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Tuberculosis Detection Using Chest X-Ray with Deep Learning and Visualization

Mr. Amit Shirsat[1], Mr. Saniket Kute[2], Mr. Rahul Haral[3], Ms. Aishwarya Patil[4], Dr. S.A.Ubale[5]
[1, 2, 3, 4]Student, [5]Project Mentor and Guide, Information Technology Engineering, Marathwada Mitra Mandal's College of Engineering, Pune, India

***Abstract:** One of the top 10 main causes of mortality is tuberculosis (TB), a bacterial infection-related chronic lung disease. A bacteria known as Mycobacterium tuberculosis is the cause of the infectious illness tuberculosis (TB). TB must be accurately and quickly identified in order to be treated; else, it might be fatal. Chest X-rays (CXR) are frequently utilized for pulmonary TB identification and screening. Chest radiographs are evaluated for the presence of TB by skilled doctors in clinical practice. But this is a subjective and time-consuming procedure. It's important to note that CXR pictures of TB are frequently misclassified to other diseases with similar radiologic patterns, which may cause patients to receive the wrong medicine, deteriorating their health. In this work, we have detected TB reliably from the chest X-ray images using image pre-processing, data augmentation, image segmentation, and deep-learning classification techniques.*
Index Terms—Tuberculosis detection, Deep learning, pre-processing, data augmentation, image segmentation.

I. INTRODUCTION

Tuberculosis (TB) is a communicable disease caused by a bacterium called Mycobacterium tuberculosis. It is the leading cause of death from a single infectious disease. Chest X-rays (CXR) are commonly used for detection and screening of pulmonary tuberculosis. In clinical practice, chest radiographs are examined by experienced physicians for the detection of TB. However, this is time consuming and a subjective process. Subjective inconsistencies in disease diagnosis from radiograph is inevitable. The World Health Organization (WHO) reported that in 2019. India was included in the list of 20 high TB burden countries with a total of 446,732 cases. WHO estimates that there are 80,000 deaths of TB patients in India in 2019. A person who has been infected with the tuberculosis disease will have symptoms such as coughing for more than 3 weeks, chest pain, fever, night sweat, weight loss, fatigue and pallor. The disease is spread when the droplet is passed from infected patient to healthy people through sneezing or coughing. The common and effective method to analyze TB through CXR images .

The common method to detect TBS from chest x-ray is using image segmentation. Deep Learning is one of powerful methods to classify large datasets. To improve the accuracy or increase the dataset. CNNs have been used in several recent studies for the detection of lung diseases including pneumonia and tuberculosis by analysing chest X-ray images. In response to the COVID-19 pandemic situation in 2020, CNN based techniques have been used for the detection of the novel coronavirus infection from CXR images. Several research groups used classical machine learning techniques for classifying TB and non-TB cases from CXR images. The use of deep machine learning algorithms have been reported in the detection of tuberculosis by varying the parameters of deep-layered CNNs. We also used a visualization technique to confirm that CNN learns dominantly from the segmented lung regions that can result in higher detection accuracy. This work presents a transfer learning approach with deep CNN for the automatic detection of TB from the chest radiographs. The classification accuracy, precision and recall for the detection of TB with segmentation.

II. MOTIVATION

If you have active TB disease, you must get treated right away. This might involve taking a number of medications for 6 to 12 months. It's important to take all of your meds, as they're prescribed, the entire time even if you feel better. If not, you can get sick again. If you have TB germs in your body but they haven't become active, you have what doctors call "latent TB." To avoid these circumstances and for early TB detection this model is very useful.

