International Journal of Advances in Computer Science & Its Applications
Volume 6 : Issue 1 [ISSN 2250-3765]
Publication Date : 18 April, 2016

Computed Automatic 3D Segmentation Methods in Computed Tomography Laser Mammography

A.Jalalian, S.Mashohor, R.Mahmud, B.Karasfi, M. I. Saripan, A.R.Ramli, N.Bahri, S. A/P.Suppiah

Abstract— The use of computer assisted diagnosis systems (CADs) has been recognized to improve sensitivity and specificity of diagnostic in radiology research. Accurate segmentation of clinical imaging is a critical step in the CAD systems which affect the efficiency of subsequence stages such as feature extraction and classification. In this paper we propose a 3-dimensional (3D) segmentation method to extract volume of interests (VOIs) in computed tomography laser mammography (CTLM). Three automatic segmentation techniques consist of Color quantization (CQ), K-Mean (Kmean) and Fuzzy C-Means (FCM) clustering have been implemented as a proposed method in a 3D structure. The evaluations were performed by comparison of segmented images and ground truth. The ground truth are extracted using windows/level technique on the original CTLM images. The Jaccard and Dice coefficients in addition volumetric overlap error are employed to quantify the accuracy of segmentation methods. According to the outcomes, the 3D Fuzzy C-Means clustering presents reasonable results compared to other methods.

Keywords— Computed Tomography Laser Mammography; Computer Aided Diagnosis; Segmentation; Breast Cancer

I. INTRODUCTION

Computer aided diagnosis systems (CADs) have developed to achieve higher sensitivity values and impound low false positive rates. The principal steps in CAD systems are comprised segmentation interest regions, feature extraction and classification. Segmentation is a critical step in CAD systems by extracting substantial anatomical structures from background of images. With advances in 3D imaging modalities have increased researches to provide 3D segmentation techniques.

Computed tomography laser mammography (CTLM) is a new laser imaging modality as adjunct to mammography and ultrasound for breast cancer detection [1]. CTLM with its 2D and 3D capabilities utilizes for detection of breast cancer especially in young women and dense breasts [2]. Detection of abnormality in CTLM images is a challenging task for radiologists due to structural complexity in appearance and closeness of color shade. Therefore 3D segmentation methods for extract volume of interests in CTLM images are required.

Subjective and supervised evaluation of segmentation techniques are impractical in many applications, so unsupervised techniques are demanded [3]. To date, there is no desirable segmentation methods that can provide satisfactory results in all medical imaging modalities. To find the most appropriate segmentation method in specific issue requires decision by experiments. One of the substantial challenge in segmentation validation is the lack of a golden standard (Ground truth) to compare segmentation outcomes. In most assessments, manual segmentation by experts be considered as a golden standard. Quantify evaluation of segmentation methods are generally classified into three categories include spatial overlap measures, distance criterions and volumetric measures. Dice similarity coefficient [4-6] and Jaccard similarity [6, 7] are statistical validation metric to assess spatial overlap accuracy in segmentation images. Different distance evaluation measures comprise Hamming distance, partition distance measure, distance distribution signature and Earth mover’s distance are introduced in [8]. Accepted approaches to quantify volumetric measure of segmented regions are categorized in four groups contain (i) percent volume overlap (ii) percent volume distance (iii) correlation with manual tracing across the sample and (iv) group-level 3D shape analysis [9].

In this study we compare three automatic segmentation algorithms include CQ, Kmean and FCM for analysis extracted VOIs in CTLM breast images. These methods have been evaluated using same data and criteria. We present quantitative evaluation of each method with golden standard which are extracted by expert radiologists in CTLM.

The rest of paper is organized as follow, section 2 will describe the background information on computed tomography laser mammography (CTLM) and the segmentation techniques which are used in this paper. Section 3 presents our materials and proposed method on 3D extraction of VOIs from CTLM images and quantify assessment of the segmentation techniques. Report the experimental results on quantitative evaluation of segmentation methods are presented in section 4. Finally, conclusion and future work are discussed in section 5.

