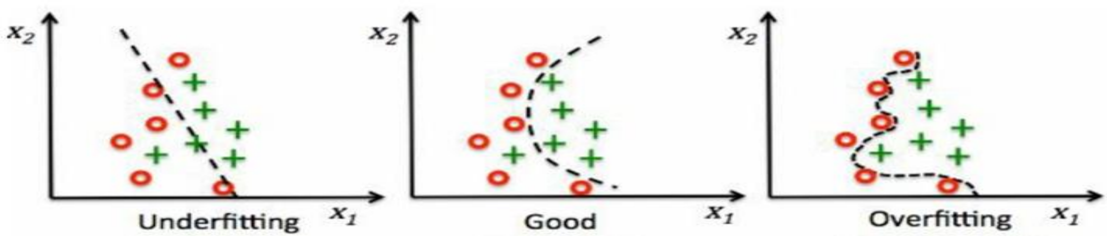


Figure 2.13 Overfitting and under fitting examples

In figure 2.13, artificial neural network learns the complexity of input and output relations that are specific only to the training purpose, and this can be stop to control or capture the very comprehensive relation between output and input networks that is what we call overfitting. Dropout can the network to prevent overfitting from becoming too dependent on any one or any small combination of neurons, and force the network to be correct and accurate even in the absence of full information in the network[39].The dropout layers are used for reduce overfitting the number of parameters and computations in a network.

2.10. Summary of the Theoretical Back ground

Tuberculosis is a very hard and highly lung infection diseases which kills millions of people each year due to diagnosis error and improper diseases treatment. The tuberculosis (TB) disease mainly attacks the lung region, but can also disturb another part of the human body or organs. This disease is caused by tuberculin mycobacterium and identifying by chest radiograph tool or techniques. Chest radiograph is a very vital role screening Medical imaging techniques for huge amount of population and differentiate active lung TB cases. Clearly, the common career for medical technologist or doctors/radiologist can identifies or detects abnormalities among normal images in digital images.

For our work automated lung TB detection, image preprocessing and lung segmentation stages are crucial steps. In image preprocessing, Gaussian filter and adaptive histogram equalization preprocessing methods are used for image quality enhancement. For lung segmentation, correct lungs region segmentation outperforms the detection, and properties of abnormal with in the lung region. Active contour, Thresholding and operator morphological operations are simple but operational type of approaches that can be used in segmentation.

Artificial neural networks are mostly elaborated a very large number of interconnected communication nodes as neurons(human nerve cell) which work twist in a distributed neural network fashion to collectively learning to represent from the input in order to optimize its final output. Deep learning approaches and methods are an important role in the area of Artificial Neural Network, which uses deep or complex layers to progressively extract very high level convolutional feature and transformation from the huge amount of input data image in order to come up with deep structure representations learning. Among deep learning techniques, CNN is a very significance model in our research to extract the feature of the whole input image (data). CNN operators are used to extract features from the medical image by sliding a filter of small size over the total input data. In CNN, Xception model architecture is used as feature extractor. Finally; Classification is a very crucial and important stage which is based on feature extraction image. Image pixels can be directly used as input to the standard feed-forward and backward neural networks to solve medical classification image problems. In classification image, LSTM is used to identify healthy and abnormal tuberculosis images.

CHAPTER THREE

LITERATURE REVIEW

3.1. Introduction

In this section, a number of previous research works that has been done related with automated lung tuberculosis detection system using different approaches. There are many proposed techniques that have been introduced by different researchers to detect lung tuberculosis with Computer Aided Diagnosis. The field of focus and the gap, results of these thesis works are also presented and discussed.

3.2. Lung Tuberculosis disease

In [40], the researchers developed a classification of Lung tuberculosis with SURF spatial pyramid features. In this paper, the authors have presented the use of local features of SURF (Speed-Up Robust Features) extracted from the segmented lung images using a grid windows of various spacing, hence controlling the consistency of the SURF features. The data set used for testing and training was collected from the US National library of Medicine (USNLM) using the services of the health department at Montgomery County (MC), USA. It contains of 138 chest-radiograph images collected under MC's tuberculosis screening program. The dataset comprises 80 chest-radiograph images that are normal while remaining 58 chest-radiographs have tuberculosis manifestations. The paper elaborates the complete implementation and designing of Computer assisted (aided) diagnosis (CAD) system to facilitate tuberculosis screening and presents the performance analysis based on the available USNLM database. They have used super vector machine (SVM) classifier for the CAD system. This model achieved performance of an Area under the Receiver Operating Characteristic curve (ROC) metric of AUC 89%. The limitation of this research work is that small numbers of data images, and used only for training and testing case.

According to [41], the authors attempted to develop Automatic classification of pulmonary (lung) tuberculosis and sarcoidosis using Random forest algorithms. In this work, the researchers proposed based on the performance analysis of super vector model, Random forest, Logistic regression, Naïve Bayes techniques for automated pulmonary tuberculosis and sarcoidosis classification system. The data set used in this paper is selected from HIS database in the counts of pulmonary tuberculosis and sarcoidosis is 485 and 1990 images respectively. With accuracy of 82%, 85.3%, 85.4%, and 85% respectively, the system can detect TB and sarcoidosis by super vector model, Random forest, Logistic regression, and Naive Bayes classifier. We can see from this paper's performance experimental data that the Random forest approaches produces better accuracy results compared other three classifier models.

Jaeger et al. [42] presented a Tuberculosis detection method in which intensity mask, lung model mask, and Log Gabor mask are used for lung segmentation. In this work, different shape and texture descriptors are used to find the pathological patterns in chest-radiograph mages. For each descriptor, histogram bins are used to represent its distribution and value of each histogram bin for every descriptor is considered as a feature. The dataset comprises 138 chest-radiograph images collected from publicly available USNLM database of Montgomery County. Linear support vector machine (SVM) is used as a classifier to classify the chest radiograph images into normal and TB positive classes. According to experiment results, the overall accuracy of detecting TB combining with all masks is 83.12%. Another work by these researchers in [43], also presented a similar automated method in which two separate feature sets namely object detection based features and CBIR (Content-based Image Retrieval)based features are used, after segmenting lung boundary using graph cut segmentation method. Finally, SVM is used as a classifier to classify chest radiograph as normal and TB infected cases. Results are obtained using three datasets with training and one for testing the method. The performance of object detection and CBIR feature vectors is found to be 0.87 and 0.90 respectively in terms of AUC.

M.K Osman and M.Y Mashor [44] proposed Compact single hidden layer feed forward network for Mycobacterium tuberculosis detection using tissue slide images. The dataset comprises total numbers of available dataset are 1603, including 620 dataset of TB; Non-TB is 498, and 485 dataset belonging to overlapped tuberculosis case. From this dataset and their proposed model used 603 samples for testing and 1000 samples for training purpose. The experimental result is indicating that their proposed model achieved accuracy of 75.46%.

A Potential Method for automatic lung Tuberculosis Detection using Chest Radiograph was conducted by Rahul Hooda, Sanjeev Sofat and Simranpreet Kaur [45].The proposed framework has been validated by the dataset of USNLM challenge using the service of health department at Guangdong medical college, Shenzhen china and Montgomery county chest radiograph. They develop, simple deep learning which is convolutional neural network architecture, that has number of layers in between LeNet and Alex Net network architecture .The performance of the extracted feature in deep convolutional network depend on the depth of the network architecture. The experimental results are evaluated by training and testing the proposed architecture based on Montgomery county and Shenzhen data set. On the total of 800 chest- radiographs images, which are used for the training purpose and 200 chest radiograph images are used for validation case. The last detection results are gained by fusing the probability prediction output of the network architecture. The average detection validation accuracy of the proposed system is 82.09%. Future works include extending the developed method to classify chest radiograph images in to different tuberculosis manifestations for which a larger dataset is required.

