Diagnosis of Tuberculosis Using Deep Learning Models

P. Abirami*[1], S. Nirmala Sugirtha Rajini[2] and V.N. Rajavarman[3]
[1]Research Scholar, Department of Computer Science
[2]Professor, Department of Computer Applications,
[3]Professor, Department of Computer Science and Engineering
Dr.MGR. Educational and Research Institute, Chennai-95

Abstract

Numerous people in the world are affected by TB disease every year. Due to huge amount of medical-based images interpretation is also very tough. Traditionally TB disease was identified using the bacteriological test. At the same time, traditional methods testing expenses are also too high. Due to the development of information technology Artificial Intelligence models are applied to various medical applications. Deep Learning is one of the subsets of AI models. In this paper, three DL models such as CNN, ANN, and RNN are offered for identifying Tuberculosis disease. The suggested models are tested with the public image dataset and among the three models, RNN produces a better result based on variousterms like Accuracy, Sensitivity, and Specificity. The proposed work is implemented using MATLAB tool.

Keywords : Deep Learning, Artificial Intelligence, Tuberculosis, Prediction, Performance, Accuracy

1. Introduction

In recent days, TB is one of the common diseases. A major indication of TB disease is cough, fever, weight reduction, and fatigue. WHO recommends CXR images and laboratory tests for predicting TB disease. TB is investigated by medical tests based on bacteriological type investigations that cannot produce an accurate result. In the next level, TB disease is tested with the help of CXR images witha CAD model. From the past few years, AI (Artificial Intelligence) and DL (Deep Learning) models produces better outcomes in image categorization and vision-based tasks.Among the various DL models CNN (Convolutional Neural Network) is one of the important model in image identification and categorization. These DL methods directly operate on given images but traditional method executes based on the features of the images. DL models are fast-growing technique in the radiology domain. CNN model is one of the primary techniques used in feature retrieval for TB identification and categorization of X-Ray images as affected or normal. Commonly CNN consists of three kinds of layers like convolutional layer, fully connected layer, and pooling layer. CT scan is oneof the radiography forms that is used to generate section-wise images at various depths and heights from pictures generated the person's body parts from various angles. Every part of the image shows the separate parts of the human body and images are merged to create 3D-shaped images, displaying organs, tissues, and anomalies occur. A CT image produces better images than normal X-ray images [2].

2. Literature review

TB is a major communicable disease, and it is oneof the important reasons for increasing death rates. Improving the facilities of TB treatment is the major requirement of many countries. Murali Krishna Puttagunta, et al., 2021 reviewed various DL models based on CAD system in which many models areused to examine the X-ray images for identifying TB. DL approaches are recently developed techniques particularly used for examining various kinds of medical-related images. CNN is mainly used for diagnosing TB and contains many layers. They present a detailed survey about the CNN model for identifying the TB disease. Based on their research work CAD-based diagnosis systems increase the speed of disease prediction [1].

According to WHO report in 2018, nearly 10 million people are affected by TB every year. Many people died every day due to that disease. The volume of death rate is decreased if the infection was recognized earlier. DL models produced a better result in the area of disease diagnosis. These models use a huge number of samples for better prediction. Khairul Munadi et al., 2020 analyses the efficiency of image quality improvement by DL model. They use UM(Unsharp Masking), HEF (High-Frequency Emphasis Filtering) and CLAHE (Contrast Limited Adaptive Histogram Equalization) algorithms to increase the features of the images. The improved images are given the input of the DL models. The above-mentioned algorithms are analyzed based on their categorization accuracy, and AUC (Area under Curve) values. These algorithms are tested with the Shenzhen dataset;it is obtained from the public dataset [2].

Stefanus Kieu Tao Hwa et al., 2019 suggest DL for TB diagnosis, and a canny edge algorithm is used for edge detection. This system presents a novel kind attribute for TB diagnosis classifier models, increasing the classifier's error values. Initially, some groups of features are retrieved from the x-ray images and the next groups of features are identified from edge-identified images. To assess the performance of the proposed work two common datasets are used. The outcome demonstrates that the new approach created the best result in terms of accuracy, sensitivity, and specificity. These results show that using various kinds of features retrieved from different kinds of images can increase the recognition rate [4].

