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IMPROVED IMAGE SEGMENTATION MODEL ON COMPLEX CURVES USING PARAMETRIC APPROACHES

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Abstract: **Due to the rapid evolution of medical imaging systems, image segmentation faces various and increasingly difficult challenges. In order to cope up with the tremendous volume of data, an effective segmentation model is required. Several geometrical approaches are developed for achieving incessant optimization issue. In this paper, an efficient segmentation model is developed using parametric approaches with contour free endpoints. The designed models operate on variant complex curve equalities with defined or non-defined image boundary. In addition to, free endpoints are also analysed. The images are viewed in linear surfaces and regions are splitted using random numbers. Based on the random numbers, the regions are segmented. It is also numerically analyzed over the curves in discretized with finite elements. Experimental results have shown the effectiveness of our proposed methodology.**

Keywords: Medical image systems, segmentation, object recognition, Image boundary, complex curves.

I. INTRODUCTION

The recent developments made in the digital image processing have attracted the healthcare sectors. Image processing is a kind of information computation where the input and output as images. It can also works on 2D signals processing system. In the general context, the computation on images are classified into two sorts namely, digital image processing and medical image processing. In the present times, medical imaging and processing tools are playing crucial roles in many applications. Such applications take place throughout the clinical track of events; not only within diagnostic settings, but prominently in the area of preparation, carrying out and evaluation before surgical operations [1], therefore, the pros and cons of the medical image will directly influence the result of the diagnosis from a doctor to the patient. Besides that, medical imaging itself have noise and speckle like ultrasound, thus it will increase the difficulties of doctors' judgment.

Diagnostic imaging is an ever-ending task in medical field. Different kinds of medical images are available which furthers taken from equipments like Magnetic Resonance Imaging (MRI), Computed Tomography (CT), digital mammography etc. Each imaging has different modalities and defines different anatomical information. The development of technology increased the knowledge of the medical research which behaves as critical component in diagnosis and treatment planning. The growing size and number of these medical images have necessitated the use of computers to facilitate processing and analysis. In particular, computer algorithms for the delineation of anatomical structures and other regions of interest are becoming increasingly important in assisting and automating specific radiological tasks.

Image segmentation and edge detection plays a vital role in the medical imaging systems. Detecting the edges from the segmented image is an important tool in medical image processing systems. In order to easily and accurately segment the images, a better model or algorithm is required. Feature extraction also plays an important part in extracting the information. This process detects outlines of an object and boundaries between objects and the background in the image. The rest of the paper is organized as follows: Section II describes the related work; Section III presents the proposed work; Section IV describes experimental analysis and concludes in section V.

II. RELATED WORK

This section explores the literature survey of our task. The survey is on different techniques presented in image segmentation. It is classified onto,

a) Edge based image segmentation:

The authors in [7] have suggested image segmentation techniques which covered edge and region based information. Using the watershed algorithm and spectral method, the medical image is segmented accurately. Bilateral filter is used for image preprocessing with region merging process. Multi-class normalized cut method was used for image segmentation process. The developed algorithm was tested on Berkely segmentation dataset. Though, the developed model yielded better results, the error rate is high. K-means segmentation model [8] was used for detecting the edges with more nos. of clusters. In specific to, the clusters are defined from threshold and Euclidean distance. It has been found that the increased cluster size incurs higher memory complexity. Further, an automatic threshold selection method was developed by [9]. It was applied on multi-scale image segmentation systems. Based on the score obtained from Normalized Difference Vegetation Index (NDVI) and edge weight, the image is segmented. The variance filter model was developed by [10] which stated the position of the edges. In further assistance with sobel gradient model, the edges are extracted in 9*9 window models. The sobel operator was further enhanced by [10] using Otsu thresholding models. It specifically detects the background and foreground pixels of an image. It degraded the accuracy and processing time of an image.

b) Fuzzy theory based image segmentation process:

The authors in [11] have studied about the fuzzy based morphological image segmentation models. In order to smooth the information, the developed algorithm performs closing and opening operations. It was aimed to derive the information details of an image and enhance the segmentation speed. Then, the fusion approach [12] using prewitt operator and watershed algorithm was used for resolving over-segmentation issues. It degraded the accuracy of the information. The author in [13] studied about the fuzzy associated image segmentation models. Based on fuzzy logics, the objects are separated onto foreground and background pixels. It was evaluated using Fast Positive Volume Fraction (FPVF) and Fast Negative Volume Fraction (FVNF). The authors in [13] presented a new method of image segmentation using Fuzzy Rule based system and Graph Cuts. Authors have firstly segmented the gray scale, color, and texture images using Graph Cuts. Weights are assigned to the features of image using Fuzzy Rules. Their algorithm works by firstly extracting the features of image, calculate the constants using fuzzy rules, calculate the weighted average of constants to find the similarity matrix, partition the graph using Normalized Graph Cut method, and finally get the segmented image from partitioned graph.

c) Partial Differentiation Equation based image segmentation:

The authors in [14] have studied about non-linear discontinue partial differential equation which was observed on gray scale images. Though, the method has achieved numerical solution, the edge detection remains unstable. The author in [15] studied about 4th order PDE with 2nd order PDE for finger vein image de-noising. They have used midpoint threshold segmentation models. These models have not reduced the noise level in an image. Further, the segmentation model was developed for color images. Geodesic Active Contour (GAC) [16] model was developed which depicted the gradient information of an image.

d) Threshold and region based image segmentation:

The authors in [17] a new image segmentation technique which joins the edge and region based information with spectral method using Morphological Watershed algorithms. Gang Chen [18] found that fast extraction of object information from a given image is still a problem for real time image processing. They also found that region based methods are also time consuming and not give effective segmentation. They proposed a new region based method based on Least Square method in order to detect objects sharply. They used a weight matrix for region based method which also takes the local information into account and also the usage of Least Square method [19] provides optimal and fast segmentation. Comparison of their method is conducted with Otsu method and Chan-Vese method [20] using Lena image. Their method can extract the features more accurately than other methods.

III. PROPOSED WORK

This section explores the proposed methodology for better image segmentation and edge detection process. The proposed methodology composes of three modules, namely,

a) Image segmentation processing with parametric contours:

It is generally observed that the medical image is not smooth over the curve Γ which is tangential in form. Let $u_0 : \Omega \to \mathbb{R}$ be the property of images with its image domain R. To find the smoothness of an image, Mumford Shah method is used for finding the discontinuities in an image. Thus, the minimized energy function is given as follows:

$$E(u,\Gamma) = \sigma|\Gamma| + \int_{\Omega\setminus\Gamma} \|\nabla u\|^2 \, \mathrm{d}x + \lambda \int_{\Omega} (u_0 - u)^2 \, \mathrm{d}x,$$

(3.1)

The Mumford shah method composes of two functions, namely, (i) a restoration of the possible noisy original image by a piecewise smooth approximation u and (ii) a segmentation of the image given by a union of curves representing the set of edges in the image. Parametric method for image segmentation with piecewise constant image approximations u and interface curves τ. The endpoint is a point inside the image domain, where no other curve continues.

b) Formation of topology:

The position of the curves τ is numerically formed in range [0, 1]. The periodicity of the individuals is $N_{i=0}$, N_{i+1}, N_{i+2}…..N_{i+m}. The derivative terms with respect to time are replaced by difference quotients of the form:

$$(\vec{x}_i)_t(q_i^j, t_m) \approx \frac{1}{\Delta t_m}\left(\vec{X}_{i,j}^{m+1} - \vec{X}_{i,j}^{m}\right).$$

(3.2)

The external term F is approximated by

$$F_{i,j}^m := \lambda \Big[(u_0(\vec{X}_{i,j}^m) - u(\vec{X}_{i,j}^m + a\vec{\omega}_{i,j}^m))^2 - (u_0(\vec{X}_{i,j}^m) - u(\vec{X}_{i,j}^m - a\vec{\omega}_{i,j}^m))^2 \Big]$$

(3.3)

The discrete scheme is linear and can be written also in matrix-vector form with a sparse system matrix.

c) Solution of Image denoising issue:

The denoised version u of u_0 is given with the discrete set,

$$\Omega^h := \{(ih, jh) \,:\, i = 0, \ldots, N_x,\, j = 0 \ldots, N_y\},$$

(3.4)

