A Robust Automated Lung Segmentation System for Chest X-ray (CXR) Images

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***Abstract*—Tuberculosis is an infectious disease that usually affects the lungs. The automatic detection of the lung regions is the critical component in CXR (digital Chest X-Ray screening) system. In this paper a robust automated lung segmentation system for chest X-ray (CXR) images is proposed. This method a content-based image retrieval approach used for identifying training images which is most similar to the patient CXR using Bhattacharyya shape similarity measure and partial Radon transform. The initial patient anatomical model of lung shape is created using SIFT-flow, and refined lung boundaries are extracted using a graph cuts optimization approach.**

***Keywords*—TB(Tuberculosis); CXR(digital Chest X-ray Screening System); CBIR(Content based image retrieval); Graph Cut Optimization**.

I. INTRODUCTION

Tuberculosis is a major health threat in many regions of the world. The automatic detection of tuberculosis from x-ray may helpful in the rural areas. So developing a CAD system for the diagnosing Tuberculosis is a challenging task. Early detection of tuberculosis can reduce the risk. The basic method includes segmentation, feature extraction and classification[8]. Detecting the lung regions in chest X-ray images is an important component in computer-aided diagnosis (CAD) of lung health. In certain diagnostic conditions the relevant information can be extracted directly from the lung boundaries without further analysis. In the case of CAD-based identification of lung diseases, accurate lung boundary segmentation plays an important role in subsequent stages of automated diagnosis. The lung boundary are determined by suitable boundary detection algorithm. The edge detection process is done by scanning the image horizontally starting from the leftmost pixel of the first row and traverse all pixels to reach the last pixel of the first row. Then scanning process is repeated till it reach the last pixel in the last row of the two dimensional image data array [9].

The lung boundary can be extracted by using Image segmentation algorithm. Image segmentation is the process of partitioning the image into essential regions with respect to the appropriate locations. Segmentation Based on Edge Detection, threshold method, Region growing method, Clustering Based image segmentation are the various segmentation methods applicable in different fields like medical imaging, object recognition, pattern recognition etc [7].

The initial process for extracting the lung boundary is selecting the image from the database which has similar feature with the input image. CBIR (Content Based Image Retrieval) retrieve the images on the basis of color, texture, and shape. CBIR involves data gathering for collecting images, extracting low level and middle level features like color, texture and shape from the database, searching suitable features from the database and find related images with lowest similar distance, index the image obtained from searching the image and allow the user to select the image[1]. CBIR (Content Based Image Retrieval) extract the features of the stored image and then the extracted features is compared with the query image. SVM based retrieval, SVM with relevance feedback method, DWT based method are the different CBIR methods used for image retrieval. [2]. CCM(Color Co-occurance Matrix) is an efficient image retrieval algorithm. CCM for each pixel of an image is found using Hue Saturation Value of the pixel and then compared with CCM of the image in the database and image is retrieved. [3]. CBIR combines the color and texture features. A weight is assigned to each features and the similarity is calculated with combined features of color and texture using Canberra distance as similarity measure. The image retrieval efficiency is increased when both color and texture features are combined [4].

Bhattacharya overlap method is used to measure the similarity between two SSM(Statistical Shape Models) . The SSM of the image are compared by evaluating the Bhattacharya overlap between their implied shape distribution. This method evaluate the quality of models built automatically from large datasets [5]. Graph cut segmentation is an efficient method to separate the foreground from background as it utilizes both boundary and regional information. The three categories of graph cut method are speed up based graph cut, interactive based graphcut and shape prior based graph cut. These methods are combined to improve the segmentation result.[6]. Graph cut Segmentation method consist of two stages, average lung shape model calculation, and lung boundary detection based on graph cut. This method calculates the lung models in a simple and an effective way[10]. The lung shape model, a segmentation mask, and a simple intensity model is combined to achieve a better segmentation mask for the lung [11]. A general iterative contextual pixel classifier is used for supervised image segmentation. The iterative procedure is statistically well-founded, and can be considered a variation on the iterated conditional modes (ICM) of Be-sag. Having an initial segmentation, the algorithm iteratively updates it by reclassifying every pixel, based on the original features and, additionally, contextual information.[12]

II. MATERIALS AND METHODS

The block diagram of the proposed algorithm is depicted below.

