International Journal of Advanced Computer Research (ISSN (print): 2249-7277 ISSN (online): 2277-7970)
Volume-4 Number-1 Issue-14 March-2014

Segmentation and Classification of Tumour in Computed Tomography Liver Images for Detection, Analysis and Preoperative Planning

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Abstract

Segmentation of CT liver images helps to analyze the presence of hepatic tumor and classify the tumor from images of diseased populations. Here, we use region growing technique to examine the neighboring pixels of initial seed points and determine whether the pixel neighbors should be added to the region or not. The process is iterative and seed point is chosen interactively in the suspected region. The contour generated by the region growing has been segmented using watershed method. The texture features for segmented region are extracted through Grey Level Co-occurrence Matrix (GLCM). These features are used to classify the tumor as benign or malignant using Support Vector Machine (SVM) approach. In this paper, a semi-Automated system has been presented which is robust, allows radiologist and surgeons to have easy and convenient access to organ measurements and visualization. Experimental results shows that liver segmentation errors are reduced significantly and all tumors are segmented from liver and are classified as benign or malignant.

Keywords

Liver Segmentation; Cancer; Tumor; SVM; Watershed; GLCM

1. Introduction

Cancer is the major public health problem in United States and many other parts of the world. One in four deaths in the United States is due to cancer [1]. Each year, the American Cancer Society estimates the numbers of new cancer cases and deaths expected in the United States in the current year and compiles the most recent data on cancer incidence, mortality, and survival based on incidence data from the National Cancer Institute. During the most recent 5 years, overall cancer incidence rates declined slightly in men by 0.6% per year and were stable in women, while cancer death rates decreased by 1.8% per year in men and by 1.6% per year in women.

Liver cancer is the sixth most common cancer in the world. The majority of primary liver cancers have their origins in alcohol-related cirrhosis and fatty liver disease associated with obesity. Other major risk factors are hepatitis B and C viruses are the main cause for liver cancer. Report also evidenced that cancer seen in people consuming foods contaminated with a flatoxins. The incidence of liver cancer has been increasing by more than 3% yearly. Mongolia has the highest rate of liver cancer followed by Gambia and Chinese Taipei. About 84% of liver cancer cases occur in less developed countries. The highest incidence of liver cancer is in Eastern and South-Eastern Asia, Middle Africa and the lowest incidence found in Central and Southern Europe, and South-Central Asia.

Liver metastases are hepatic cancers that have spread from another primary source in the body. The liver is a prime candidate for metastases form cancers in the breast, colon, prostate, lung, pancreas, stomach, esophagus, adrenal glands, or skin (melanoma) [2]. A hepatic metastasis can be found at the time of the diagnosis of the primary cancer or appear later after the removal of the primary tumor. The treatment and prognosis of secondary liver cancers vary largely depending on its source and stage. Systemic chemotherapy is usually used to treat the metastases, but ablation and remobilization are also common, while surgery is a rarer option. Although secondary liver cancer is generally untreatable, treatments may improve life expectancy.

1.1 Computerized Tomography (CT)

Computed Tomography (CT) is a powerful evaluation technique for producing 2D and 3D cross-sectional images of the organs under test by providing the characteristics of the internal structure of an organ

Manuscript received on February 16, 2014.

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such as dimensions, shape, internal defects, and density. Computerized Tomography scanner uses thin beam of x-rays that uses a special type of radiation and a computer to make pictures of the inside of patient body [3]. The principal advantages of CT mainly are rapid acquisition of images, a wealth of clear and specific information and view of a large portion of the body. The following sections brief about segmentation of the tumor from the liver and classifying tumor as benign and malignant.

2. Related Work

In [5], comparison study has been made between 10 automatic and six interactive methods for liver segmentation from contrast-enhanced CT images. Employed algorithms include statistical shape models, atlas registration, level-sets, graph-cuts and rule-based systems. All results were compared with reference to segmentation five error measures that highlight different aspects of segmentation accuracy. The general, interactive methods reached higher average scores than automatic approaches and featured a better consistency of segmentation quality from this it increase the transparency in medical image analysis and potentially establishing a common benchmark for segmentation performance. In [6], a system was developed for automatic segmentation of the liver from computed tomography scans of the abdomen for 3D visualization is discussed. In [7], to measure the accuracy of the tumor segmentation, 5 metrics used are volume overlap, relative volume difference, average symmetric surface distance, RMS symmetric surface distance, maximum symmetric surface distance is discussed.

