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A Survey on Ultrasound Image Segmentation Algorithm for Detection of Female Pelvic Masses

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Abstract- Imaging is a very precious tool for diagnostic purpose and various modalities provides an excellent way for viewing the anatomy of the organs. These various imaging modalities are used for differentiating normal and diseased anatomy. For providing support to these imaging modalities computers are used for processing and analysis. This research paper provides a review of recent image segmentation algorithms for medical images. From the recent survey, the various methods and applications of medical image segmentation are discussed. The narrative of this paper is focused on different image segmentation algorithms used for computer aided diagnosis of female pelvic masses for ultrasound.

Keywords: Female Pelvic Masses, Ultrasound Images, Segmentation Algorithms, Clustering

I. INTRODUCTION

Ultrasound is used by an innumerable of imaging technologists because it is considered practical, safe, fast and easy to utilize with low cost. Ultrasound image segmentation is highly agreed for its quality of data. Attenuation, speckle, shadows and signal dropout are few of the characteristics artifact which makes the segmentation task complicated.Due to low cost and less radiation effect, the ultrasound imaging is widely used for segmentation [1-2]. Because low cost and less ionizing radiation, medical imaging is a more flexible for ultrasound images. Due to degradation of ultrasound signals, the quality of the image is affected when propagating through biological tissues. This enhancement algorithms classified into pre-processing and post-processing algorithms. Further,this algorithm analyzeditsmerits and demerits. It can reduce speckle and reverberations, and make the more uniform PSF across theimage. The pelvis is a complex anatomicregion contains few organs and systems which take care of different and independent functions. Gastro intestinal tract,urinary tractare abdominal pelvic sites. Fibroids are an abnormal growth of smooth muscle. These growths are benign tumors that occur as a single large mass or many smaller masses [3-4]. Four different types of fibroids are: Submucosal fibroids develop just under the inner lining of the uterus and grow into the uterine cavity.

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Intramural fibroids are the most common type and develop and expand inside the uterine wall, which make the entire uterus feel larger than normal (and may cause "bulk symptoms. Though, these fibroids can pay to infertility and miscarriages, thus upsetting the reproductive health of women [5-6]. Organization of this paper follows: Section 2 provides the various Ultrasound image segmentation Algorithms. Section 3 concludes this paper.

A. Ultrasound Image Segmentation Algorithms

Ultrasound examination can show the variance between cysts and solid tumors such as fibroids. It cannot exactly diagnose the number, size or position of the fibroids. Various Segmentation methodsare used for segmenting this images. The 2-D ultrasound images are segmented using Split-and merge image segmentation approach [7].In block comparison, a texture based measure is used which accounts the block size. Also, developed a texture characteristics segmentation [8-9].

a. Histogram Thresholding

This is very simple and effective mage segmentation algorithm in which it provides low-cost and fast computation. A threshold value(constant) is used to segment object and boundary. Optimal thresholding results in minimum error segmentation. Thresholding method can find initial lesion boundary [10 - 11]. Optimal threshold selection algorithm:

1) Making an assumption that no prior knowledge about the exact object was knownand the remaining is object, this is been the first approximation.

2) At step s,compute μ_B^s and μ_O^s is the mean of backgroundand graylevel objects. It is described as:

$$\mu_B^s = \frac{\sum_{(i,j)\in background} f(i,j)}{\#background\_pixels} \mu_O^s = \frac{\sum_{(i,j)\in objects} f(i,j)}{\#object\_pixels} \quad (1)$$

3) Set $T^{s+1} = \frac{\mu_B^s + \mu_O^s}{2}$ (2)

Where, T^{s+1} indicates the background object updation.

4) If $T^{s+1} = T^s$, stop the procedure otherwise go to step 2.

