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A Study on Tumor Segmentation from CT Liver Images Using Region Growing and Otsu Segmentation Techniques

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***Abstract*— Abdomen/Liver cancer is the rapid creation of abnormal cells that grow beyond their usual boundaries and spread to other organs. Computer aided technique helps to identify the shape and the distribution of cells of tumor automatically without human intervention resulting in early diagnosis. The work in this paper presents an image processing pipeline, consisting of noise reduction, feature extraction by image segmentation, morphological operations to extract the region of interest i.e. tumor. Two segmentation techniques, namely, region growing and Otsu segmentation are implemented to extract the area of abdomen/liver containing tumor from the CT images. The performance of both the methods performed on local data set of CT liver images is compared with the ground truth and it has been observed that the region growing segmentation technique yielded better results. An accuracy of 87.5% with specificity and sensitivity of 66.66% and 94.44 respectively has been observed for region growing method.**

***Index Terms*—** Region growing and Otsu segmentation methods.

I. INTRODUCTION

Image segmentation is the process of partitioning an image into regions. It is the most essential and crucial process for facilitating the delineation, characterization and visualization of regions of interest in medical imaging. The main goal of segmentation is to represent an image to be more meaningful and easier to analyze. The result of image segmentation occurs as a set of regions that collectively covers the entire image [1]. Despite intensive research, segmentation remains a challenging problem due to diverse image content, cluttered objects, occlusion, image noise, non-uniform object texture and other factors [2,3]. Numerous algorithms and techniques have been proposed in the literature for image segmentation [4]. In particular, histogram based method, edge based method, artificial neural network based segmentation method, physical model based approaches, region based methods (region splitting, growing and merging) and clustering method (fuzzy c-means clustering, k-means clustering, Means shift and Expectation Maximization techniques) are adopted in medical image segmentation [5-8]. Medical image segmentation is difficult and challenging problem due to poor, contrast, complex nature of medical images and image segmentation methods. Image segmentation methods are depends on imaging modality, image feature and dimension [9-11]. In this paper, we explore the two popular segmentation techniques, namely, region growing and Otsu for detection of tumor from CT liver images and compare their performance with the ground truth [12-16].

When healthy cells change and grow out of control, they form a mass called a tumor. A tumor can be malignant or benign. The cancerous tumor is malignant, meaning it can grow and spread to other parts of the body. A benign tumor means the tumor can grow but will not spread. Liver cancers can be categorized as Hepatocellular Carcinoma (HCC), Cholangiocarcinoma and Angiosarcoma. Approximately, in 80% of adults, primary liver cancers are of Hepatocellular Carcinoma (HCC) and 10 to 20% are of Cholangiocarcinoma [17]. Many treatments are available depending on tumor type, size and location, age and medical health of the person [18, 19]. In India, eighty percent of all Hepatocellular Carcinoma (HCC) occur with cirrhosis of liver and sixty percent of all cases are hepatitis B positive carriers [20].

Ultrasonography (US), Computed Tomography (CT), Magnetic Resonance Imaging (MRI) are the most common medical imaging techniques used for acquiring CT abdomen/liver images for study. Computed Tomography (CT) is the most widely used technique for diagnosing cancer to conform the presence and size of tumors. By examining CT images, radiologist can plan and decide the proper treatment. Analysis of computerized Tomography (CT) medical images is advantages over human interpreters such as speed, large knowledge base and non-sensitivity to fatigue [21].

The aim of this paper is to segment out the tumor from abdomen/liver image using two popular techniques, namely, Region Growing and Otsu techniques, and compare their performance by experimenting on liver and abdomen CT scan images of local database collected from PRISM Diagnostic Center, Solapur. Section II presents the related work. Section III describes the methodology i.e. Region Growing and Otsu image segmentation techniques in brief. Section IV focuses on the experimental results of

segmentation algorithms. Finally, section V presents conclusion.

II. RELATED WORK

Few of the related work with respect to region growing and Otsu method available in the literature, is given below. Chang et. al. [22] presented analysis and comparison of various threshold based segmentation techniques. Threshold based image segmentation method differentiate regions on the basis of intensity value difference between pixels. The main objective of region growing method is to map individual pixels called seeds in the input image to a set of pixels called regions. It was first introduced by Rolf Adams and Leanne Bischof in 1994 [23]. Wonkai Deng et al. [24] used region growing method based on gradients and variances along and inside of the boundary curve. Selection of initial seed plays an important role in region growing method because it decides the overall segmentation. To select initial seed, watershed algorithm was adopted by Jun Tang [25] to segment the image to calculate no overlapped regions and then used centroid of region as initial seed. Weihong Cui et.al.[26] studied the Harris corner detector to calculate initial seed. But it increases the computation overhead. Region growing method is based on clustering of neighboring pixels of a region that specify a specific assumption [12].