A novel segmentation scheme based on a true 3D segmentation refinement concept utilizing a hybrid desktop/virtual reality user interface is discussed [8]. The work about the approach for automatic liver segmentation from computed tomography scans that based on a statistical shape model integrated [9] with an optimal-surface-detection strategy has been discussed. The results of the experiment demonstrate availability and effectiveness of the proposed method. Computer-aided diagnostic (CAD) system for the classification of hepatic lesions from computed tomography images is discussed in [10]. In [11], the semi-automatic method based on 2D region growing with knowledge-based constraints is proposed to segment lesions from constituent 2D slices obtained from 3D CT images. In [12], Segmentation is an important operation before surgery planning, and automatic methods offer an alternative to laborious manual segmentation is given. In addition [13], segmentations of automatic methods are reproducible, reliably evaluated and do not depend on the performer of the segmentation. Tumor in a liver will be differentiated by intensity difference between tumor and liver. The intensity of the tumor can be lower and or higher than that of the liver. However, the main problem of liver tumor detection from CT images related to low contrast between tumor and liver intensities. Tumor sometimes presents in a very small dimension and makes the detection even more difficult. The contrast enhancement of CT images containing liver and tumor has been discussed here.

3. Proposed System

The proposed system architecture is shown in Fig. 1. It consists of image database, segmentation, feature extraction and classification modules. In segmentation module, the selection of ROI from the suspicious region is done using region growing algorithm. The region growing is a region-based image segmentation method. Here, the human expert intervention is needed to select the seed point of the suspected region. For this purpose, the CT image has to be pop up from the location where it is stored and then seed pixel has to be selected by using plus mark curser with clicking one time on the suspected area of the image. Once the region is grown, the image is segmented from the liver. Watershed algorithm is used to extract the contour generated by region growing technique. Watershed segmentation is a morphological based method of image segmentation relies mostly on a good estimation of image gradients. Feature extraction module extracts texture features such as mean, standard deviation, variance, energy, range and maximum probability from segmented region using GLCM. Based on these features, the classification module classifies the image data using SVM.. This classifies whether the selected region belongs to benign or malignant category.

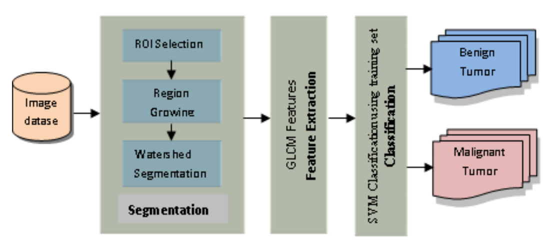

Fig. 1: Proposed System Architecture.

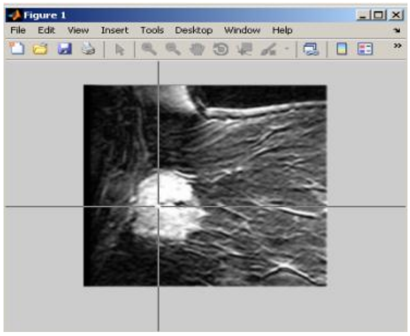

Fig. 2: Process of selecting the seed point

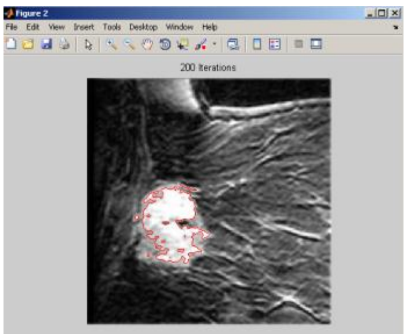

Fig .3: Region growing from the selected seed pixel

3.1 ROI (Region of Interest) selection

First, the initial seed point has to be chosen from ROI as shown in Fig 2. Based on the seed point value the region starts growing by examining neighboring pixels of initial seed points and determines whether the pixel neighbors should be added to the region or not. This procedure helps to identify homogeneous regions in the image. The eight neighbors of the seed are checked to see whether their gray level values are within a specified deviation from the seed. Pixels that meet the criterion added to the region by labeling the pixel. The neighbors of the labeled pixels are checked for inclusion. The procedure stops when it surrounds by a layer of pixels that do not meet the criterion for inclusion. Fig. 3 shows the region grown from the selected seed pixel.

The basic formulation of region growing process is given below.