The work done in [46] proposed Framework of Predicting Drug Resistance of Lung Tuberculosis by Utilizing Radiological Images. The authors proposed a general framework to do the predicting of lung drug-resistant tuberculosis in radiological images. To solve the sample of predicting problem with convolutional neural networks, they have used VGG16 network architecture as the basic model. They introduce VGG16 network architecture to predict drug resistance of lung TB and test proposed method on imageCLEF2017 tuberculosis image acquisition. The total numbers of dataset are 230 including 134 dataset of tuberculosis drug sensitivity, and 96 dataset belonging to multi drug resistance. Their proposed method was based on 2D and 3D analysis of the radiological image data. And they have test the proposed methods on ImageCLEF2017 tuberculosis dataset, and obtained the accuracy of 64%. The performance of the model can be further improved by more testing radiological image, with huge number of data more features will be learned by the proposed model.

TB Detection in Chest Radiograph using CNN was proposed by Rahul Hooda and Ajay Mittal [47]. In this work, they have used two convolutional network architecture such as: VGGNet and AlexNet network architecture. CNNs are based on feed-forward neural network architectures and automatic selection of features. The performance of extracted features in CNN depends on the depth of the architecture. They evaluate and verified their proposed method on two publicly available datasets and combined to form the final dataset. This data set includes Shenzhen and Montgomery chest x-ray (chest radiograph) set. Their proposed method was based on 3-dimensional analysis of the chest radiological image data .The MC Dataset comprises 138 CXR images consisting of 80 normal images and 58 abnormal (TB) images while Shenzhen dataset has 662 images consisting of 326 normal and 336 abnormal cases. Therefore, the data set comprises a total number of 800 images are collected. Among total number of 800 images, 560(70%) images were used for training and 240 (30%) for the remaining part of 240 images used for testing purpose. To increase the number of images in the dataset the method of image augmentation was used. With deep network architecture, VGGNet gives an acceptable result with the dataset used. The proposed system has achieved an accuracy of VGGNet and Alex Net is 81.6%, 80.4% respectively. From accuracy results, VGGNet is better accuracies value than Alex Net architecture. The gap of this work is reduced computing system performance in terms of accuracy measures. The performance of the proposed model (approach) can be further enhanced by increasing the chest-ray dataset, with maximum number of data more features will be learned by the model. These authors [48] also presented tuberculosis classification using CNN based on chest radiograph images. For performing the proposed system, images from four different data set namely Montgomery, JSRT, shenzhen, Belarus dataset have been used .In this work method for TB classification is proposed which uses deep learning architecture, ResNet. They have used 34 layered network architecture which uses skip layers (identity short connection) to increase the number of layers in the architecture without decreasing the performance. In deep architecture, best features are automatically extracted based on the training images and their outputs. The number of training image is increased by using data augmentation techinques.The ResNet architecture has been customized to perform classification of chest radiograph images in to two classes, that is Positive and TB negative image. The experiment result are obtained on the data set of 1133 images, among 1133 images ,499 are TB positive and TB negative images. This model achieved on test accuracy of 84.12%.

Betsy Antony and Nizar Banu P K [49], proposed Lung Tuberculosis detection based on chest radiograph images (x-ray images). The major objective of their research is focused on designing and developing an application which can signifies in the detection of lung tuberculosis using Matlab as a research tool. The method consists four steps: filtering, segmentation, feature extraction and classification stages. To remove unwanted noise from an image, median filtering technique is done at the first stage. For the next stage they combined two segmentation methods like watershed model and gray level thresholding model, and a fused image is generated which yields an accurate result. Features like area, major and minor axis, eccentricity feature, mean, standard deviation, skewness, and kurtosis are extracted from ROI of fused image. Finally, they have used the approach of three classifiers algorithm: KNN, SMO and Simple linear regression classifiers. The dataset comprises of a total number of 662 images available where 326 images are TB negative and 336 images are TB positive, collected from publicly available National Library of Medical medicine (NLM) data acquisition. The Proposed systems have achieved with 80%, 75% and 79% accuracy by KNN, SMO and Simple linear regression classifiers respectively. From the accuracy results obtained we observed that KNN classifier performs maximum accuracy compared to the two classifiers algorithm. The research gap is mainly caused by two major impediments:

- Necessary to design and implement with huge amount of data set
- Reduced accuracy measures of computing system for accurate medical diagnosis by analyzing the chest radiograph images.

Mostofa Ahsan and Rahul Gomes [50], presented Application of convolutional neural network based on transfer learning for lung tuberculosis detection. In this work, they have presented a Convolutional network architecture approach that can uses VGG16 Net for classifying CXR(chest radiograph) images to identify patients suffering from tuberculosis diseases. The average classification accuracy from both Shenzhen and Montgomery were approximately 80.4% .The authors also achieved the classification accuracy by using only Shenzhen data set(82.5%)and Montgomery having 78.3% .For this work, they have used a total 276 CXRs data images from Montgomery and 1324 from publically available Shenzhen datasets. The dataset was split/depart using 75 to 25 ratios were 75% used for training case and 25% for testing. Their proposed method was used 3-dimensional analysis of the chest- radiological (chest x-ray) image data. To increase the total of images in the tuberculosis dataset, the method of image augmentation was used. Image augmentation formulates or creates new images by modifying the existing images based on rotation, flip, and color or brightness. The augmentation process in general is used to enlarge the size of the training dataset to help find patterns. It is also applied to reduce over fitting in the model. In Future work, would extend in the work include running the model on a system with a higher configuration so that the augmentation could be done on all images before training the model using VGG16 Net. They achieved performance accuracy measures by training case of batch size of 16, there is a scope for further increase if the image augmentation would be applied for all CXRs (chest radiographs) images.

Tuberculosis diagnosis using chest x-ray was conducted by Lokeshwaran V, Monish Kumar and, Lakshman Raaj [63]. In this paper, they have used four deep convolutional network architecture such as: Xception, VGG19, InceptionV3 and ResNet50 model network architecture. The proposed framework has been validated by team of researchers challenge from Qatar University, Qatar, Doha and the University of Bangladesh, Dhaka along with their collaborators from Malaysia in collaboration with medical technologist from Bangladesh and Hamad Medical Corporation data acquisition comprises both negative and positive chest radiograph with manifestations of lung tuberculosis. The performance result is obtained on the data set of 4200 images, among 4200, 3500 TB negative and 700 TB negative images. The detection accuracy gained for each model was 95% for InceptionV3, 83% for VGG19, 98% for ResNet50 and Xception. The paper does not reveal a percentage split between the training and testing case data. The performance accuracy of the network architecture can be further improved by increasing the chest radiograph dataset, with a big amount of data images, thus more features will be learned by the network architecture.

Therefore, from this chapter that we reviewed the literature papers, we examine that a new significant approach is expected to obtain an improved performance in lung tuberculosis detection system. We design and implement a system to improve lung tuberculosis detection performance in terms accuracy by using deep learning approaches. Besides this, a new approach of preprocessing and lung segmentation was provided.

3.3. Summary

In this chapter of the research, a number of previous thesis works were carried out on the screening of Lung tuberculosis diseases detection using machine leaning approaches and deep Convolutional neural network model architecture methodologies. The reviewed research work focused on Lung tuberculosis detection using biomedical chest radiograph images. Some of the

Lung tuberculosis detection systems have been done on shape, texture descriptors, Speed-Up Robust Features and Content-based Image Retrieval features ,to find the pathological patterns in chest-radiograph mages [40][43].While the other researchers have been done on Sequential minimal optimization, K-nearest-neighbor.Xception,VGG19, and InceptionV3 and ResNet50and Simple linear regression classification approaches [49][63] .More precisely, the other works also carried out on deep Convolutional model architecture to decrease the overfitting of the model network architecture.