Otsu method selects the threshold value by minimizing the within class variance of the two groups of pixels which is separated by the thresholding operator [16]. Otsu method is mainly used for the reduction of a grey level image to a binary image [27]. In Otsu method, image contains two classes of pixels following bimodal histogram. It calculates the optimum threshold by separating two classes so their inter class variance is minimal or equivalently.

III. METHODOLOGY

Segmentation techniques include the following stages, in general.

A) Preprocessing of the image.

B) Segmentation on the preprocessed image.

C) Post processing applied on segmented image.

The two segmentation techniques employed in this paper are described below. Median filter is used to eliminate the noise while preserving the tumor edges.

A) Otsu Method

Otsu method was proposed by Scholar Otsu in 1979. It is a global thresholding method, which is widely used because of simplicity and effective [15]. Otsu method has better threshold selection method for real world images with regard to uniformity and shape measures [28]. Otsu method is mainly used for the reduction of a gray level image to a binary image [14]. It assumes that the image contains two classes of pixels (foreground pixels and background pixels) following bimodal histogram. It calculates the optimum threshold for separating the two classes so their inter-class variance is minimal or equivalently their inter-class variance is maximum [15-16, 29].

Otsu method searches for the threshold that minimizes the inter-class variance, defined as a weighted sum of variances of the two classes-

$$\sigma_w^2(t) = w_0(t)\,\sigma_0^2(t) + w_1(t)\,\sigma_1^2(t) \quad \text{---------- 1}$$

weights $w_{0,1}$ are the probabilities of the two classes separated by a threshold t and $\sigma_{0,1}^2$ are variances of these two classes.

The class probability $w_{0,1}(t)$ is computed from the histogram of the image.

$$w_0(t) = \sum_{i=0}^{t-1} p(i) \text{ and } w_1(t) = \sum_{i=t}^{t-1} p(i) \quad \text{---------- 2}$$

Minimizing the inter-class variance is equivalent as maximizing inter-class variance [15].

$$\sigma_b^2(t) = \sigma^2 - \sigma_w^2(t) = w_0(\mu_0 - \mu T)^2 + w_1(\mu_1 - \mu T)^2 \text{ ---------- 3}$$

$$= w_0(t)\,w_1(t)\,[\mu_0(t) - \mu_1(t)]^2 \quad \text{---------- 4}$$

Where,

$$\mu_0(t) = \sum_{i=0}^{t-1} i\,p(i)/w_0 \quad \text{---------- 5}$$

$$\mu_1(t) = \sum_{i=t}^{L-1} i\,p(i)/w_1 \quad \text{---------- 6}$$

$$\mu_T(t) = \sum_{i=0}^{L-1} i\,p(i) \quad \text{---------- 7}$$

Let μ_T be the mean intensity, then

$$w_1\mu_1 + w_2\mu_2 = \mu_T \quad \text{---------- 8}$$

$$w_1 + w_2 = 1 \quad \text{---------- 9}$$

Using discriminant analysis, Otsu method defines the between-class variance of the thresholded image [15].

Algorithm:

1) Compute histogram and probabilities of each intensity level.
2) Set up initial $w_i(0)$ and $\mu_i(0)$.
3) Step through all possible thresholds $t = 1 - - - - - - -$ max intensity
   a) Update w_i and μ_i
   b) Compute $\sigma_b^2(t)$.
4) Desired threshold corresponds to the maximum $\sigma_b^2(t)$.

Otsu method is implemented using greythresh function of MATLAB, a threshold value is found. Since tumor region is highly illuminated region, a value of 0.3 is added to the threshold value computed to correctly identify the tumor area. The final threshold value obtained is used to convert the preprocessed image into a binary image. The image is segmented and is ready for post-processing to obtain final tumor image which involves repeated use of dilation and erosion operation [30].

B) Region Growing Method

Region growing is region-based image segmentation method [23]. It involves the selection of initial seed points. This segmentation method examines neighboring pixels of initial seed points and determines whether the pixel neighbors should be added to the region. The process is iterated on. The main objective of this method is to partition an image into regions.