III. RELATED WORKS

1) Reliable TB detection using chest X-Ray with DL, segmentation and visualization - This work presents a transfer learning approach with deep CNN for the automatic detection of TB from the chest radiographs. The classification accuracy, precision an recall for the detection of TB with segmentation

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2) Early Detection of Tuberculosis using Chest X-Ray (CXR) with Computer-Aided Diagnosis- In this paper, a Computer-aided Diagnosis (CADx) system based on image processing is proposed to assist doctors and radiologists in interpreting Chest X-rays (CXR) for early detection of lung Tuberculosis (TB).This system may increase the specificity of an early TB diagnosis.
3) IOS Mobile APP for Tuberculosis Detection Based on Chest X-Ray Image- This research aim is to classify Chest X-Ray (CXR) images into TB suspect.The dataset was increased by using + augmentation method. The model was created by using Caffie Framework. The GoogLeNet network was selected to train CXR images.GoogleNet accuracy was 98.39%. The testing time took 10 minutes 45 seconds.
4) Tuberculosis Detection In Chest X-Ray Images Using Optimized Gray Level Co-Occurrence Matrix Features- In this paper, CXR images were classified as normal, primary TB (PTB) and secondary TB (STB). The results of this paper indicate that the classification system with optimized GLCM as input has better performance than the classification system with regular GLCM as input.
5) Deep Neural Network for Foreign Object Detection in Chest X-rays- In this paper, we have employed a Deep Neural Network (faster Region-based Convolutional Neural Network (R-CNN)) to detect circle-like foreign objects in chest X-Rays..

IV. ANALYSIS MODELS: SDLC MODEL TO BE APPLIED

The SDLC model applied in our system is the Waterfall Model. Waterfall model is very simple to understand and use. In a waterfall model, each phase must be completed before the next phase can begin and there is no overlapping in the phases. The Waterfall model is the earliest SDLC approach that was used for software development. The waterfall Model illustrates the software development process in a linear sequential flow. This means that any phase in the development process begins only if the previous phase is complete. In this waterfall model, the phases do not overlap. Waterfall approach was the first SDLC Model to be used widely in Software Engineering to ensure success of the project. In "The Waterfall" approach, the whole process of software development is divided into separate phases. In this Waterfall model, typically, the outcome of one phase acts as the input for the next phase sequentially.

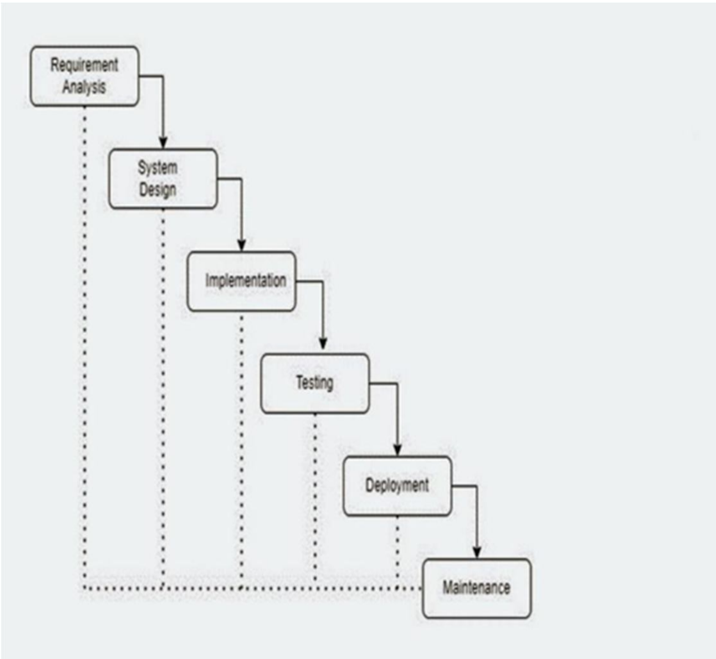

Figure 4.1: Waterfall Model

Sequential Phases:

1) *Requirement Analysis:* All possible requirements of the system to be developed are captured in this phase and documented in a requirement specification document.
2) *System Design:* The requirement specifications from the first phase are studied in this phase and the system design is prepared. This system design helps in specifying hardware and system requirements and helps in defining the overall system architecture.
3) *Implementation:* With inputs from the system design, the system is first developed in small programs called units, which are integrated in the next phase. Each unit is developed and tested for its functionality, which is referred to as Unit Testing.

