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## An Improved Images Segmentation Methods Based on Level Set

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### ABSTRACT

Times New Roman, 8.5. Level set methods have been extensively used in image segmentation, but their implementation is complex and computationally expensive. By analyzing all segmentation algorithms based on level set, a new one based on template is proposed. This method firstly preprocessed the images by gray processing and de-noising. Then, optimized the image contour by using level set algorithm based on partial sample. Finally, extracted the target object by using the mean value replaced extraction algorithm. The experiment results show that this algorithm can obtain the satisfactory effect in segmentation precision and speed.

**Key words:** Level set, milk somatic cell, partial sample, image segmentation

### INTRODUCTION

With the continuous development of the computer the application of digital image processing technology in the biomedical field is more and more extensive. Changes in morphology, size or the quantity in unit volume of the same kind of cells under different conditions of physiology, pathology or experiment are important basis for pathological study and disease diagnosis. Calculation and analysis of morphology, size and the quantity etc of cell in micro-cell image using image processing technology is a challenging subject. Image segmentation is an important foundation for the subsequent image analysis, segmentation directly influences the subsequent image analysis tasks (Yang and Yang, 2007; Merkin *et al.*, 2013).

Edge detection of cell is the basis for the quantitative calculation and analysis of cell area, roundness and the number. If the edge detection is not ideal, morphological analysis of cells cannot continue. The classical edge detection methods are sensitive to noise, the edge pixels are isolated or small section of the continuous, the edge width is larger than the real and it causes defects such as overlapping adjacent cells, unable to detect the reliable edge position of cell (Li *et al.*, 2010; Lee *et al.*, 2009; Choi and Choi, 2011). In order to solve the problem of the coordination between edge detection accuracy and anti-noise performance, the author puts forward the level set algorithm based on templates and this algorithm is applied to image segmentation of milk somatic cell.

### MATERIALS AND METHODS

**Segmentation algorithms based on level set:** Firstly, the basic idea of segmentation method based on level set (Zuo *et al.*, 2011; Gao, 2012; Li *et al.*, 2005) is given a closed initial contour.

Then the initial contour gets close to target in a series of external and internal forces. Finally, the initial contour will stop at the edges of objects according to the certain constraint conditions until finish the segmentation.

We hypothesize that  $\phi(x, y, t): \mathbb{R}^2 \times [0, T] \rightarrow \mathbb{R}$  is a continuous level set function,  $t$  is time parameter, the family of closed curve  $C(p, t): 0 \leq p \leq 1$  express the zero level set that  $t$  moment  $\phi(x, y, t)$  corresponded, that is:

$$\begin{cases} C(p, t) = \{(x, y) \mid \phi(x, y, t) = 0\} \\ C(p, 0) = \{(x, y) \mid \phi(x, y, 0) = 0\} \end{cases} \quad (1)$$

Corresponding to the level set equation:

$$\begin{aligned} \frac{\partial \phi}{\partial t} + F \nabla \phi &= 0 \\ \frac{\partial \phi}{\partial t} + F \left\{ \left( \frac{\partial \phi}{\partial x} \right)^2 + \left( \frac{\partial \phi}{\partial y} \right)^2 \right\}^{\frac{1}{2}} &= 0 \\ F &= k \end{aligned} \quad (2)$$

The value can be approximated to be:

$$\phi_{ij}^{n+1} = \phi_{ij}^n - \Delta t [\max(F_{ij}, 0) \nabla^+ + \min(F_{ij}, 0) \nabla^-] \quad (3)$$

$$\begin{aligned} \nabla^+ &= [\max(D_{ij}^{-x}, 0)^2 + \min(D_{ij}^{+x}, 0)^2 + \max(D_{ij}^{-y}, 0)^2 + \min(D_{ij}^{+y}, 0)^2]^{\frac{1}{2}} \\ \nabla^- &= [\max(D_{ij}^{+x}, 0)^2 + \min(D_{ij}^{-x}, 0)^2 + \max(D_{ij}^{+y}, 0)^2 + \min(D_{ij}^{-y}, 0)^2]^{\frac{1}{2}} \end{aligned} \quad (4)$$

$D_{ij}^{+x}, D_{ij}^{-x}$ , respectively express forward and backward partial differential operators.

