A COMPLEX IMAGE SEGMENTATION PROCESSING METHOD

ZHAO Min-rong[1], ZHANG Xi-wen[2]
[1] Department of Basic Sciences, Air Force Engineering University, Xi'an 710000, China
[2]Telecommunication College, Air Force Engineering University, Xi'an 710000, China

ABSTRACT

Image Segmentation is a Classical problem in Image processing and Image Analysis, The 3D reconstruction technology based on image has become a research hotspot, and the segmentation effect directly affects the accuracy of the model after 3D reconstruction. For complex images, it is difficult to describe the changing process of contour by parameterized curves or surfaces because of the complexity and randomness of the topological changes of the contours of the main parts. The method of segmenting terrain and geomorphology image is studied in this paper, which lays a foundation for 3D terrain reconstruction based on image.

Keywords *- C-V model, image segmentation, level set*

I. INTRODUCTION

The successful reconstruction of 3D world in many important fields, such as remote sensing image and medical image processing, has been widely used. The key technology of image reconstruction is to identify the image region corresponding to the object of interest, that is, image segmentation. Complex images , such as terrain and geomorphic graphics , need to be split across multiple features , all of which are equally important, The purpose of image segmentation is to identify all the contours that isolate two different grayscale areas, as shown in figure 1. At this point, image segmentation is to get a simplified version of the original image.

II. LEVEL SET THEORY FOR NUMERICALLY SOLVING M-S SEGMENTATION MODEL

The basic idea of image segmentation and reconstruction based on level set is: The evolutionary boundary $C(p,t)$ is expressed as $\phi(x,y,t)$ a zero level set of functions $\phi(x,y,t)=0$. Function $\phi(x,y,t)$ is represented as

$$\phi(x,y,t): R^2 \times [0,T) \to R$$

The $0 \le t < T$, Because its value is usually taken as the algebraic distance from the point in the plane to the boundary curve, that is, the distance between the points inside the curve is negative, the distance from the outer point of the curve is positive, and the distance from the point on the curve is zero. Therefore $\phi(x,y,t)=0$, The implicit $\phi(x,y,t)=0$ representation of the reflecting curve $C(p,t)$, that is,

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

The goal is to close the plane curve of the zero level set $C(p,t)=\{(x,y)|\phi(x,y,t)=0\}$ in the evolution of the level set function:

$$\phi[C(t),t]=0. \tag{2}$$

Partial differential equations that always satisfy the Evolution of Curves $\frac{\partial C}{\partial t}=V(k)\overline{N}$, For (1) all differential equations.

$$\nabla\phi\frac{\partial C}{\partial t}+\frac{\partial \phi}{\partial t}=0 \tag{3}$$

Where: $\nabla\phi$ is the gradient tof ϕ.

The above velocity function is positive in the similar region and 0 at the edge. When the driving level set evolves, the implicit upper speed function is positive in the similar region and 0 at the edge. When V driving level set evolves, the implicitly represented curve C evolves. When the speed is 0, evolution stops, so the final contour can be extracted.

Level set methods can be easily extended to high-dimensional situations, and it is easy to implement numerical calculation approximation algorithms, which can use finite difference methods to realize the evolution of functions, etc. However, the result of level set segmentation is prone to cause boundary leakage. For the segmentation of complex images, there is a choice of velocity field parameters, so the segmentation speed is slow.

III. COMPLEX IMAGE SEGMENTATION MODEL

A Model Description

This complex image of the terrain and uneven grayscale texture images are shown in Figure 2.