4) *Integration and Testing:* All the units developed in the implementation phase are integrated into a system after testing of each unit. Post integration the entire system is tested for any faults and failures.
5) *Deployment of system:* Once the functional and non-functional testing is done; the product is deployed in the customer environment or released into the market.
6) *Maintenance:* There are some issues which come up in the client environment. To fix those issues, patches are released. Also, to enhance the product some better versions are released. Maintenance is done to deliver these changes in the customer environment.

V. ALGORITHM ANALYSIS AND DIAGRAM

In this research, the proposed method for CXR image analysis consists of 4 steps: pre-processing, image segmentation, feature extraction, and classification.

A. Image Pre-processing

The size of the input images for different CNNs were different and therefore the datasets were pre-processed to resize the X-Ray images. In this process unwanted ,noisy and blurry parts of the chest X-ray will get removed and also foreign objects like surgery related parts get removed.

B. Image Segmentation

This segmentation was done to remove sources of error such as the spinal structure, diaphragm, and surrounding tissues which were not part of the lungs, all which had the same intensity as lung nodules and could be mistakenly interpreted as such.

C. Feature Extraction

Here the extracted features were the first-order statistical features of the lung region image histogram, consisting of the image's mean, variance, skewness, kurtosis, and entropy.

D. Fully Connected Layer

A fully connected layer adds a bias vector after multiplying the input by a weight matrix. One or more fully connected layers come after the convolutional (and down-sampling) layers. As the name implies, every neuron in a layer that is fully linked has connections to every neuron in the layer above it.

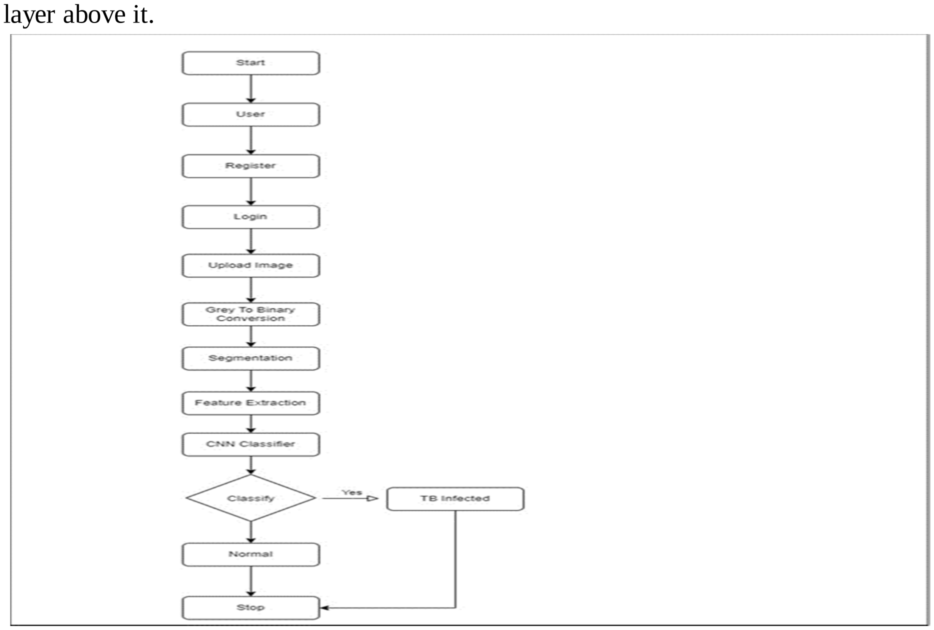

Figure 5.1: Methodology

E. Dropout

Another typical characteristic of CNNs is a Dropout layer. The Dropout layer is a mask that nullifies the contribution of some neurons towards the next layer and leaves unmodified all others.