Where N_x and N_y are horizontal and vertical pixels information. The energy of the given curves τ is given as

$$E_{\mathrm{discr}}(u^h) = \sum_{i=1}^{N_x}\sum_{j=1}^{N_y}\left(A_x(i,j)\left(\frac{u_{i,j}^h - u_{i-1,j}^h}{h}\right)^2 + A_y(i,j)\left(\frac{u_{i,j}^h - u_{i,j-1}^h}{h}\right)^2\right) + \lambda \sum_{i=0}^{N_x}\sum_{j=0}^{N_y} h^2 \left(u_0(ih, jh) - u_{i,j}^h\right)^2,$$

(3.5)

By taking the derivatives of eqn. 3.5, the resulting term leads to zero in linear systems. Thus, the edges are preserved with better image smoothing at the end of curve evolution process.

d) Modification in topology:

The evolution of curves leads to changes in topology due to the prior knowledge of edge information. In some cases, the curves are classified into different forms according to edge information. Topology changes involving curves with free endpoints can be detected similarly by using such a back-ground grid. If two free endpoints of one curve are located in one square of the background grid, an open contour becomes a closed contour. If two free endpoints of two different curves meet, the two curves merge to one single curve, and the former free endpoints become inner nodes of the new curve. If a free endpoint and an inner point of a curve meet, a triple junction is created.

IV. EXPERIMENTAL RESULTS AND ANALYSIS

This section explores the experimental analysis of our proposed methodology. It is experimented on constant time sizes of $\Delta t_m = \Delta t,\ m = 0, \ldots, M-1$.. In some cases, the images can't be smooth over the curves. The enhancement of curve stops when the linear inequality becomes equalities.

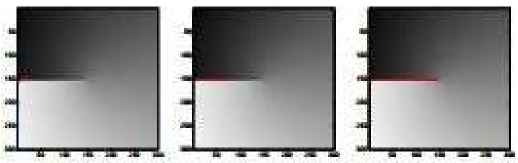

Fig.1 represents the contour with one free endpoints and its boundary intersection point.

Then, the dependency of the contour evolution and image diffusion are analyzed for the given image. Gaussian noise is added to the image for every defined parameter. The higher the noise of the image, the less smooth is the denoised image since the same value for τ is used for comparison. Due to local high gradients of the image, the polygonal curve is less smooth, if the noise of the image is very high.

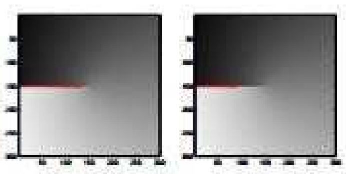

Fig.2. Finding the dependency of the weighting parameters.

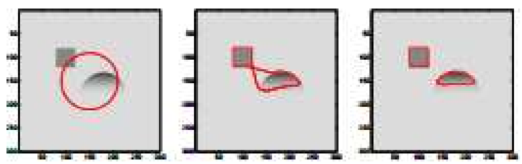

Fig.3. Developing interface curves and piecewise constant for image segmentation

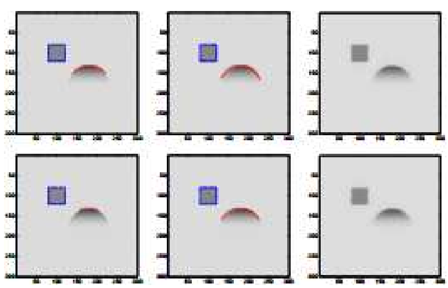

Fig.4. Obtaining contour with free two endpoints using post processing evolution

Fig.5. Image segmentation and contour detection with topology changes

The proposed model is effective in 1D issue where the curve evolution with free endpoints is done earlier.

V. CONCLUSION

The development made in image processing has attracted the researchers in healthcare environment. To easily interpret the medical images, a proper image segmentation model is required. This paper concentrates on developing efficient image segmentation model using parametric approaches. The developed methods can handle complex curve networks with possible triple junctions and intersections of the curves with the image boundary. Also curves with free endpoints are supported. The methods can be used to segment a given image in regions of arbitrary number, separated by linear surfaces. Numerically, the evolving curves and surfaces are discretized and the resulting schemes are solved by finite differences and finite elements. Experimental analysis is carried out in real images and proved the efficiency of our proposed methodology in several real time applications.

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