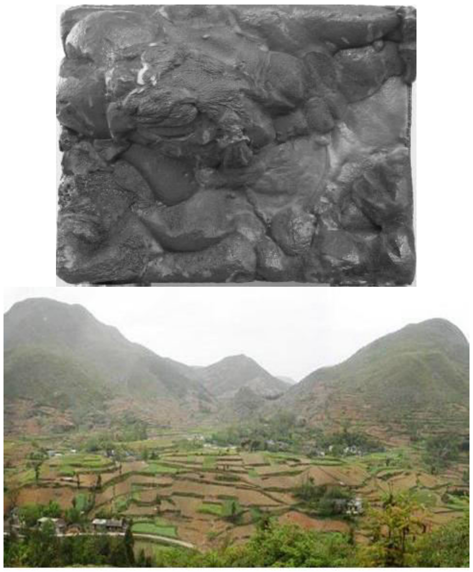


Figure1. Complex image of the terrain

Traditional level set methods use separate Chan-Vese models or separate RSF models for curve evolution [1，3，5]. None of them is sufficient to complete the analysis of the complex imagery of the terrain in the map. herefore, we combine the Chan-Vese model with the RSF model, taking into account the global grayscale information and the local grayscale information in the image, and combine the items based on the tensor field to process the texture image segmentation problem.

Define the energy function:

$$
\begin{aligned}
&E(T_1,T_2,f_1,f_2,C)=\mu\cdot Length(C)+\nu\cdot Area(inside(C))\\
&+\lambda_1\cdot\int_{inside(C)}(w|T(x)-T_1|^2+(1-w)\int_{inside(C)}K_\sigma(x-y)(|I(y)-f_1(x)|^2)dy)dx\\
&+\lambda_2\cdot\int_{outside(C)}(w|T(x)-T_2|^2+(1-w)\int_{outside(C)}K_\sigma(x-y)(|I(y)-f_2(x)|^2)dy)dx
\end{aligned}
$$

(4)

Where w is a positive constant $0\le w\le 1$. T(x) is given by (4.32). When the grayscale unevenness in the image is serious, the parameter w should take a smaller value. When it is a texture image, it should take a larger value.

B Level Set of Energy Function

The level set implementation of the energy function is to solve the minimization of the energy function by replacing the n-dimensional curve C with a n+1-dimensional function, and replace the two-dimensional curve with a three-dimensional surface function, so the level set function is rewritten as:

$$
\begin{aligned}
&E(T_1,T_2,f_1,f_2,\varphi)=\mu\cdot\int|\nabla H_\varepsilon(\varphi)|dx\\
&+\lambda_1\cdot\int(w|T(x)-T_1|^2H_\varepsilon(\varphi)+(1-w)\int K_\sigma(x-y)|I(y)-f_1(x)|^2H_\varepsilon(\varphi(y))dy)dx\\
&+\lambda_2\cdot\int(w|T(x)-T_2|^2(1-H_\varepsilon(\varphi))+(1-w)\int K_\sigma(x-y)|I(y)-f_2(x)|^2(1-H_\varepsilon(\varphi))dy)dx
\end{aligned}
$$

(5)

Use the variational method and steepest descent method to find the minimum value for , to get the corresponding gradient descent flow:

$$\frac{\partial\varphi}{\partial t}=-\lambda_1\delta_\varepsilon(\varphi)((1-w)e_1+w(T-T_1)^2)+\lambda_2\delta_\varepsilon(\varphi)((1-w)e_2+w(T-T_2)^2)+\mu\delta_\varepsilon(\varphi)div(\frac{\nabla\varphi}{|\nabla\varphi|})$$

(6)

(The proof reference [5]): The standard method of minimizing the energy function is to solve the following gradient flow pattern:

$$\frac{\partial\varphi}{\partial t}=-\frac{\partial E}{\partial\varphi}$$

(7)

Where, $\frac{\partial E}{\partial\varphi}$ is the differential of the energy function [3]

Combining the above three kinds $G\hat{a}teaux$ of differentiation, you can get:

$$\frac{\partial E}{\partial\varphi}=\lambda_1\delta_\varepsilon(\varphi)((1-w)e_1+w(T-T_1)^2)-\lambda_2\delta_\varepsilon(\varphi)((1-w)e_2+w(T-T_2)^2)-\mu\delta_\varepsilon(\varphi)div(\frac{\nabla\varphi}{|\nabla\varphi|})$$

(8)

By using equation (7) for the energy function E, we can obtain its gradient flow equation (6).)