A MODS (Microscopic Observed Drug Susceptibility) is one kind of test used to identify TB disease. Due to less trained staff and low- quality resources, an alternative approach is needed for better diagnosis. Santiago Lopez-Garnier et al., 2019 trained and assess the CNN model for MODS digital images interpretation in an automated way. Here the authors train the CNN model using three datasets collected from various laboratories. The performance of the proposed model was assessed based on their sensitivity, specificity, and accuracy values. The outcome of this model suggests the CNN models can provide assistance to the laboratory people with low resources and simplify the diagnosis process [5].

Nowadays DL models, particularly CNN models learn features from the images directly. Abdela A. Mossa et al.,2020 designed a model for TB identification in an automatic manner using various CNN frameworks trained based on 2D type images carved from the huge number of CT scan images. This study uses Multi-View and Triplanar type CNN framework using trained AlexNet framework, VGG11 framework, VGG19 framework, and GoogLeNet attributes retrieval layers used in the backend. With the help of the fivefold cross- validation method, the accuracy, specificity, and sensitivity values are identified [6].

3. Proposed System

Identification of TB disease is a problematic process from the images due to various kinds of issues like image clarity and intensity level. Manual clinical testing methods do not generate exact results. The growth of computer-based learning models influences disease prediction. Now DL based models offered various frameworks to categorize the images and predict the diseases. This research work uses three types of DL models for forecasting TB diseases.

CNN

Stefanus Tao Hwa Kieu et al., 2020 says that the familiar DL approach is CNN. It is specifically used to find various patterns available in the given images. Similar to the human brain NN (Neural Network), CNN contains several neurons with weight value and a trainable bias value. Every neuron accepts many input values. Then the total weight of the input is calculated. Then this value is transferred to the activation method, and the output value is generated. The major difference between the other NN and the CNN is, CNN contains convolutional type layers. Convolutional operation is performed on the convolutional layer. It is the linear type operation that consists of multiplication activity of groups is given with weight values with the given input. The group of weights is known as filter or kernel.

The given input value is bigger than the filter value. Multiplication among the filter and the input value is a dot product. Finally, the product values are accumulated and it generates a single result. The pooling type layer slowly decreases the spatial representation and calculations in the model to control the over fitting. ReLu is merged with the CNN to substitute component-wise activation methods like sigmoid to the output created by the earlier layer.

The major components used in the CNN model are classification and feature retrieval. In the feature retrieval phase, convolution is developed in input type data using kernel or filter. Next, a feature map is generated. During the classification phase, CNN calculates the probability value of the images that fit the concern label or class. Specifically, CNN is used for image categorization and identification in automatic manner feature retrieval without using traditional feature retrieval techniques [3].

ANN (Artificial Neural Network)

ANN is one of the nature simulated techniques that contains input, hidden, and output layer nodes. Each node in the layer consists of single parallel type nodes in the following layers. The gradient-based back propagation approach is handling the correlation weight value. The output value of each neuron is the collection of data in earlier level neurons multiplied with parallel type weight value with bias value. Input type of value is transferred to the output level based on the activation method [7].

RNN

RNN s_i is one of the famous x_i NN models based s_{i+1} on the human brain. Its input values are not associated with other values and the output x_{i+1} value of every component is based on the calculations of its earlier components. Mainly RNN is used in a time-related application, analysis sentiment values, and various text-related applications. According to D. Harlianto et al., w 2019 every layer consists single neuron and represent a weight value that is updated with the learning task. Figure 1 demonstrates that unfolding type RNN contains the input type layer(yellow), unseen layer (green), and the layer for output (blue). The weight value associates unseen state which is caused by to unseen state , which is produced by , and this element differentiates RNN with FFNN (Feed Forwarded $u, w, and v$ $x_1, x_2, \ldots, x_T$ Neural Network). RNN in Fig.1 is the kind of 'one to many' due to its input value contains some data element, namely, but the output value single, namely $\hat{x}_{T+1}$ [8].

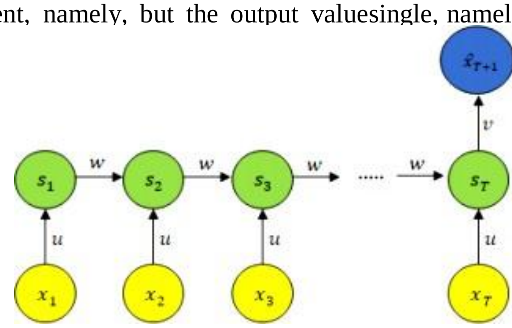

Figure 1 Unfolding RNN [8]

The proposed system contains various stages like preprocessing, segmentation, and classification. Following figure 2 shows the overall process of the proposed system.

