DEFORMABLE IMAGE SEGMENTATION

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Abstract

Computer based image processing has played a huge role in medical image segmentation. Segmentation images are now used routinely in a multitude of different applications such as quantification of tissue, diagnosis, localization of pathology, study of anatomical structures, treatment planning, partial, volume correction of functional imaging data and computer imaging surgery. In particular, medical images are often corrupted by noise which can cause considerable difficulties when applying classical segmentation techniques such as edge detection and thresholding. Deformable image models have been studied and extensively used in medical image segmentation with promising results. Deformable models are curves or surface defined within an image domain that can be under the influence of internal forces, which are defined under the curve surface itself and also the external forces which are constructed from the image data. Making use of medical image segmentation and by constructing a deformable model approach, accurate and quantitative data can be efficiently extracted to support the spectrum of biomedical investigation and clinical activities, from diagnosis to radiotherapy as well as surgery.

Keywords: *deformable, Image processing, segmentation*

1. Introduction

In image processing, image segmentation has become an important step and has defined its role to define features of an object. Powerful and non-invasive techniques are used by physicians to probe the structure, its functions and pathology of the human body. Using Manual Tracing however is quite inaccurate as its inoperability to detect accurate object boundaries. It can also be time consuming. Also further, manual segmentation is only limited to 2-D slice wise processing, therefore it further suffers due to these inabilities.

Efficient, accurate, flexible and reproducible segmentation methods are required if ever quantitative analysis has to be done in medical segmentation. Purpose of this paper is to look out and review a set of methods that have been used in medical image segmentation over the past years and also see the transition that have happened in the research field over the past decade. In this paper, various approaches are discussed.

2. Proposed Methodology

Realization of a true and accurate 3-Dimensional Deformable model can be done with the help of The Active Contour Algorithm or Multiple Active Contours/Chan-Vese Algorithm. The Active Contour Model/ Chan-Vese Model tries to segment the image based on the energy value function i.e. the internal energy values and the external energy value in a given image.

With the help of this applied algorithm realization of the edges/ boundaries of the segmented image are more accurate. Furthermore while representing the segmented sliced images in a 3-D model; a better view of the deformable image is obtained.

3. Literature Review

The main goal of any medical image processing algorithm was to transform a set of raw images into a better symbolic form so that assessment, portrayal and its analysis could be easier. The most essential step in the transformation was the segmentation of structures to satisfy the homogeneity or similarity criteria that is the task to partition the image in regions for foreground and background. After the segmentation process, the exact appearance and exact shape features can be calculated for pattern analysis, clinical evaluation or for discovery of knowledge. Missing edge areas or lack of texture or contrast between regions of interest and background due to boundary insufficiencies proved to be a huge problem.

Many Researchers have put in considerable efforts to analyze medical images and maximize feature extraction with the use of various segmentation algorithms.

Mark Piotrowski *et al* used active contour methods for segmenting low-contrast images. The edge driven technique was represented by active contours. In this algorithm, the definition of the energy function value played a huge role in determining the edges and boundaries so as the exact shape is extracted out. To enhance the edge detecting skills of algorithm, an energy function for radiographic images was developed Figure.1 shows the energy training algorithm results. The size of the object was roughly estimated by them to improve the performance. It proved to be time saving however the rough estimation of the object size provided some inaccurate results [1].

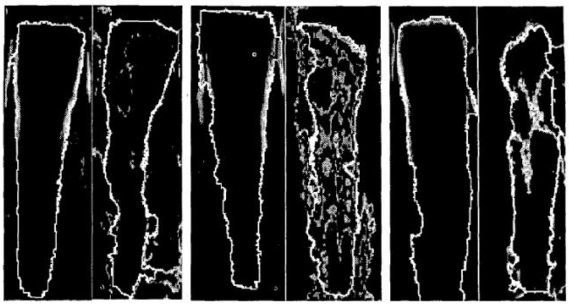

Figure.1 Results of segmentation for the energy training algorithm

Kenneth Byrd *et al* worked *on* assessment of mammography image segmentation algorithms [2]. Three medical segmentation models were studied and applied to a set 50 malignant images i.e. Kinnard Model, Snake Model and the Standard Potential Field Model. The Kinnard model made use predefined properties to predict the contours which would represent the best mass and borders of the given shape. This procedure used the intensity of the pixel and also took into account the intensities of the neighboring pixels in the ROI. The intensity values of the seed pixel thus determined the threshold and the contours of the object were determined. The Snake model made use of a modified force balance condition as its basis. A new external force field v(x,y) was defined which is called as the Gradient Field Vector or GVF. A comprehensive evaluation protocol was applied to evaluate the expert outlined and computer segmentation results and the mean accuracy was computed for all the algorithms as shown in Figure.2 and Table.1