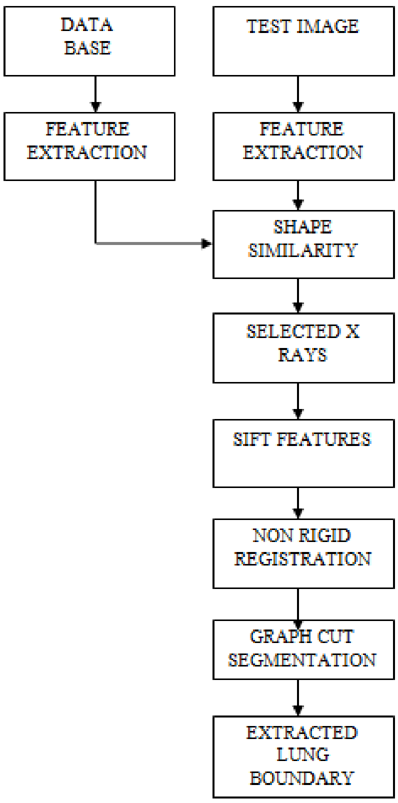


Figure 1. Block diagram of the proposed algorithm

The flow of the block diagram is described below

- The feature from the Database as well as test image is extracted by using Radon transform
- The most similar images are selected from the database by using Bhattacharya shape similarity measure.
- The local feature of the image like gradient orientation and magnitude is calculated by using SIFT flow.
- From the SIFT feature estimate a triangle point and non rigid registration is applied to that value to get the registered image.
- From the registered image the lung boundary is extracted by using graph cut segmentation.

A. Content-Based Image Retrieval(CBIR)

Content-based image retrieval (CBIR) technique is used for retrieving similar images from the databases. It uses visual contents to search images from large scale image database. A CBIR automatically extract visual attributes such as color, shape, texture and spatial information of the image in the database based on its pixel values.

- Identifies training images similar to patient CXR.
- Uses Partial Radon Transform and Bhattacharyya similarity measure.
- Read test image and resize it to 512x512.
- Adaptive Histogram Equalization improves image quality.
- Compute image gradient in X and Y direction.
- Apply Radon Transform to patient CXR and images in database.
- Images with least Bhattacharya coefficient are retrieved.

B. Scale Invariant Feature Transform(SIFT)

Scale-invariant feature transform (or SIFT) is used to detect and describe local features in images. SIFT detects salient, stable points in an image and uses a much larger number of features from the images.

The scale space is defined by the function given below:

$$L(x, y, \sigma) = G(x, y, \sigma) * I(x, y) \qquad (1)$$

Where * is the convolution operator, $G(x, y, \sigma)$ is a variable-scale Gaussian and $I(x, y)$ is the input image.

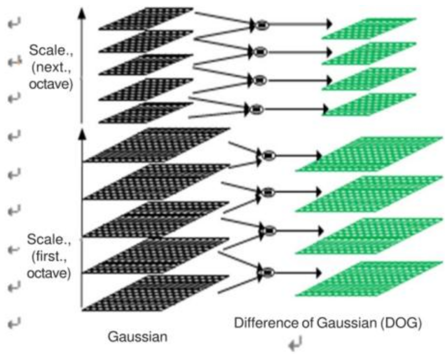


Figure 2. Differences in Gaussian Pyramids

Eliminate more points from the list of keypoints and find low contrast are poorly localised on an edge.

Assign a consistent orientation to the keypoints based on local image properties. Image gradient magnitude and orientation is calculated as,

Compute gradient magnitude, *m*

$$m(x,y)=\sqrt{(L(x+1,y)-L(x-1,y))^2+(L(x,y+1)-L(x,y-1))^2} \qquad (2)$$

Compute orientation, θ

$$\theta(x,y)=\tan^{-1}\left(\frac{(L(x,y+1)-L(x,y-1))}{(L(x+1,y)-L(x-1,y))}\right) \qquad (3)$$

The local gradient data is used to create keypoint descriptors. The gradient information is rotated to line up with the orientation of the keypoint. This data is then used to create a set of histograms. Keypoints between two images are matched by identifying their nearest neighbours. Scale Invariant Feature Transform Flow is as follows

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 04, April-2017

- Local gradient information is evaluated using SIFT.
- SIFT features are calculated.
- Gradient orientations and magnitudes are computed at each pixel.
- Gradients are weighted by a Gaussian pyramid in a K x K region.
- The regions are subdivided into k x k quadrants.
- In each quadrant, a gradient orientation histogram is formed.
- The concatenation of orientation histograms form the SIFT descriptor vector.