The selection of seed points is based on some user criteria such as pixels in a certain grayscale range, pixels evenly spaced on a grid, area, shape, and texture etc. The initial region begins as the exact location of these seeds. The

regions are grown from these seed points to adjacent points depending on region membership criteria such as pixel intensity, grayscale texture or color [31]. The region growing algorithm is presented below.

Algorithm:

1) An initial set of small areas are iteratively merged according to similarity constraints.
2) Select an arbitrary seed pixel and compare it with neighboring pixels.
3) Regions are grown by adding in neighboring pixels that are similar from the seed pixel and increasing the size of the region.
4) If the growth of one region stops then we choose another seed pixel which does not belong to any region and start again.

The above steps are repeated until all pixels belong to some region.

IV. EXPERIMENTAL RESULTS

A) Qualitative Results

MATLAB 8.3 software has been used for implementing the segmentation techniques. Experiments are performed on local dataset of CT liver images collected from PRISM Diagnostic, Solapur, Maharashtra. The results drawn by respective methods are compared with the images containing manually segmented tumor regions (Fig. 1). Region growing technique yielded better results in terms of accuracy for extracting tumor compared to Otsu technique. Manually segmented image (the ground truth) is overlaid over the segmented image output by both the methods. It is observed that the results produced by region growing are in agreement with manual segmentation. Sample output images are shown in Fig.2.

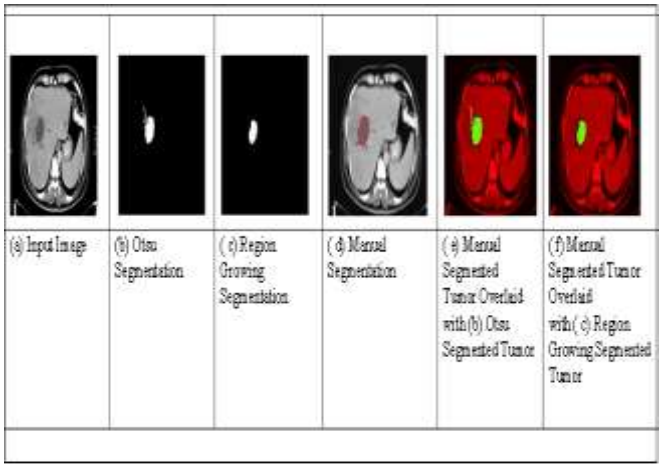

Fig. 1 Segmented regions obtained using Otsu and Region growing methods.

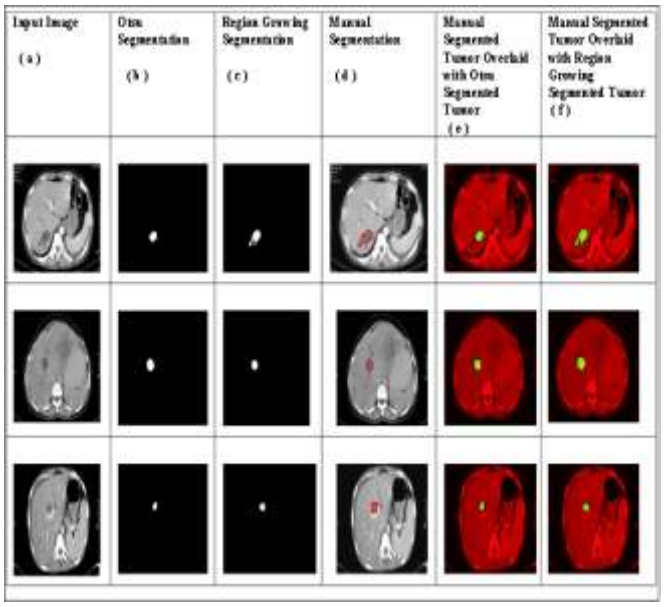

Fig. 2 Sample images of segmented regions obtained using Otsu and Region growing methods.