The level set segmentation method is simple but this method needs to calculate the distance from each grid point to the current contour line in all image at each  $\Delta t$  moment. Then connect all the points with zero distance as a new profile curve. So, repeated iteration until the segmentation is done. The complexity of the 3D image by using this algorithm is  $O(n^4)$ . Where,  $n$  is the size of the image with a large amount of computation and it is difficult to put into practice. But as long as the time step  $\Delta t$  value is small enough, the change quantity  $\psi$  of function is not great after one iteration. That is after a  $\Delta t$ , the new contour will only move a short distance inward or outward in the current contour position. So, limit a  $t$  moment calculation on narrow band around the current contour grid, instead of the whole image calculating, the complexity will be reduced to  $O(kn^2)$ . This is the basic idea of a narrowband method for rapid realization algorithm.

### **Implement of image segmentation**

**Image preprocessing:** In order to get better segmentation effect and better to case analysis, this study firstly choose a cell image in which cells are relatively uniform distribute by visual inspection.

- **Image gray processing:** Using the maximum method, the mean method, weight method for gray image processing, respectively to obtain the optimal effect. It can be seen through the experiment that the gray scale is the best in the sample by weight method
- **Image de-noising:** Using gauss filtering method for image filtering

**Optimized image contour by using the partial sample level set algorithm:** Using the level set method, an outline  $C \subset \Omega$  can be represented by a zero level set of a Lipschitz function  $\phi: \Omega \rightarrow \mathbb{R}$ . Represented by level set, energy function  $\varepsilon_x^{\text{LBF}}(C, f_1(x), f_2(x))$  can be written as:

$$\varepsilon_x^{\text{LBF}}(C, f_1(x), f_2(x)) = \lambda_1 \int K_\sigma(x-y) |I(y) - f_1(x)|^2 H(\phi(y)) dy + \lambda_2 \int K_\sigma(x-y) |I(y) - f_1(x)|^2 (1 - H(\phi(y))) dy \quad (5)$$

where,  $H$  is the Heaviside function. Therefore, the sample energy  $\varepsilon$  can be written as:

$$\begin{aligned} \varepsilon(\phi, f_1, f_2) &= \int_{\Omega} \varepsilon_x^{\text{LBF}}(\phi, f_1, f_2) dx = \lambda_1 \int \left[ \int K_\sigma(x-y) |I(y) - f_1(x)|^2 H(\phi(y)) dy \right] dx + \\ &\lambda_2 \int \left[ \int K_\sigma(x-y) |I(y) - f_1(x)|^2 (1 - H(\phi(y))) dy \right] dx \end{aligned} \quad (6)$$

In order to get the stable evolution of the level set function  $\phi$ . Add the distance regularization term in the equation:

$$P(\phi) = \int_{\Omega} \frac{1}{2} (|\nabla(\phi)| - 1)^2 dx \quad (7)$$

In order to prevent the level set function is no longer a signed distance function through evolution. At the same time, we need the length of zero level curve of  $t$  to regulate the zero contours. The length term is given by the equation:

$$L(\phi) = \int_{\Omega} \delta(\phi(x)) |\nabla \phi(x)| dx \quad (8)$$

Hence, finishing the above energy item, I can define the overall energy function:

$$F(\phi, f_1, f_2) = \varepsilon^{\text{LBF}}(\phi, f_1, f_2) + \mu P(\phi) + \nu L(\phi) \quad (9)$$

where,  $\mu, \nu$  are nonnegative constants.

