Image Segmentation Of Medical Images Using Deformable Model

Komal Maheshwari

Information Technology Mehran
UET Jamshoro, Pakistan

ABSTRACT

Image segmentation is a process of dividing an image into sub-parts for further analysis. This technique plays an important role in the field of image processing. The aim of this technique is to make the representation of image into precise form and easy to study. Currently there are different techniques for image segmentation. Every technique have its own advantages and disadvantages. Usually segmentation is performed by traditional techniques like thresholding, and edge-based. However, it is liable to some limitations which include sampling artifacts and noise. To remove these artifacts, noise and extra boundaries some post processing is required. The main goal of this research is to examine different techniques of image segmentation and to identify the limitations of traditional image segmentation techniques and to highlight the strengths of new segmentation technique that is Deformable Model in the field of medical imaging by comparing their results. Comparison is done on the basis of mean square error (MSE) and peak signal to noise ratio (PSNR) on different types of medical images like MRI, Heart CT etc. Furthermore, our work addresses the open problems and provides the perspective of the future work for comprehension of automated diagnosis of other diseases.

Keywords: *Image segmentation, Deformable Model, Medical Images, Active contours*

1. INTRODUCTION

Image segmentation is a process in which images are divided into portions to simplify or change the demonstration of image into somewhat that is significant and easier to recognize [1]. The division of image into parts based on some features like texture, intensity or color. Finally the results obtained are a set of contours that extract the image or collection of parts or segments that cover entire image. Image segmentation is helpful in many applications for example Machine Vision, Object detection, Traffic control system, medical field etc.

Medical image segmentation plays a dynamic role in many applications of medical. Different segmentation techniques applied on medical images like thresholding, edge-based, region-based, model based segmentation, pixel based and watershed transform etc.

✉ komalramchandani02@gmail.com

But still this field requires more work because there are many limitations of these classical techniques and each technique has its own drawbacks.

To overcome those limitations of traditional image segmentation techniques a new model (i.e. deformable model) is introduced. Deformable model is newly introduced technique which helps to get accurate results especially in the field of medical. Deformable models are simply curves that can move with the help of two forces i.e. internal and external. Internal force is used to make image smoother and external force is used to collect the data for further analysis.

This research identifies the limitations of traditional image segmentation techniques; study the newly introduced technique i.e. deformable model. Then finally compares the results of traditional image segmentation techniques and deformable model with the help of mean square error (MSE) and peak to signal noise ratio (PSNR).

2. RELATED WORK

M. Lee, S. Park [2] lodged an approach in which they displayed 3D representation results of segmented image by using a cubes algorithm. They visualize the objects for detail examination and compare the results of synthetic images with snake and also proposed the new model of speed function that is sum of three geometric functional measures such as leveling term, arrangement term and minimal variance. The purpose of this model is to improve the accuracy of images when boundaries of images were flatter.

A. Valsecchi [3] has introduced the Hybrid Level Set method that combines both edge based and region based segmentation techniques. The proposed mechanism that is based on Genetic Algorithm (GA) provides the ability to adapt different image segmentation tasks. They also compare their result with six state-of-the-art image segmentation techniques and also analyze the performance of image registration and parameter learning steps.

A. Gupta et al [4] introduced a method that is used for testing an automatic initialization of ventricular boundaries in Cardiac MR Images. The proposed algorithms can study the cardiac MR in less than 10 minutes by loading, sorting, visualizing, and analyzing the images.

A. M. Pouch et al. [5] proposed an automatic method for segmentation in 3D transesophageal echocardiographic images of mitral leaflets. The system is used to make for 3D patient-specific improvements of the mitral leaflets and annulus from 3D TEE image data with no user communication from associates opposite segmentation and modeling techniques.

P. Singhal [6] works on the graphs of image segmentation techniques. The goal of this is to extract the object boundaries by using different techniques of image segmentation and gives the comparison results.

3. TRADITIONAL IMAGE SEGMENTATION TECHNIQUES

There are many techniques of image segmentation but different techniques have different types of limitations on different images. Even choosing a technique for specific type of images is a difficult problem. In this paper we have discussed the traditional techniques of image segmentation and have compared their results with deformable model. Traditional techniques are thresholding, edge based, region based and watershed.