For automated lung TB medical images detection, our implementation focusing on deep convolutional neural network model architecture combined with deep recurrent neural network for detection case ,and Gaussian ,AHE ,thresholding ,active contour and operator morphological methods are used for preprocessing and lung segmentation purpose. We develop and implement lung tuberculosis detection system with Computer assisted diagnosis based on deep learning technique. Specifically, in deep convolutional algorithm, Xception model is important in detection part because of it used as depth width separable convolution to reduce over fitting of the network and efficient, Captures information of size, position, shape, etc., high accuracy, relatively easy rather than other convolutional network model. On the other hand, in deep recurrent network, LSTM model is crucial part of classification stage. LSTM is used to address vanishing gradient problem in our case. In the part of lung region segmentation, reduce Region of interest is done by segmenting the lung image with the method referred to as morphological, thresholding and active contour model approaches.in preprocessing part of our work, Gaussian and Adaptive histogram equalization used enhance the quality of the medical images.

Generally, we implement and design Tuberculosis detection using chest radiographs with CAD based deep learning approach. The design is developed in the other way of that we reviewed related works based on the method and techniques approaches.

CHAPTER FOUR

PROPOSED APPROACH

4.1. Introduction

In this thesis work, we proposed the design and testing of automatic tuberculosis detection with computer assisted diagnosis. The proposed framework has four main stages: image preprocessing, Lung region segmentation, feature extraction and classification. The preprocessing stage performs image resizing, AHE, Gaussian filter ((noise removal) and normalization technique tends to enhance or improve the quality of the image. The second stage of our proposed the framework is Lung region segmentation. In the lung region segmentation, we can reduce the search space by using threshold, morphological and active contour model operators. The output obtained from those taken as an input enhanced preprocessed image and were performed by threshold, morphological and Active counter model which can helps to focus on the lung region of the obtained results. Output map from these lung segmentation methods is used to get a Region of Interest reduction. The output result of lung segmentation integrated with feature extraction and classification by applying deep learning approach. Feature extraction system was done by deep learning (deep Convolutional neural network) which is Xception model architecture. In the fourth stage of classification process, long short term memory outputs the decision that whether image is TB positive or TB negative based on chest-radiograph images.

Chest radiograph is the most important diagnosing mechanism in tuberculosis detection medical images. And then we have to input the enhanced pre-processed chest radiograph images, and the lung segmented images into Xception and LSTM Network model to extract feature and binary classification of the lung tuberculosis from the lung chest radiograph images. Developing the current accurate and correct Computer-Assisted Diagnosis system has significance role for medical technologist and doctors to interpret Chest medical images. We use four performance metrics for our proposed system like precision, f1-score, Recall, and accuracy measures with confusion matrix on our approach proposed frame work to clearly point out the effectiveness or usefulness of the proposed models. In general our proposed work flow is shown in the following:

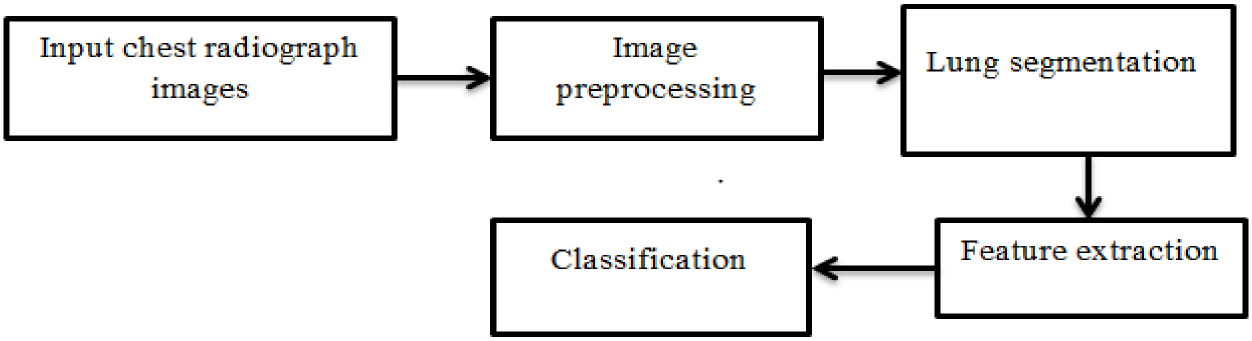


Figure 4.1 work flow of the proposed system

4.2. Image Preprocessing

Image pre-processing is conducted before analysis of any image set can take place, preprocessing should be performed on all the images. This process is reveals in order to make that all the data (images) are consistent in desired characteristic. The ultimate goal of the image preprocessing stage is to enhance or improve the image quality and to reduce the undesired ones. The image preprocessing stage should have including in normalization, image resizing, contrast enhancement method (AHE), noise removing (using Gaussian filtering technique) and normalization those we enhances the quality of an image based on image processing.

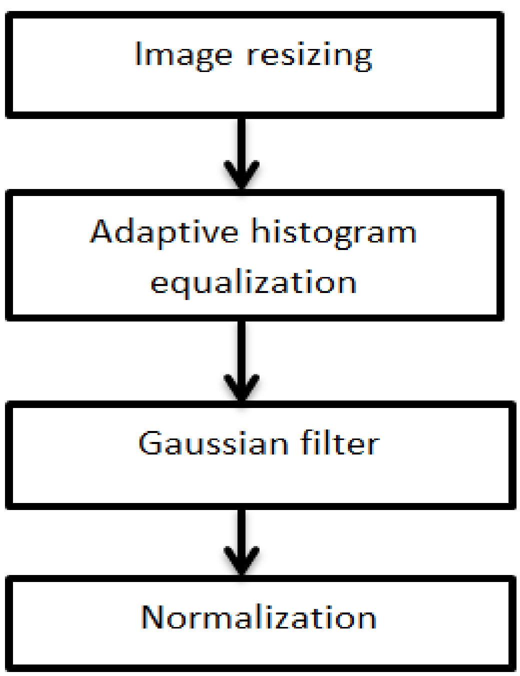
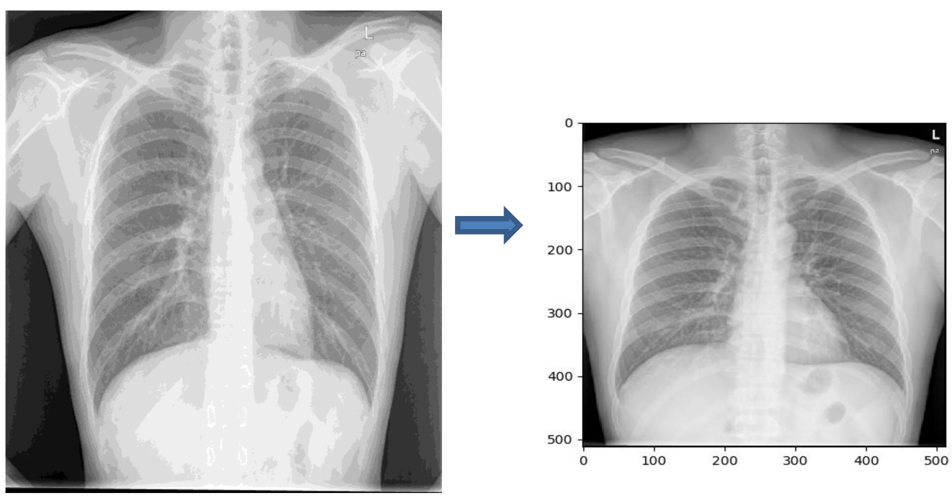


Figure 4.2 work flow of image preprocessing

4.2.1. Image Resizes

Image resizing is a very important part in image processing technique, to enlarge and decrease the given medical image (dataset) size in pixel by pixel format. It helps in reducing the amount of pixels count from an image. Image resizing is necessary to decrease the time required of training of a neural network as more is the amount of pixels in data image more is the amount of input nodes that in turn increases the complexity of the network model. It is often used to increase a model's accuracy, as well as decrease its network complexity [47][64]. It is altering the image size without avoiding anything out. To resize, we need to elaborate the height and weight of the resulting output of the new screening image. The resizing image can rescales lung TB image dimensions to 512x512 pixels format in size. Since the images in the data set consist of different aspect ratios and dimensions, we resize the entire image to 512x512 in order to make all the pictures to have similar aspect ratio and dimension.