F. TB Classification

In this stage, the CXR images were classified and interpreted as normal or abnormal. The 2D convolutional layer applies sliding convolutional filters to the 2D input. In the next step Max pooling will be used to select the maximum element from the region of the feature map covered by the filter. After TB classification process it will generate an output showing chest X-ray is TB infected or normal

VI. DATA ANALYSIS

Data analysis helps to understand the nature of the data which can be used for finding out more information from the historical data. These data can be compared with real data for predicting. The multidisciplinary field of data science combines the study of data using a statistical method, machine learning, and database technology..

By obtaining the proper data from the model, the processed data can be analyzed for further estimations. The data model steps for prediction are as follows:

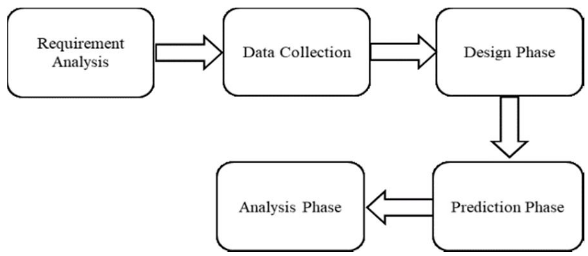

Figure 6.1: Data analysis

VII. SYSTEM ARCHITECTURE

Figure shows the system architecture diagram of Tuberculosis Detection .In this architecture we use CNN algorithm.In this diagram first we take input as a chest X-ray image from the dataset. In the next step the image will get pre-processed and converted from original image to gray level image and next to the binary image. After that different features get extracted from the dataset images. In the next step CNN algorithms are used for matching extracted features from the feature extraction process of trained images in the dataset. In the last step the system gives an output that the patient is tuberculosis infected or not.

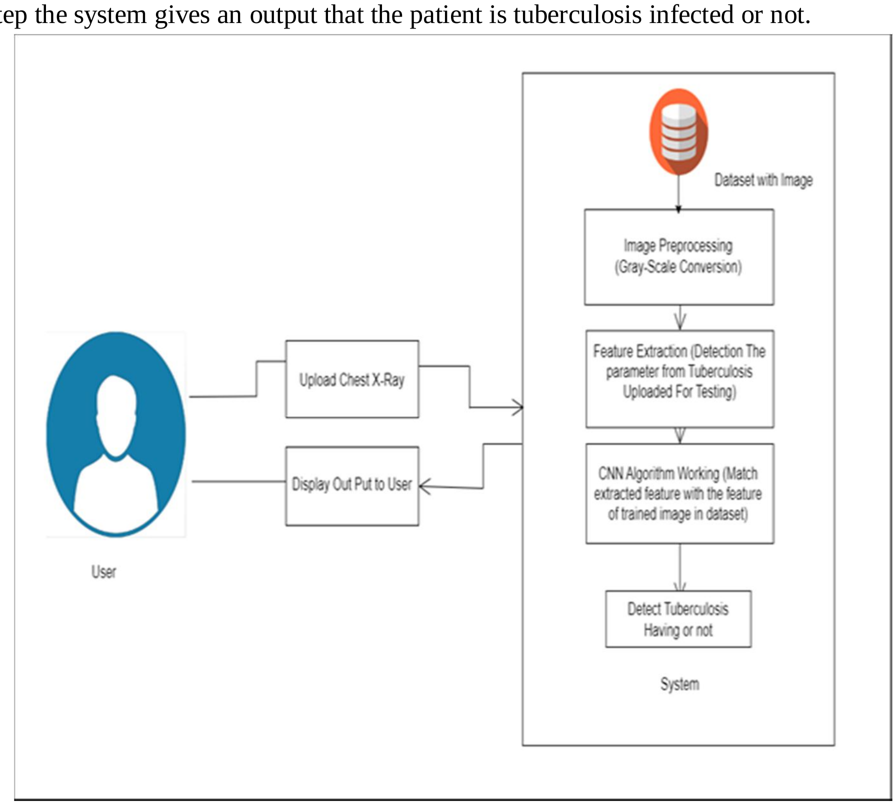

Figure 7.1: System Architecture

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VIII. FUNCTIONAL MODEL AND DESCRIPTION

Functional Modeling gives the process perspective of the object-oriented analysis model and an overview of what the system is supposed to do. It defines the function of the internal processes in the system with the aid of Data Flow Diagrams .