Figure 2 Process Flow of the Proposed System

Preprocessing

The main intention of preprocessing is to increase the quality of the input images. During the preprocessing stage, the unwanted features are eliminated and improve many attributes which are important for specific applications. The features are varied based on the type of applications.

Image Segmentation

In this segmentation phase images are sliced into various small groups based on pixel values calledobjects. It reduces the complexity level of the images and assesses the images becomes easier. Here edge- based segmentation algorithm is offered for segmenting images. It is to identify the image edges depends on gray level discontinuities values like color, texture, saturation, gray level, contrast level, etc.

Classification

It means the system can assess the images and recognize the class of the input images. Classifying images also assists in healthcare people. It can analyze and identify the abnormal portion of the given images.

4. Simulation result

TB is one of the bacterial-type infections that primarily disturb the human lungs. It is a curable disease with better antibiotic medicines. Manual identification of this disease is a very difficult process, and many investigations are directed by doctors. At the same time, automatic detection based on CT images produces better results. Recently a DL (Deep Learning) method plays an important part in various domains like face identification, vehicle categorization, automobile classification, etc. It is mainly used in the medical domain for diagnosing and predicting diseases. Early prediction reduces the mortality rate. For our research we have downloaded the TB dataset from kaggle.com. Our dataset contains 400 images of lung MRI images which consists of both affected and non-affected persons. Following figures 3,4, 5, and shows the output images of the various stages of the current research work.

