# AUTOMATIC DETECTION OF TUBERCULOSIS BY ENHANCING X-RAY IMAGE USING DEEP LEARNING

**Kancharana Divya**

*Department of Electronics and Communication Engineering(ECE)*

*Andhra Loyola institute of Engineering and technology(ALIET)*

*Vijayawada, Andhra Pradesh, India*

**TallaGreeshma**

*Department of Electronics and Communication Engineering(ECE)*

*Andhra Loyola institute of Engineering and technology(ALIET)*

*Vijayawada, Andhra Pradesh, India*

**BoyinaManasa**

*Department of Electronics and Communication Engineering(ECE)*

*Andhra Loyola institute of Engineering and technology(ALIET)*

*Vijayawada, Andhra Pradesh, India*

**Pranob K Charles**

*Department of Electronics and Communication Engineering(ECE)*

*Andhra Loyola institute of Engineering and technology(ALIET)*

*Vijayawada, Andhra Pradesh, India*

***Abstract*-Tuberculosis is one in all the infectious diseases that cause inflammation, the formation of TB and alternative growths inside tissue will cause death of tissue. As per survey of World Health Organization(WHO) a worldwide case detection decreases by a mean of 25% over a amount of few months, in comparison with the detection before pandemic which is able to cause extra 190,000 TB deaths. This may increase total foretold deaths from TB in 2021 to quite 1.66 million. The chest x rays can show advanced tuberculosis. Chest tuberculosis(CTB) could be a widespread drawback, particularly in our country where it's one in all the leading causes of mortality. Since Deep Learning is earning exceptional leads to several applications, we have a tendency to use decilitre for the study of Tuberculosis(TB). As several researchers have an interest in victimisation of computer Aided Diagnosis(CAD), we have a tendency for using MATLAB for the study of Tuberculosis(TB). The abnormality detection is predicated on two-level of hierarchy to reason healthy and unhealthy teams. 1st level can extract handcrafted geometrical options like form, size, eccentricity, perimeter etc. and in level a pair of ancient 2nd order applied math options like energy, entropy, contrast, correlation etc. are extracted from metameric lungfields. Further, a supervised classification approach is used on the extracted options to observe traditional and abnormal CXR pictures. Since our work additionally includes enhancing for prime quality pictures ,here chiefly 2 image sweetening techniques Unsharp masking and High-frequency Emphasis Filtering Filtering(HEF) were utilized. All the results are obtained from public dataset accessible in kaggle web site.**

***Keywords-- Deep Learning, Chest XRay(CXR), MATLAB, Image Enhancement,Supervised Classification***

## I. INTRODUCTION

TB could be a doubtless serious communicable disease that not solely affects Lungs however additionally alternative elements of the body. Its symptoms typically embody cough, weight loss, night sweat and fever. The TB diagnostic test or biopsy will diagnose the malady. Most infections not disclose any symptoms, during which it's the case in Latent TB. TB unfold by mobile metastasis droplets (coughs or sneezes), by spittle ( caressing or shared drinks). TB is caused by a distinct form of microorganism known as Mycobacterium tuberculosis. It unfold once someone with active TB coughs or sneezes and somebody inhale the expelled droplets from someone WHO contain TB. Below mentioned ar symptoms of someone with TB. A cough that may stay for quite three weeks, Chest pain, coughing of blood, feeling tired largely, Night sweating. Once someone doesn't have disease, however has TB microorganism within the body, the Latent TB infection is diagnosed. The one that got infected by eupneic TB microorganism, then the body is ready to fight with the TB germs to prevent them from growing , however they continue to be alive within the body and become active later. This is often the malady with high mortality rates there when HIV/Aids.

