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Study of Active Contour Modelling for Image Segmentation: A Review

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Abstract

Active contour models are widely used for image segmentation. In this paper the study of various active contour models based on Chan-Vese approach is given. Partial differential equation based method widely used on real and artificial noisy images with different shapes and blurring boundaries and energy minimization has been achieved. The possibilities of extracting exact contour using these methods on artificial and real pictures depends upon the number of iterations and resulted into efficient and accurate segmentation but the dependency of method is on initial points of contour and subject to constraints from a given image. Development of video segmentation, a combination of active contour method and watershed presegmentation for tracking of moving objects is aimed to differentiate ROI and NROI efficiently but uncertainty of the moving micro objects partially deviate the results. The overall techniques can be implemented for the configuration based quality analysis of food products.

Keywords: active contours; image segmentation; level sets; PDM; GDM; watershed segmentation.

Introduction

Active contour is the name for all methods that find the curve that best separates object in an image. It is also called image segmentation. In the past two decades, active contour models (ACM) or snakes have been widely used for shape representation and object segmentation in image processing. The shape of an object can be described in two terms: either of its boundary or the region it occupies. The shape representation based on boundary information requires image edge detection and edge following. On the region based approach shape representation requires image segmentation in several homogeneous regions [2]. An active contour is energy minimizing spline that detects the specified features within an image [3] .The features of an image are the image properties like intensity, color, texture etc. The fundamental idea of active contour model is to start with a curve around the object to be detected and the curve moves toward its interior normal and stops on the true boundary of the object. The two main classes of active contours are present in literature: parametric deformable models (PDM's) and geometric deformable models (GDM's). The PDM's represents the contour explicitly as a parametric curve. The GDM's represents the contour implicitly using level-sets [3].

Active Contour Models

ACM given by Chan et al. [1], 2001 is the curve evolution implementation of piecewise constant case of Mumford-Shah functional and level-sets for image segmentation. It is called Chan-Vese active contour model. The partial-differential equations based model is widely used for image segmentation. The classical ACM used an edge-detector, depending on the gradient of image. The Chan-Vese model detects objects whose boundaries are not necessarily detected by the gradient. The information from region based level set methods used to segment image in terms of energy functional. The purpose of utilization of global region information is to stabilize the responses to local variations such as noise and weak boundaries. The research show that model works on noisy & synthetic image with various shapes and blurred boundaries.

The active contour is made by applying the number of control points in sequence order. According to the paper given by Bakos [3], 2007 the active contour models are categorized as: 1) parametric deformable models and 2) geometric deformable models. The PDM represent curve and surfaces during deformations explicitly in curve form and their description is given by formulation of energy minimization. Energy minimization is finding the curve that minimizes the weighted sum of internal energy and potential energy. Dynamic forces are those which cannot be described as a negative gradient of potential energy functional. The second

category GDM is based on evolution curve theory and level set method. The topological changes are controlled easily by using geometric deformable models. The author showed some possibilities of the use of active contour methods on artificial and real pictures, the experiments was realized in method shown below in figure. After initialization the formation of exact contour is depend on iterations and the number of iterations required are depend on the size of scanned surrounding. If the surrounding is large then small number of iterations is required. The results were obtained fast and efficient but there is dependency of the method on initial points of contour and types of pictures.