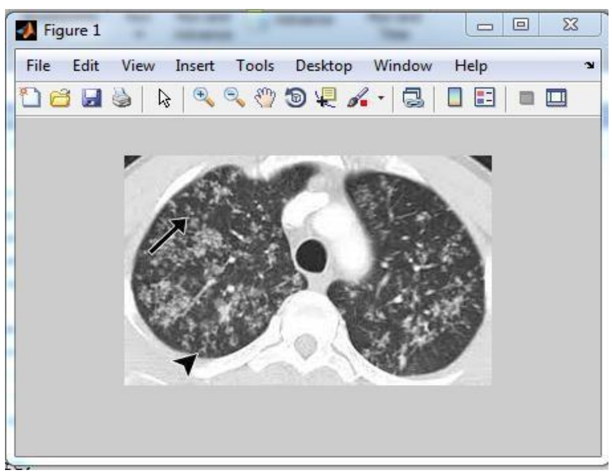

Figure 3 Input Image

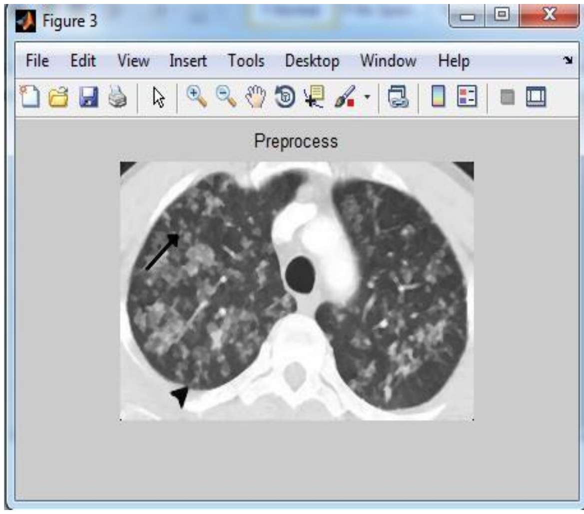

Figure 4 Preprocessed Image

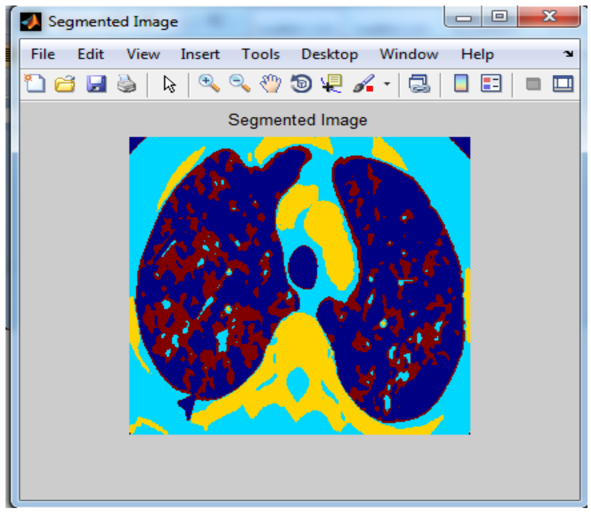

Figure 5 Segmented Image

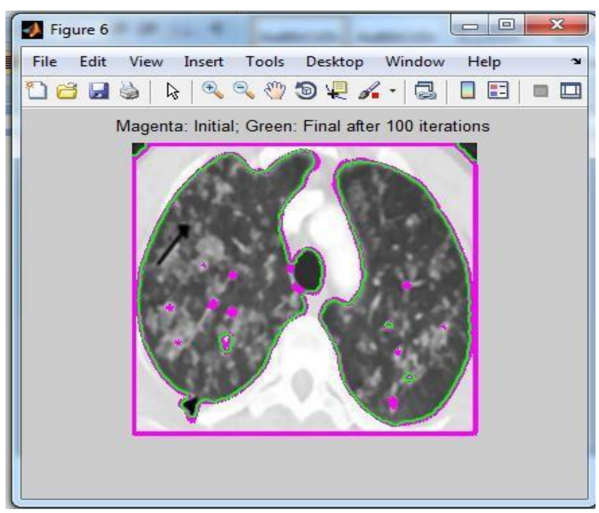

Figure 6 Classified Image

The performance of the system is assessed based onthe accuracy rate, precision, and recall value.

Accuracy:

It is the common metric that defines how the developed system executes across entire classes. This metric is valuable when every class has a similar position. It is measured as the ratio among the total number of right predictions to the entire quantity of predictions. The following formula is used to evaluate the accuracy rate of the model.

$$Accuracy = \frac{TruePositive + TrueNegative}{TruePositive + TrueNegative + FalsePositive + FalseNegative}$$

Following table 1 shows an accuracy Comparison of ANN, CNN, and RNN Models

Table 1 Accuracy Comparison of ANN, CNN, andRNN Models

No of Images	ANN Accuracy %	CNN Accuracy %	RNN Accuracy %
10	70	80	88
20	73	81	88.8
30	74.5	83	89.2
40	77	87	90.2
50	79	87.5	91

Figure 7 demonstrates the Accuracy Comparison of ANN, CNN, and RNN Models based on several images.

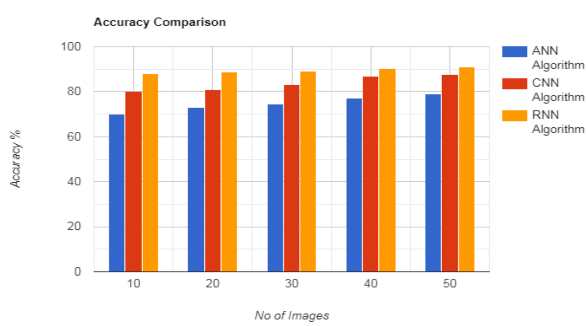

Figure 7 Accuracy Comparison of ANN, CNN, andRNN Models

Sensitivity:

It is the same that assess the model's ability value to forecast the true positive value of every existing group. The following formula is used to measure the sensitivity value.

$$Sensitivity = \frac{TruePositives}{TruePositives + FalseNegatives}$$

The following table 2 shows the SensitivityComparison of ANN, CNN, and RNN Models based on image quantity.

Following Figure 9 shows the specificity value Comparison of ANN, CNN, and RNN Models based on the total amount of images.

Table 2 Sensitivity Comparison of ANN, CNN, andRNN Models

No of Images	ANN Sensitivity %	CNN Sensitivity %	RNN Sensitivity %
10	81.2	83.5	85
20	81	83	85.8
30	82.4	84.7	86
40	83	85	86.4
50	83.2	85.5	88

Following figure 8 illustrates the Sensitivity Comparison of ANN, CNN, and RNN Models based on a total number of CT images.

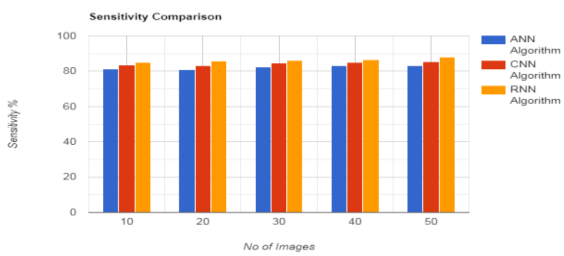

Figure 8 Sensitivity Comparison of ANN, CNN, and RNN Models

Specificity:

It is the familiar metric that calculates the ability ofthe developed model to forecast the true negative value of every available group. The following formula is used to measure the specificity value of the model.

$$Specificity = \frac{TrueNegatives}{TrueNegatives + FalsePositives}$$

The following table 3 shows the specificity Comparison of ANN, CNN, and RNN Models depends on the total quantity of the images.