Tuberculosis had bated life time of individuals. Over ten million of world population ar infected by malady and quite four million ar deed death yearly. Throughout history , the malady TB has been diversely referred to as consumption, phthisis, and also the White Plague. It's found that it's caused by tubercle bacillus that could be a actuating agent. In 2014, results from a brand new DNA study of a TB order reconstructed from remains in southern Peru suggest that human tuberculosis is less than 6,000 years old. Even there's little proof that TB is of nine,000 years previous. Even it had been detected a few years before, still its diagnosing strategies ar less and ineffective. this is often the second malady with high mortality rates nowadays. we will use molecular analysis and medicine culture, however it's still high price , particularly for many of developed and developing countries. It additionally expressed that the low price and most typical process supposed bronchoscopic smear research have issues with sensitivity [1]. could be a set of machine learning strategies that is especially supported artificial neural networks with illustration of learning. Deep Learning applications will embody virtual assistants, Health care, News Aggregation and faux News Detection, Image coloring, AI etc. this idea may be used even within the study of chest X-Ray pictures to observe the person with TB at early stage and might be diagnosed.

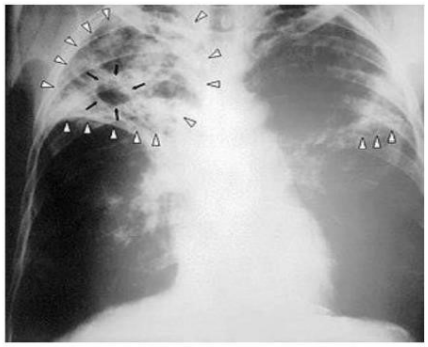

Fig1: Chest X-Ray of someone with advanced tuberculosis: Infection in each lungs is marked by white arrowheads, and also the formation of a cavity is marked by black arrows.

## II.RELATED WORKS

### A.TB DETECTION VICTIMISATION CONVENCTIONAL MACHINE LEARNING ALGORITHM

It is troublesome task of detection TB chiefly attributable to varied styles of manifestations like giant opacities, aggregation, cavities, focal lesions, little opacities, and CXR image nodules. connected works used options of color, texture, pure mathematics or form to observe TB(especially just in case of Machine learning).[2]-[4]. this method consists series of modules that ought to adapt many steps so as to classify input image.

B.TB DETECTION USING PRE-TRAINED CNN(TRANSFER LEARNING)

CNN principally used for vision applications in system mainly for classification, recognizing and for detection. Typically, CNN consists of many layers specifically Convolutional layer, Pooling Layer, absolutely Connected Layer. CNN additionally referred to as asconvNets, include multiple layers and principally used for detection and process of image.

CNN have multiple layers containing many filters for Convolution operations. Pooling carries out down-sampling operation that reduces the size of feature map, and it converts resulted 2-D arrays from pooled feature map to single , continuous, long and linear vector by flattening it. The next fully connected layer formed when this flattened matrix is fed as an input. It will classify and identifies the images.In recent studies shown that [5], [6], [7], pretrained Convolutional neural networks (ImageNet trained Network used here) shows smart performance in medical applications. Researchers typically train various pictures that need great amount of memory. This memory wastage be avoided by Transfer Learning. Transfer learning stores data from one domain and apply it to a different till similar domain. It always takes a lot of time once coaching from scratch, because the random distribution is employed to initialize all model parameters [6].

In recent literature [7],[8] it had been tested that fine standardisation of terribly advanced datasets resulted in glorious classification and detection exploitation pre-trained ImageNet dataset model. It should be noted that most of the previous existing systems for TB detection .

C.ENHANCEMENT FOR PRETRAINED CNN

In very recent publication [10] evaluated the effect of image enhancement on pre trained CNN model. This was inspired from the study of [11] where it shown promissory results by using image enhancement method with Laplacian Operator on RNN and CNN networks. They compared the enhanced image dataset with the Laplace operator and the original image. The enhanced approach could increase the detection rate by 2% and 1% for the two R-CNN models, respectively. The paper's experiments used the transfer learning by fine tuning of the pretrained R-CNN model. Kuang et al. [12] proposed a night-time vehicle detection approach that has three key techniques: night-time image enhancement focused on ROI extraction incorporating light detection for the vehicle. In [13], Chen provided a comprehensive evaluation of image enhancement on RGB and general CXR images. In addition, the accurate detection of retinal blood vessels via deep learning and image enhancement is discussed in a recent paper by Soomro, et al. [14]. While several works have been proposed, none of the work thoroughly investigates the effect of image enhancement through pre-trained CNN for TB detection.