A.Jalalian, S.Mashohor, M. I. Saripan, A.R.Ramli
Department of Computer and Communication Systems Engineering, Universiti Putra Malaysia
Malaysia

R.Mahmud, N.Bahri, S. A/P.Suppiah
Faculty of Medicine and Health Sciences, Universiti Putra Malaysia
Malaysia

B.Karasfi
Faculty of Computer and Information Technology Engineering, Islamic Azad University
Iran

SEEK DIGITAL LIBRARY

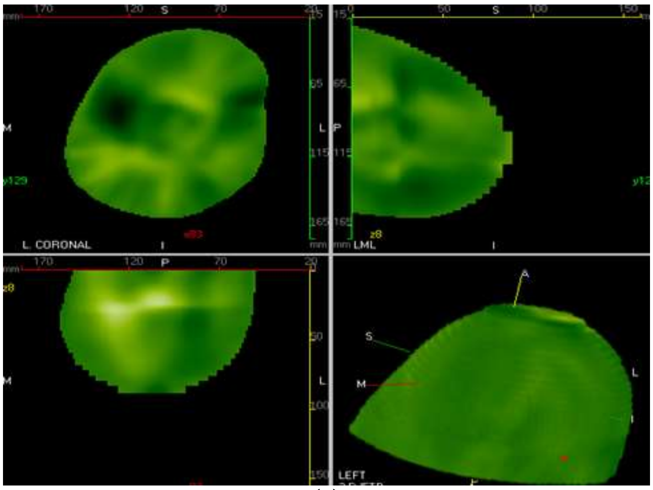
International Journal of Advances in Computer Science & Its Applications
Volume 6 : Issue 1 [ISSN 2250-3765]
Publication Date : 18 April, 2016

II. Preliminary Information

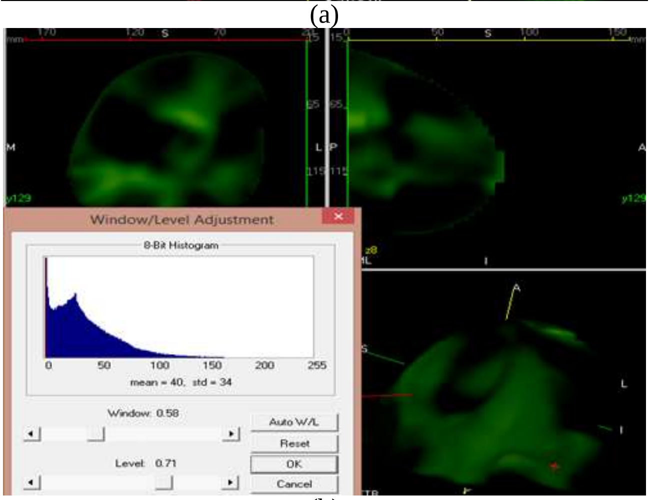
A. *Computed Tomography Laser Mammography (CTLM)*

CTLM use laser beam in specific wavelength (808 nm) which is absorbed by blood and able to visualized neovascularization [10]. The images analyzed in two different projections, Maximum Intensity Projection (MIP) and Front to Back Projection (FTB) [11], which are shown in Fig.1. Angiogenesis occur only in deep veins and window levelling in FTB mode use to eliminate super facial veins, highlight the deep vein and to improve image quality. Detection of angiogenesis rely on the brightness, shape and volume which appear in different form of free standing, spindle shape, dumb-bell shape and diverticulum [1].

In Fig.1 (a) the FTB of CTLM image is shown. The radiologists use window/level adjustment for extracting significant parts of images which is presented in Fig. 1 (b). A diverticulum volume is shown by red arrows in Fig. 1 (b). In our study, the values of window/level which are adjusted by the CTLM expert radiologist, are applied to obtain the ground truth image to evaluate the proposed segmentation methods.