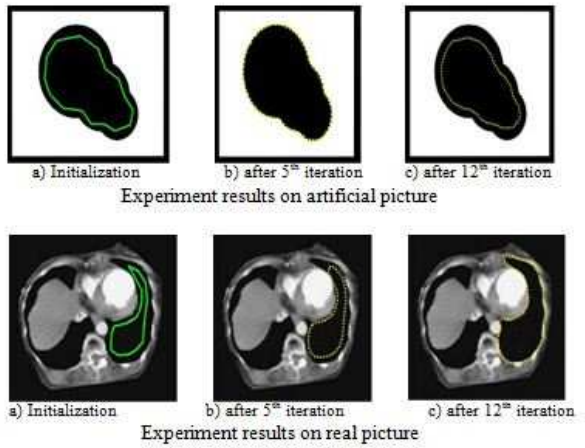
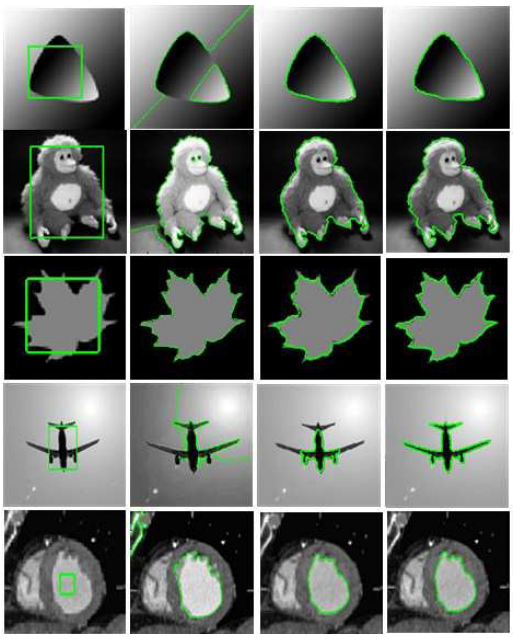
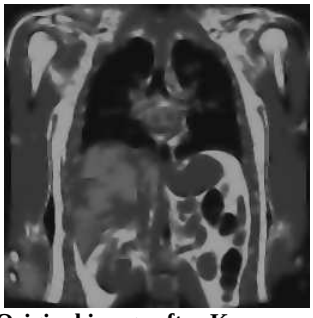


Figure 1

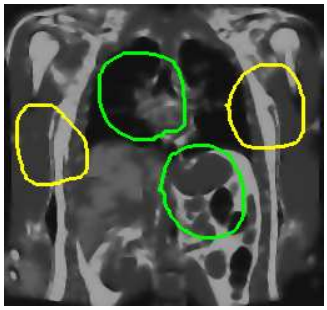
The existing ACM's can also be classified into two types: Edge based model and region based models. The edge based model utilize image gradient as an additional constraint to propose to stop the contour on boundaries of desired object. Region based model utilize the image statistical information to construct constraints. Srikham [8], 2012 developed a novel ACM for image segmentation. The model utilizes the geodesic active contour (GAC), an edge based model and localizing region based active contour (LRAC), a region based model. The benefit of combination of above two techniques is efficient detection of weak boundaries and capability to reach into deep concave shapes of contour. The proposed method has been applied both on synthetic and real images and achieved efficient and accurate results as compared to selective binary and Gaussian filtering regularized level set (SBGFRLS) method, LRAC method as shown in figure 2. The technique is applicable for segmentation of heterogeneous texture objects of U-V shapes.



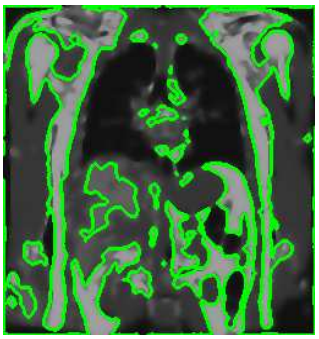
Comparative results of segmentation a) Initial contour b) SBGFRLS method c) LRAC method d) Developed method Figure 2



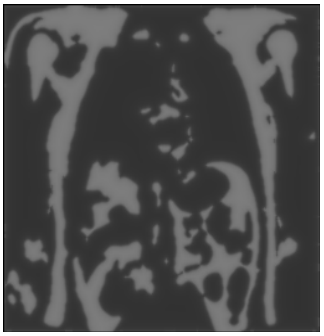
a) Original image after K-means smoothing



