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Contour Independent Real-Time Improved Level Set Method for Segmentation

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Abstract— ***The recent development of parallel processing, is a fast alternative approach for solving partial differential equations and has attracted recent research work and is applied in the level set method for image segmentation. In this paper we propose an independent of selection of initial contour based approach with high efficiency algorithm. The proposed algorithm is validated on the standard database which consists of standard, astronomical and medical images.***

Keywords— LSM, log transformation, gray scale, adiabatic, sobel operator.

I. INTRODUCTION

There is a growing demand of image processing in diverse application areas such as multimedia computing, remote sensing , biomedical applications, texture and pattern recognition, secured data communication and so on [1]. Active contour has become a very important and successful approach in image segmentation and has been employed in various applications. This active contour approach can be formulated mathematically using two models: snakes and level set. The early work on active contour was pioneered by Kass et al. (1988), who has introduced the snake model. A later development by Osher & Sethian (1998), introduced a new direction to active contour, which is referred to as level set based active contour (LSAC). LSAC is introduced to overcome some limitations of the snake model. Image segmentation plays a very curious role in image processing and widely employed in many applications like object detection [2], object-based coding [3,4], object tracking [5], image retrieval [6] and many more.

II. LITERATURE REVEIW

A lot of research has been carried out in the above mentioned techniques. In [1], different image segmentation techniques along with their merits and demerits are discussed. The [7] provides detailed study of different edge detection techniques for segmentation approaches with their advantages and disadvantages. As we know image segmentation remained an old and important problem in recent times, so variety of image segmentation methods are briefly explained in [8]. Numerous segmentation algorithms have been proposed in the literature but there is no single algorithm that works well for all types of images. Some algorithms work well for certain types of images while others work for some other set of images. A good amount of research has been explored in level set based active contour, which are categorized into edge-based, region-based and hybrid methods in [9,10,11]. In [3] parametric deformable models are represented explicitly as parameterized contours. Osher and Sethian discussed the level set method and the issues related to it in [2]. The work is extended to make it conceptually simple and easy to implement in [12]. The level set approach in [13] is slightly different from the previous works and do not need to find explicitly the location of the interface in the space domain. The paper [14] describes the adapted curve evolution theory and level set method to model geometric active contour for shape recovery of objects in specially 2D and 3D images. In [15], DRLSE formulation was proposed to maintain the signed distance profile near the zero level set. The level set formulation is briefly discussed and the contour evolution is performed using the Split-Bregman method in [16]. The [17] explains the Split-Bregman method with its detailed mathematical formulation. The same is extended in [18].

III. LEVEL SET METHOD

Consider a curve shown in figure 1. It moves in normal direction with some speed function say F and $F=F(L, G, I)$ where L is Local properties, G is Global properties and I is Independent properties. For developing a mathematical model for the same, we need to parameterize the moving interface. A high dimensional function ϕ is introduced in level set method to represent the interface implicitly i.e. we usually defines the interface as an iso-contour of some function [19]. Here we define the segmentation boundary as part of a surface where the contour level is 0, i.e., the zero level set [20].
Let $\phi(x, t = 0)$ be defined as

$$\phi(x, t = 0) = \pm d$$

where x is a point in R^N [21] , t is time, and d is the distance between position x and the zero level set. The d is positive if x is outside zero level set, otherwise, the sign is negative [20]. We want the propagating surface to always match with the zero level set of the evolving function ϕ. For this, it must have

$$\phi\,(x\,(t),\,t) = 0$$

By chain rule [22],

$$\phi_t + \nabla\phi\,(x(t),t).\,x'(t)=0$$

Here the speed function F is defined as the speed in the outward normal direction,

$$x'(t).n=F$$

$$n=\nabla\phi\,/\,|\nabla\phi|$$

Therefore we have the evolution equation [23] for ϕ,

$$\phi_t + F\,|\nabla\phi|=0, \text{ given } \phi(x,t=0)$$

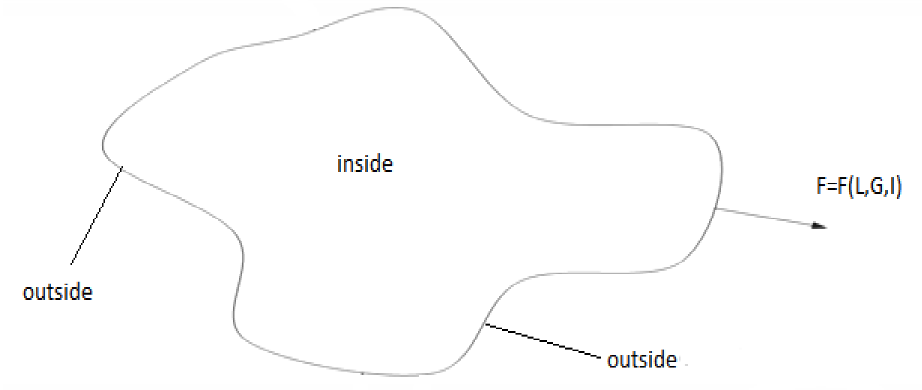


Fig 1. Curves moving with Speed F in Normal Direction [20].