A. Thresholding

Thresholding is an influential process based on characteristics of images in which images have light objects on dark background. Thresholding is an approach which convert multilevel or grayscale image into binary image. This conversion is completed by selection of proper seed or initial value (Threshold value T). When the value of T is constant or fixed, than this method is called global thresholding else it is local thresholding. Multiple thresholds are used to recompense for uneven brightness in local thresholding as global thresholding process can fail in uneven brightness for background [7].

Let G(x, y) is a threshold form of f(x, y) at Threshold value T, as shown in equation (1)

$$G(x,y) = \begin{cases} 1, & if\ f(x,y) \geq T \\ 0, & Otherwise \end{cases} \qquad (1)$$

Limitations of thresholding method are that selection of automatic threshold value is difficult as well as it is sensitive to noise and this approach cannot be applied to multichannel images.

B. Edge Based Segmentation

The process represents the information about boundaries in the images. Edge based segmentation helps to identify sketches of objects and boundaries between object and background in an image. In this technique more prior information found and give the best result of segmentation. This approach is good for those images having better difference between objects.

In our research we used Sobel edge detection method [8]. Sobel edge detection method computes the estimate of gradient. There are two 3*3 kernels used in this operator one for horizontal and other is for vertical, where Gx is used for horizontal kernel and Gy is used for vertical kernel as shown in equation (2).

$$Gx = \begin{matrix} 1 & 0 & -1 \\ 2 & 0 & -2 \\ 1 & 0 & -1 \end{matrix} \quad Gy = \begin{matrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -2 \end{matrix} \qquad (2)$$

After finding the resultants of gradient approximation then find the gradient magnitude as shown in equation (3).

$$G = \sqrt{Gx^2 + Gy^2} \qquad (3)$$

The limitation of edge based segmentation techniques is that it is not suitable for those images having noise or those images which are edgeless and also not suitable for images having smooth boundaries.

C. Region Based Segmentation

This approach is useful for partitioning an image into homogeneous regions. As edge based segmentation gives information about boundaries in the image similarly region based approach gives information about objects found in the image that are related to a set of predefined conditions.

The limitations of region based segmentation are difficult to set seed or initial value as well as this method is very expensive with regard to memory and time and also sensitive to noise.

D. Deformable Model

Deformable model is robust method to extract smooth boundaries as well as other desirable information. This model can allow finding missing or fake data and it is well suited for time varying.

Deformable models are simply curves, volume or surface and used to overcome the limitations of traditional image segmentation techniques. These curves defined within image area that can move under two forces i.e. internal and external. Curves, volume or surface is defined by internal forces and data is computed by external forces [9].
Deformable model is divided into two types. One is parametric and other is geometric deformable model. Parametric deformable model, introduced by [10], also called snakes model. This model allows directing interaction with real time applications and representing by curves during deformation in parametric form.

On the other hand geometric deformable model, introduced by [11], represent by curves and independent on parametric form. This model depends on curve theory of evolution and level set. Geometric deformable model can handle the topology automatically as in parametric deformable model that is a drawback. Recovery of images or objects cannot be handled by parametric deformable model. Geometric deformable model helps to address limitation of parametric deformable model.

4. METHODOLOGY

In our research first we take input a real image that is MRI or CT scan image. Then preprocess those images by both techniques i.e. classical segmentation techniques and deformable model. The obtained result i.e. mean square error and peak signal to noise ratio are compared.

Mean square error measures the quality of estimator. It is simply difference of estimator and what is expected.

The mean square error of an estimator Φ w.r.t unknown parameter θ is:

$$\text{MSE}(\Phi) = \sum[\Phi - \theta]^2 \qquad (4)$$

Peak signal to noise ratio is the ratio between maximum possible value and corrupting noise that affects the reliability of the representation of image.
The PSNR in decibels (db) is well-defined as