C. Non Rigid Registration

Non rigid registration is an Elastic transformation involve a large number of parameters they are Nonlinear and Curved. It Can map straight lines into curves

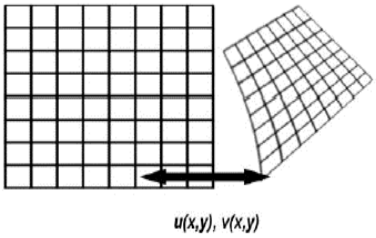


Figure 3. Non Rigid Registration

Non rigid image registration is used to optimize an image similarity measure with respect to the transformation parameters. The non-rigid registration steps are as follows

- Registered image into multiple blocks
- Extract block features
- Block-node block feature-link
- Assign rate value to each link based on feature similarity
- Assign foreground and background pixel
- Estimate mini cost
- Extract lung and background region

D. Graph cut segmentation

A graph cut method partition a directed or undirected graph into disjoint sets. The graph cut technique represent the image in the form of graphs. It contain nodes and vertices. Each pixel is represented as a node and the distance between those nodes as the edges.

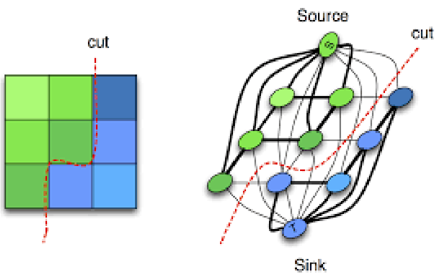


Figure 4.Graph cut Segmentation

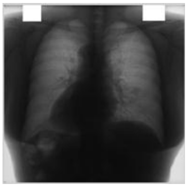
The simplest and best known graph cut method is the min-cut formulation. In the minimum cut technique the size of the cut is not larger than the size of the any other cut. The min-cut of a graph is the cut that partitions G into disjoints segments.

$$C_{min}(A,B) = \sum_{u\in A, v\in B} W_{uv}.$$

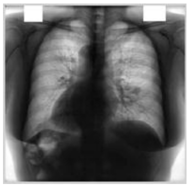
The steps of Graph cut segmentation is as follows

- Image is divided into multiple blocks(node).
- Extract each block feature similarity(edge).
- Neighborhood edge{p,q}, models boundary properties.
- Edge between terminals and pixels {p,S}{p,T}.
- p,q are vertices and S,T are fg and bg terminals.
- Assign a weight for edge based on block features.
- The edge weight between the terminals and the pixels are integrated for image intensity.
- The neighborhood edges are integrated for smoothness.
- Compute min-cut which partition the graph.
- Distinguish foreground and background.

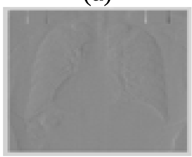
III. RESULT ANALYSIS



(a)

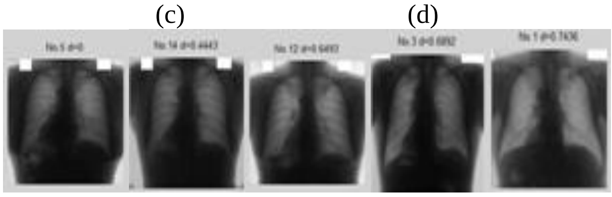


(b)

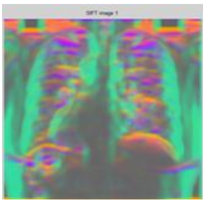


(c)

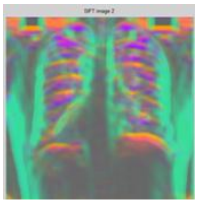
(d)



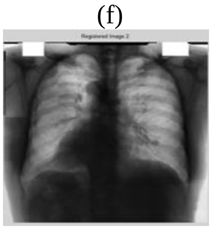
(e)



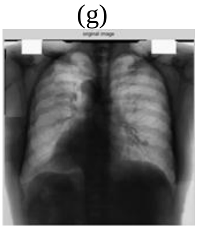
(f)



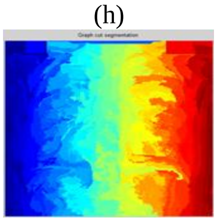
(g)



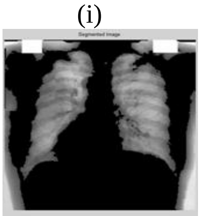
(h)