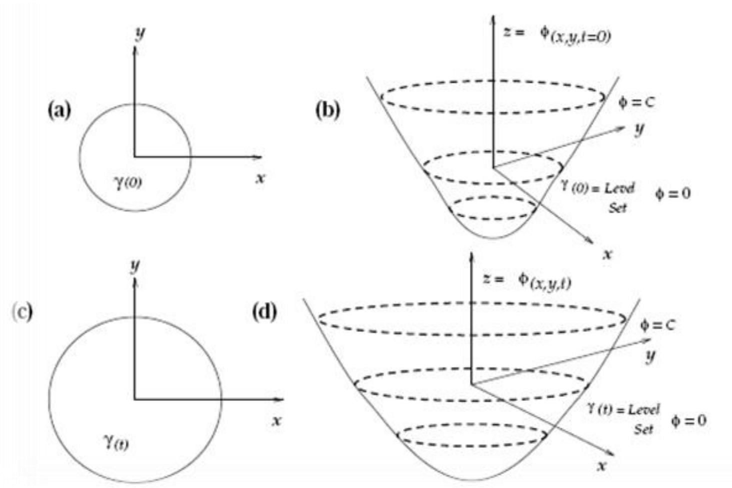


Fig 2. Propagating Circles [20]

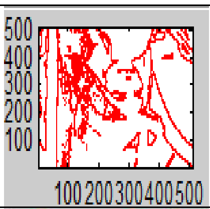
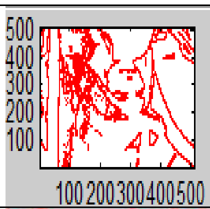
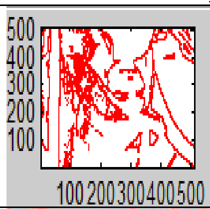
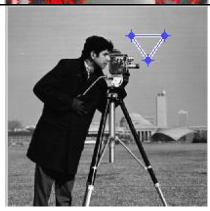
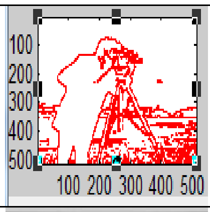
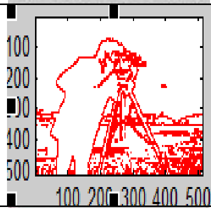
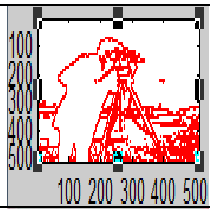
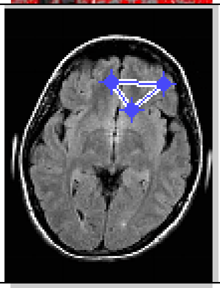
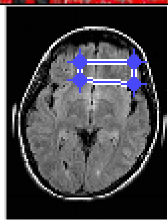
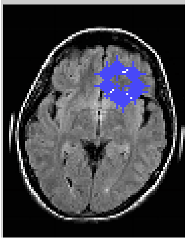
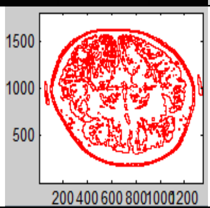
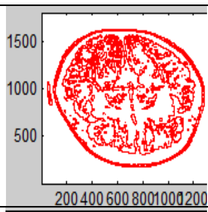
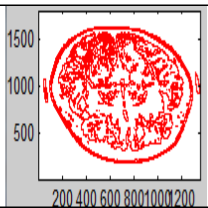
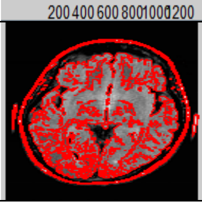
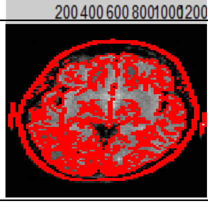
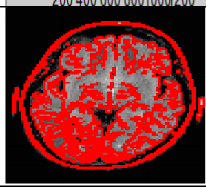
This is the level set equation given by Osher and Sethian. The figure 2shows the outward propagation of an initial curve and the accompanying motion of the level set function (ϕ) . The initial circle is shown in figure 2a and figure 2c shows the circle at a later time. In figure 2b, we show the initial position of the level set function ϕ , and figure 2d show this function at a later time. This is also referred to as Eulerian formulation because the underlying coordinate system remains fixed.

IV. RESULTS AND DISCUSSION

The proposed algorithm is tested on standard set of images from the standard database which consists of noisy and medical images. The grace of the algorithm is that it works independently of the shape of the contour. The different contour shapes are taken and promising results are obtained as shown in Table 1.

TABLE I

Images	Triangular Geometry contour	Rectangular Geometry contour	Circular Geometry contour
			

Test Image 1			
			
Test Image 2			
			
			
Test Image 3			
			
			

V. CONCLUSION AND FUTURE SCOPE

Image segmentation has played a vital role in image enhancements. Contour extraction is the key feature of all time for all researchers. This paper has proposed the new adiabatic approach towards the contour extraction. Here, LSM is studied in detail and the improved LSM is implemented using the mathematical modelling. Here, contour independency and format independency is achieved in real time domain. Further, this work can be extended to the more set of images which can include the video processing and real time image extraction from the video. This method can also be implemented on real set of data which contain high calibrated pixel density. The satellite image contour extraction can also be successfully implemented using above mentioned approach.

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