D.SPECIFIC DL IN IMPROVING TB DETECTION IN CHEST RADIOGRAPHS

The work of Raja Raman [15] proposed modalityspecific deep learning models in improving TB detection. Data driven deep learning (DL) algorithms such as convolutional neural networks (CNN) self-discover hierarchical feature representations from raw data pixels and perform end-to-end feature extraction and classification with minimal intervention[15]. These models are shown to achieve state-of-the-art performance in visual recognition tasks [16]. Here Computer Aided Design(CAD) tools were applied at CXR analysis use CNNs to support expert radiologist decisions by analysing the CXRs of existed disease manifestations and to localize suspicious regions for interpretation[17]

## III. METHODS AND MATERIALS

A.DATA SET

We have used publicly available Kaggle dataset. The data set includes chest X-Ray images of all groups of people. It has both abnormal i.e., Tuberculosis affected person X-ray images and normal i.e. Healthy person chest X-Rays. Team of researchers from Dhaka University, Doha and Qatar University, Bangladesh with collaboration of medical doctors from Corporation of Hamad Medical have createdchest X-Rays database for Tuberculosis(TB). In this scenario 700 Tuberculosis Images publicly accessible and 2800 TB images are downloaded from NAID TB portal[18] and 3500 normal images. Within the period of one month, it has captured the entire CXR images for improvisation of work from researchers.

B.DE-NOISING The Chest X-Ray image quality will not be good always, because the X-Ray had small amount of data. The image should get rid of noise and go through certain Image Enhancement methods. Primarily we

had three types of Image Enhancement techniques Un-sharp Masking(UM), High Emphasis Filtering(HEF), Contrast Limited Adaptive Histogram Equalization(CLAHE). In recent literature[10] it was evaluated that LightnessOrder Error(LOE) score for CLAHE is very worse with poor techniques (UM,HEF). So, we have utilised Unsharp masking and High Emphasis Filtering Combination for X-Ray image enhancement.

1. UNSHARP MASKING(UM)

Unsharp masking is a linear image processing technique which is used sharpen the image. It had the specialty of identifying sharp details from the difference between the original and blurred image. The difference between original and negative image is multiplied with some constant parameter. The resultant image should be added with original image to get the enhanced output. In simple words Unsharp masking is a linear filter which used to amplify high frequencies of image. First step in this process was to copy original image and applying Gaussian blur on it. It can be denoted in mathematical form as following.

$$G(i,j) = \tfrac{1}{2}\pi\sigma^2 [e^{-i^2+j^2} /2\sigma^2] \quad (1)$$

Here i,j indicates horizontal and vertical axis respectively. Sigma(σ) denotes Standard Deviation in Gaussian Distribution. Second step is the blurred image to be subtracted from original image to get blurred edges only. This is called “Unsharp mask”. At last enhanced image obtained by

$$I_{um\_enhanced.} = I_{ori} + \text{amount} * (I_{u.}). \quad (2)$$

Where Ium_enhanced is the final enhanced output, Iori is original image and Iu is unsharp image.Since we used MATLAB as our CAD tool, Unsharp masking had an inbuilt function in MATLAB.

