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LEVEL-SET ALGORITHM BASED SYSTEM FOR SEGMENTATION OF MEDICAL IMAGES

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Abstract:

Segmentation means dividing an image into connected regions. It is the basic procedure to enhance the image. This process accommodate to identify and envisage objects in an image. In medical imaging, this algorithm is useful to elevate organ, cells or structures in the body. But there are many difficulties occurred in the segmentation process, they may be noise, variation of contrast, motion blurring artifacts. There are many segmentation methods have been proposed from the past years, but we used in this paper the segmentation algorithm based on level-set.

The application in this work is to assess the performance of the six level-set algorithms on a given MRI image of Brain segmentation in 2D. The initialization implemented in this process is common for all the algorithms and the reference contour chosen for the computation of Dice criterion. MATLAB tool based application is used to evaluate the performance of various level-set algorithms in the segmentation of an image particularly on medical images. Classical methods such as Chan & Vese and Shi algorithms only evolve on their narrow band and are region based. We propose the recent methods such as Li and Lankton algorithms which are localized region based. Analyse and compare various level set algorithms on medical images in terms of Dice criterion, computational time , PSNR, Hausdorff distance and the mean sum of squared distance(MSSD).

Keywords— **Level set Algorithms, performance visualization, Dice Criterion, Computational time.**

I. INTRODUCTION

The segmentation of an image is the process of divide up a digital image into several parts which are in the form of pixels. It is used to simulate objects and boundary lines, curves in an image. The process of categorized pixels and assigned a label to each pixel in an image such that same characterized pixels share their similarities. The output of image segmentation is the combination of several segmented images. In medical image processing, there are numerous methods used to enhance and identifies the effected area in deceased images. But still some difficulties are raised due to that the pathologists were unable to identifies deceases. In present days, technology has been gown up new methods are developed which are simplifies the difficulties.

Level set algorithms are generally used as numerical technique for locate the interface and shapes. Which are graphical representation in lines and curves so that it can be useful for computing contours. To minimization of energy through mathematical equations. In level set algorithms , contours or surfaces are represented as the zero level of higher dimensional function , this function called as level set function.

II. LITERATURE REVIEW

Image segmentation is the basic step in image processing. Segmentation is the process of divide image into some meaningful subsets.

2017, the author P.Yugander explains the advantages of k-means clustering and distance regularized level set evolution(DRLSE) [1]. DRLSE model eliminates the re-initialization problem in conventional level set method. When it is applied to niosy images, it leads to significant drawbacks like number of iterations and computational time is increased. In order to avoid disadvantages of conventional DRLSE, the author introduced a method to combine the median filtering, k-means clustering and DRLSE model.

2016, Rong Wang and Xuelong et.al describes the level set function generation by utilizing fuzzy clustering region[2]. It is able to recognize and locate the arbitrary combination of chosen elements or objects. A series of synthetic and real images have been verified by using its performance . This formulation is consistent to Bayesian clustering, Gaussian mixture modelling or other kinds of PSF for selective level set segmentation.

In 2016, Khamael AL-Dulaimi and Jasmine Banks et.al used level set methods and geometric active contours[3]

to segment the nucleus of white blood cells from the cytoplasm and the cell wall. The algorithm has been experienced with nucleus images at unusual stages of development and with changeable explanation and orientation, without any awareness of the object shape. The performance of the this algorithm has been considered and compare with that of other methods using the indices RI,GCE,VOI,JD and BDE. Which yield better segmentation results according to these metrics in all cases, except for edge displacement error cases. The results shown in [3], the level set method via GACs is significantly faster than other methods which use larger time steps to speed up the curve evolution while GACs maintain the stable evolution of the level set function.

One of the the most popular and successful method is the active contour method. This method implemented by level set methods have been used for image segmentation successfully. The main thought of active contour method is to represent a contour as zero level set of higher dimensional level set function completely, and formulated a level set function for the evolution of the contour.

2015, A new hybrid active contour model for image segmentation was introduced. The authors Zhiwei Liu et al, defined a new region based signed pressure force(SPF) function[4]. This combines the local and the global image information. The models can segment all objects in image domain. The author compared this model with chan and vese model [7], and the results displayed that the implement model is less sensitive to the initial contour. experiment demonstrate that these models can segment the artificial image and real images.