The following figure 4.3 shows the resized lung tuberculosis image based on chest radiograph images.



(a) Original Lung TB image (b) Resized image

Figure 4.3 resized lung TB image

4.2.2. Adaptive Histogram Equalization

In medical application, images are affected by noise and might have full contrast in case of poor contrast, and which may give improper diagnosis. Image contrast enhancement is significant role in medical image processing applications. The enhancement method is due to the fact that visual screening and examination of medical digital image is important in the diagnosis of the diseases.

To enhance an input preprocessing the given medical data(image), it is required to some image preprocessing technical approaches in order overcome better visualization of the images before screen out the diseases in particular.

Therefore on this proposed system we have used Adaptive Histogram equalization technique, in order to enhancement contrast of the preprocessed image by adjusting its intensity. Because of Adaptive Histogram equalization technique is an excellent technical method in medical application [51].Adaptive histogram equalization is clearly different from the ordinary histogram equalization method because histogram equalization implies only single or one histogram form, however Adaptive histogram equalization method generates various histograms corresponding to other different field of the medical image application in image processing. Adaptive histogram equalization helps to redistributes every and each value of intensity in digital image. Adaptive histogram equalization can improves/enhances on this by transformation of each and every pixel with a function transformation based on derived form of neighborhood region. Each pixel can is transformed using the ordinary histogram method of a square surrounding the pixel value. In adaptive histogram equalization, the intensity of value each pixel of the transformed function is based on the ordinary histogram of square surrounding the pixel value.

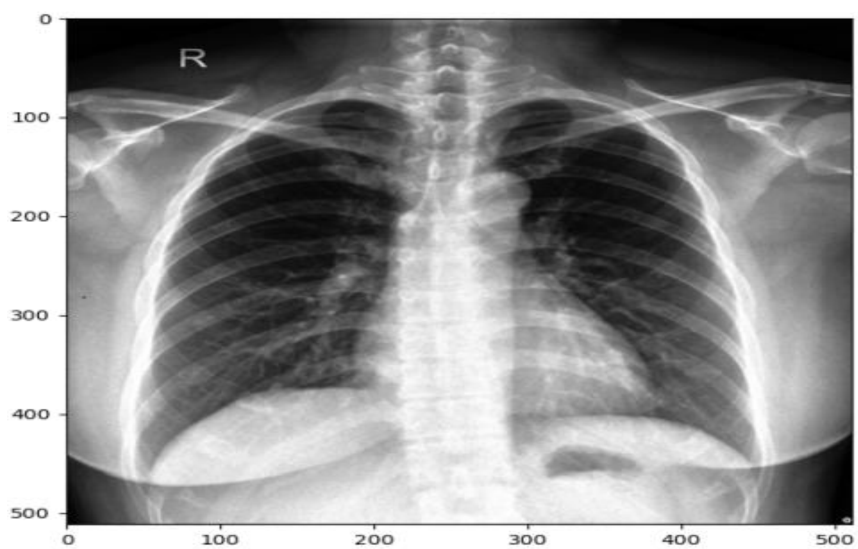


Figure 4.4 Output image for Adaptive histogram equalization

4.2.3. Gaussian filter

As part of the whole image pre-processing stages Gaussian filtering has been designed and implemented for the avoidance of unnecessary image features (noise). Gaussian filtering is a nonlinear digital image filtering technique, which is very effective and efficient for removing Gaussian noise, and is the weights give higher important role to pixels near to the edge (decreases edge blurring).It works by weighted the entire data image and the value of each pixel point is gained weighted average by other pixel values in its own and neighborhood. Gaussian filtering technique is done after Adaptive histogram equalization [65].

When we compare it with other type of methods, Gaussian filter is computationally efficient (large amount of filters are design and implemented based on small 1D filter) [57]. The outputs of Gaussian filter shown in the following figure 4.5.

Figure 4.5 Output of Gaussian filter

4.2.4. Normalization

The concept in image preprocessing is used to improve or enhance the image quality for each input pixels by contrasting an input image. Hence, normalization is an important stage to preprocess each input pixels using different preprocessing method. Based on our data we have use the value between zero and one based on standard deviation bounds. By Partitioning each input parameter or pixel by its standard deviation distribution, the pixel values from pixel between values 0 and 1 [52]. Therefore, we applying intensity normalization based on our medical image processing to make optimization basically simple and used to diminish the pixel value range from 0 –255 to 0 – 1.

4.3. Lung Region Segmentation Algorithm

Lung region segmentation is a vital role and an essential process in image medical enhancement (preprocessing) procedure. Our aim is segmentation of lung image as region of interest (search space) extraction to simplify or modifying the level representation of a medical image into something that is more meaningful and easily to analyze properly. Abnormality and normality of medical lung images will be indicated according to lung image segmentation of accurate region of interest extraction. Segmenting the lung regions from the data of chest radiograph scans decreases the problem space and hence feature extraction becomes more effective. Segmentation in medical imaging is challenging and complicating task for the exact recognition of lung TB images. In specifically, many of the existing technical approaches for data image screening and description depend on the segmentation outcomes. The appropriate selection of Lung Segmentation algorithm with low bias and high accuracy is a challenging in the screening of abnormalities in the region of lung based on Computer assisted diagnosis.

Various methods for lung segmentation are presented which includes pixel classification, rule-based methods, active shapes, the intensity mask, the Log Gabor mask and the lung model mask thresholding, morphological, active contour etc. However, the segmented image gained from thresholding, and morphological operators has the significance of fast processing speed and smaller storage space, and ease in manipulation, compared with other technical approaches. And also active contour model better to segment for lung area and clear the border of the image accurately. In the following figure 4.6 illustrates the work flow of our proposed lung image segmentation algorithms:

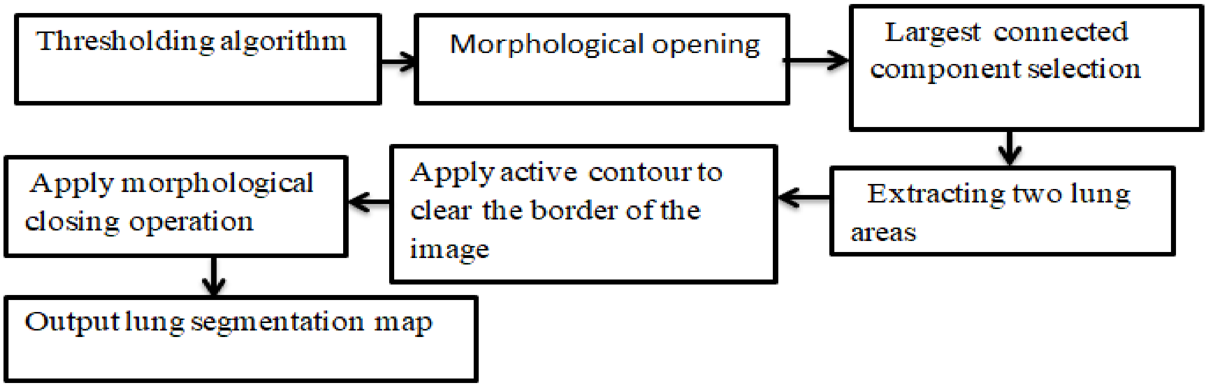


Figure 4.6 lung region segmentation image procedure

In the lung region segmentation image procedure, the first step is Image threshold algorithm. Threshold algorithm is a simple, computationally effective and efficient lung area segmentation of partitioning or splitting data image into a foreground region of pixels and background. This type image technique analysis is isolating the targeted object by converting image gray scale into image binary. In the threshold operation of the algorithm, the equation one implies the value of x and y as an input which is basically the pixel values of images with in respect to x and y-axis is one should be the threshold value when we compare the value of inputs. When the input value pixel is greater than the value of threshold then it gives output value is set to one and it reveals color of white in gray medical images. The procedures that follow the image thresholding algorithm are:

$$Z(x, y) = \begin{cases} 1 & L(x,y) > T \\ 0 & otherwise \end{cases} \quad \text{.......} (1),$$

Where L(x, y) is an input image, Z(x, y) is an output image and Tis threshold value [53]. To find the thresholding value T, The threshold value T is for each pixel (x, y) is calculated by [54]:

$$T(x, y) = \frac{\max + min}{2} \quad \text{.......} (2),$$

Where min and max are the minimum and maximum Gray level value.