Further, by embedding our fast Chan-Vese model into equation (6), we can get the following formula:

$$\frac{\partial\varphi}{\partial t}=-(1-w)\delta_\varepsilon(\varphi)(\lambda_1e_1-\lambda_2e_2)+w(T-\frac{T_{\max}+T_{\min}}{2})(T_{\max}-T_{\min})+\mu\delta_\varepsilon(\varphi)div(\frac{\nabla\varphi}{|\nabla\varphi|})$$

(9)

C Level Set Functions and Numerical Methods

Apply formula (4.54) to the curve evolution theory, $T_{\max},T_{\min}$ gived by:

$$T_1(\varphi)=\frac{\int_\Omega T(x)H(\varphi)dx}{\int_\Omega H(\varphi)dx}\qquad T_2(\varphi)=\frac{\int_\Omega T(x)(1-H(\varphi))dx}{\int_\Omega(1-H(\varphi))dx}$$

$T_{\max} = \max(T_1(\varphi), T_2(\varphi))$ $\quad T_{\min} = \min(T_1(\varphi), T_2(\varphi))$

(10)

Where H(.) is the Heaviside function, When $x \in ourside(C)$ $H(\varphi(x)) = 0$, otherwise $H(\varphi(x)) = 1$.

In practical applications, we use a Gaussian kernel function to avoid irregular surfaces of the level set function by using regular items in order to eliminate the time required for the reinitialization process. We use an iterative approach to the proposed model and the iterative steps are as follows:

(1) Initialize to level set function φ:

$$\varphi(x, t=0) = \begin{cases} -\rho & x \in inside(C) \\ 0 & x \in C \\ \rho & x \in outside(C) \end{cases}$$

(11)

(2) Evolve the level set function φ according to (9);

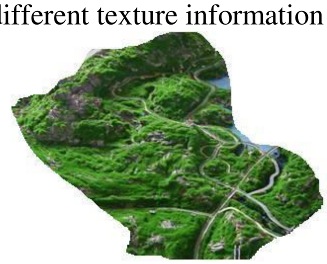
(3) Gauge the level set function by using a Gaussian filter:

(4) Check if the evolution is convergent, if not, go to step (2)

In step (3), G_ζ represents a Gaussian filter. The proposed method has low computational complexity compared to the conventional active contour model. In the proposed method, the most time consuming step is the third step Gaussian convolution, where the complexity is $O(m^2 \times N)$, where N is the size of the image. Then reinitialize the computational complexity as . Because of $m^2 << N$, our method is more efficient than the traditional level set method.

D Experiment

The following is the segmentation result of several typical landforms using the method in the text. Apply our method to different artificial and actual images. During the experiment, we set the same parameters as: $\rho = 1, \varepsilon = 1, \zeta = 0.5, m = 5, \sigma = 3,$ The time step is: $\Delta t = 0.025$, In addition, parameters are selected according to different texture information in the image.



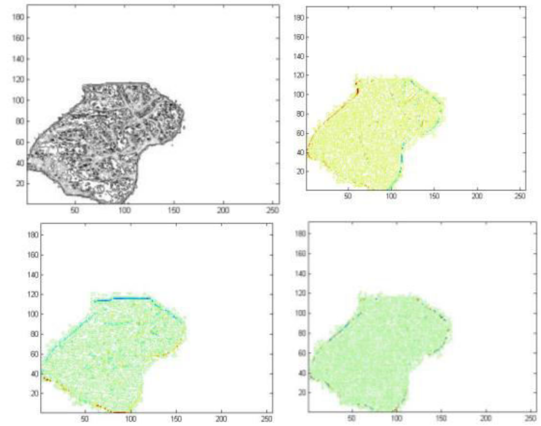


Figure2. The segmentation result

IV. SUMMARY

Aiming at the time-consuming characteristics of the partial set differential equations for solving partial differential equations, a fast implementation method of the Chan-Vese model is proposed. On the one hand, this method maintains the good topological performance of the traditional level set method, and on the other hand avoids the The numerical solution of the differential equations allows the same segmentation results to be obtained in a shorter time and improves the efficiency of the segmentation. The basis for 3D reconstruction based on images was identified.

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