In practical application,  $H_\varepsilon$  commonly used approximate Heaviside function  $H$ :

$$H_\varepsilon(x) = \frac{1}{2} \left[ 1 + \frac{2}{\pi} \arctan\left(\frac{x}{\varepsilon}\right) \right] \quad (10)$$

Derivative of the function  $H_\varepsilon$ :

$$\delta_\varepsilon(x) = H'_\varepsilon(x) = \frac{1}{\pi} \frac{\varepsilon}{\varepsilon^2 + x^2} \quad (11)$$

Substituting the above two formulas into the overall energy function  $\epsilon^{\text{LBF}}$  and  $L$  to get  $\epsilon^{\text{LBF}}$  and  $L_\epsilon$ . Generally choose  $\epsilon = 1.0$  can get value of  $H_\epsilon$  and  $\delta_\epsilon(x)$  which is closer to  $H$  and  $\delta$ . Therefore, the energy function  $F(\phi, f_1, f_2)$  can be approximated by:

$$F_\epsilon(\phi, f_1, f_2) = \epsilon^{\text{LBF}}(\phi, f_1, f_2) + \mu P(\phi) + \nu L_\epsilon(\phi) \quad (12)$$

Get the object boundary by minimizing the above energy function.

**Extraction of the target object:** Using the optimization algorithm can obtain smooth communication boundary of object, which achieved better contour and then extract objects based on the evolution. This study presents mean value replaced extraction algorithm. The basic idea of extraction algorithm is that scanning the contour image to find the position of the contour, this position is in one-to-one correspondence with the location of gray scale image. Due to the contour divide the whole image into different areas, replace each pixels of each part of each row with a mean value. Because the difference between the target and the gray background is larger, so as to realize the enhanced contrast between target and background, thus complete the extraction of objects. The concrete algorithm is as follows:

- Uses the images with contour evolution as a contrast image, the single component image of this image are put to use as the operation image (below contrast image and operation image express their own representative)
- Firstly scan the contrast image in each row, record the boundary points of each line and points which is located in the contour. They divide one line into several segments. As the same, the point in corresponding position on the operation image also divide points on the operation image into the corresponding number. The gray scale of each pixel on operation image is replaced by the mean value of the pixel in this section
- In order to get better results, repeat step 2 after transpose the results obtained in step 2, reconstitute the operation image into a image with sharp contrast.
- Converting the results to binary
- Using the open-close operation of mathematical morphology to process the final segmentation results (Li *et al.*, 2009, 2011; Wayalun *et al.*, 2012; Papari and Petkov, 2008). Removing isolated point and burr through the open operation. Filling holes and bridging small cracks through he closing operation
- Complete extraction of the target object

## RESULTS AND DISCUSSION

Taking milk somatic cell for instance to achieve process. The samples graph is shown in Fig. 1. Gray process color samples of milk somatic cell image by the method of weighted mean, the process result is shown in Fig. 2. Using Gauss filtering method for image filtering. The iterative effect of partial sample functions optimization method is shown in Fig. 3.

Because the traditional level set method for contour evolution is time-consuming, in order to compare, in this study the initialized contour of milk somatic cell image is manually given and the zero level set is defined.

This method relates to time step parameters  $\tau = 0.1$ , optimization algorithm  $\mu = 1.0$ ,  $\nu = 0.001 \times 255^2$ , Gaussian operators  $\sigma = 3.0$ ,  $\lambda_1 = \lambda_2 = 1.0$ .