(a)



(b)

Figure 1. The CTLM image, (a) Coronal, Sagittal and axial view in FTB view (b) Window /level on FTB image

B. *Segmentation Techniques*

In this study three previously proposed automatic segmentation methods include CQ, Kmean and FCM clustering are utilized. These methods are used to implement 3D segmentation methods for computed tomography laser mammography images.

Color quantization techniques is a hierarchical clustering method [12] to design a binary tree quantization which attempt to minimize total squared error (TSE) criteria. K-mean clustering is a hard clustering technique to assortment objects based on their specific features into the K groups [13]. Fuzzy C-means is a soft clustering method to assign objects to each category by using fuzzy membership function [14]. In this study, the three methods are used to extract VOIs from consecutive coronal slices of CTLM breast images.

III. Materials and Method

A. *Materials*

The CTLM images used in this study are representative sample of cases obtained in clinical screening in breast wellness center, Malaysia and two datasets of Medoc center in Budapest, Hungary and TATA Hospital in Mumbai, India. In this paper we use total of 95 CTLM images including 56 cases collected data from Malaysia and 39 images from Hungary. Our dataset also include ultrasound and mammogram images respectively for those patients below and above 40 years old. The coronal plane of CTLM images are used for segmentation in this work.

B. *Method*

The objective of this study is to present a 3D automatic segmentation method to extract VOIs in CTLM images. Three segmentation methods include Kmean, FCM and Colour quantization [12] are proposed to develop 3D segmentation techniques. In order to accept the segmentation results in clinical practice, the quantitative evaluation is crucially important. The challenging task in quantitative evaluation is finding the ground truth for evaluation segmentation results. In field of radiology, window width and window level are used to optimize the visualization of the images [15]. This feature is used by radiologists to review CTLM images in conventional diagnosis. The windows/level values adjusted by radiologist in manual diagnosis are utilized to extract the ground truth in our work. The overall diagram to extract VOIs and quantify segmentation techniques is presented in Fig. 2.

Among the number of region-based coefficient, the Jaccard [7] and Dice [5] coefficient have been widely used for performance evaluation of segmentation methods in clinical imaging. These coefficients measure are calculated with true positive, false positive and false negative values. If G is the set of voxels in ground truth image and S is the set of voxels in segmented image, TP is the number of voxels in the intersection of G and S, FP is number of voxels in G not belong to S and FN is number of voxel in S and not belonging in G.