b) Begin curve drawing with seed point and initial level set



c) **Segmented image by Chen-Vese approach**



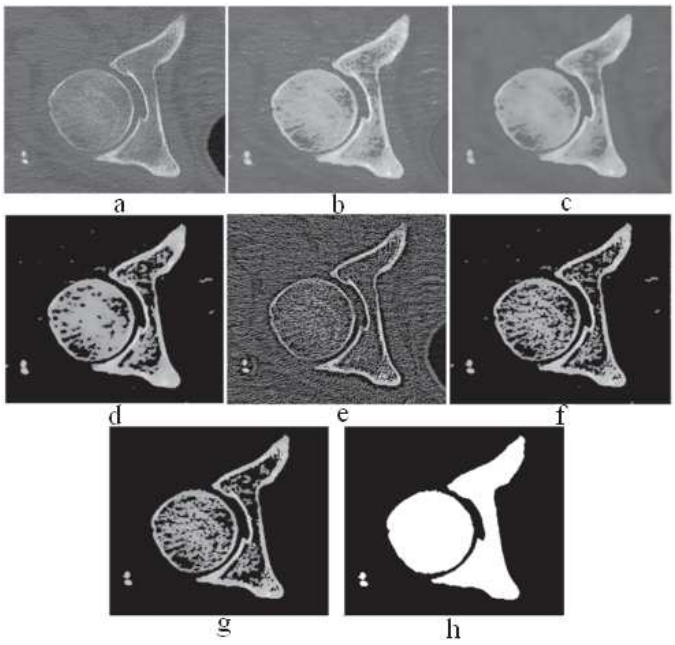
d) **Map of segmented regions of pervious c-step**

Experiment results on abdomen medical image
Figure 3

Gouze et al. [4], 2005 developed a new method for video segmentation which combines an active contour and a watershed presegmentation. The active contours are utilized for tracking of moving objects. The watershed method is used to improve segmentation after tracking. It divides the topographical surface in different catchment basins separated by watershed lines. The approach is applicable for moving object detection in video for static camera only.

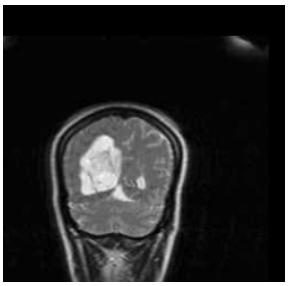
Wang et al. [5], 2010 developed a new Local Chan-Vese (LCV) model for image segmentation. The LCV method is based on techniques of curve evolution, local statistical function and level set method. The energy functional of the model consists of global term, local term and regularization term. Local image information is used to efficiently segment the homogeneous regions based on intensity. The level set based regularized term is used to fast up the segmentation process. The complex method worked out on synthetic and real image and provides two modal images of two segments i.e. foreground and background.

In medical science, the aim of segmentation is to differentiate between Region of Interest (ROI) and Non-Region of Interest (NROI). Morar et al. [6], 2012 designed a new segmentation algorithm based on active contour without edges. The other image processing techniques such as non-linear anisotropic diffusion and adaptive thresholding are also used to overcome the image problems of accurate segmentation. The algorithm gracefully deals with the noisy and more inhomogeneous objects in CT scanned images as shown in figure 4. The results achieved 96% accuracy, but time complexity is a drawback.

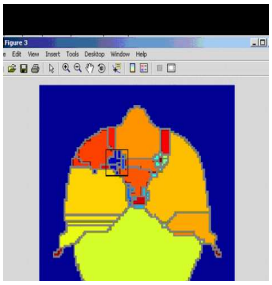


Output images in the image segmentation steps: (a) original image(b) image enhanced with active contours without edges (c) imagesmoothed with nonlinear anisotropic diffusion (d) result of adaptive thresholding (e) output image after applying an adaptive threshold onthe original image (f) image obtained by combining the images u3and u4 (g) image resulting from connecting the foreground pixels into slice islands and removing those islands with a low intensity (h) final image after applying the hole filling step.
Figure 4

