Image processing approach to determine the severity level of tuberculosis

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ABSTRACT

Tuberculosis (TB) is a disease caused by a bacterium called **Mycobacterium tuberculosis**. Basically there are two types of TB, latent and pulmonary TB. It symptoms include persistent cough for more than two weeks, cough with blood, night sweat, tiredness, fever, chest pain, lymph node enlargement. It treatment depends on severity level such as mild, moderate, severe and very severe and this can be obtained from TB diagnosis such as chest x-ray image, nucleic acid amplification test and culture and sensitivity. The main aim of this work is to determine severity level of TB using image processing techniques. Chest x-ray (CXR) images of TB patients were obtained from Google image. Firstly, the CXR images were enhanced from Red Green Blue (RGB) to gray image (GI) form. Secondly, GI were decomposed, convolved, compressed and filtered these processing is called image degradation. Thirdly, These GI were restored and binarized. Threshold value ≥ 53 was obtained to classify the severity level of the infected image Furthermore, average error was calculated and system performance obtained. This work revealed that image 1, 2, 6 and 11 has a total pixel value 11067, 6735, 9256 and 3894 respectively ≥ 53 which indicates that the % of the infected areas as 99.62%, 99.52%, 96.70% and 82.78% respectively which shows the severity level are very severe. While the image 3, 4, 5, 8 and 9 has a percentage of infected areas 73.13%, 72.90%, 76.80%, and 76.84% respectively which indicate the severity level as severe. Image 7 has a percentage of infected area 51.21 which shows the severity level as moderate. This research work revealed that image processing is a suitable technique for determine the severity level of TB.

***Keywords*:** Tuberculosis, Mycobacterium Tuberculosis, Image processing, severity level, X-ray, culture and sensitivity.

1. Introduction

Tuberculosis (TB) is a contagious disease caused by bacteria called Mycobacterium Tuberculosis [1]. According to [2] Tuberculosis is the second leading killer disease from an infectious disease worldwide, after the Human Immune deficiency Virus (HIV). Basically, there are two main types of TB infections; Latent and Active TB, in latent TB the bacteria remain in an inactive state but there are 10% chances of latent TB becoming active TB. However people with HIV are more prone to TB infection. The typical indicators of active pulmonary TB are persistent cough for more than two weeks, cough with blood, fever, Night sweat, tiredness, and lymph node enlargement [3]. In the context of medicine, mild (M), moderate (M), severe (S) and very severe (VS) are the major yardstick for measuring the severity level of the diseases, Chest radiography is one of the most important way of screening and determining the severity level of TB. Image processing techniques in recently applied to many research areas such as security, engineering, forensic science, Material science, Medical diagnosis and film industries among others. Image processing combine with computer algorithms to enhance, Restore, filter, classify, compress, segment, or threshold in order to obtain necessary information and draw conclusion or make decision [3].

Some other techniques in computational intelligence are applied in medical diagnosis, prognosis and determining the severity level of the disease for example genetic programming was used to detect diabetes in [5]. Pulmonary tuberculosis was diagnosed using artificial neural network in [6]. Fuzzy inference system was applied to predict risk level in [7]. In the work of [8] Fuzzy Logic based Health Care System using Wireless Body Area Network was implement. Generic Medical Fuzzy Expert System for Diagnosis of Cardiac Diseases was implemented in [9]. In [10] they uses two image processing techniques repetitive smoothing-sharping and ridge detection algorithm to diagnose the early stage of TB and the results was tested on lung X-ray image which enhance the image contrast for easy classification of TB. [11] conducted texture analysis on TB X-ray images using image processing techniques 49 images were used for the experiment to measure the 1st and 2nd order texture features. Image processing techniques (image enhancement, segmentation and feature extraction) has been applied in [12] for the detection of lung cancer. Support Vector machine approach was used in [13] for detecting and counting the number of TB bacteria from Microscopic imaging. [14] Developed CXR tuberculosis detection using image processing techniques. [15] Introduced the concept, sign and symptom of brain tumor and also provide an overview on the various method and algorithm use to detect brain tumor such as image processing, image enhancement, image segmentation and classification. [16] Presented a method for automatic identification of TB using segmentation and post processing techniques and they obtained the overall sensitivity level at 96.80% and the error rate at 3.38%. [17] provide an overview of publications between 1998 and 2014 on the automatic diagnosis of TB and the review proved that the algorithms used for this diagnosis and detection significantly increased year by year. Digital image processing techniques were presented in [18] for TB screening, lungs region were extracted using K-means segmentation.