2015, Lei Liu and Rumin Yang et.al explained combining graph cuts and level set algorithm[5] for breast ultrasound image segmentation. Initially, speckle reducing anisotropic diffusion then the initial contour is achieve through graph cut. To soft the boundaries , a boundary item is added into the energy function of level set. The graph cut produced good initializations and global item and neighbouring element information was taken into level set, which efficiently help overcome the costly re-initialization process and local minima of traditional level set method.

2015, The Alain coron et.al explained a level set segmentation of 2D and 3D Ultrasound data by local region based gamma distribution fitting energy(LRGDF) [6]. To deal with the local statistics of speckle noise. The data term of the level set energy function is based on local gamma distributions which have shown an ability to model envelope data and gray-level pixel intensities of B-mode clinical images. Local data are estimated at a controllable scale using a smooth function. This method provide a high Dice similarity coefficient (DSC) on 3D replicated data. It also outperforms methods that use local Gaussian statistics instead of local gamma statistics.

2015, Faouzi Adjed et.al implemented a generalization of chan and vese (CV) model[7] and used in the case of skin cancer images. This method is used to minimize Mumford and shah equation[9]. The algorithm forces the two zero level set functions to follow one specific direction, and it become less sensible to some small variegation in the pigment. The algorithm allows the segmentation inside the pigment to detect different colors if development of the disease as inclusion, or separates categorically these functions to make two adjacent regions. The results shown are qualitatively good and more accurate for the detection of the region of interest and the details inside this region.

2014, Ahmad Chaddad et.al presented the level set method[8] used in medical image segmentation. It is employed and implemented using real data of carcinoma cancer cells. And also defined its speed function influence, and the convenient of choosing its coefficients in an appropriate value. It is discussed by using some performance metrics, where the experimental results showed a promise similarity metric between the level set and manual segmentation.

III. NEED AND IMPORTANCE

Image segmentation is still a challenge in the fields of image processing and computer vision, the goal of which is to divide image into some meaningful subsets. Earlier, various algorithms have been proposed for the implementation of image segmentation. Among these methods active contour method is most popular and successful. Recently active contour models(ACM) are implemented by using level set methods. These methods have been executed for the image segmentation triumphantly. The purpose of ACM is correspond to a contour as zero level set of higher dimensional level set function completely. These LSF formulated for the evolution of the contour. Basically, active contour models are classified into two types. They are edge based models and region based models. The region based active contour models have more advantages than the edge based models. To manage the contour region based models are vigorous to the noise for using statistical data in the interior and exterior the contour. These are less sensitive to the track the initial contour and the boundaries detected effectively. Region based models are used the sub regions information in an image, therefore can segment the image with delicate boundaries. The chan & vese models has been successfully applied to binary phase techniques. However, the C-V model does not allows the images with intensity of inhomogeneous competently.

The level set method for representing vigorous interfaces, curves and shapes introduced by osher and sethian in 1988. The level set algorithms are used for denominate the problems for propagation of curves and surfaces in indirectly.This method is useful to represent initial contour as zero level set of dimensional function, these function called a level set function(LSF). The implemented level set function formulated the motion of contour. LSF represented the improved contour by using the signed function and its zero level correspondent to the actual contour. The level set algorithms have many advantages: it is implicit, level set methods provides parameter free and it also provide an easy to estimate the geometric properties of the structures. In interface, singularities formation, modify the topology, curvature

dependent and other issues are appeared. Localized energies segmented successfully heterogeneous statistics within the objects.

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IV. PROPOSED METHOD

In the present methods, we implement a six level set algorithms on different medical images. From the existing method like chan & vese, the computation of energy criterion calculated on region based statistics. It facilitate to differ an image into two homogeneous region based on their mean value. The evolution of this algorithm is computed on narrow band of level set thus accomplishing it as sensitive to initialization. But chan & vese algorithm has some limitations: when an image size is too large this method works slowly, In real time applications the problem may be occurred on video sequences and an efficient implementation on image.

In this work, we use a software tool which access all level set algorithms. All six level set algorithms have been pre coded into one framework. It also accommodate the features which are required for the evolution of the performance of segmentation algorithm in a single framework and it is easy to use these algorithms. It supports all types of image formats for segmentation of image and comparison of parametric results.