SEEK DIGITAL LIBRARY

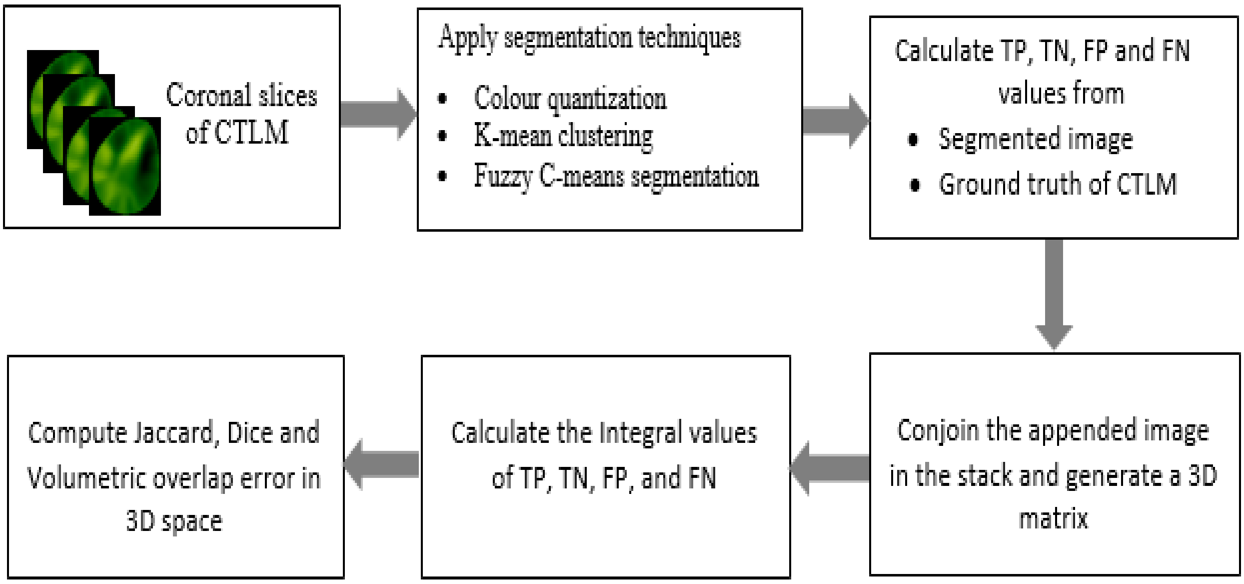


Figure 2. Entire steps of extraction volume of interests (VOIs) and evaluation segmentation techniques

$$J_c = \frac{|G \cap S|}{|G \cup S|} = \frac{TP}{TP + FP + FN} \quad (1)$$

$$D_c = \frac{2\,|G \cap S|}{|G| + |S|} = \frac{2\,TP}{2\,TP + FP + FN} \quad (2)$$

Ratio of volumetric overlap error [15] can also be assessed by

$$VOE = 1 - \frac{|G \cap S|}{|G \cup S|} \times 100 \quad (3)$$

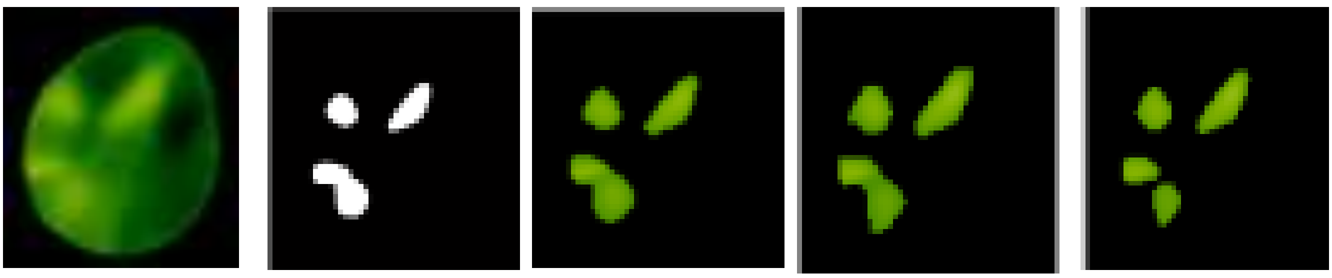
The value varies from 0 – 100 and zero value is for perfect segmentation.

In our work to calculate the coefficients value for 3D segmentation evaluation total value of *TP*, *FP*, *TN* and *FN* for all slices are used to measure Jaccard, Dice factor and volumetric overlap error.

IV. Results and Discussion

To find the most appropriate segmentation method in specific issue requires decision by experiment .The objective of this study was to acquire a reasonable segmentation technique in CTLM images to extract volume of interests. In our investigation three automatic segmentation techniques include CQ, Kmean and FCM clustering are applied in 3D space in 95 CTLM images.

The ground truth images are extracted by windows/level values adjusted by expert radiologist to evaluate proposed segmentation method. A comparison of segmented images by FCM, Kmean and CQ technique with ground truth image for a sample slice is shown in Fig. 3.



(a) (b) (c) (d) (e)

Figure 3. Comparison of Ground truth and segmented images. (a). Original image, (b) Ground truth image, (c) Segmented image by FCM, (d) Segmented image by Kmean, (e) Segmented image by CQ method