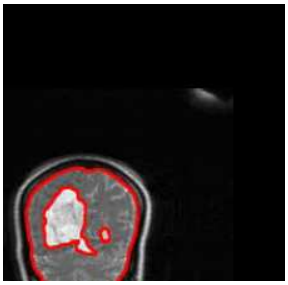
The clustering algorithms can do well segmentation in absence of noise. The segmentation of medical images suffers from computational complexity and presence of noise. Bhat et al. [7], 2010 designed a method that is combination of watershed algorithm and active contour algorithm to improve above stated problem. The ROI extraction of MR image is done by watershed method and boundaries are detected by applying active contour method. The proposed model is evaluated on MR image with concave tumor region, Gaussian noise, speckle noise, and salt & pepper noise. The semi-automatic technique has been provides 95% accurate results on above mentioned MR images.



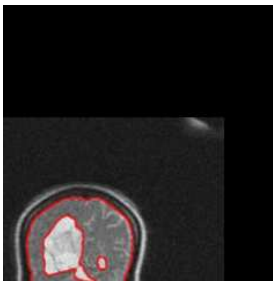
a) Real Brain MR image



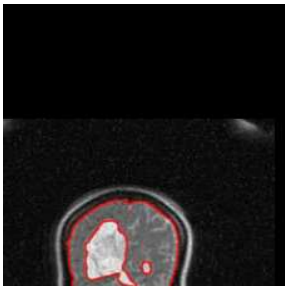
b) Watershed segmented tumor



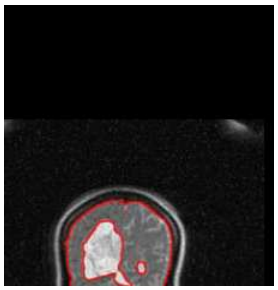
c) Segmented tumor



d) Gaussian noise



e) Speckle noise



f) Concave tumor region

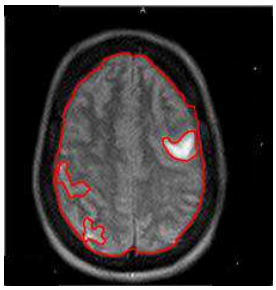
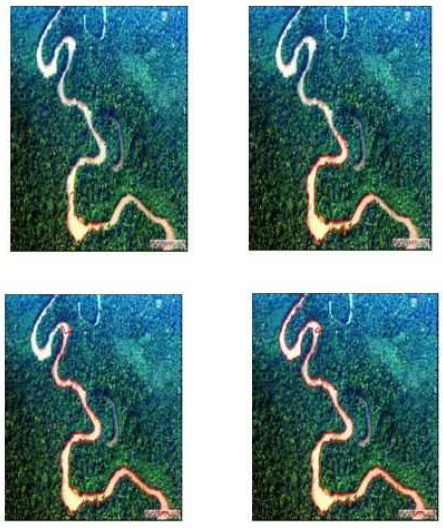


Figure 5

A shape restrained Chan-Vese model to segment the tubular objects such as vessel, road and river is presented by Zhu et al. [9]. The method combines the Chan-Vese model using level sets and elliptic shape restraint for papilla object segmentation. The algorithm relies on the tubular structure response information to enhance the tubular structure and the response direction which is obtained by adding pulling term in evolution equation which force the curve evolving along tubular direction. The method can be used in road detection and vessel segmentation. The model provides effective segmentation as shown in figure 6.



The contour evolution for a river image
Figure 6

Conclusion

The classical ACM's used an edge detector depending on the gradient of image whereas the basic Chan-Vese model used the global region information and level sets. The model is highly appreciable for extraction of contour boundary. In medical field, the results of segmentation provide accurate region extraction. Many experiments on real images as well on synthetic images have been performed by researchers and they obtained computationally efficient and accurate results. The Chan-Vese method is less sensitive to noise because it used local and neighboring points of an image, provides the benefit of detection of broken edges, topological changes and disconnected regions. Reference model is used by all above discussed techniques for segmentation. Yet the segmentation techniques are not much successfully utilizing the developed algorithms in measurement of quality of food products and can minimize the time consumption with better measurement results.

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