The threshold value in the lung region segmentation approach used to normalize the value ranges from -1024 to around 400 [55]. Anything that comes above the value 400, we cannot take into regard as those are the bones with in different radio density. The gray level value is calculated as [53].

Gray level value = T + 1024 ………… (3), then gray level value is: min = 0 and max = 1424. Therefore, the threshold value T(x, y) is 712.

After thresholding algorithm, morphological opening is clearly pointed out. However, Morphology operational algorithm can be implies as a collecting of medical image processing technical approaches that makes the processes images by taking size and shapes into morphology of an image.

The approach morphological operations considered by using the element structure on the top of an input medical image to create an image of similar size. In the operator, by considering the information, compare the value of pixels in the given information image with it's the region of neighbors into regard to approximate each and every pixel values in the return medical image.

Therefore the boundary of the morphological opening image is applying in the structuring element y that reaches the absolute points of the boundary of morphological opening x as y is rolling around inside of the boundary [56].

$$x \circ y = (x \ominus y) \oplus y \quad \text{..........} \quad (4)$$

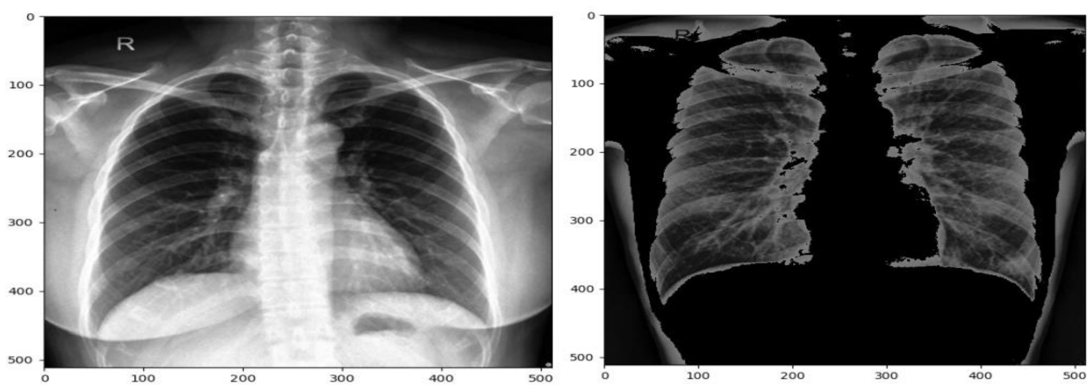
The above morphological operations to give an opening (space) between regions that are connected through very thin holes, and almost without affecting the original shape of the larger regions. And then extracting the lung of the two regions and largest lung region of the component connected selection and also applying active contour to clear and extract the border of the image. Active contour used as an energy minimization of spline, and it deforms itself to minimize the energy function. The energy function is designed for the contour to converge toward the boundary of the target or image. The contour image boundaries in the function energy are named as internal energy and external energy. The function is estimated for internal and external forces, which is capable of finding the accuracy of Region of interest. Due to the internal and external forces created within the image the contour is moved near to the target by an iterative process. For each iteration in this process, a new location is searched among neighboring hood pixels. A contour moves to a pixel that has lower energy contour of obtained initial lung areas is assumed as initial contour boundaries. External energy function is designed to capture desired image features and image energy or push the contours near to the region of interest whereas internal energy is shape energy, prevent and clear outlier point in data image.

Finally, the morphological closing operation smooths region of contours. In general fusing narrow breaks, fills small holes in the region, and fills gaps in the contour. As a result it fills the small holes and gaps and in the section of contour objects boundaries. Structuring element plays important role or task in morphological. It is the shape and size of the binary element of structure that can implies the nature of the output. So that it is important to given to its shape and size. The boundary of the morphological closed image is the points in the structuring element (binary structuring element) y that reaches the absolute points of the boundary of x when y is revolve over x around outside of its boundary [56].

$$x \bullet y = (x \oplus y) \ominus y \quad \text{.......} (5)$$

Where x is morphological closing of an image x and structuring element y.

Generally, closing operation fills the small holes in the regions keeping initial region sizes.



(a). Preprocessed chest - Radiograph image (b). Output lung segmentation map

Figure 4.7 The result of lung segmentation using thresholding, morphological and ACM technique

4.4. Lung Tuberculosis Detection

4.4.1. The proposed Xception and LSTM Model Architecture

Our Xception network architecture is based on separable convolution or depth wise separable convolution that can factorizes standard convolutions into separable convolution / convolutional depth wise and pointwise convolutions. This network architecture that can factorizes as follows:

Standard 3x3 convolutions ⟶ 3x3 depth wise convolution ⟶ 1x1 pointwise convolutions

The standard 3x3 convolution out performs the spatial wise and channel-wise computation in one way step, and depth wise separable convolution(3x3) depart the computation into depth wise convolution that can applies one convolutional filter component per each input channel and pointwise convolution(1x1 convolution) is used to produce a linear stack combination of the output. In applying component convolutional layers inside the Xception network architecture, there is layer outperforms after the input layer, creating convolutional kernels to produce feature maps to reveal the extract features of the data input. The input image, by requirement size and channels of 512 x 512, starting the work flow section in the first module with 2 convolutional layers by determining the 32 and 64 filters on a kernel size of 3 x 3, the first two convolutional blocks followed by relu blocks with stride of 2 .The second to fourth modules, works a kernel size of 3 x3 and separable convolution filters of 128, 256, and 512. Each separable convolution/ depth wise separable convolution followed by max pooling layer with stride of 2 plus padding layer. In particular, the architecture has 3 residual blocks, each outputting 128,256,512 feature channels. Each block consists of 1 residual block. Al1 residual block added two convolutional layers before separable convolution consisting of 3 x 3 convolutional filters. The skip connections enables successive convolutional layers with separable /depth wise separable convolution to learn and produce better output, allowing the network to perform more accurate classification results. The network ends with a pooling layer of global average pooling layer. The significance of global average is decreasing learnable parameter, and this operation of pooling layer is designed to reflect fully connected layer in classical deep convolutional neural network. The feature extraction of map of the last layer network is global average pooling layer transformed in to the feature vector. The feature vector from the last layer (global average pooling layer) of the Xception network are extracted and used as input vector for the LSTM network (used for classification stage). LSTM network is an improvement and cyclic connection of recurrent neural network with three type gates such as an input gate, output gate and forget gate. It learns the long terms dependencies in temporal direction with the aforementioned gates. LSTM is easier to optimize and address vanishing gradient problems and these gates enable the input features vector to propagate through the hidden layer node without effecting the output. LSTM also used to effectively address vanishing gradient problem by it frees up the memory locations and helpful in the final classification stages. The following figure 4.8 shows the proposed detection of the network architecture.