SEEK DIGITAL LIBRARY

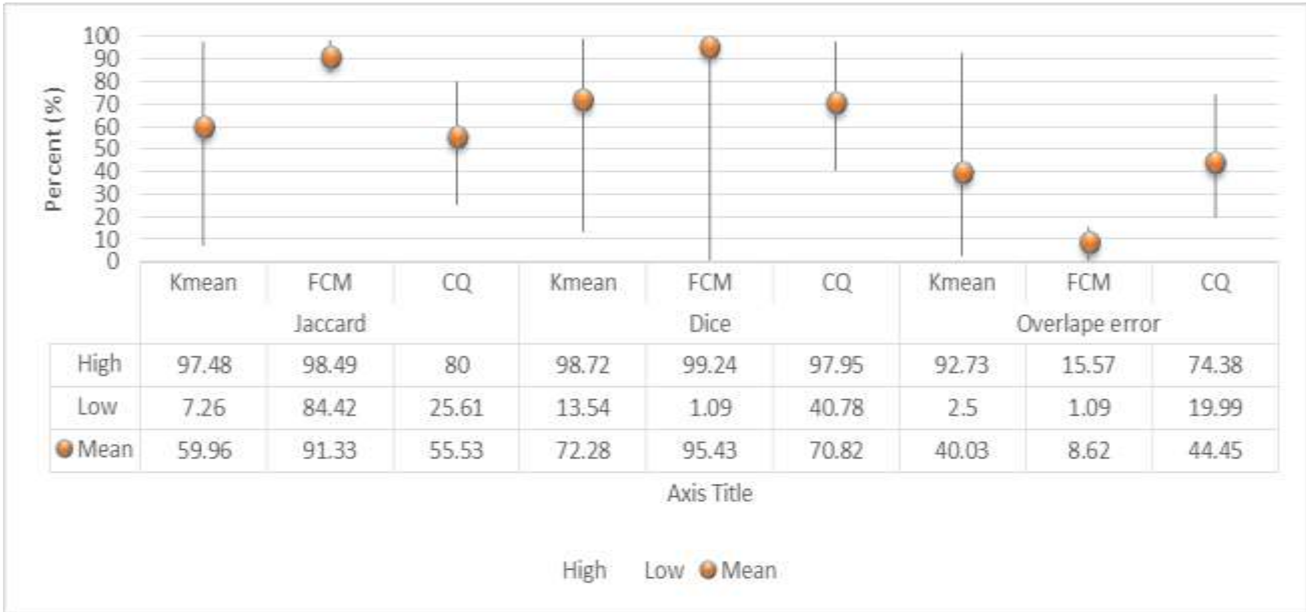


Figure 4. Comparison between the Jaccard, Dice and volumetric overlap error to evaluate 3D Kmean, FCM and CQ methods in segmentation of 95 CTLM images.

There has been much attention to use Jaccard and Dice coefficients besides volumetric overlap error in the field of medicine for assessment the performance of segmentation algorithms. Fig. 4 presents an overall assessment for segmentation techniques based on Jaccard, Dice and volumetric overlap error. The results illustrate that 3D FCM surpasses two other methods by providing maximum values of 98.49, 99.24 and minimum values of 84.42, 91.55 for Jaccard and Dice indexes. Since in the calculation Dice coefficient weight of positive attribute is doubled thus the outcomes always be greater than or equal to Jaccard measure.

Further metric that used to quantify the accuracy of segmentation methods is volumetric overlap error. The value is varies among 0 to 100, which zero value shows the perfect segmentation. Based on results obtained on segmentation of 95 CTLM images, 3D FCM Clustering has produced acceptable results than other two methods. The mean volumetric overlap error were 40.03, 8.62 and 44.45 for 3D Kmean, FCM and CQ algorithms respectively. The minimum value for volumetric overlap error in 3D FCM was 1.09 and maximum value 15.57. FCM gives better result in overlapping measure than Kmean and CQ since the data point may belong to more than one cluster based on assigned membership function. The overall results have shown that 3D FCM clustering presents reasonable outcomes in extraction volume of interests for computed tomography laser mammography.