$\bigcup_{i=1}^{n} \mathrm{Re}_i = \mathrm{Re}$, Where Re_i is a connected region, for i=1, 2 …n and

$\mathrm{Re}_i \cap \mathrm{Re}_j = \phi$, for all, i=1, 2 …n

P (Re_i) = TRUE, for i = 1, 2… n and $p(\mathrm{Re}_i \cap \mathrm{Re}_j) = \mathrm{FALSE}$

3.2 Watershed Segmentation

The purpose of image segmentation is to partition an image into meaningful regions with respect to a particular application [8]. Watershed segmentation produces good results for gray level images with different minima and catchment basins. Here, the gray level of a pixel is interpreted as its altitude in the relief and the length of the gradient is interpreted as elevation information. For binary images, there are only two gray levels 0 and 1 standing for black and white. If two black blobs connected together in a binary image, only one minimum and catchment basin are formed in the topographic surface. To use watershed to segment the connected blobs, distance transforms is used to preprocess the image to make it suitable for watershed segmentation. The Euclidean distance transform is used to take the distance from every pixel of the object component, black pixel to the nearest white pixel. In the Euclidean plane, if p = (p1, p2) and q = (q1, q2) then the distance is given by: $d(p,q) = \sqrt{(p_1 - q_1)^2 + (p_2 - q_2)^2}$. The result is shown in Fig 4.

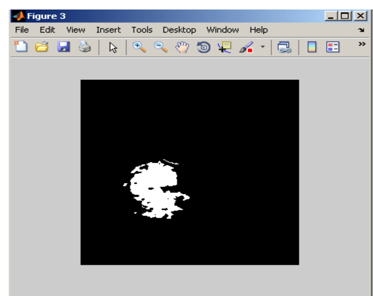

Fig .4: Segmented tumor with watershed method

3.3 GLCM Features

Texture is one of the intrinsic characteristics of an object and important for image analysis. A statistical method of examining texture that considers the spatial relationship of pixels is the GLCM. The GLCM functions characterize the texture of an image by calculating how often pairs of pixel with specific values and in a specified spatial relationship occur in an image. The GLCM calculates how often a pixel with gray-level of value i occurs either horizontally, vertically, or diagonally to adjacent pixels with the value j. Textural measures for the nearest pixels taken in four directions are horizontal (0^0), Vertical (90^0), Diagonal: Bottom left to top right (-45^0) and Top left to bottom right (-135^0). GLCM method is used to reduce the number of false detections and classify the tumour as benign or malignant by setting the threshold value by set of trials. The features collected for image data sets are mean, variance, energy, range and probability are as tabulated in Table 1. The threshold values chosen are 0.0617, 0.0674, 0.0033, 0.0006580, and 0.0050 respectively. Depending on these values the classification of tumor is done using SVM [4]. The SVM produces a model, which predicts the target values of the test data given only the test data attributes [13]. The testing data contains all the images loaded onto the database. The training data contains two categories: '01' for benign and '02' for malignant.

4. Experimental Results

Experiments have been conducted on 136 CT liver images of 63 cases. A utility in Matlab has been designed and developed to carryout various stages of operations. This consists of creation of database, segmentation, feature extraction and classification options. The figures from 5 to 8 shows the results for benign case and figures 9 to 10 shows results for malignant case. These images are classified with an accuracy of 96% and verified with domain experts. The results are better compared to the results of paper [14].

5. Conclusions

Segmentation concept presented in this paper analyzes the hepatic tumor from the CT liver images. This methodology is tested on 100 CT images of 63 patient cases. The results depict that the performance of the system is more than 96% accuracy to classify tumors as benign or malignant. This has been verified with the domain expert's knowledge. Results of the proposed system may help experts in the medical field for further diagnosis and treatment planning. Future enhancements of this work aim to develop a fully automated computer-aided diagnostic system for tumor segmentation and classification with large datasets.

Acknowledgment

The authors wish to thank All India Council for Technical Education (AICTE), New Delhi, for having Supported in part under Research Promotion Scheme (RPS): 8023/RID/RPS-55/Pvt (II Policy)/2011-12,7th Feb 2012 and RNS Institute of Technology, Bangalore, also the CLUMAX Diagnostic Centre for the image dataset and suggestive discussions with domain experts.

References

[1] Rebecca Siegel; Deepa Naishadham; Ahmedin Jemal, *Cancer Statistics*, CA: A Cancer Journal for Clinicians, Volume 62, Issue 1, pages 10–29, 2012.

[2] R. L. Lewis, L. Goldman and D.Ausiello, Eds., 23rd ed. Philadelphia, PA: Saunders Elsevier, *Liver and Biliary Tract Tumors*, 2007.

[3] E-Liang Chen, Pau-Choo Chung, Ching-Liang Chen,et al, *An Automatic Diagnostic System for CT Liver Image Classification*, IEEE transactions on biomedical engineering, vol. 45, no. 6, 1998.

[4] Chih-Wei Hsu, Chih-Chung Chang, and Chih-JenLin, A Practical Guide to Support Vector Classification., National Taiwan University, 2010.