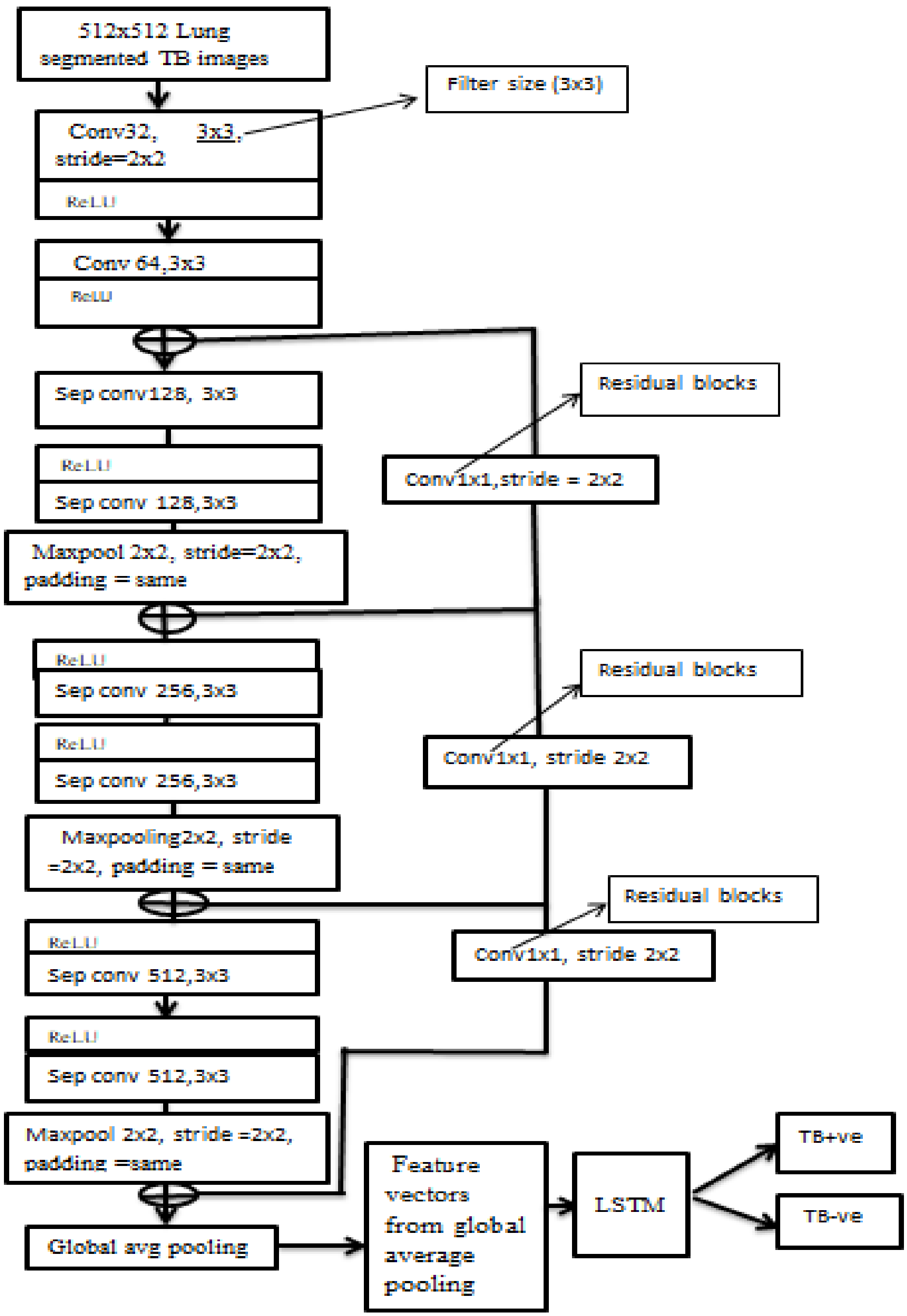


Figure 4.8 The proposed network architecture for lung tuberculosis detection

4.5. Performance Evaluation Metrics

For evaluation of the designed and implemented model we use four types of performance metrics for our proposed system like precision, Accuracy, f1-score and Recall measures with confusion matrix on our approach proposed frame work to clearly point out the effectiveness of the proposed models.

4.6. Summary

This chapter of the thesis work describes designing and implementing automatic lung tuberculosis detection with computer assisted diagnosis based on deep learning approaches via tools named as chest radiograph. In this proposed methodology the data set were taken from the data set of USNLM challenge using two public available dataset which are the service of health department at Montgomery county and Shenzhen in china.

Our proposed model architecture is based on combining with two deep learning techniques which are deep convolutional neural network with deep recurrent neural network. In addition to this, in image preprocessing stage; AHE and Gaussian used improve the quality of the bio medical images. In the part of lung image segmentation, reduce Region of interest (ROI) is done by segmenting the lung region or area image with the propose operators named as active contour, morphological, thresholding approaches. In thresholding algorithm, select the thresholding value between -1024 and 400, and evaluating the threshold value based on average thresholding between the two values. To do the second steps, morphological closing and opening morphological operator can be used to smooth and fill holes of the medical images. Finally active contour model can be used to clear the border of the images.

For our proposed work, the designing and implementing model can be based on the performance measure of evaluations metrics. These performance metrics are evaluated or conducted on the confusion matrix and clearly pointed out the precision, recall, f1-score, accuracy and comparison on performance measures of evaluation metrics.

In general, chest radiograph is the most important screening mechanism in tuberculosis detection medical images. We implement and design TB detection using chest radiograph image with computer assisted diagnosis based on deep learning. Developing Accurate and correct Computer-

Assisted Diagnosis system is significance role for medical technologist and doctors to interpret Chest bio medical images. The most important technical approaches and methods are deep learning. In deep learning, Xception and LSTM model architecture are served as high level feature extraction and classification purpose. And finally AHE, Gaussian for image enhancement then reduce ROI by morphological, threshold and active contour operations.

CHAPTER FIVE

EXPERIMENTAL RESULTS AND DISCUSSIONS

5.1. Introduction

In this section of the work, we will present and elaborates detailed description of experimental result analysis and implementing or designing of automatic lung tuberculosis detection with computer assisted diagnosis using deep learning approaches via tools named as chest radiograph. The experimental data set splitting and description, experimental setups, experimental result evaluation criteria and experimental result analysis are discussed in our proposed method/system. However, the obtained result works or experimental result works are explained and presented in the form of experiments so that the best classifying proposed model will help to detect for lung Tuberculosis. We will discuss and compared our experimental result works with the results of other previously thesis works and based on performance metrics. We will use four performance evaluation metrics like accuracy, Recall, f1-score and precision with confusion matrix on our approach to clearly point out effectiveness of proposed the models. We will also discuss how research question are addressed in the discussion section of this thesis work.

5.2. Data set Splitting and Description

The experimental data set were obtained or taken from the data set of USNLM challenge using two public available dataset which are the service of medical health department at Guangdong medical college, Shenzhen china and Montgomery County [66]. The set of two public data set comprises chest radiographs images (chest x-ray images) information gathered under the two Shenzhen and Montgomery County's tuberculosis disease screening. The Montgomery county dataset contains total of 138 CXR (chest radiographs) images consisting of 80 normal images and 58 abnormal (TB) images whereas Shenzhen dataset has total of 662 images under those Shenzhen data images 326 normal and 336 abnormal cases. Therefore, a total of 800 images are collected in this thesis work. The two combined data set are splitting or partitioned into two parts; training and testing purpose. The data set were contained only lung tuberculosis infection data.

Among 800 images, 640(80%) images were used for training and the other part (20%) for the remaining 160 images used for testing purpose. Hence our ultimate goal is carefully employed in order to address our research objectives and to develop a system for lung tuberculosis detection system.