Table 3 Specificity Comparison of ANN, CNN, andRNN Modelss

No of Images	ANN Specificity %	CNN Specificity %	RNN Specificity %
10	80	83.5	87
20	80.7	84	87.9
30	81	84.4	87
40	83.2	85.2	87.5
50	83.8	86	89

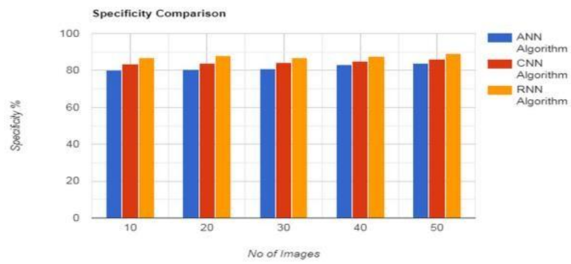

Figure 9 Specificity Comparisons of ANN, CNN, andRNN Models

5. Conclusion

TB is a kind of transferrable disease and due to this disease, many people are affected by hard health issues and losses their life. The major key to the patient's recovery is timely disease diagnosis. The major cause of TB disease is Mycobacterium Tuberculosis. Identification of the diseases in earlier stages decreases the death date. Earlier detection of the disease using chest part X-ray examination. TB disease and lung cancer symptoms are the same, it is the major problem for the healthcare people to reduce the misdiagnosis rate. In this research work, TB is diagnosis using DL models. Here the performances of the DL methods are tested using a public CT image dataset. This system is implemented with the help of MATLAB software tool. Compare the outcome of three models RNN produces a better result in terms of accuracy, sensitivity, and specificity.

References

[1]. Murali Krishna Puttagunta & S. Ravi(2021), “Detection of Tuberculosis based on Deep Learning based methods”, Journal of Physics: Conference Series1767, IOP Publishing doi:10.1088/1742- 6596/1767/1/012004, pp. 1-10.

[2]. Khairul Munadi , Kahlil Muchtar, Novi Maulina& Biswajeet Pradhan (2020), "Image Enhancement for Tuberculosis Detection Using Deep Learning", IEEE ACCESS, Vol. 8, pp. 217897-217907

[3]. Stefanus Tao Hwa Kieu, Abdullah Bade, Mohd Hanafi Ahmad Hijazi & Hoshang Kolivand (2020), “A Surveyof Deep Learning for Lung Disease Detection on Medical Images: State-of-the-Art, Taxonomy, Issuesand Future Directions”, Journal of Imaging, Vol. 6, 131, doi:10.3390/jimaging6120131, pp. 1-38.

[4]. Stefanus Kieu Tao Hwa, Mohd Hanafi Ahmad Hijazi, Abdullah Bade, Razali Yaakob & Mohammad Saffree Jeffree(2019), “Ensemble deep learning for tuberculosis detection using chest X-Ray and canny edge detected images”, IAES International Journal of Artificial Intelligence (IJ-AI) Vol. 8, No. 4, pp. 429~435, pp429-435.

[5]. Santiago Lopez-Garnier, Patricia Sheen, & Mirko Zimic(2019), “Automatic diagnostics of tuberculosis using convolutional neural networks analysis of MODS digital images“, PLOS ONE, pp. 1-16,

[6]. Abdela A. Mossa, Halit Eri & Ulus C¸ evik2(2020), “Ensemble of Deep Learning Models for Automatic Tuberculosis Diagnosis Using Chest CT Scans: Contribution to the ImageCLEF-2020 Challenges”,
International (CC BY 4.0), .pp. 1-15

[7]. Muhammad Tahir Khan, Aman Chandra Kaushik, Linxiang Ji, Shaukat Iqbal Malik, Sajid Ali& Dong-Qing Wei(2020), “Artificial Neural Networksfor Prediction of Tuberculosis Disease“, Frontiers Microbiology, Vol 19, Article 395, pp. 1-9.

[8]. D. Harlianto, S. Mardiyatia), D. Lestari, A. H. Zili & Devila(2019), “Indonesia Tuberculosis Morbidity RateForecasting Using Recurrent Neural Network”, Proceedings of the 5th International Symposium on Current Progress in Mathematics and Sciences (ISCPMS2019).