$$\text{PSNR} = 10.\log_{10}\left(MAX^2/MSE\right) \qquad (5)$$

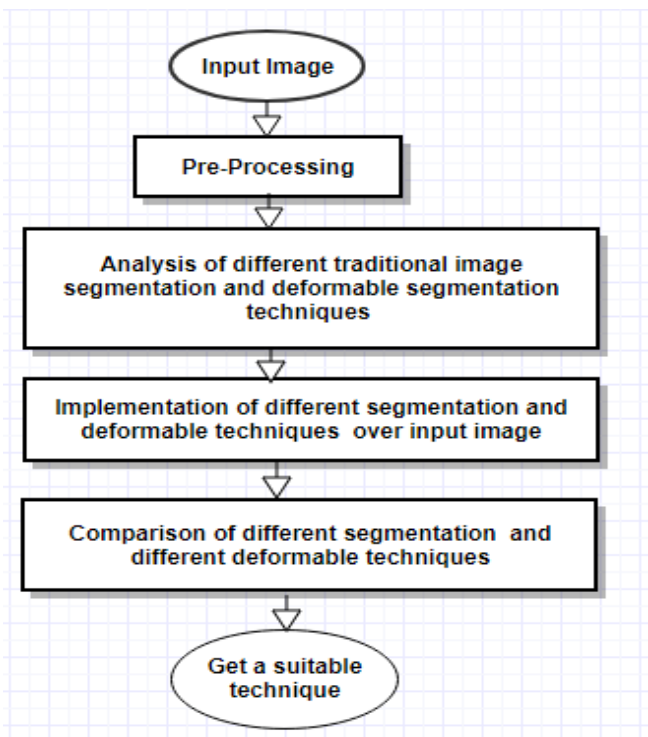


Fig. 1. Flowchart

5. RESULTS

Here are MATLAB experiments results of comparison of traditional segmentation techniques and deformable model. Following results are based on mean square error and peak signal to noise ratio.

The input images have been taken from "Radiopaedia.org". Firstly we take input image of MRI brain then apply traditional segmentation technique and deformable technique. Following figure (2) shows the results of different techniques. Fig. 2(a) is input image. Fig. 2(b) is a result of edge based segmentation. Fig. 2(c) is a result of thresholding by using edge based segmentation. Fig. 2(d) is a result of region based segmentation. Fig. 2(e) is the result of deformable model.