2.HIGH-FREQUENCY EMPHASIS FILTERING(HEF)

HEF[19] is a technique that uses Gaussian highpass filter to highlight and accent the edges. The edges usually contain high frequency information as it holds high intensity values. This algorithm will result in low contrast image generally, hence we apply histogram equalization method to increase the contrast. First step in HEF is applying Fourier Transform on the input cxr image.

$$G\_Filter(i,j). = 1 - e^{-\left(\frac{D^2(i,j)}{2D_0^2}\right)} \quad (3)$$

Here D0 denotes the cut-off distance. For f(x,y) the Fourier transform can be represented as F (i , j). This Fourier function mathematically given as[10]

Finally, the contrast adjustment is done by histogram equalization algorithm, it is denoted

$$F(i,j) = \sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y)\, e^{-j2\pi\left(\frac{ix}{M}+\frac{jy}{N}\right)} \quad (4)$$

Finally, the contrast adjustment is done by histogram equalization algorithm, it is denoted as follows Finally, the contrast adjustment is done by histogram equalization algorithm, it is denoted as follows:

$$I_{hef\_sharpened=} (I_{ori.} + (G\_Filter)) * (Hist\_Eq). \quad (5)$$

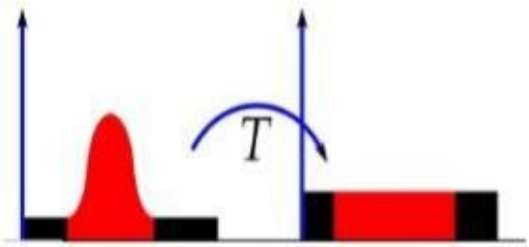


Fig2: Before and after Histogram Equalization

C.HIERARCHICHAL CLASSIFICATION

The Healthy and Unhealthy CXRs are detected based on two level hierarchical model. In first level air cavities in lungs are taken , and from air field we consider some of the features like size, shape, eccentricity, perimeter etc. and in case of level 2 detection classification of raw field based on second order features like entropy, contrast, energy, correlation etc. are extracted. Further classification is exhibited on extracted features for detecting whether X-Ray is Normal or Ab-normal. At the time of Classification Gray Level Co-occurrence matrix(GLCM) which is a square matrix and First Order Statistical Features are mainly used for detection of exact result.

1.GRAY LEVEL COOCCURRENCE MATRIX It is an approach to texture the analysis with various applications especially in medical image analysis. By calculating we can know how often the pairs of pixels with specific values and in specified spatial relationship occur in an image creating a GLCM and then extracting. We get Statistical measures from this matrix. First order statistical features include mean, standard Deviation, Skewness, Kurtosis etc. Second order Statistical features are homogeneity, energy, correlation, energy, entropy, contrast. It is based on correlation between pixels adjacently. Based on the results obtained from both the levels are verified and image is classified of TB or non-TB. Supervised learning uses labelled data to train models. Labelled data refers to whose output is already known.


Fig3:Image processing of gray images[10]

In previous work , the LOE score allows to prove best approach among tested methods, it is utilized in order to find the best parameter setting in each method[10]. Following table depicts the parameters used in our project. It was noticed that contrast image enhancement with lightness order enhancement(LOE) score of 1852.1.

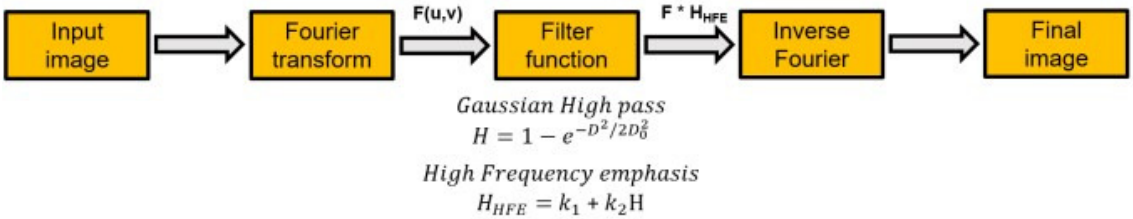


Fig4:Steps in High Emphasis Filtering

Table1:Training options used in training

| Parameter | Value |
|---|---|
| Sgdm | …… |

| | |
|---|---|
| MaxEpoch | 300 |
| Learning rate | 0.01 |
| Validation Frequency | 30 |
| Learning rate Schedule | constant |
| Image size | 224 |