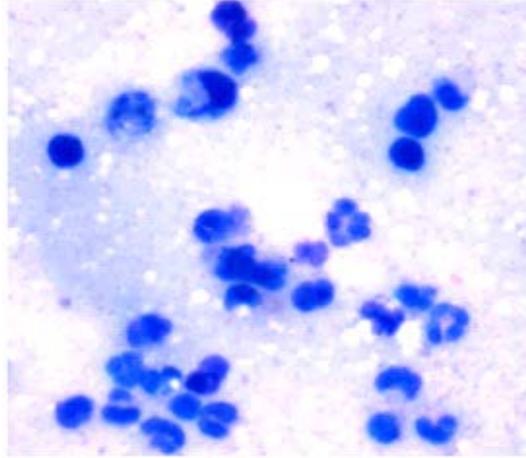


Fig. 1: Master drawing

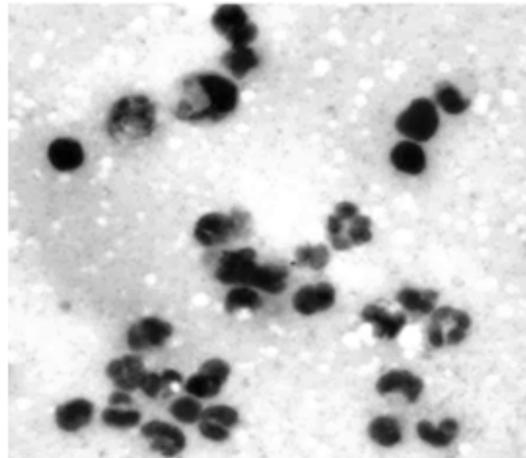


Fig. 2: Gray processing

For the above-mentioned evolution results, by using the method of extraction is proposed in this paper to extract the somatic cell in the image. the process result is shown in Fig. 4.

**Post-processing of overlapping cell:** There have been many studies on the separation of overlapping cells (Dong *et al.*, 2013; Song and Wang, 2009; Genctav *et al.*, 2012). On the basis of the analysis of these studies, the study mainly aimed at the characteristic that the boundary intersection of cell is concave while the normal boundary points is convex. Using the watershed algorithm to segment the overlapping cells and achieved good results. The main steps of segmentation are as follows:

- Implement the distance transform to binary image which obtains packed cell after segmentation
- Reconstruction of distance graphs
- Then watershed transform
- To get the image of separated cells through superimposition of watershed and binary image

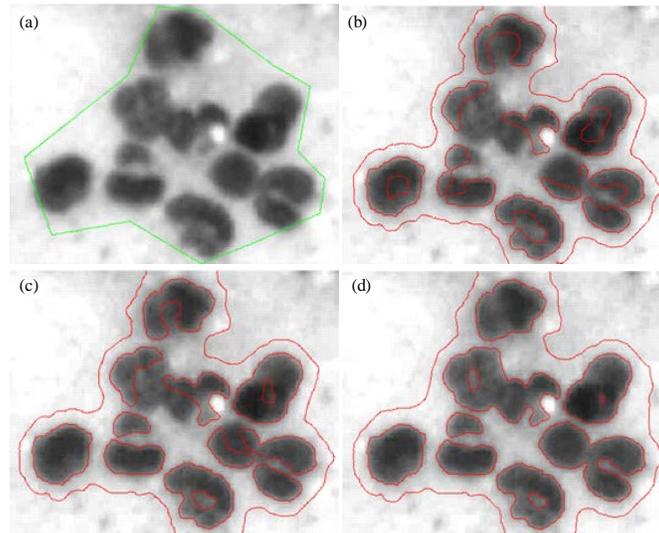


Fig. 3(a-d): Iterative effects of partial sample functions optimization method, (a) Initial contour, (b) 50 iteration, (c) 100 iteration and (d) 400 iteration