B. Region Based Segmentation Algorithm

Segmentation based on edge based method and region growing methods are different .region growing techniques are better for noisy image whose borders of object all extremely difficult to detect. Important property of region is homogeneity. Region growing segmentation should satisfy the following condition,

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$R=\cup_{i=1}^{s} R_i, Ri \cap Rj=\theta, i\neq j$ (3)

and the maximum region homogeneity conditions,

H(Ri)=True , i=1,2,…,S

H(Ri∪Rj)=False, i≠j,Ri adjacent to Rj (4)

This methodis mostly used for image segmentationdue to its fast processing speed. The main drawbacks is that it cannot detect the boundary exactly for US images [12- 13].

C. Active Contour Model based Image Segmentation

This model is defined as energy minimization splineand it is used to find the boundaries[14].The snake is defined parametrically as v(s)=[x(s),y(s)];where x(s),y(s) are x,y coordinates along the contours ϵ [0,1]. The minimizedenergy function is described as:

$$\boldsymbol{E^*_{snake}}=\int_0^1 (\boldsymbol{v(s)})\boldsymbol{ds}$$

$$=\int_0^1 \ (\boldsymbol{E_{int}}\left(\boldsymbol{v(s)}\right) + (\boldsymbol{E_{image}}\mathbf{(v(s))}+ +(\boldsymbol{E_{con}}\mathbf{(v(s)))ds}(5)$$

The internal energy described by Kass [16] et al and it is defined as

$$\boldsymbol{E_{int}} = \boldsymbol{\alpha(s)}|\frac{\boldsymbol{dv}}{\boldsymbol{ds}}|^2 + \boldsymbol{\beta(s)}|\frac{\boldsymbol{d^2v}}{\boldsymbol{ds^2}}|^2 \qquad (6)$$

Where, $\alpha(s), \beta(s)$are elasticity and stiffness of the snake.The total energy of the image is described as:

$E_{image}=w_{line}E_{line}+w_{edge}E_{edge}+w_{term}E_{term}$ (7)

This method is also describedalong with genetic algorithm in order to over-come the limitations of active contours and local minima 14-15].

D. Fuzzy-C-Means Clustering Algorithm

Clustering is the process of organizing the objects into groups whose members are like in certain way. It is a vital process in image segmentation. The main use of clustering algorithm is to make detection and handling of noisy data easy. Crisp clusteringare defined boundary and Fuzzy clusteringare soft clustering which is not having defined boundaries [16]. The following objective function has to be minimized.

$$J_m = \sum_{j=1}^{N}\sum_{k=1}^{C} \mu_{jk}^m ||x_j - c_k||^2, 1\leq m<\infty \quad (8)$$

The cluster centers c_k by:

$$u_{jk} = \frac{1}{\sum_{l=1}^{C}\left[\frac{||xj-ck||}{||xj-cl||}^{\frac{2}{m-1}}\right]}, c_k = \frac{\sum_{j=1}^{N}\mu_{jk}^m.x_j}{\sum_{j=1}^{N}\mu_{jk}^m} \qquad (9)$$

This iteration will stop when,

$$max_{jk}\{|ujk^{l+1} - ujk^l|\} < \epsilon$$

where ε isa stop criterion between 0 and 1, whereas l are the iteration steps. FCM algorithm steps:

- Initialize U=$[u_{jk}]$ matrix,$U^{(0)}$
- $c_k = \frac{\sum_{j=1}^{N}\mu_{jk}^m.x_j}{\sum_{j=1}^{N}\mu_{jk}^m}$
- $U^{(l)}$,$U^{(l+1)}$) where $u_{jk} = \frac{1}{\sum_{l=1}^{C}\left[\frac{||xj-ck||}{||xj-cl||}^{\frac{2}{m-1}}\right]}$
- If$||ujk^{l+1} - ujk^l|| < \epsilon$ then stop, or else go to step 2.

Due to fast convergence and its simplicity,this clustering mostly used to segment the images[16].