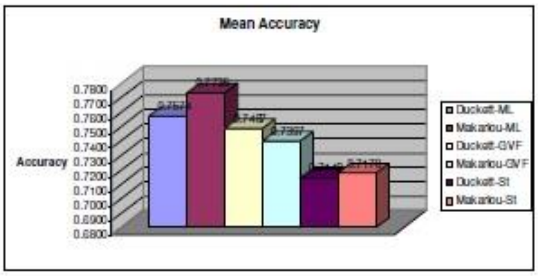

Figure.2 Mean Accuracy (All Algorithms)

Table.1 Mean Accuracy (All Algorithms)

ML	0.5122	0.7574	0.6234	0.8954
GVF	0.5318	0.7487	0.8052	0.7789
STD	0.5450	0.7142	0.7587	0.7724

Zixin Zhang *et al* work focused on majorly a deformable model algorithm which was used to segment high curvature shapes that had sub resolution accuracy and which provided a driving force to slide into boundaries of object corners [3]. This algorithm could be applied could be applied to 3-D and 2-D models. However this method did not define well the intrinsic smoothness constraint. Several methods were proposed to solve this problem such as segmenting diving the splines into two stages and later reach its convergence state or by applying an extreme contour curvature with potential corners at multiple nodes. Added to each of the node would be an external force which could vary the contour curvature and could move the corners without any resistance. These algorithms worked by relaxing the external smoothening force on the candidate corner nodes so as to allow the contour to bend at these nodes as seen in Figure.3.

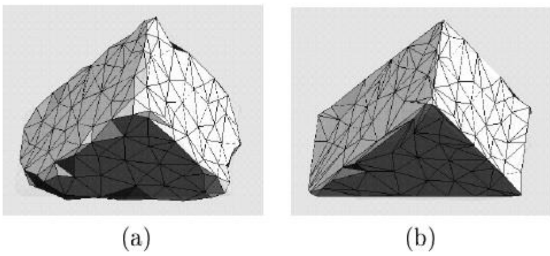

Figure.3 3-D views of the corner segmentations without (a) and with (b) using the computed algorithm

Mashiat Fatima *et al* work was based on the HIS color model and the K-means clustering algorithms [4]. The human ocular recognition can be very much associated with the Hue Saturation and Intensity model. Therefore it is a better choice to associate with the HIS model than using the RGB model because the RGB model does not relate with color perception. Since the Hue, Saturation and Intensity were independent of each other, the color spaces could be processed separately without worrying much about it and correcting it. Clustering was one of the easiest algorithms to untangle the clustering problem. It was used to classify the dataset based on the value located near to the centroid value. It was a re-iterative process of dividing the input image. The segmentation results obtained showed that segmentation based on K-means clustering gave better results preserving some of the important information and removing the Background as seen in Figure.4.

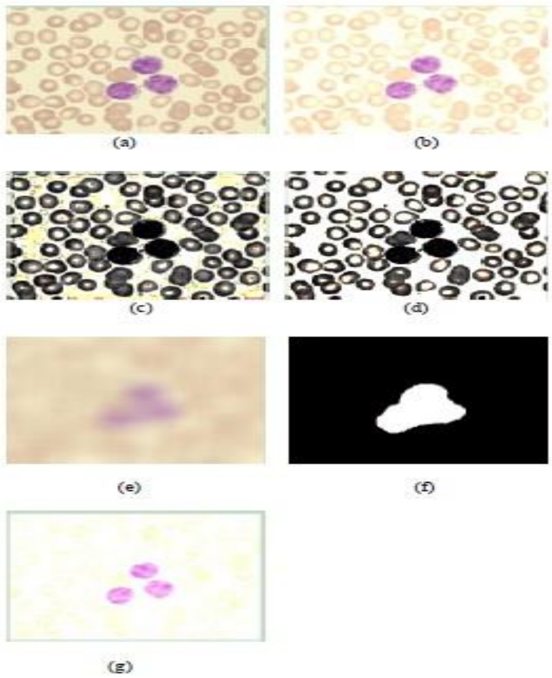

Figure.4 (a) Original image and resultant image after applying (b) Linear Contrast, (c) HIS-Color Model, (d) K-Means Clustering, (e) Median Filter, (f) Binary image and (g) Final segmented image