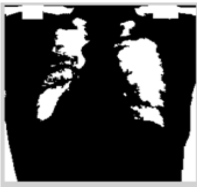
(i)



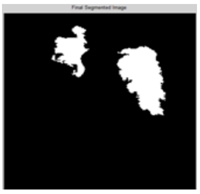
(j)



(k)



(l)



(m)

Figure 5.Extracting Lung boundary from the X-ray image

Figure (a) shows the input X-ray image of the lung region. The contrast of the image is enhanced by using Adaptive Histogram Equalization (AHE) and the enhanced image is shown in figure (b). The image gradient along x and y direction is shown the figure (c) and (d) respectively. The images with similar radon feature of the test image is retrieved by using radon transform as shown in figure (e). The local feature of the original and related image from the database is described using SIFT flow as shown in figure (f) and (g) respectively. The registered image is shown in figure (h). The original image is shown in figure (i). The graph cut segmentation is shown in figure (j). The segmented image is shown in figure (k) and figure (l) shows the next level of segmented image and the final segmented image is shown in figure (m).

IV. CONCLUSION

We have presented a robust lung boundary detection method that is based on a patient specific lung atlas using fast partial Radon profile similarity selection and SIFT- flow non rigid registration with refinement using a graph cuts segmentation algorithm. We evaluated the algorithm using three different datasets containing 585 chest radiographs from patients with normal lungs and various pulmonary diseases. On the publicly available JSRT dataset, experimental results showed an accuracy of 95.4% (overlap measure), compared to the expert segmentation gold standard, which is the highest machine performance reported in the literature.

ACKNOWLEDGMENT

The authors would like to acknowledge the support provided by DST under IDP scheme (No: IDP/MED/03/2015). We thank Dr Sebastian Varghese (Consultant Radiologist, Metro Scans & Laboratory, Trivandrum) for providing the medical CT/MR images and supporting us in the preparation of manuscript.

REFERENCES

[1] Ritika Hirwane, “Fundamental of Content Based Image Retrieval”, (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 3 (1) , 2012, 3260 – 3263

[2] Amit Singh, Parag Sohoni, Manoj Kumar , “A Review of Different Content Based Image Retrieval Techniques”, International Journal of Engineering Research and General ScienceVolume 2, Issue 5, August – September 2014 ISSN 2091-2730

[3] K. Arthi , J. Vijayaraghavan , “Content Based Image Retrieval Algorithm Using Colour Models”,International Journal of Advanced Research in Computer and Communication Engineering Vol. 2, Issue 3, March 2013

[4] S. Mangijao Singh , K. Hemachandran ,”Content--Based Image Retrieval using Color Moment and Gabor Texture Feature”, IJCSI International Journal of Computer Science Issues, Vol. 9, Issue 5, No 1, September 2012 ISSN (Online): 1694-0814

[5] K.O. Babalola, T.F. Cootes, B. Patenaude, A. Rao, and M. Jenkinson2 , “Comparing the Similarity of Statistical Shape Models Using the Bhattacharya Metric”

[6] Faliu Yi , Inkyu Moon ,“Image Segmentation: A Survey of Graph-cut Methods”, 2012 International Conference on Systems and Informatics (ICSAI 2012)

[7] Amanpreet Kaur , “A Review Paper on Image Segmentation and its Various Techniques in Image Processing”, International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064

[8] Hrudya Das,Ajay Nath“An Efficient Detection of Tuberculosis from Chest X-rays”, International Journal of Advance Research in Computer Science and Management Studies Volume 3, Issue 5, May 2015

[9] Samir Kumar Bandyopadhyay, “A Method for Lung Boundary Detection”, International Journal of Information and Communication Technology Research Volume 2 No. 2, February 2012

[10] Sema Candemir, Stefan Jaeger, Kannappan Palaniappan, Sameer Antani, and George Thoma,” Graph Cut Based Automatic Lung Boundary Detection in Chest Radiographs”, 1st Annual IEEE Healthcare Innovation Conference of the IEEE EMBS Houston, Texas USA, 7 - 9 November, 2012

[11] Stefan Jaeger, Alexandros Karargyris, Sameer Antani, and George Thoma,” Detecting Tuberculosis in Radiographs Using Combined Lung Masks”, 34th Annual International Conference of the IEEE EMBS San Diego, California USA, 28 August - 1 September, 2012

[12] Marco Loog and Bram van Ginneken , “Supervised Segmentation by Iterated Contextual Pixel Classification”