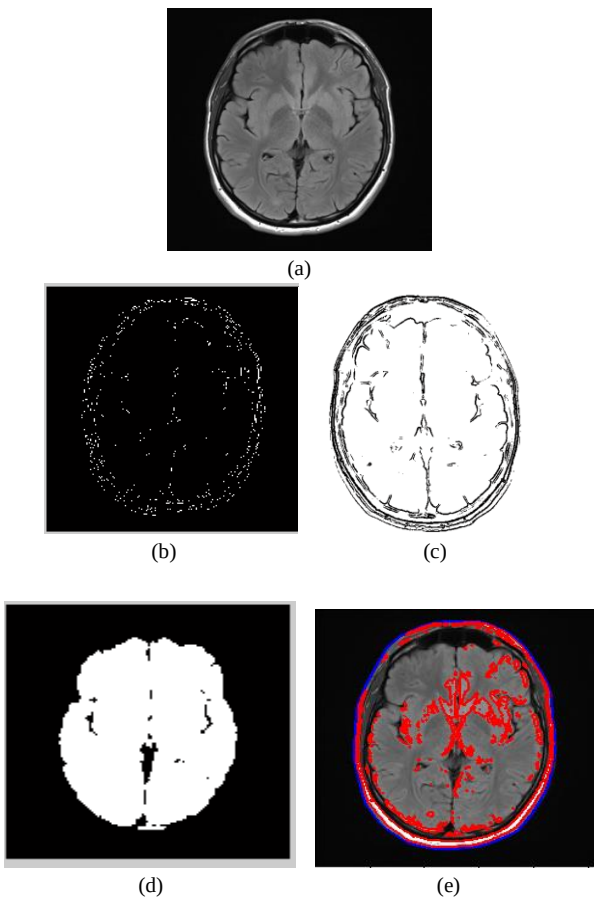


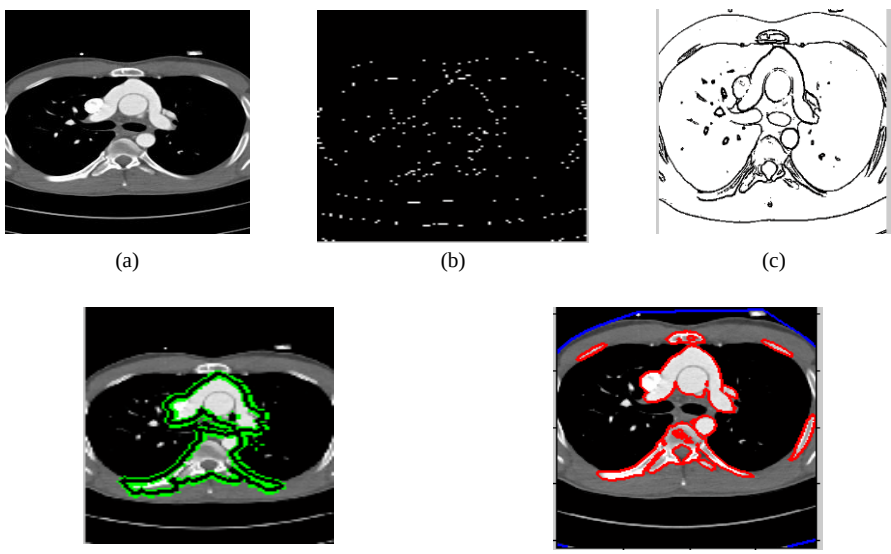
Fig. 2. Case courtesy of Dr Bruno Di Muzio, Radiopaedia.org, rID: 41113

Following chart shows the main difference between techniques. As shown in Table 1, the MSE value of region based segmentation is less than other techniques at the expense of more iterations and it detects less regions than deformable model however MSE value of deformable model is greater than region based but less than other techniques. More over deformable model uses less number of iterations than region based and it not only detects the inner region but edges as well.

Table 1 Comparison Results of Techniques of MRI

Techniques	MSE	PSNR	No.of Iterations
Edge Based	150.67	26.3846524 dB	NA
Region Based	0.32	53.0628600 dB	700
Thresholding	139.93	26.7056287 dB	NA
Deformable Model	138.50	26.7502730 dB	300

In second case traditional segmentation technique and deformable technique is applied on heart CT. Following figure (3) shows the results. Fig. 3(a) is input image. Fig. 3(b) is a result of edge based segmentation. Fig. 3(c) is a result of thresholding by using edge based segmentation. Fig. 3(d) is a result of region based segmentation. Fig. 3(e) is the result of deformable model.



(a) (b) (c)

(d) (e)

Fig. 3. Case courtesy of Dr Matt A. Morgan, Radiopaedia.org, rID: 31607

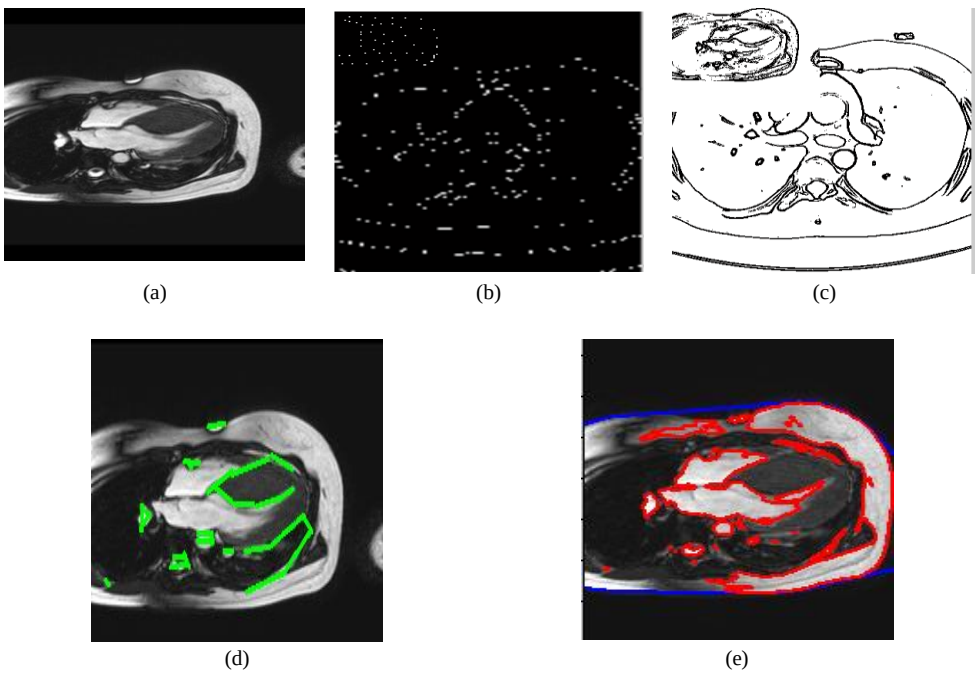
Following chart shows the main difference between techniques. As shown in Table 2, the mean square error value of region based segmentation is less than other techniques at the cost of more iteration and selects less inner region as compared to deformable model.