## III. BLOCK DIAGRAM

In First step we consider the public dataset and in next step noise is to be removed from the X-Ray images by applying different filters. And for effective classification image enhancement methods Un-sharp masking(UM) and High-Frequency Emphasis Filtering(HEF) are used in our work. For better accuracy and classification, the image is divided to two fields. One field will extract air cavities from lung to calculate sensitive parameters. Second field related to lungs raw field to calculate insensitive parameters. From air cavities shape features to study how air is spreading in lungs. It, was undergone through DL training. It classifies the image to Normal and Abnormal. From raw field section First order statistical features and GLCM were calculated and undergone through classification into Normal and Abnormal. Performance Evaluation Measures are applied for results from both the levels, and final dataset classification is obtained. This process can be understandable from Fig5.


Fig5: Block diagram to detect Tuberculosis

## IV.RESULTS

From supervised classification approach we have detected the X-Ray of person with Tuberculosis. We used MATLAB 2019a as tool for our work. By applying both enhancement methods we have achieved 100% accuracy.

As we have used automatically generated convolutionalnetworks for training , we trained for 300 epoch which even took less time to get the expected results. We enhance training images , the image contrast is increased, the disparity between the TB areas was observed and the remaining regions were more noticeable. Inaddition, the observed edge region and outline were more distinct. As a result, the trained model can extract better features, and contour details of the obtained region[10].

Table3: Parameters comparison of existing and proposed.

| Parameters | Existing | Proposed |
|---|---|---|
| Accuracy | 0.8560 | 1.00 |
| Sensitivity | 1.00 | 1.00 |
| Specificity | 0 | 1.00 |
| Precision | 0.8560 | 1.00 |
| Recall | 1.00 | 1.00 |
| f-measure | 0.8920 | 1.00 |
| g-mean | 0 | 1.00 |