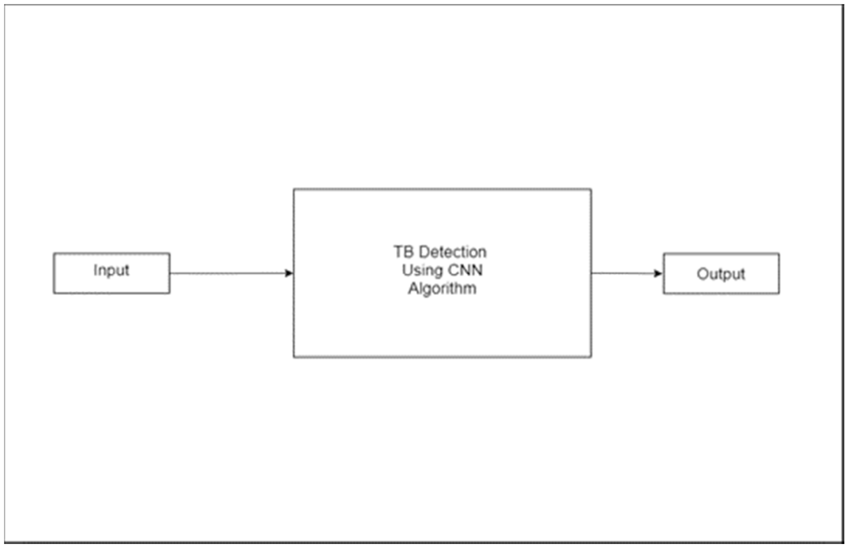

Figure 8.1: DFD Level 0

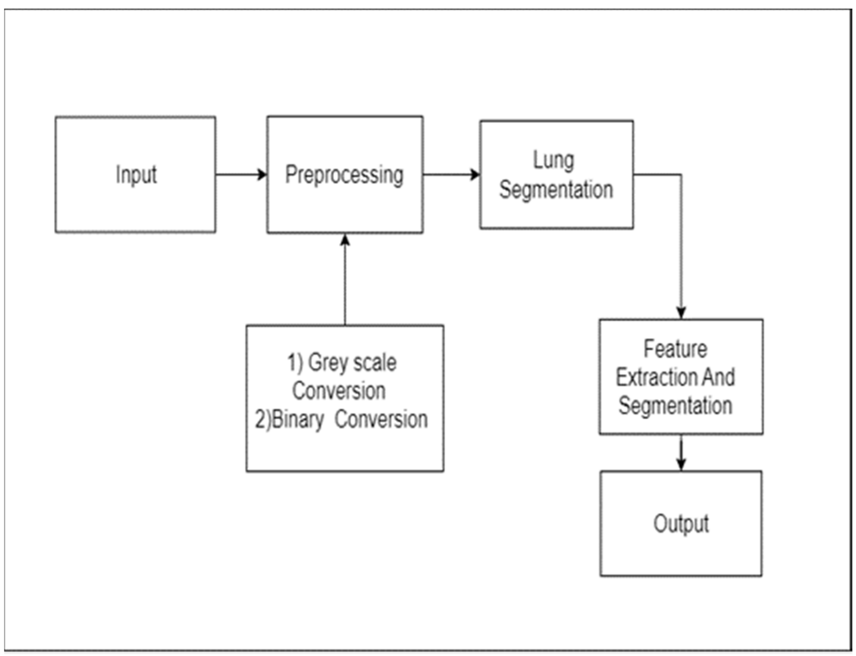

Figure 8.2: DFD Level 1

IX. RESULTS

Evaluating a system is an essential part of an experiment, and it includes several measurements used to evaluate the final system's performance in terms of its expected goals and to assess its future applicability. Machine learning is a data analytics technique that provides machines the potential to learn without being comprehensively programmed. Unlike the traditional methods of demand forecasting that were not suitable for historical unstructured and semi structured data, machine learning takes into account or has the capabilities for analyzing such data.