However MSE value of deformable model is greater than region based but less than other techniques. More over deformable model uses less number of iterations than region based and it not only detects the inner region but edges as well.

Table 2 Comparison Results of Techniques of HEART CT

Techniques	MSE	PSNR	No. of Iterations
Edge Based	79.14	29.1805987	NA
Region Based	0.09	58.4858855 dB	750
Thresholding	70.68	29.6720888 dB	NA
Deformable Model	55.50	26.7502730 dB	350

In second case traditional segmentation technique and deformable technique is applied on heart CT. Following Fig. 4 shows the results. Fig. 4(a) is input image. Fig. 4(b) is a result of edge based segmentation. Fig. 4(c) is a result of thresholding by using edge based segmentation. Fig. 4(d) is a result of region based segmentation. Fig. 4(e) is the result of deformable model.



(a) (b) (c)

(d) (e)

Fig. 4. Case courtesy of Dr Matt A. Morgan, Radiopaedia.org, rID: 31527

Following chart shows the main difference between techniques. As shown in Table 3, the mean square error value of region based segmentation is less than other techniques at the

cost of more iteration and selects less inner region as compared to deformable model. However MSE value of deformable model is greater than region based but less than other techniques. More over deformable model uses less number of iterations than region based and it not only detects the inner region but edges as well.

Table 3 Comparison Results of Techniques of MRI

Techniques	MSE	PSNR	No. of Iterations
Edge Based	79.14	29.1805987 dB	NA
Region Based	0.77	55.3948742 dB	750
Thresholding	110.54	30.5613228 dB	NA
Deformable Model	50.88	32.3571751 dB	450

REFERENCES

[1] R.Yogamangalam and B.Karthikeyan, “Segmentation Techniques Comparison in Image Processing”, in School of Computing, SASTRA University, Thanjavur, TamilNadu, India, vol. 5, 2013.

[2] M. Lee, S. Park, W. Cho, S. Kim and C. Jeong, "Segmentation of medical images using a geometric deformable model and its visualization," in *Canadian Journal of Electrical and Computer Engineering*, vol. 33, no. 1, pp. 15-19, Winter 2008.

[3] A. Valsecchi, P. Mesejo, L. Marrakchi-Kacem, S. Cagnoni and S. Damas, "Automatic evolutionary medical image segmentation using deformable models," *2014 IEEE Congress on Evolutionary Computation (CEC)*, Beijing, 2014, pp. 97-104.

[4] A. Gupta *et al*., "Cardiac MR image segmentation using deformable models," *Proceedings of Computers in Cardiology Conference*, London, 1993, pp. 747-750.

[5] A. M. Pouch *et al*., "Fully automatic segmentation of the open mitral leaflets in 3D transesophageal echocardiographic images using multi-atlas label fusion and deformable medial modeling," *2012 IEEE International Ultrasonic Symposium*, Dresden, 2012, pp. 220-223.

[6] P. Singhal and A. Verma, "A review on graph based segmentation techniques," *2016 10th International Conference on Intelligent Systems and Control (ISCO)*, Coimbatore, 2016.

[7] R.Yogamangalam and B.Karthikeyan, “Segmentation Techniques Comparison in Image Processing”, in School of Computing, SASTRA University, Thanjavur, TamilNadu, India, vol. 5, 2013.

[8] Irwin Sobel, History and Definition of the Sobel Operator, 2014.

[9] Chenyang Xu, Dzung L. Pham, Jerry L. Prince, “Image Segmentation of Image Segmentation”.

[10] M. Kass, A. Witkin, and D. Terzopoulos, “Snakes: Active contour models,” Int. J. Comput. Vision, vol. 1, no. 2, 1987, pp. 321–331.

[11] V.Caselles, R.Kimmel, and G.Sapiro, “Geodesicactivecontours,”inProc.5thInt. Conf. Comput. Vision (ICCV’95), Cambridge, Mass., June 1995, pp. 694–699