Dr. Eeva Boman *et al* evaluated the major effects of non-rigid and fractionation-corrected dose summation on the total number of doses in radiotherapy and the benefits of such doses by a better decision making or planning of retreatments [5]. The Organs At Risk (OARS) were investigated in the stage of 3 cases and after each radiotherapy treatment the reduction in the tumor size was evaluated as seen in Fig.5. This was executed with the help of deformable models. The deformable model was considered to offer the most concrete data of the reduction in structure of the tumor and according the dosage was planned for the further treatments

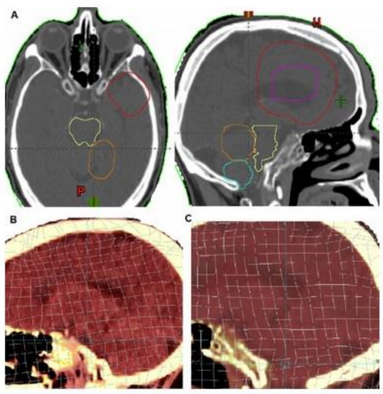

Figure.5 (A) Last planning CT with all 3 PTVs shown in red or magenta (PTV1/booster), orange (PTV2), and cyan (PTV3). The pons is contoured in yellow. (B) Registration map for first and second treatments. (C) Registration map for the second and third treatments.

Jing Yang *et al* had proposed a deformable model based on level-set analysis used to segment multiple objects from 3-D images using a shape prediction prior to multiple objects as seen in Fig.6. To achieve this objective, only one level-set function was utilized which acted as descriptor for multiple objects within the region of interest(ROI) of the image. They then defined the probability density distribution function over the multiple objects which were contained in the training set. They found the algorithm had to be free from computationally constraints [6]. Later they defined a Maximum A Posteriori (MAP) estimation model by using information based on the applied level-set analysis which provided information prior to object segmentation as seen in Fig.6. This made the segmentation robust to noise, able to handle wide scale of multi-dimensional data and avoid any errors taking place during the training phase.

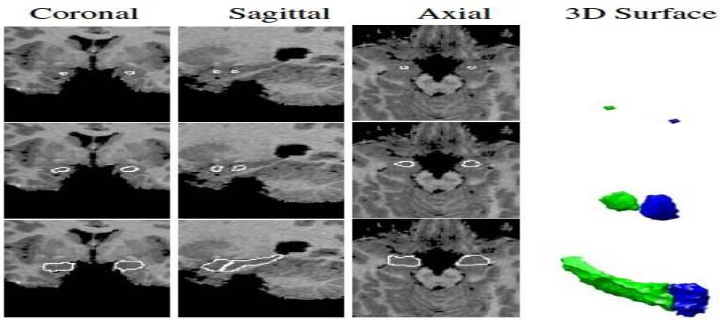

Figure.6 Initial, Middle and Final steps in the segmentation of 2 shapes in Brain MRI. Three orthogonal slices and the 3D surfaces are shown for each step.

4. Conclusion

Segmentation of shapes with similar boundaries and blurred intensities is possible. With the help of an efficient shape changing algorithm which will provide an accurate deformable approach visualization of the boundaries and edges will become accurate.

Using a Deformable Model Approach, it would be of huge advantage in medical applications since cost of error is more prone in this field. It would also help in radiation therapy to predict the extent of reduction in tumor size after citation.

Acknowledgment

It gives immense pleasure in bringing out this review paper of the project entitled "Deformable Image Segmentation". Firstly, we would like to thank our guide "Ms. Manali Tayade" who gave us her valuable suggestions and ideas when we were in need of them. She encouraged us to work on this project.

We are also grateful to our college for giving us the opportunity to work with them and providing us the necessary resources for the project. Working on these projects also helped us to do lots of research and we came to know about so many new things.

We are immensely grateful to all involved in this project as without their inspiration and valuable suggestion it would not have been possible to develop the project within the prescribed time.

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