Detecting tuberculosis in chest radiographs using image processing techniques

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Abstract—A method for detecting tuberculosis in radiographic images is explored. A background to the disease and its relation to CAD (Computer Aided Diagnosis) is discussed. The proposed CAD system will use image processing paradigms to analyse and identify suspected tuberculosis nodules. A GPU (Graphics Processing Unit) will be employed to process the images using the required image processing algorithms. Several stages of processing will be required relating to the identification of micro- and macrostructures, nodule accentuation and rib suppression.

Index Terms—Tuberculosis, Image Processing, GPGPU, CAD, Pattern Recognition

I. INTRODUCTION

South Africa has the seventh highest incidence of tuberculosis in the world [1]. The occurrence of the disease in this region demands all possible avenues of detection and diagnosis to be explored. Furthermore, miners in Southern Africa exhibit the highest prevalence of tuberculosis of any working population [2]. The exposure to silica dust and the resulting silicosis in many miners, especially gold miners, is closely related to the development of pulmonary tuberculosis in this population [3]. The volume of chest radiographs captured from both miners and the civilian population means that reading these images can become a repetitive task for a radiologist.

To address this problem a combination of CADe (Computer-Aided Detection) and CADx (Computer-Aided Diagnosis) will be developed. Although there has been research into this problem [4] [5], a novel solution is being proposed. To make the proposed method as efficient as possible, the parallelisation potential the GPU (Graphics Processing Unit) will be exploited to compute the algorithms at each of the required stages.

II. ANALYSIS OF MICROSTRUCTURES

The detection of tuberculosis-related microstructures within the radiographic images will be performed using the LBP (Local Binary Pattern) classifier as proposed by Ojala et al. [6]. Various GPU implementations of this algorithm will be utilised [7]. By applying the LBP operator to extracted textures, as seen in Figure 1, we can generate feature histograms to test the classifier.

III. NODULE ACCENTUATION

Nodules within the lung can be accentuated by applying a LoG (Laplacian of Gaussian) filter to the radiograph [8]. The LoG kernel is given by equation (1):

$$\text{LoG}_\sigma(x, y) = \frac{1}{\pi\sigma^4} \left(1 - \frac{x^2 + y^2}{2\sigma^2}\right)e^{-\left(\frac{x^2 + y^2}{2\sigma^2}\right)}$$  (1)

where \((x, y)\) is the pixel position and \(\sigma\) is the standard deviation. By choosing the correct \(\sigma\) and filter size, an image that highlights possible areas of interest can be generated, as shown in Figure 2.

This technique will assist in the manual identification of nodules and may improve the accuracy of automated detection.
IV. DETECTING THE LUNG AREA

To find the lung area and hence the shape of the lung, several stages of processing is applied to the image. By using a high-pass FFT filter and suitable cutoff frequency, the soft tissue within the lungs can be isolated. The resulting high frequency areas are non-uniform, so the filtered image is first dilated to a suitable degree and then eroded to separate these uniform regions. A binary image is then generated by thresholding the image. Thresholding can introduce further non-uniformity to these regions but can be rectified by an additional step of dilation and erosion. An approximation of the lung area after performing these steps is shown by Figure 3. Many of the errors present in the processed image (especially the upper left and right hand corners) can be attributed to the high frequency nature of the patient text on the sample radiograph.

Fig. 3. Lung area detection

V. ANALYSIS OF MACROSTRUCTURES

Once the lung area is found, the shape of each lung will be analysed using simple geometry. Figure 4 shows the maximum height ($H_m$) and maximum width ($W_m$) of a sample lung. Using a database of radiographic images, such as the JRST database [9], a ratio between $H_m$ and $W_m$ for an average healthy lung will be found.

Fig. 4. Maximum height ($H_m$) and width ($W_m$)

VI. RIB SUPPRESSION

The density of the ribs affect the image by changing the luminance values of the underlying textures. This can affect the detection of nodules. A method for suppressing the contrast of the ribs and chest clavicles may be implemented using an algorithm such as the one suggested by Suzuki et al. [10]. The previously suggested method obtains a representation of the bone structure in a radiograph by using a dual-energy subtraction technique. This involves a multi-kV (multi-kilovolt) radiographic analysis using two separate radiographs, each captured at a different kV rating. The generated bone structure is then used to train a classifier and suppress the ribs in a lung radiograph.

VII. FUTURE WORK

Further research into the texture classification, filtering and macrostructure analysis of tuberculosis will be undertaken. Many of the required processing stages will be fully GPU implemented. The LBP classifier will be trained using a database of textures containing tuberculosis-like structures and may be used in conjunction with LoG filtering. Lung area detection will be further developed to improve approximation and allow for suitable analysis of the lung structure. A simulation of dual-energy technique using only a single radiograph will be explored.

REFERENCES


Joshua Leibstein is a postgraduate student at the University of Johannesburg currently studying towards an Honours Degree in Information Technology. He is a research assistant at the HyperVision Research Laboratory and was chosen as one of the winners of the UJ Image Processing Challenge in 2009. His research interests include pattern recognition, audio DSP and GPGPU programming.