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.**

I. 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.

II. 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.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].

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.

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.

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.

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. 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.

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. To achieve this objective, only one level-set function was utilized this 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. 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.

III. Methodology

An active contour is essentially a curve made up of various energies. The curve deforms dynamically to mould to the shape of a targeted object. There are various methods for implementing an algorithm to achieve object outlining. Traditionally, the active contour algorithm requires an initial user approximation surrounding the interested object and then deforms this curve by minimizing the energies contained to achieve the object outline matching.

The energies in the active contour can be divided into two categories: Internal and External energy functions. The Internal energy functions focus on the intrinsic properties of the contour such as elasticity and curvature, while the external energy functions are related to the image properties like contrast and brightness.

$$Esnake = Einternal + Eexternal$$

These energy functions are then given various weightings to control the different properties of the contour which are crucial for a good match of object outline. These weightings have the effect of controlling the rate at which the contour minimizes and most importantly stop the contour from further shrinking once the outline of the object is tracked. This is known as the final approximation of the contour. Energies contained in the contour, are minimized due to simulated forces acting upon it. When all the forces involved are at equilibrium, the contour has essentially reached its minimal state and the outcome of the curve is the final approximation of the object outline.

The Internal energy of the active contour controls the shaping of the curve that eventually models the area of interest on a given image. It also controls the spacing between the control points that form the curve. The properties of the Internal energy can be further subdivided into two parts with individual weightings to influence the motion of the contour:

$$Einternal = \alpha * Eelastic + \beta * E\ bending$$

The Eelastic is the elastic energy, which enforces the contraction of the contour like an elastic band while Ebending introduces a resistance to bending like a metal strip trying to a smoother curve.

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.

IV. Implementation

The software being used for our project is MATLAB2018a. The first step involves the creation of database of multiple slices of the brain MRI images which is sourced from cancerarchives.org. The database constitutes of a database of 20 patients identified according to their "PATIENT ID" number. A directory is created to link this database folder to the MATLAB code.

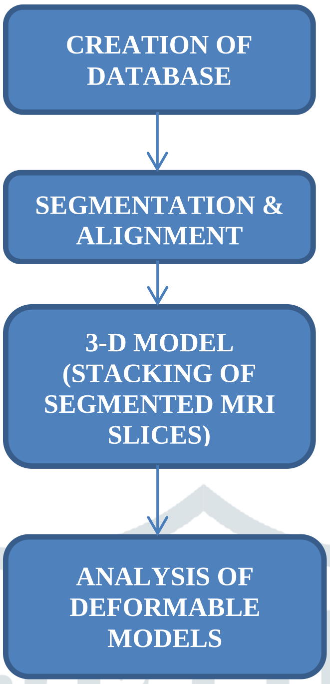

Fig.1 Process Flow

The next step is the segmentation and alignment of the of the MRI slices. Here, the algorithm used for segmentation is an Active contour which is already defined in MATLAB. A Fast Bounding Box (FBB) is drawn around the tumour. The number of iterations is kept high to get a perfectly segmented shape of the tumour. The segmented tumour slices are later saved in a tumor mask directory for each MRI slices

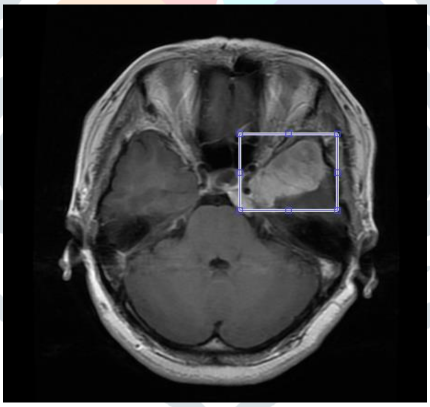

Fig.2 Fast Bounding box using Active Contour

Fig.3 Segmented Tumour Slices

The next step is to stack the different segmented slices of the tumour to get a Deformable 3-Dimensional (3D) model. This is done with the help of an inbuilt application in MATLAB called Volume Viewer. The opacity and thickness of the slices can be adjusted in the volume viewer.

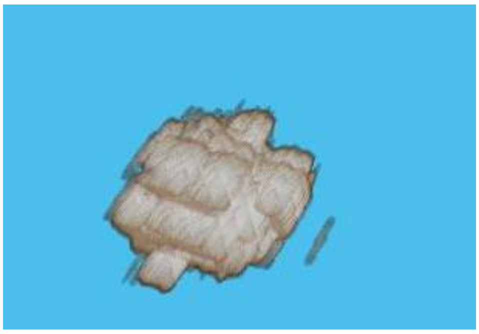

Fig.4 3D Deformable Model of Segmented Tumour

The final step is to construct deformable models of tumours from other patient's MRI slices and compare them by their size and dimensions.

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IV. CONCLUSION

Using Active contour algorithm the extraction of the tumor slice becomes easier. The 3-D Deformable model is achieved however sharp edges are observed. Also during extraction of tumor from the MRI slices, unwanted brain fluid is also segmented. Further advances in algorithm with the help of neural networks such as K-Means Algorithm, can help in better segmentation of tumor and achieve a smoother deformable model.

V. ACKNOWLEDGMENT

It gives immense pleasure in bringing out this paper of the project entitled "Deformable Image Segmentation". Firstly, we would like to thank our guide "Prof. 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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