B) Quantitative Results

The performances of both the methods are computed in terms of sensitivity and specificity statistical measures.

a) Specificity:

Specificity computes the proportion of negatives that are correctly identified as such. It relates the test to detect the absence of characteristics in someone without the characteristics. It can be stated as,

$$Specificity = \frac{TN}{TN+FP} * 100 \quad \text{---------- 10)}$$

A highly specific test rarely misses negative outcomes. Therefore, it is reliable when their result is positive [32].

b) Sensitivity:

Sensitivity computes the proportion of positives that are correctly identified as such. It relates the test to detect the presence of a characteristic in someone with the characteristics [32]. It can be stated as,

$$Sensitivity = \frac{TP}{TP+FN} * 100 \quad \text{---------- 11)}$$

c) Accuracy:

Accuracy is the proportion of correctly diagnosed cases from the total number of cases. It can be calculates as,

$$Accuracy = \frac{TP+TN}{TP+TN+FP+FN} * 100 \quad \text{---------- 12)}$$

Table. 1 Confusion matrix of prediction level for Region growing method

Test images:24	**Condition**	
	Present	**Absent**
Positive	17 (TP)	2 (FP)
Negative	1 (FN)	4 (TN)

Table.2 presents the values of performance measures obtained for Region Growing and Otsu techniques, respectively.

Table. 2 Performance measures for test images

Total test images: 24	**Region Growing Method**	**Otsu Method**
True Positives (TP)	17	16
True Negatives (TN)	4	3
False Positives (FP)	2	2
False Negatives (FN)	1	3
Sensitivity	94.44 %	84.21 %
Specificity	66.66 %	60 %
Accuracy	87.5 %	79.16 %

Region growing method yielded better results in terms of the measures considered compared to the Otsu method. Also, the percentage accuracy of 87.5% is observed for region growing method. Below table presents the accuracy presented by authors in the literature for the methods implemented.

Table. 3 Comparison of methods implemented in this paper with other authors

Sr. No.	**Author**	**Classification technique is used**	**% of accuracy of overlaid images**
1	Chang et. al. [23]	Region Growing	not available
2	Aminah Abdul Malek et.al. [13]	Region Growing	not available
3	Sheenam Bansal, Dr. Raman Maini [17]	Otsu Region Split & Merge	83.33 % 64 %
4	Proposed Method	Region Growing Otsu	87.5 % 79.16 %

V. CONCLUSION

Two popular segmentation techniques, namely, region growing and Otsu are implemented on CT liver/abdomen images for tumor detection. Experimental results, both qualitative and quantitative, shows that Region Growing segmentation technique performs better in extracting the tumor as compared to Otsu segmentation technique in terms of test statistic considered. Other parameters, namely standard deviation and tumor burden are employed in our previous work [33] showing the significance of region growing method for tumor detection from CT liver images.

REFERENCES

[1] Janani V, Meena P. "Image segmentation for tumor detection using fuzzy inference system". International Journal of Computer Science Mobile Computing (IJCSMC) 2013;2(5):244–8.

[2] Dong B, Chien A, SHEN Z. "Frame based segmentation for medical images". Commun Math Sci 2010; 32(4):1724–39.

[3] Suetens,P.,2002. "Fundamentals of Medical Imaging". Cambridge University Press, New York.

[4] Gajanayake, Randike, Yapa, Roshan Dharshana, Hewavithana and Badra. 2009. "Comparison of standard image segmentation methods for segmentation of brain tumors from 2D MR images". In Proc. IEEE 4th International Conference on Industrial and Information Systems, ICIIS'09, pp. 301-305.

[5] G.G. Rajput, Anand M. Chavan. "Automatic Detection of Abnormalities Associated with Abdomen and Liver Images: A Survey on Segmentation Methods". International Journal of Computer Applications (0975 – 8887) Volume 140 – No.4, April 2016.

[6] Naik D, Shah P. "A review on image segmentation clustering algorithms". Int J Comput Sci Inform Technol 2014; 5(3):3289–93.

[7] Christe SA, Malathy K, Kandaswamy A. "Improved hybrid segmentation of brain MRI tissue and tumor using statistical features". ICTACT J Image Video Process 2010;1(1):34–49.

[8] Seerha GK, Kaur R. "Review on recent image segmentation techniques". Int J Comput Sci Eng (IJCSE) 2013;5(2):109–12.

[9] M.Rastgarpour and J. Shanbehzadeh. 2011. "Application of AI Techniques in Medical Image Segmentation and Novel Categorization of Available Methods and Tools". International Multi Conference of engineers and computer scientists, IMECS'11, Vol. 1.

[10] A. Halder and D.K. Kole. 2012. "Automatic Brain Tumor Detection and Isolation of Tumor Cells from MRI Images". International Journal of Computer Applications, Vol.39, No.2.

[11] S. E. Schaeffer, "Graph clustering, " Computer Science Review, pp. 27– 64, 2007.