5.3. Experimental Setup

In this thesis work the following hardware, software characteristics and hyper parameter configuration have been used:

Table 5.1 hardware and software characteristics

No.	Hardware characteristics	Software used
1	Intel core I5 CPU with 2.7 GHZ	Window 10 OS
2	4GB RAM	Python 3.7.6
3	GPU:Intel® HD Graphics 620	Tensor flow backend-CPU

In our experiment setup, the proposed Xception and LSTM models are implemented and tested in Python programming language using Tensor Flow backend and Keras library. Python language is one of modern and currently developed object oriented programming language. First, we have to install python 3.7.6 and then to write our python code, train and testing the proposed model, we need to install all the necessary packages and compilers. Experimental result works are done using the two combined Shenzhen and Montgomery data set with a resolution of the pixel 512x512 in order to use all the proposed feature extractor and classifier networks. All networks are trained for 150 epochs and batch size of 32. During our proposed model of the training process, spatial regularization method (dropout) with a rate of 0.5 was used after the feature extractor path.

5.3.1. Hyper Parameters Configurations

To develop and implement our proposed frame work, some model hyper parameter are evaluated or configured to achieve good experimental result. By using some of the model hyper parameter and their values basically based on our experimental result step, and is a very significant role in order to get an excellent experimental result work. A value of some of the model parameters will be able to evaluating by reviewing different research works, but for some other contributes it is significance role to undertake some model preliminary experiments results. The ultimate goal of testing different hyper parameters is to decrease the percentage of loss function whereas improving the performance values for our evaluation metrics. Some model hyper parameters are outlined below:

Activation function: activation function is the most important part in our designing implementation models which decides whether or not a neuron will be activated or not and transformed to the other layer of the network. This function simply meaning that it will able to decide whether the neuron's input to the other network is relevant or not in the process for classification. For this case, it is also the neurons /artificial neurons transformation which can converge the layer of network. The function used in normalizing the value of the output result between 0 to 1 or/and -1 to 1 (between-1 and 1).It plays important in the process of the network backpropagation. During back propagation, loss function gets updated, and activation function important the gradient decent curves to achieve to local minima.

Epochs: a group of samples which are passed through the training data set is epoch. Increase the number of epochs until the testing accuracy begins decreasing even when training case accuracy is increasing (overfitting).To compute the weight update for each input sample, but store these values during one pass through the training set which is named as an epoch. At the end of the epoch, all the contributions are added, and only the weights will be updated with the composite value. This method adapts the weights with a cumulative weight update, so it will follow the gradient more closely. Training case basically involves feeding training samples as input vectors through a neural network.

Optimizer: for updating weight model parameter we can use optimizer to reduce loss function. The optimizer is responsible of reduction of the objective function neural network. The choice of a best optimizer is very significant. A wide range of optimizer options are available to reduce loss function. Some optimizers such as Nestov, Momentum optimzer,Adagrad, RMSProp, and the list goes on. But the best is the Adam optimizer which stands for Adaptive Moment

Estimation [37]. Adam is a combination of sparse descent gradients and RMSprop. Therefore our network was trained case with Adam optimizer parameter.

Learning rate: in our test model, learning rate is an important part of parameter for training process. During the training case, a hyper parameter that effective and efficiently controls the step size and makes the training process faster. However, selecting the value of the learning rate hyper parameter is sensitive. If the selected learning rate is too much large, then the local minimum may be overstepped constantly, resulting in oscillations and very slow convergence to the lower error rate case. If the selected learning rate value is too very low, the amount of iterations required may be too high amount update steps, resulting in poor performance. We use in our work; the model parameter set to learning rate value is 0.001.

Dropout rate: to reduce over fitting from the training data set based on our proposed models, we employed a recently-developed, very effective and efficient dropout regularization method. Dropout is referred to as an alternative regularization technique by decreasing the impact of any particular node on the output. And we integrated the parameter optimizer and learning rate value with regularization (dropout to 0.5).

Loss function: The aim of training and testing different model parameter is used to decrease the percentage of loss function whereas enhancing the performance based our performance evaluation metrics. Now, the loss function used our work while training is binary Cross-Entropy Loss Function. The reason behind using a binary Cross-Entropy Loss Function is that we have binary output classes of the medical input images.

5.4. Evaluation Criteria and Experimental Results

In the performance evaluation section, we will be described in detail and comprehensive experimental result analysis evaluation which is outperformed is done for research work. In our work, this proposed model network architecture which were used for the design and implementation for these researches and are selected from the hyper parameter values and the proposed model which performed can best results. For this study the models were selected for detecting the lung TB are Xception and LSTM network architecture.

5.5. Experiment Result Evaluation Criteria

In many of deep learning fields, the fundamental problem is that of obtaining an accurate estimate for the generalization capability of a deep learning Algorithm trained on dataset. So that, the fundamental concern in deep learning is to get an accurate estimate of capability the generalization error of a proposed model trained on a huge data. The dataset acquisition splitting into a single testing and training case may not give the good performance. In general, in our proposed system we used different evaluation and model parameter techniques with confusion matrix on our approach proposed to clearly point out the performance accuracy measure of the network model.

5.5.1. Confusion Matrix

A confusion matrix is a table that is usually used to elaborate classification performance. In our implementation, Classification performance is evaluated or conducted based on precision, Recall, accuracy and F1-score. We can compute the performance evaluation metrics in terms of the combining all the conditions of amount of false positives, number of true positives, and number of false and true negatives. True positive means the total amount of abnormal cases correctly classified, true negative signifies the total amount of normal cases perfectly classified, false positive describes the total amount of abnormal case wrongly detected/classified when they are clearly normal cases and false negative signifies the number of wrongly classified normal cases when they are clearly abnormal cases.

Precision: indicates how the model is precise based on perfect or correct true positive values.

$$\text{Precision} = \frac{TP}{TP+FP} \quad (1)$$

Recall: It provides how the actual true positive of the model is evaluated (true positive rate or sensitivity).

$$\text{Recall} = \frac{TP}{TP+FN} \quad (2)$$

F1_score: is indicates the balance between Recall and precision means that the function of recall and precision.

$$\text{F1\_score} = 2 * \left(\frac{\text{precision} * \text{Recall}}{\text{precision} + \text{Recall}}\right) \quad (3)$$

Accuracy: Accuracy indicates that how many true positives and negatives, false positives and negatives were identifies correctly classified or total number of correctly classified in all samples.

$$\text{Accuracy} = \frac{TP+TN}{TP+TN+FN+FP} \quad \text{......} (4)$$

5.6. Experimental Results

The obtained experimental results are explained and presented in the form of experiments so that the best classifying model can be detected for lung Tuberculosis classification. These experiment results are evaluated on f1-score, precision accuracy, recall and comparison on measures of evaluation metrics.

Table 5.2 Classification performance based on precision, recall, f1-score and accuracy metrics

Task	System	Precision (%)	Recall (%)	F1-score (%)	Accuracy (%)
Lung tuberculosis image detection	Xception stacked with LSTM	90.35	85.10	87.65	86

The network architecture is trained using different model hyper parameters and its classification performance is computed using training and testing dataset. The classification performance metrics obtained is shown in table 5.2. From the performance metrics it is clear that Xception stacked with LSTM trained with model hyper parameter obtained in terms of accuracy (86%), F1-score (87.65%), Recall (85.10%), precision (90.35%) for lung tuberculosis detection. The performance is based on the TB positive and TB negative classification of the classifier.

5.7. Discussion Result

In this thesis, we investigated Computer assisted or aided diagnosis (CAD) system for the binary classification of lung tuberculosis (TB positive and TB negative) using chest radiograph dataset based on the new deep learning method. Table 5.3 shows the computational speed improvement of lung image segmentation.