Fuzzy C-means algorithm and Adaptive Neuro-fuzzy were proposed in [19] to diagnoses diabetes with the reduction of fuzzy rules with small number of linguistic variables and they have obtained CC= 83.85%, Se = 82.05% and 86.23% based on their comparison with other cases. Genetic programming methodology has applied in [20] for detection of diabetes. Stepwise Classification algorithm was developed in [21] for detecting and counting the number of TB bacteria. Adaptive Neuro-fuzzy was applied to medical imaging in [22] to detect and recognize brain tumor. Neuro-fuzzy system was used in [23] to classify electrocardiogram (ECG) for Heart rate Variability (HRV). [24] developed a system that would determine the severity level of osteomyelitis using Adaptive Neuro-fuzzy model. [25] Applied Neuro-fuzzy approach to diagnosis TB and control where they used symptoms of TB yield good results. [26] Used adaptive Neuro-fuzzy inference system to diagnosed Ebola. [27] Used adaptive Neuro-fuzzy system to create intelligent system for diagnosing tuberculosis. [28] Applied Neuro-fuzzy model to predict the presence of mycobacterium TB. In [29] Neuro-genetic technique applied in diagnosing chest disease were presented. In [30] Soft computing were applied in predicting TB

The main aim of this research work is to determine the severity level of TB using Image processing technique and this can be achieve by addressing the following challenges; To enhance the CXR images collected, to degrade the images and covert them from Red Green Blue (RGB) to gray images, to restore the images and binarize them cut the threshold value and to calculate the error and performance of the model.

2. METHOD OF DATA COLLECTIONS

Chest X-ray images of TB patients were collected from Google images the images were cropped to get the exact region of interest of which all of them are 161x161 dimension, which form our image datasets. The images were converted from RGB color map to Gray scale color map. Then these images are read one by one to the workspace and display their Histogram equalization to see the intensity levels of every image and the number of pixels which is used to judge the severity level of patients. Team of medical expertise was interviewed to indicate the severity level by circling the infected areas on the images state the severity level of the image either mild, moderate severe and very severe. We have then used image processing techniques to make judgment also either mild moderate severe and very severe. The two results were compare and contrast to arrive at conclusion. The data collected were presented in the Figure 1.a - k;


Figure 1a


Figure 1b

Figure 1c


Figure 1d


Figure 1e


Figure 1f


Figure 1g


Figure 1h


Figure1i


Figure 1j


Figure 1k

3. METHOD OF DATA ANALYSIS

Cameras and x-ray images usually contain periodic noise or electromechanical interference during the image acquisition. In medical diagnosis, if the information supplied to the medical experts is inadequate, wrong treatment may be offered to the patient which in return may led to increase in the severity level of the disease or triggers different illness. Therefore, to guarantee correct medical treatment, adequate medical information should be provided to the medical expertise especially, in TB treatment information about all infected areas have to be cleared and this can be done using digital image processing (DIP). In the DIP chest x-ray (CXR) images need to be enhanced, degraded and restored.

3.1 IMAGE ENHANCEMENT

Image enhancement involves the conversion of CXR image in red green blue (RGB) form to gray image. This can be done to determine basic information about CXR image. In this work, model of expression (1) is applied to convert the CXR image to gray form.

$$g(x, y) = 0.299 \times R + 0.587 \times G + 0.114 \times B \tag{1}$$

Where x and y are image dimensions, then the gray image is further degraded.

3.2.IMAGE DEGRADATION

Image degradation involves decomposition, convulsion, compression and filtering. In this work, the degradation function $f(\boldsymbol{x}, \boldsymbol{y})$ and noise term operate as inputs, is given by

$$g(x, y) = H[f(x, y) + Z(x, y)] \tag{2}$$

Where $f(x, y)$ gives the image intensity position at (x, y) and is the operator that provides knowledge about the degradation function and $Z(x, y)$ gives the knowledge about the noise terms. It is believed that, when $H\ and\ Z$ are properly chosen, information about the CXR may be closer to the original. In other words, if $H\ and\ Z$ are linear then the spatial invariants are seen clearly and the image degraded in the spatial domain is given by (3)

$$g(x, y) = h(x, y) \times f(x, y) + z(x, y) \tag{3}$$

Where $h(x, y)$ is the spatial representation of the degradation function and "×" indicates the convolution. However, the multiplication in frequency domain forms what is called Fourier information pair and its Fourier corresponding model in equivalent frequency domain is expressed in (4).

$$G(u, v) = H(u, v)F(u, v) + N(u, v) \tag{4}$$

Where $H, F\ and\ N$ are the Fourier transforms that correspond to the terms in (3) which forms the degradation model.