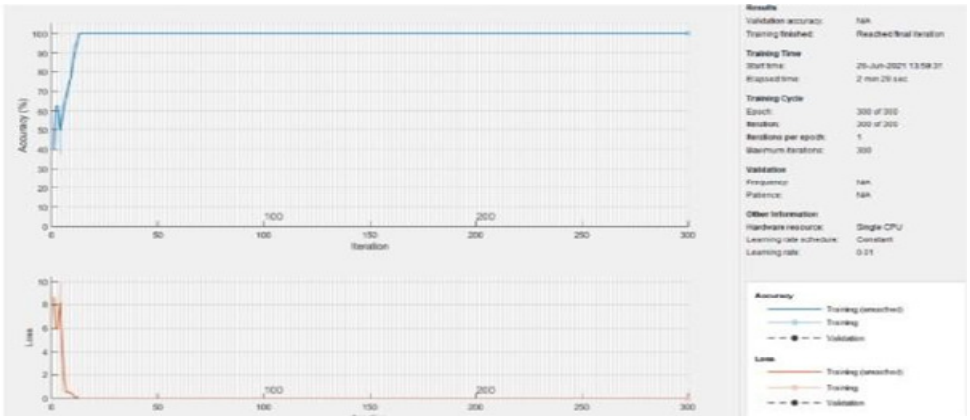

Fig6:Loss and acuracy for proposed method

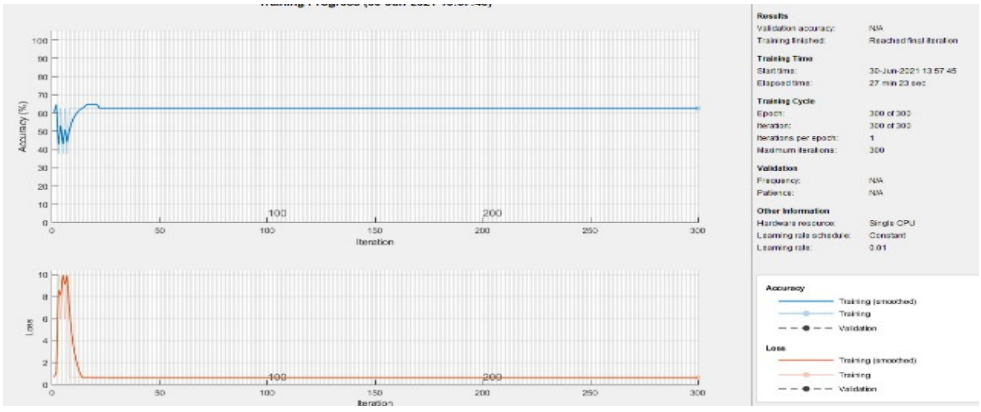

Fig7:Loss and accuracy for existing method(HEF)

**Fig7: (a) original image, (b) Unsharp masking image, (c) HEF image**

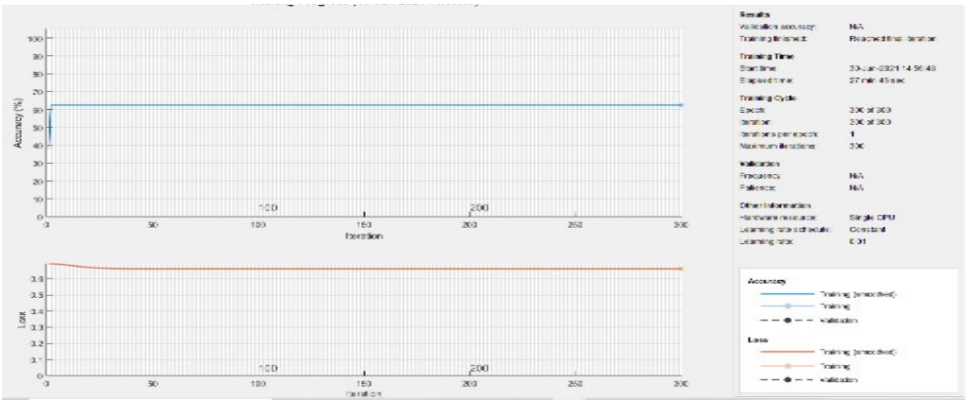

**Fig8:Accuracy and loss curve for existing UM.**

## 6.CONCLUSION

By combining DL with Enhancement methods Unsharp masking(UM) and High emphasis filtering(HEF), this paper uses two level hierarchy and undergone supervised learning to detect person with Tuberculosis. This has achieved better results compared to normal classification. The accuracy for our project is shown in fig6. We achieved accuracy nearly to 100% with less loss percentage. The advantages of our scheme are it will mimic the behavior of radiologist and their interpretation procedure.

## REFERENCES

[1] C. C. Leung, ‘‘Reexamining the role of radiography in tuberculosis case finding,’’ Int. J. Tuberculosis Lung Disease, vol. 15, no. 10, p. 1279, Oct. 2011.

[2] N. Singh and S. Hamde, ‘‘Tuberculosis detection using shape and texture features of chest X-Rays,’’ in Proc. Innov. Electron. Commune. Eng., Feb. 2019, pp. 43–50.

[3] T. B. Chandra, K. Verma, B. K. Singh, D. Jain, and S. S. Netam, ‘‘Automatic detection of tuberculosis related abnormalities in chest X-ray images using hierarchical feature extraction scheme,’’ Expert Syst. Appl., vol. 158,Nov. 2020, Art. no. 113514.

[4] A. Chauhan, D. Chauhan, and C. Rout, ‘‘Role of gist and PHOG featuresin computer-aided diagnosis of tuberculosis without segmentation,’’ PLoS ONE, vol. 9, no. 11, Nov. 2014, Art. no. e112980.

[5] U. K. Lopes and J. F. Valiati, ‘‘Pre-trained convolutional neural networks as feature extractors for tuberculosis detection,’’ Comput. Biol. Med., vol. 89, pp. 135–143, Oct. 2017.

[6] C. Liu, Y. Cao, M. Alcantara, B. Liu, M.
Brunette, J. Peinado, and W. Curioso, ‘‘TX-CNN: Detecting tuberculosis in chest X-Ray images using convolutional neural network,’’ in Proc. ICIP, 2017, pp. 2314–2318.