The implementation of every algorithm describes their properties and computed the similar parameters which are common for all algorithms presented here. Caselles method describes the evolution of segmentation in narrow band and minimization of energy is contour based. Chan & vese and Shi methods describes the minimization of energy criterion is a region based and the evolution of performance of segmentation is a narrow band. Recent algorithms like Chunming Li and Lankton are localized region based, the evolution is whole domain and narrow band respectively. Bernard has region based criterion and the performance of evolution on whole domain. Among all these methods Chunming Li and Lankton are localized region based , which improves the computations on each pixel present in boundaries and shapes in an image. Localized region based methods performing initialization on each pixel in the narrow band between the initial contour and neighbouring objects. The phenomena of this computation varies on the implemented energy criterion.

The measurements are shown in comparison panel after implemented all algorithms. These measurements are computed between the result of the algorithms and the reference.

Dice criterion: Dice coefficient is measured by using segmented region and reference region. $Dice = \frac{2(X \cap Y)}{X+Y}$ where X and Y are the result mask region and reference mask region of an algorithm.

PSNR: Peak signal to noise ratio calculated from the mean square error of an image. PSNRD $PSNR = 10 \log_{10}\left(\frac{d}{MSE(X,Y)}\right)$, where d is the maximum possible value of the image and MSE(X,Y) is the mean square error computed between X and Y: $MSE(X,Y) = \frac{1}{MN}\sum_{m=1}^{M}\sum_{n=1}^{N}\|X(m,n) - Y(m,n)\|^2$

Hausdorff distance: It measured by the distance between two sets. It is the largest distance between one point in one region and another point in other region. $Hausdorff = max(D_1(X,Y), D_1(Y,X))$, where X and Y are the reference contour and the result contour of an algorithm.

MSSD: Mean sum of square distance is defined as summed up the distance between each point and the line of best fit squared. $MSSD = \frac{1}{N}\sum_{n=1}^{N} D_2^2(X, Y(P_n))$, where X and Y are the reference contour and the result contour of an algorithm.

The results and the reference are binary images for the computation of Dice criterion and PSNR. The binary value 1 indicates inside and 0 indicates outside.

The following diagram shows chronological process of the present method.

BLOCK DIAGRAM OF PROPOSED METHOD:

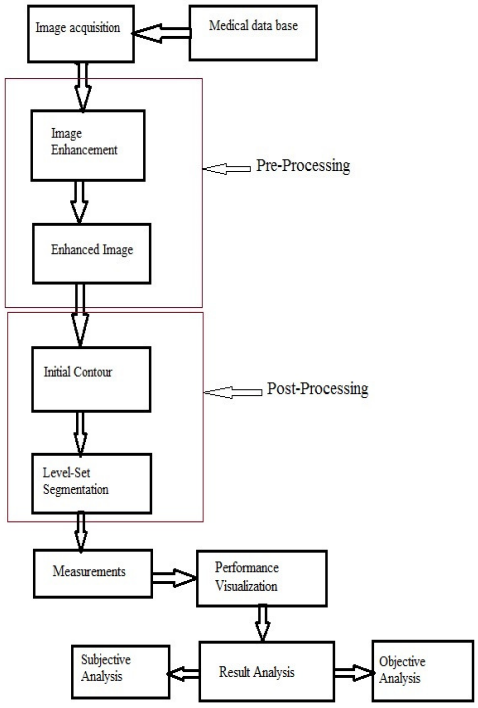

Fig 1: The block diagram shows the process of implementation

ALGORITHM:

Step-1: Image acquisition module allows the user to load a grayscale or color image. Image from Medical data can be initialized.

Step-2: In pre-processing unit, Initialized image is Enhanced by using the Enhancement methods and the output of Enhanced image is collected.

Step-3: In post-processing unit, an initial contour is selected from the reference image where ever required. Then implement level-set methods, the result of level set methods can be stored.

Step-4: To execute the level set algorithms one after another by using a software tool. The result of the each algorithm can be saved. Then the measurements are computed for every algorithm.