E. Spatial FCM

In this, both the image intensity and generated speckle pattern are utilized properly and spatial relationship between pixels is important in this algorithm [17 - 18]. Here, misclassification occurs due to noise and it can be overcome by the selection of noise probability. This FCM algorithm is proposed based on changing themembership values of each cluster [19]. The spatial membership function is described as:

$$u'_{jk} = \frac{u_{jk}^p f(u_{jk})^q}{\sum_{l=1}^{C} u_{lk}^p f(u_{lk})^q} \qquad (10)$$

Where$p$ and q are control parameters andthe relative significance of u and f terms. As a result, the noisy pixel can be classified correctly. Based on this requirement, the spatial FCM algorithm is defined as,

1) Generate random numbers and considered as initial memberships. Set the number of cluster then, calculatec_k which is described in FCM algorithm.
2) For a very small positive number ∈, Compute u_{jk}described in FCM algorithm.
3) Relateu_{jk}into the pixel position then, compute the modifiedmembership u'_{jk}. Finally, obtain the objective function J_m.
4) Update the cluster center$c$.
5) Until the stopping condition is satisfied, Repeatthe steps from 2 to 4.

F. Kernel Fuzzy C-Means Algorithm

This most popular algorithm used in medical image segmentation. In FCM, the pre-defined cost function is minimized using the centroid and it has estimated adaptively.In Kernel Induced Fuzzy C Means (KFCM) clustering algorithm, the spatial neighborhood information are incorporated with traditional FCM theniterativelyupdating the objective function of each cluster. Gaussian kernel function is used to minimize the objective function..

The Gaussian function $\eta_j$computed using the following equation:

$$\eta_j = K\frac{\sum_{j=1}^{n} u_{jk}{}^m(2(1-K(xk,vi)}{\sum_{j=1}^{n} u_{jk}{}^m} \qquad (11)$$

This clustering overcomes the drawbacks of FCM efficiently and improves the clustering performance [20] The various image segmentation algorithms which is developed and discussed earlier along with their advantages and disadvantagesis summarized in Table 1.

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Table 1. Summary of Various Image Segmentation Algorithms

Methods	Descriptions	Advantages	Disadvantages
Histogram Thresholding	Inorder to segment the image, the threshold value is used..	• Computationally inexpensive.	• Highly noise sensitive.
Region growing	By adding the seed point of similar neighbouring pixels, the region is grows.	Fast processing speed	• Seed point has to be selected manually for low quality ultrasound image. • It cannot promise accurate boundary detection for US images.
Active Contour Model Segmentation	Based on energy minimization, the image boundaries are computed.	In minimal energy state, this has robust and self adapting one. Used for dynamic image data.	In local minima states, the snakes are frequently get stucked.
Fuzzy-C-Means Clustering Algorithm	Ffor the analysis of data and construction of models, the Fuzzy clustering is a most powerful unsupervised clustering technique widely used.	FCM is an Unsupervised algorithm.	• This traditional FCM based image segmentation algorithm classifies only based on the character vector without considering the spatial information of the image. • Distorted and more sensitive to noises. • It requires long computational time.
Spatial FCM	SFCM incorporates spatial information into the iteration to eliminate noises and the outliers.	High accuracy	Classification is carried out based on Euclidian distance and it is only way suitable for spherical and ellipsoidal noises.
Kernel Fuzzy C-Means Algorithm	This KFCM clustering algorithm incorporates the spatial neighborhood information with traditional FCM algorithm. For each cluster, the objective function is minimized.	• KFCM has best performance.	KFCM clustering is sensitive to noise; some redundant boundaries will appear.

II. CONCLUSION

In this research paper, the Ultrasound Image Segmentation algorithms for detection of Female Pelvic Masses are critically reviewed and discussed their merits and demerits. In addition, thebrief review of current methods for image segmentation used fordetection of Female Pelvic Masses is discussed through mathematical equations. The issues related to various image segmentation algorithms are elaborated in detail for further direction of this research work.

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