Furthermore, the degraded image is compressed using (5) to reduce the number of bits required in presenting the image

$$g(x, y) = f(x, y) + \frac{1}{N}\sum_{k=i}^{n} n_{\mathrm{k}}(x, y) \tag{5}$$

The compressed image is filtered to remove all the unwanted terms (noise). In fact, it is important to note that, attention must be given to the choice of right filter, this because information about the image at that time is not cleared, since the image is compressed. In this work, Butterworth notch filter is chosen because the major possible approach to filter noise components is via notch filtering, since periodic noise manifest itself and becomes visible in Fourier spectrum. The filter model is given in (6)

$$H(u,v) = \frac{1}{1+[Do2 \div D1(u,v)D2(u,v)]n} \qquad (6)$$

$$D1(u,v) = [\left(u - \frac{m}{2} - Uo\right)^{2} + (V - \frac{N}{2} - Uo)]^{1/2} \qquad (7)$$

$$D2(u,v) = [\left(U - \frac{m}{2} + Uo\right)]^{1/2} \qquad (8)$$

Where (Uo, Vo) and $(-Vo - Uo)$ are the locations and the notation D_o is their radius.

After successful filtering the CXR image needs to be restored.

3.3.RESTORATION OF CXR

The simplest approach to restore a degraded image is to form an estimate of a form

$$\hat{}F(u,v) = \frac{G(u,v)}{H(u,v)} \qquad (9)$$

Usually Fourier transform of $G(u,v)$ and $H(u,v)$ takes the degraded CXR image. So, the inverse filtering model can be obtained as

$$\hat{}F(u,v) = F(u,v) + \frac{N(u,v)}{H(u,v)} \qquad (10)$$

The ratio $\hat{}F(u,v) = \frac{G(u,v)}{H(u,v)}$ gives limit to the frequency range i.e. near the original. The idea is that zero's in $H(u,v)$are less likely to occur near the original CXR image because the intensity of transform is typically at the peak value is that region. In a broad sense, special treatment is given to (u,v) for which H is zero or near zero. In some cases, after the inverse filtering Wiener filter may be applied to further filter the remaining noise components, which in this case is not applied.

Therefore, the statistical error function is estimated using (11)

$$E^2 \; E[(f - \hat{F})^2] \tag{11}$$

Where E is the expected value operator, f is the ungraded CXR image and $\hat{F}$ is the restored CXR image and the restored image becomes

$$g(x, y) = \hat{F}(x, y) \tag{12}$$

The performance of the DIP is given by

$$ʎ = (100 - e)\% \tag{13}$$

3.4.ALGORITHM

i. Preparation of X-ray image datasets

ii. Upload the images to the MATLAB workspace

iii. All the Images were enhanced that is conversion from RGB to gray images

iv. All the images are decomposed, convolved, compress and filtered

v. All the images are restored and binarized and a threshold value ≥ 53 were set

vi. % of the infected region of interest were calculated

vii. Based on this severity level of all the image were obtained

4. RESULTS

Figure 2(a-r) present the final restored images, and Table 1 shows the restored images in terms of pixel values.

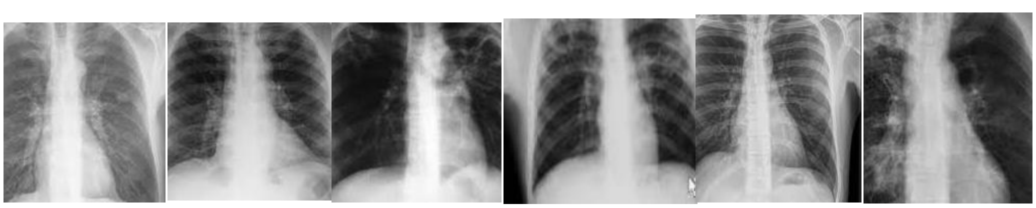

Fig. 2a Fig. 2b Fig.2c Fig.2d Fig. 2e Fig. 2f

Fig. 2g Fig. 2h Fig.2i Fig. 2j Fig. 2k

Table 1 Image information analysis

Image	F	$\hat{F}$	e	infected pixel ≥ 53	% of the infected area
Image 1	11250	11109	141	11067	99.62%
Image 2	9414	9300	114	9256	99.52%
Image 3	7918	7866	52	5753	73.13%
Image 4	8790	8710	80	6908	79.31 %
Image 5	7821	7705	116	6162	79.97%
Image 6	7172	6954	218	6735	96.71%
Image 7	9371	9304	67	4765	51.21%
Image 8	5521	5406	115	3941	72.92%
Image 9	6411	6367	44	4890	76.80%
Image 10	6412	6380	32	4903	76.84%
Image 11	4815	4704	111	3894	82.78%

Difference between F and $\hat{F}$

The Fig. 3 represents the raw images (F) and the processed ($\hat{F}$), the number of pixels in the raw images are higher than the number of pixels in the processed images, that is noised are removed during the processing. The red line indicates the raw images and the blue line indicates the processed images, the Y axis represents the number of pixels and X axis represent the images. In image 1 the number of pixels are 11250 while the processed image has 11109 pixels making the difference of 141 and so on.