Step-5: Performance visualization, Analyse the segmented image shows result contour of individual algorithm and reference image.

Result analysis: The result analysis panel is to yield an easy evaluation of an image segmentation. User can easily choose from the implemented all level set algorithms. After completion of segmentation process, the result contours of every method are displayed on the same image it can be called as comparison image. This image contains different colours, each colour differentiate type of algorithm.

IV. IMPLEMENTATION & RESULT

A software tool is used to access the six different level-set algorithms that have been preferred in order to represent a wide range of applications. These algorithms test on different medical images to ensure that the behaviour of the method. Every algorithm is allied to a panel these are shown on the left side of the interface. This panel contains toolbar that displayed the specific parameters of the method and provides access to modify them. The left part of the interface facilitate the parameter panel and the right part displayed the segmentation result. The following table describes the properties of each proposed method.

s. no	Algorithm	property	Evolution
1.	Caselles	Active Contour-based	Narrow band
2.	Chan&Vese	Region oriented	Narrow-band
3.	Shi	Region oriented	Narrow-band
4.	Bernard	Region oriented	Whole-domain
5.	Chunming Li	Localized region	Whole-domain
6.	Lankton	Localized region	Narrow-band

Table 1: The table describes the main properties of level set algorithms .

The energy type and segmentation evolution of Caselles is Contour based, Narrow. For Chan&Vese, Shi, Bernard the energy type and evolution are same except Bernard. Evolution of Bernard is Whole domain. The last two methods such as Li and Lankton has the energy type of Localized region based and evolution is whole domain, Narrow band.

The following are the final results of the implemented level-set methods.

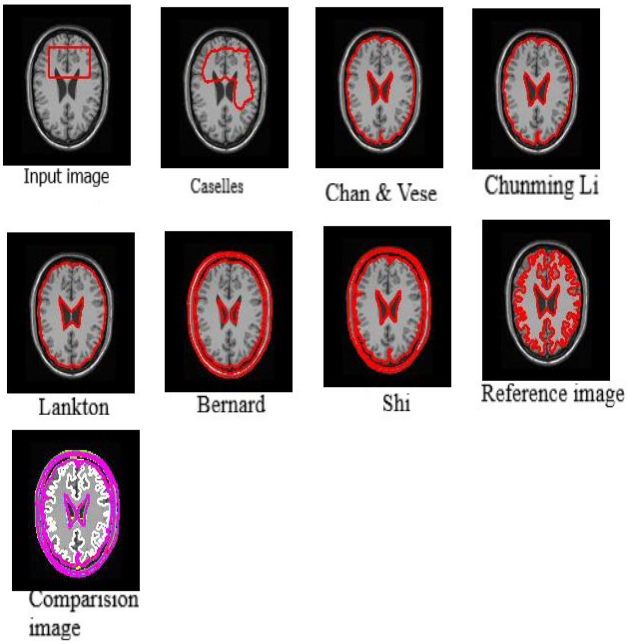

Fig 2: Segmented images obtained from various level set algorithms.

The first step is to initialize the input image of brain. The initialization used is the same for all the algorithms and the reference contour used for the computation of the Dice criterion is shown in fig 2. The final segmentation evolution of images obtained depending on the implementation of each algorithm. The parameter values are calculated from the respective algorithms.

s.no	Algorithm	Calculation Time	Dice Coefficient	PSNR	Hausdorff	MSSD
1.	Caselles	0.788	0.572	6.6	18.2	90.2
2.	Chan & Vese	0.294	0.621	7.5	16.0	54.5
3.	Chunming Li	0.467	0.000	0.8	14.8	48.4
4.	Lankton	4.443	0.630	7.7	17.0	86.1
5.	Bernard	6.610	0.599	7.1	16.1	58.4
6.	Shi	0.476	0.000	0.8	14.8	48.6

Table 2: Parameter values of six implemented methods obtained for the segmentation of MRI image of brain.

CONCLUSION

In this research work, we described the evolution of the performance of various level-set based algorithms in the circumstances of image segmentation. This work has been implemented in MATLAB tool based application to access six different level-set algorithms thus the final segmentation images are obtained. Compared the parametric values of six algorithms in terms of Dice criterion, computational time, PSNR, Hausdorff distance and MSSD.

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