[5] Tobias Heimann, Bram van Ginneken, et al , *Comparison and Evaluation of Methods for Liver Segmentation From CT Datasets*. IEEE Trans Med Imaging, pages 1251-1265, 2009.

[6] Lumoin Gao, David Heath, Brian S.kuszk, Elliot K.Fishman, *Automatic liver segmentation technique for 3D visualization for CT data*, Vol 201, Number 2, Radiology, 1996.

[7] Xiang Deng and Guangwei Du, *3D Segmentation in the Clinic: A Grand Challenge II - Liver Tumor Segmentation*, Siemens Corporate Technology, 2009.

[8] Reinhard Beichel12, Christian Bauer, Alexander Bornik, Erich Sorantin, and Horst Bischof, *Liver Segmentation in CT Data: A Segmentation Refinement Approach. In Proceedings of "3D Segmentation in The Clinic: A Grand Challenge", pages 235-245, 2007.*

[9] Xing Zhang, Jie Tian, Fellow, Kexin Deng, Yongfang Wu, and Xiuli Li, *Automatic Liver Segmentation Using a Statistical Shape Model With Optimal Surface Detection*. Engineering in Medicine and Biology Society (EMBC), 2010 Annual International Conference of the IEEE, pp.5351,5354, 2010.

[10] Miltiades Gletsos, Stavroula G. Mougiakakou, George K. Matsopoulos et al, *A Computer-Aided Diagnostic System to Characterize CT Focal Liver Lesions: Design and Optimization of a Neural Network Classifier.* IEEE transactions on information technology in biomedicine, vol. 7, no. 3, 2003.

[11] Damon Wong1, Jiang Liu1, Yin Fengshou1, et al, *A semi-automated method for liver tumor segmentation based on 2D region growing with knowledge-based constraints, In Proceedings of "3D Segmentation in The Clinic: A Grand Challenge",2008.*

[12] Yrjo Hame, *Liver Tumor Segmentation Using Implicit Surface Evolution.* The Midas Journal, 2008.

[13] Jean Stawiaski1, Etienne Decenci`ere1 and Fran¸cois Bidault, *Interactive Liver Tumor Segmentation Using Graph-cuts and Watershed,* 11th International Conference on Medical Images and computer assisted intervention, 2008., ACM Hypertext 2002.

Table 1: Sample image features extracted from the images in the database

Image Id	Mean	Variance	Energy	Range	Maximum probability	Category
Imgb14	0.0221	0.0095	0.0024	0.0002960	0.0024	Benign
Imgm3	0.0635	4.1624	0.1099	0.0153	0.1099	Malignant
Imgm32	0.0642	0.9189	0.0389	0.0033	0.0389	Malignant
Imgb6	0.0066	0.0020	0.0033	0.0006580	0.0033	Benign
Imgb10	0.0617	0.0645	0.0023	0.00026500	0.0023	Benign
Imgb12	0.0575	0.0674	0.0016	0.0003160	0.0016	Benign
Imgm33	0.1038	6.2978	0.4026	0.1660	0.4026	Malignant

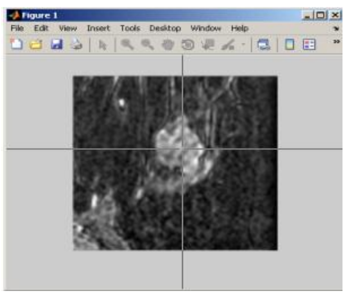

Fig. 5: ROI selection

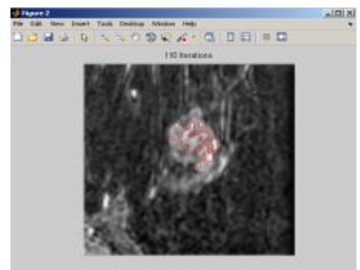

Fig. 6: Region growing from the selected seed pixel

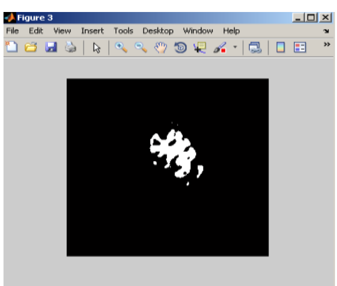

Fig .7: Segmented tumor with watershed method

Fig. 8: Segmented tumor classified as benign

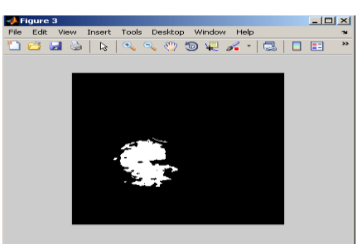

Fig. 9: Segmented tumor

Fig. 10: Segmented tumor classified as malignant

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