[12] Aminah Abdul Malek, Wan Eny Zarina Wan Abdul Rahman, Siti Salmah Yasiran, Abdul Kadir Jumaat, Ummu Mardhiah Abdul Jalil , "Seed Point Selection for Seed-Based Region Growing in Segmenting Micro calcifications" , International Conference of the IEEE SSBE Langkawi ,Sep 10-12 ,2012.

[13] Megha Ganjre, J. P. Gawande," Automated Segmentation Of Liver and Tumor and Feature Extraction From Abdominal CT Images Using Region Growing Method ", 10th IRF International Conference, Pune, India, ISBN: 978-93-84209-23-0.

[14] Zhong Qu and Li Hang" Research on Image Segmentation Based on the Improved Otsu Algorithm.", 2010.
[15] Nobuyuki Otsu (1979). "A threshold selection method from gray-level histograms". IEEE Trans. Sys., Man., Cyber. 9 (1): 62–66. doi:10.1109/TSMC.1979.4310076.
[16] Sheenam Bansal, Dr. Raman Maini," Performance Analysis of Color Based Region Split and Merge and Otsu's Thresholding Techniques for Brain Tumor Extraction" International Journal of Engineering Research and Applications (IJERA), Vol. 3, Issue 4, Jul-Aug 2013, pp.1640-1643.
[17] Liver Cancer: Approved by the Cancer.Net Editorial Board, 05/2016.
[18] Maintz, J. and Viergever, M. (1998). "An overview of medical image registration methods". Medical Image Analysis,Vol 2,1–36.
[19] John R. Haaga, Charles F. Lanzieri (2002). "CT and MR Imaging of the whole body". Vol. 1 and 2 Fourth Edition.
[20] International Agency for Research on Cancer "GLOBAL 2012" World Health Organization.
[21] Nader H. Abdel-massieh, Mohiy M. Hadhoud, Khalid M. Amin, "Fully Automatic Liver Tumor Segmentation from Abdominal CT Scans", 2010 IEEE.
[22] Chang, C.-I., Du, Y., Wang, J., Guo, S.-M., Thouin, P.D.," Survey and comparative analysis of entropy and relative entropy thresholding techniques", IEEE Proceedings Vision, Image and Signal Processing, Vol. 153, Page(s): 837 – 850.
[23] Adams, R., Bischof, L., "Seeded region growing", IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 16 , page 641-647, June 1994.
[24] Wankai Deng , Wei Xiao, He Deng, Jianguo Liu, "MRI Brain Tumor Segmentation With Region Growing Method Based On The Gradients And Variances Along And Inside Of The Boundary Curve", International Conference on Biomedical Engineering and Informatics,Vol. 1, Page(s): 393 - 396.
[25] Jun Tang, "Color Image Segmentation algorithm based on Region Growing". International Conference on Computer Engineering and Technology. Vol 6, Page(s): V6-634 - V6-637 2010.
[26] Weihong Cui, Zequn Guan, Zhiyi Zhang, "An Improved Region Growing Algorithm for Image Segmentation", International conference on Computer Science and Software Engineering Vol. 6, Page(s):93 – 96.
[27] M. Sezgin & B. Sankur (2004). "Survey over image thresholding techniques and quantitative performance evaluation". Journal of Electronic Imaging 13 (1): 146–165. doi:10.1117/1.1631315.
[28] P. K. Sahoo, S. Soltani, A. K. C. Wong, and Y. Chen, "A survey of thresholding techniques," Computer Vision Graphics Image Processing, Vol. 41, 1988, pp. 233-260.
[29] https://en.wikipedia.org/wiki/Otsu's_method.
[30] Rafael C. Gonzalez, Richard E. Woods, "Digital Image Processing", 2nd ed., Beijing: Publishing House of Electronics Industry, 2007.
[31] Abdelsamea, M., "An Automatic Seeded Region Growing for 2D Biomedical Image Segmentation", International Conference on Environment and BioScience IPCBEE, vol.21 (2011) © (2011) IACSIT Press, Singapore.
[32] www.wikipedia.org/wiki/Sensitivityand_ specificity.
[33] G.G. Rajput, Anand M. Chavan. "A Study on Automatic Segmentation of Liver Region for Tumor Detection and Grading of Tumor Using Tumor Burden Parameter". International Journal of Pure and Applied Research in Engineering and Technology, 2016, Volume 4 (9) : 680-696.