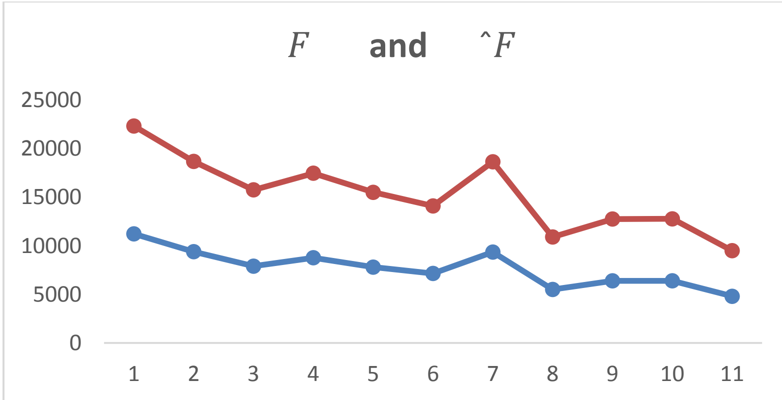

Figure 3 The difference between F and $\hat{F}$

The severity level of the disease is measure using mild, moderate, severe and very severe as indicated in the work of [24], in this work from Fig. 4 image 1 has a severity level as very severe (99.62%), follow by image 2 which has 99.52%, and image 6 also has 96.71%, However, image 7 has 51.21% and so on.

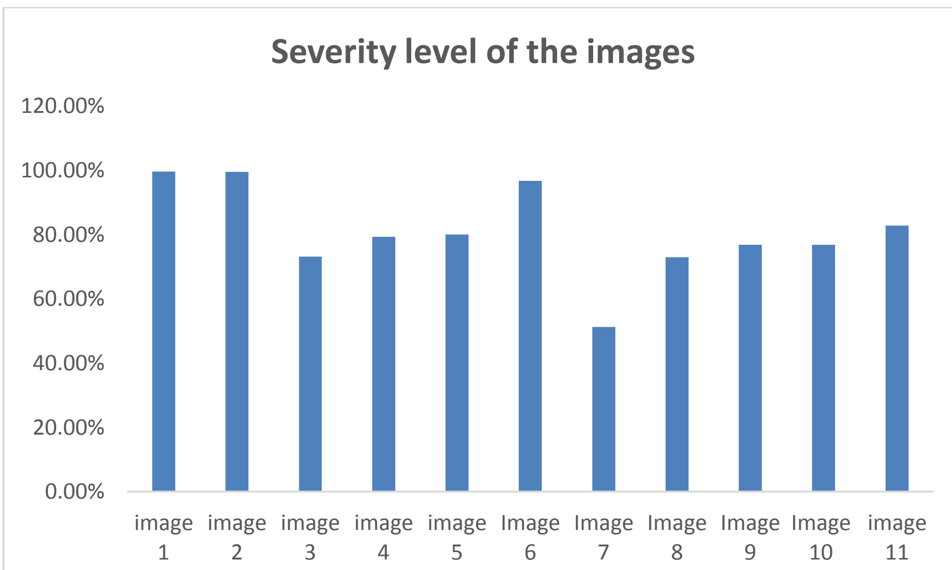

Figure 4 Severity level of the images

5. DISCUSSION

From table 1. processed images ($\hat{F}$) 1, 2, 6 and 11 has a total pixel values 11067, 6735, 9256 and 3894 respectively $\geq$ 53 which indicates the percentage of the infected areas are 99.62%, 99.52%, 96.70% and 82.78% respectively which shows the severity level are very severe. While the image 3, 4, 5, 8 and 9 respectively has a percentage of infected areas 73.13%, 72.90%, 76.80%, and 76.84% respectively which indicate the severity level as severe. Image 7 has a percentage of infected area 51.21% which shows the severity level is moderate. Furthermore Fig. 3 depict the differences between the raw images (F) and the processed images ($\hat{F}$) which also shows that raw images has noised. Finally Fig. 4 indicates the severity level of all the images in terms of percentages.

6. CONCLUSION

In this research work image processing techniques are applied to determine the severity level of Tuberculosis. This research work pave away and proved that image processing is suitable techniques would be applied to medical diagnosis especially disease that require medical images in diagnosis.

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