V. Conclusion

VI. We have presented a 3D extraction of volume of interests (VOIs) for breast cancer detection in CTLM images. In this study, three segmentation techniques include K-mean, Fuzzy C-means and color quantization clustering were evaluated to extract volume of interest areas. In order to quantify the segmentation results Jaccard, Dice and volumetric overlap error were computed for 95 CTLM images. Overall results indicate superiority of 3D Fuzzy C-means technique compared to other methods. The mean values of Jaccard, Dice and volumetric overlap error for 3D Fuzzy C-means technique in our CTLM data set are 91.33, 95.43 and 8.62 respectively. Investigation of the mean values for quantify factors indicate that 3D Fuzzy C-means have greater values for Jaccard and Dice coefficients and minor value in volumetric overlap error. The outcomes of this research will be used for designing a computer aided detection/ diagnosis system in CTLM image for breast cancer detection.

Acknowledgment

This work was funded by Ministry of Science, Technology & Innovation (MOSTI) Malaysia. Research grant No: 5457080.

We gratefully acknowledge who helped us to do our study. Without their continued efforts and support would have not been able to gather the data set and successful complementation our work.

- Laszlo Meszaros: For Sharing dataset
- Dr Ahmad Kamal Bin Md Alif: For help us to review and report CTLM images.
- Nur Iylia Roslan: For assisting us for data collection

References

1. Qi, J. and Z. Ye, *CTLM as an adjunct to mammography in the diagnosis of patients with dense breast.* Clinical imaging, 2013. **37**(2): p. 289-294.
2. Eid, M.E.E., H.M.H. Hegab, and A.E. Schindler, *Role of CTLM in early detection of vascular breast lesions.* Egyp J Radiol Nucl Med, 2006. **37**(1): p. 633-643.

SEEK DIGITAL LIBRARY

3. Zhang, H., J.E. Fritts, and S.A. Goldman, *Image segmentation evaluation: A survey of unsupervised methods.* computer vision and image understanding, 2008. **110**(2): p. 260-280.
4. Zou, K.H., et al., *Statistical validation of image segmentation quality based on a spatial overlap index 1: Scientific reports.* Academic radiology, 2004. **11**(2): p. 178-189.
5. Dice, L.R., *Measures of the amount of ecologic association between species.* Ecology, 1945. **26**(3): p. 297-302.
6. Crum, W.R., O. Camara, and D.L. Hill, *Generalized overlap measures for evaluation and validation in medical image analysis.* Medical Imaging, IEEE Transactions on, 2006. **25**(11): p. 1451-1461.
7. Jaccard, P., *The distribution of the flora in the alpine zone.* New phytologist, 1912. **11**(2): p. 37-50.
8. Jiang, X., et al., *Distance measures for image segmentation evaluation.* EURASIP Journal on Applied Signal Processing, 2006. **2006**: p. 209-209.
9. Morey, R.A., et al., *A comparison of automated segmentation and manual tracing for quantifying hippocampal and amygdala volumes.* Neuroimage, 2009. **45**(3): p. 855-866.
10. Bílková, A., V. Janík, and B. Svoboda, *[Computed tomography laser mammography]*. Casopis lekaru ceskych, 2009. **149**(2): p. 61-65.
11. Floery, D., et al., *Characterization of benign and malignant breast lesions with computed tomography laser mammography (CTLM): initial experience.* Investigative radiology, 2005. **40**(6): p. 328-335.
12. Orchard, M.T. and C. Bouman, *Color quantization of images.* Signal Processing, IEEE Transactions on, 1991. **39**(12): p. 2677-2690.
13. Hartigan, J.A. and M.A. Wong, *Algorithm AS 136: A k-means clustering algorithm.* Applied statistics, 1979: p. 100-108.
14. Bezdek, J.C., R. Ehrlich, and W. Full, *FCM: The fuzzy c-means clustering algorithm.* Computers & Geosciences, 1984. **10**(2): p. 191-203.
15. Kohlberger, T., et al., *Evaluating segmentation error without ground truth*, in *Medical Image Computing and Computer-Assisted Intervention–MICCAI 2012*. 2012, Springer. p. 528-536.

SEEK DIGITAL LIBRARY