[7] I. D. Apostol Poulos and T. A. Mpesiana,
‘‘Covid 19: Automatic detection from X ray images utilizing transfer,’’ Phys. Eng. Sci. Med., vol. 43,pp. 635–640, 2020.

[8] N. Taj bakhsh, J. Y. Shin, S. R. Gurudu, R. T. Hurst, C. B. Kendall,M. B. Gotway, and J. Liang, ‘‘Convolutional neural networks for medicalimage analysis: Full training or fine tuning?’’ IEEE Trans. Med. Imag.,vol. 35, no. 5, pp. 1299–1312, May 2016.

[9] Y. Cao, C. Liu, B. Liu, M. J. Brunette, N. Zhang, T. Sun, P. Zhang,J. Peinado, E. S. Garavito, L. L. Garcia, and W. H. Curioso, ‘‘Improving tuberculosis diagnostics using deep learning and mobile health

technologies among resource-poor and marginalized communities,'in Proc. IEEE 1st Int. Conf. Connected Health, Appl., Syst. Eng. Technol. (CHASE), Jun. 2016. [10] Khairul munadi, Kahilmuchtar, Novi maulina "Image Enhancement for tuberculosis Detection using Deep Learning", Dec 15,2020.

[11] Q. Tian, G. Xie, Y. Wang, and Y. Zhang,
''Pedestrian detection based on laplace operator image enhancement algorithm and faster RCNN,''in Proc. 11th Int. Congr. Image Signal Process., Biomed. Eng. Informat.(CISP-BMEI), Oct. 2018, pp. 1–5.

[12] H. Kuang, L. Chen, F. Gu, J. Chen, L. Chan, and H. Yan, ''Combining Region-of-Interest extraction and image enhancement for nighttime vehicle detection,'' IEEE Intell. Syst., vol. 31, no. 3, pp. 57–65, May 2016

[13] X. Chen, ''Image enhancement effect on the performance of convolutional neural networks,'' Dept. Comput., Blekinge Inst. Technol., Karlskrona,Sweden, Tech. Rep., 2019.

[14] T. A. Soomro, A. J. Afifi, A. A. Shah, S. Soomro, G. A. Baloch, L. Zheng, M. Yin, and J.
Gao, ''Impact of Image Enhancement Technique on
CNN Model for Retinal Blood Vessels
Segmentation,'' IEEE Access, vol. 7, pp. 158183– 158197, 2019.

[15] S. Rajaraman and S. K. Antani, ''Modalityspecific deep learning model ensembles toward improving TB detection in chest radiographs,'' IEEE Access, vol. 8, pp. 27318–27326, 2020.

[16] A. Krizhevsky, I. Sutskever, and G. E. Hinton,
''ImageNet classification with deep convolutional neuralnetworks,'' Commun. ACM, vol. 60, no. 6, pp. 84–90, May 2017

[17] S. Rajaraman, S. Candemir, I. Kim, G. Thoma, and S. Antani, ''Visualization and interpretation of convolutional neural network predictions indetecting pneumonia in pediatric chest radiographs,'' Appl. Sci., vol. 8, no. 10, p. 1715, Sep. 2018.

[18] Tawsifur Rahman, AmithKhandakar, Muhammad A. Kadir, Khandaker R. Islam, Khandaker F. Islam, Zaid B. Mahbub, Mohamed ArseleneAyari, Muhammad E. H. Chowdhury.
(2020) "Reliable Tuberculosis Detection using Chest X-ray with Deep Learning, Segmentation and Visualization". IEEE Access, Vol. 8, pp 191586 - 191601. DOI. 10.1109/ACCESS.2020.3031384

[19] A. Bundy and L. Wallen, ''High-emphasis filtering,'' in Catalogue of Artificial Intelligence Tools. Berlin, Germany: Springer, 1984, p. 47