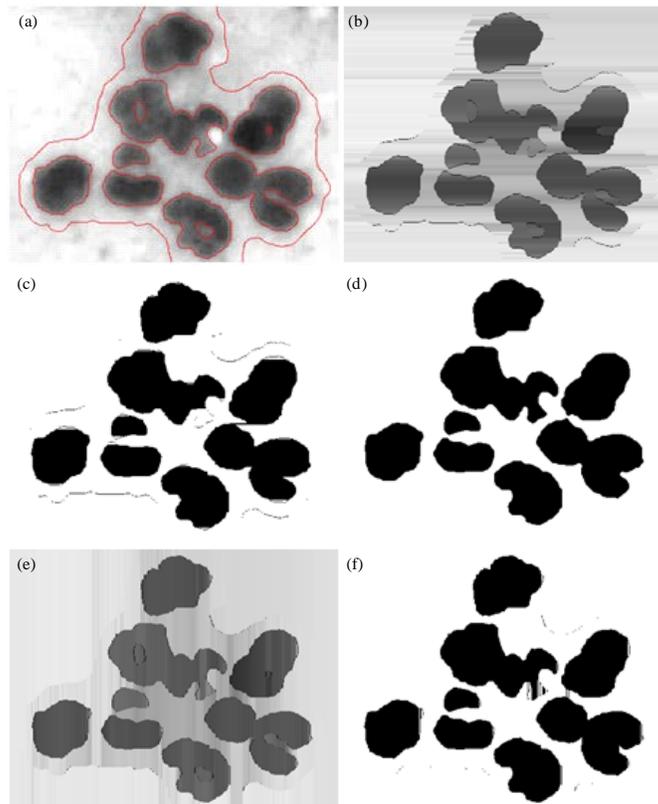


Fig. 4(a-f): Extraction of the target object, (a) Segmentation results of optimized level set method, (b) Transverse scan the mean substitution results, (c) Results are converted to binary after transverse treatment, (d) Extractions of cell image, (e) Longitudinal scan the mean substitution results, (f) Results are converted to binary after longitudinal treatment

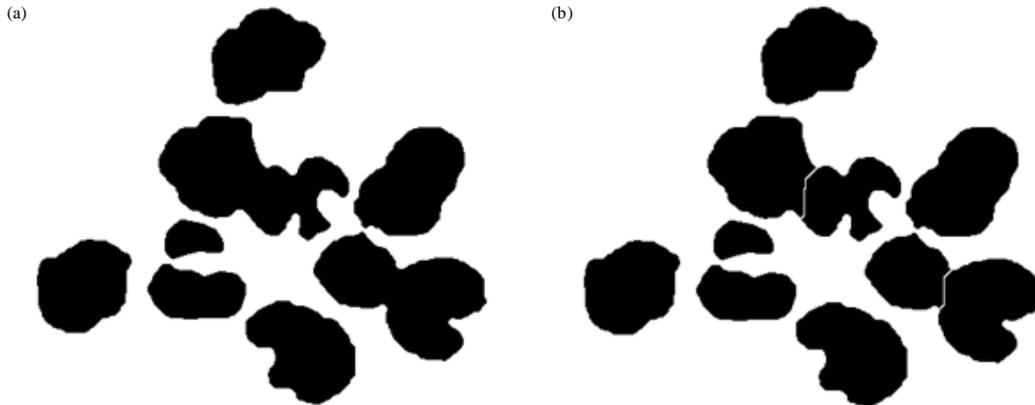


Fig. 5(a-b): Post-processing of overlapping cell

The followed graph show the separation results by this method. According to Fig. 5, those packed cells have been separated.

## CONCLUSION

This study analyzes the theory of image segmentation at home and abroad, especially the cell image segmentation method and some main problems of this method. To put forward the main research contents of this subject by aiming at the specific segmentation object-milk somatic cell image.

By synthesizing several factors such as segmentation speed, efficiency and dividing target to determine the conditioning regimen of milk somatic cell image based on analysis and experimental comparison of the common gray algorithm and filtering algorithm.

Thoroughly learn and analyze the typical variation level set method such as classical M-S model and C-V model of the simplified M-S model. The constant model is difficult to deal with inhomogeneous image inside and outside the region. For this characteristic, the methods based on variation level set which optimized by partial sample functions has been presented. Smooth functions have been adopted to take the place of the constant of the C-V model in partial sample functions optimization method. This method is a good solution for the problem of inhomogeneous image segmentation. At the same time, introducing the distance regularization term in the energy function to ensure that the level set function can keep to be signed distance function in the evolutionary process of level set function. The numerical experiment shows that the segmentation speed and effect has been improved significantly by using variation level set method.

Progressive scan the segmentation image that obtained by using optimized level set method. Reconstruct the gray scale image by using the mean substitution method and convert it to binary. The separation of milk somatic cell and background is achieved through the above process. Using the watershed algorithm to segment the overlapping cells can get the better effect.

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