Table 5.3 Computational time of before and after lung segmented image based on parameter values

Lung TB image	Dataset	Optimizer	Regularizer	Epochs	Learning rate	Batch size	Computational time(in seconds)
Before segment	300	Adam	dropout(0.5)	30	0.001	32	629.186
	500	Adam	dropout(0.5)	50	0.001	32	2828.888
	800	Adam	dropout(0.5)	150	0.001	32	25003.802
After segmented	300	Adam	dropout(0.5)	30	0.001	32	599.457
	500	Adam	dropout(0.5)	50	0.001	32	2389.644
	800	Adam	dropout(0.5)	150	0.001	32	14460.729

According to the above table 5.3, it is clearly observed that the average computational speed of the testing and training data is presented based on before segment and after segmented lung tuberculosis dataset. Before segmentation of the training data was employed, the computational time of the first 300 image is 629.186 sec and after segmented the training data, the computational time of 500 lung TB image is 599.457sec. When we train the data of before segmented image of 500 images, it results the computation time of 2828.888 sec but after segmented image it results the computation time of 2389.644sec and also when we train the data set of before segmented image of 800 images is 25003.802sec and after segmented image, it is 14460.729sec.

5.7.1. Comparable Result Work

In this section of the work reveals the CNN (Xception) combined with LSTM model of the experimental result has outperformed as compared to other deep convolutional neural network models. The following table shows feature extraction and classification of lung tuberculosis using chest radiograph images based on the proposed Xception model with LSTM and compared with other CNN methods.

Table 5.4 Comparative result work of different CNN models with the proposed CNN combined RNN models

Authors	Method	Data set	Number of images	Accuracy
Rohilla[47]	Alex net and VGG net	Mixed Shenzhen and Montgomery	800	81.6%
R.Hooda[45]	Layerb/n LeNet and Alex net	Mixed Shenzhen and Montgomery	800	82.09%
Proposed model	Xception stacked With LSTM	Mixed Shenzhen and Montgomery	800	86%

To evaluate the performance of our proposed system, we will discuss and compared our experimental result works with the results of other previously thesis works and based on performance metrics. Comparative result work of different CNN models with the proposed CNN combined RNN models elaborated from table 5.4.The performance of the evaluation or comparison results is based on accuracy performance metrics. The System or method in Rohilla and Rhoda give the performance in terms of accuracy are 81.6%, 82.09%, respectively, whereas, the results obtained using the network architecture used here, give an accuracy of 86%. When we compared with the previous published research work and existing methods, our proposed method achieves the better performance in terms of accuracy measures based on mixed Shenzhen and Montgomery lung tuberculosis data set.The research work proposed by [45], uses deep convolutional neural network (layer between LeNet and Alex Net) architecture. They have used architecture CNN with three fully connected layer, and seven convolutional layers. Their proposed approach based on two publicly available dataset which are Montgomery (138 images) and Shenzhen (662) data set. The method by [45], was not capable to reveals huge feature model parameter like, max pooling, global average pooling, separable convolution or depth wise separable convolution etc. Therefore the approach was not efficient and effective to extract their proposed frame work. The research work proposed by [47] used deep Alex Net and VGG Net model architecture. They achieved the accuracy of 81.6%. The method is not efficient and effective method.

In this research work, we designed and implemented lung tuberculosis feature extraction and classification system by using computer assisted detection system of the new deep learning approach. The new deep learning techniques and approaches are Xception and long short term memory network architecture. The experiment result of our proposed approach is based different hyper parameter configuration and their values like activation function, learning rate, regularization (dropout) etc. The features generated by our Xception deep convolutional model are relatively good enough to be used in medical usage. From the above table, our comparable experimental result work shows that combined CNN (Xception) and RNN (LSTM) and compared with other CNN models. Our deep learning approaches have adequate performance results in terms of accuracy measures.

5.7.2. Research Questions

1. Can we improve the accuracy of TB detection in chest radiograph images using CNN stacked with RNN over CNN network architecture?

In our design and implementation, image quality is very important to detect lung tuberculosis image accurately. So, we have used Preprocessing and segmentation method to enhance the image and reduce the search space. In the first preprocessing stage Gaussian and AHE used and thresholding, morphological and active contour model also used as segmentation technique. Finally, we designed the proposed Xception model combined with LSTM models. In CNN models, Xception model is best model because less number of model parameters to adjust as compared to other CNN network architecture which reduces over fitting. It is also Efficient, Captures information of intensity, position, shape, etc., high accuracy, relatively easy. In RNN usually suffers from vanishing gradient problems when the dimension of input feature vector is high. Therefore we employed recently well-developed method which is long short term memory recurrent neural network approach. LSTM is effectively address vanishing gradient problems by its freeing up memory locations in temporal sequences.

Therefore, based on our experiment result, we get a maximum accuracy improvement of 3.91 % for the previous base line research. And then we can conclude that integrating AHE and Gaussian preprocessed with thresholding, active contour model and morphological lungs area segmentation approaches with Xception stacked with LSTM enables to detect lung tuberculosis chest radiograph images.

2. What is the impact of lung segmentation to enhance computational speed of the system?

In order to answer this research question, we conducted a set of experiments using lung tuberculosis image before and after segment and the result shows that the overall computational speed is improved 38.7%.

CHAPTER SIX

CONCLUSION AND FUTURE WORK

6.1. Conclusion

The main objective of our thesis work is to develop detection system for lung tuberculosis using deep learning approach. The approaches were performed by chest radiograph images for lung tuberculosis detection and comparative experiment result analysis were evaluated with existing detection proposed frame work.

The proposed frame work has four stages pre-processing, lung segmentation, feature extraction and classification. In pre-processing stage, we have used Adaptive histogram equalization and Gaussian filter technique. Adaptive histogram equalization is done for image contrast and Gaussian filter is done for noise removal. The output gained from thus preprocessed image taken as an input and were performed by thresholding, morphological and Active counter model which aid to focus on the lung region of the gained results. The result obtained from lung region integrated with feature extraction and classification part by applying deep learning approach specifically Xception and LSTM network architecture. Among deep learning techniques, Xception deep convolutional neural network model is a very important model in our thesis to extract the feature of the whole input image (data). It used as depth width separable convolution to reduce over fitting of the complex network and efficient, Captures information of shape, position, size, etc. It's also relatively simple, high accuracy rather than other deep convolutional network model. The feature of Xception network are extracted and taken as input for the LSTM (used for classification purpose). LSTM also used to effectively address vanishing gradient problem by it can frees up the memory and important in the final classification purpose.

The automatic detection of lung tuberculosis from our proposed deep leaning algorithm might be used as the base line for the research direction. Since, to reduce large amount of tuberculosis patients, there is a need for accurate computer assisted diagnosis method that enable to detect the disease property. The output gained from our proposed frame work based on computer assisted diagnosis (CAD) method can be used to help medical technologist or radiologist as a second opinion. The experimental result work showed that our proposed framework using CAD system is based on in terms of accuracy, recall, f1-score, and precision and well suited for the detection of lung Tuberculosis. The performance of our proposed computer-assisted diagnostic method for lung tuberculosis detection system, achieves accuracy (86%), precision (90.35%), recall (85.10%), f1-score (87.65%). And also we conducted a set of experimental result using lung tuberculosis image before and after segment, and the experiment result show the overall computational speed is improved 38.7%.

In general, we conclude that the preprocessing and lung segmentation method integrated with deep learning algorithms can achieve adequate performance results.

6.2. Future Work

We used different technical approaches to effectively address our research objectives and to develop a system for lung tuberculosis detection system. However, to improve the performance of Automatic Lung TB detection system, we plan to do the following points.

- In order to improve the performance further, we will apply Ensemble Learning Technique for our proposed approach.
- We will apply 2 D and 3D computer tomography images for our proposed approach
- In order to improve the performance, we will use large number of depth wise separable convolutional blocks with large number filter.

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