This work presents a transfer learning approach with deep Convolutional Neural Networks for the automatic detection of tuberculosis from the chest X-rays. The performance of CNN models were evaluated for the classification of TB and normal CXR images.

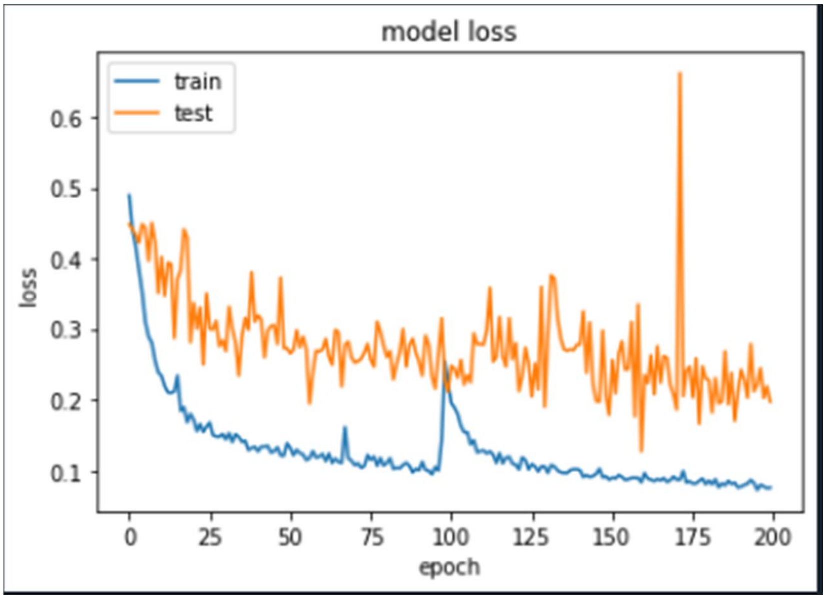

Figure 9.1: Accuracy and Loss

X. LIMITATIONS

1) *Monitor failure*: The system will not work properly as a result access is not given to the user properly To avoid this risk we will make sure to learn all the new unfamiliar things in depth. Get deep knowledge of that thing before implementing it.
2) *Back up plan to Avoid*: Probabilistic approach consists in running models repeatedly using uncertain input variables randomly chosen from defined probability distribution. Sample their values based on randomized techniques. Calculate forecast for large no. of sample.

XI. FUTURE WORK

We can increase the accuracy by using CNN models with lung segmentation. Chest X-Ray images and dataset combinedly used as input for detection of Tuberculosis. Using CNN models with lung segmentation to optimize the system. When we take the input image from outside the training folder then it is not giving the high accuracy. We can overcome this problem by improving the system.

XII. CONCLUSION

In this paper we discussed different stages for tuberculosis detection. In comparison with clinical diagnosis image processing techniques produce more efficient results to detect useful part from the chest X-ray image. In this project, different phases of image processing were applied on CXR images. Lung segmentation is used on CXR images to increase the accuracy. Feature extraction is used to extract the different features of an image and which takes less time for generating the result. The results are passed through CNN models for matching extracted features from the feature extraction process of trained images in the dataset. A considerable number of individuals who die each year as a result of inaccurate or delayed diagnosis might be saved because of this cutting-edge performance, which can be a highly helpful and quick diagnostic tool.

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