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Algorithm of Image Contour Extracting Based on Human-Computer Interaction

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Abstract: An algorithm based on human-computer interaction is put forward aiming at the disadvantages of low accuracy of image contour and low degree thinning of contour. First, to reduce image noise is necessary by filtering, the following thing is to change image into gray image. The gray image is segmented by fuzzy c-means clustering algorithm. In the algorithm, the edge is traversed at given initial vertex. According to neighbor relationship between the point on the contour with neighbor pixels, curve can be confirmed to remain or not. In the following, curve contour vertices can be concluded by the traversal order. Experimental results show that high contour accuracy can be obtained to detect image by the algorithm. In regional consistency, the algorithm is better than some traditional algorithms of image edge detection. *Copyright © 2014 IFSA Publishing, S. L.*

Keywords: Contour Extracting, Human-computer interaction, Feature point, FCM, Edge traverse.

1. Introduction

Contour is a kind of main sensory information in the human vision and computer vision, which is used to distinguish the different objects [1]. As an important basic research subject in computer vision, contour detection and extraction are always paid close attention to by field experts. Nowadays we achieved a lot of meaningful research results in contour detection and extraction, such as the literature [2-5]. In some applications, the contour extraction can greatly reduce the need to deal with the data, while preserve the useful object boundary structure information [6]. As a result of a variety of technical reasons, the contour of image is often difficult to accurately detect. In image processing, we often need to decline the noise, detect image edge and do further processing.

For image edge detection and contour extraction, commonly algorithms include: (1) Algorithms based on convolution and directional derivative, such as Sobel operator, Canny operator, Robberts operator and Laplacian operator [7-8], these operators for high noise of the image processing are poor, and can't get a continuous single pixel edge. (2) Algorithms based on wavelet method and active contour, such as Snake model [9], the level set model.

Based on the fuzzy c-means clustering algorithm for image segmentation, we combine graph traversal with collective knowledge. On the basis of the human-computer interaction, the algorithm gives initial vertex and design corresponding algorithm for processing in the paper.

2. Image Contour Extraction

2.1. Contour Extraction Process

In the natural image contour extraction process, because there are too many types of natural images, too many image acquisition ways, contour from traditional algorithm processing has many

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deficiencies, such as contour as the contour discontinuity, unreasonable weak boundaries, too many edge lines with branch, and so on. For contour extraction, the first thing is to initializes the image, filter to reduce noise. The following thing is to convert color image to grey image, go on edge detection and extract closed curve. The algorithm process is shown as Fig. 1.

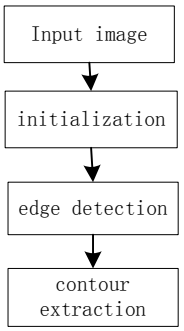


Fig. 1. Contour extraction process.

2.2. Correlation Algorithm

Fuzzy c-means clustering algorithm (FCM algorithm) is an iterative optimization algorithm, which is commonly used in gray image segmentation, and is to use membership function to determine each pixel belong to some clustering. The basic idea of algorithm is [10]: pixel point set *S*, $S = \{x_1, x_2, \ldots, x_n\}$, is divided into *C* classes, x_j is a pixel in *S*, whose membership degree is u_{ij} for class i, classification results are expressed by a fuzzy membership degree matrix *U*, $U = \{u_{ij}\}$. $\{u_{ij}\} \in [0, 1]$.

Fuzzy c-means clustering make clustering by the minimizing objective function *J (U, V)*.

The function formula is:

$$J(U,V) = \sum_{i=1}^{c}\sum_{j=1}^{n} u_{ij}^{m} d_{ij}^{2} \tag{1}$$

$$V=\{V_1, V_2, \ldots, V_c\} \tag{2}$$

where:

C : clustering number;

n : the total number of pixels;

U_{ij} : membership degree that pixel x_j relative to the clustering center Vi;

$$\sum_{i=1}^{c} U_{ij} = 1;$$

$$v_i = \sum_{j=1}^{n} u_{ij} x_j \Big/ \sum_{j=1}^{n} u_{ij};$$

$$d_{ij} = \left| x_j - v_i \right|$$

m: weighted index number, here m=2.

FCM makes *J (U, V)* minimizing by selecting the U and V, and perform the following steps.

1) Initialize clustering center V;

2) Calculate the membership degree matrix;

$$u_{ij} = \left[\sum_{k=1}^{c} \left(\frac{d_{ij}}{d_{kj}} \right)^{2/(m-1)} \right]^{-1} \quad \text{j=1,2,…,n} \tag{3}$$

3) Update the clustering center;

$$v_i = \frac{\sum_{j=1}^{n} (u_{ij})^m x_j}{\sum_{j=1}^{n} (u_{ij})^m} \quad \text{i=1,2,…,c} \tag{4}$$

4) Repeat step (2), (3), until formula (1) is in convergence.

Because we can't ensure that FCM converges to an optimal solution. FCM algorithm convergence depends on the initial clustering centers. Therefore, the algorithm repeatedly runs several times with different initial clustering center for getting an optimal solution.

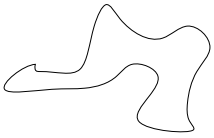
2.3. Feature Point Extraction

For input image I (x, y), the first thing is to filtering noise, reduce image data source effects the result of contour extraction, and then detect the image edge. In this paper, we use fuzzy c-means clustering to cluster, the advantage of FCM is that the algorithm suffering from the noise is small. In the case of initial value of reasonable clustering, image segmentation effect is better, and the result retains more image detail. As well known that the ideal image segmentation result is to get closed contour curve, but in most cases it is not possible, on the contour tend to has intersection, as shown in Fig. 2.

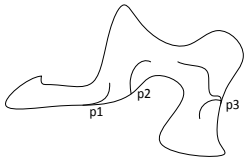
After contour extraction, we can get the edge of image that is closed curve. In order to obtain ideal contour, first, we must make the feature point of the curve being filtered, in order to eliminate redundant vertices on the curve. Contour feature points are different from image feature points, the former is single pixel closed contour curve, there is only one kind of feature points that is the angular point. The latter feature point has cross branches.

Next, we must eliminate cross branches of the contour curve, the noise, closed curve and loop curve within contour curve, such as eliminating cross connected curve in p1, p2, p3 of Fig. 2 (b), cross connected curve in p1, p2, p3 of Fig. 2 (c) and connected curve in p4 of Fig. 2 (c).

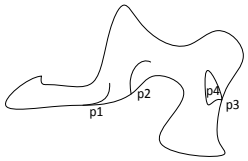
Feature point filtering algorithm usually have Douglas-Peucker method, Pedal method and Diaphragm method, Macro synthetic method, Minimum area of de-duplication and Long side endpoint seeking method [11].



(a) Ideal result.



(b) Contour with intersection.



(c) Closed curve in contour.

Fig. 2. Result after segmentation.

In this paper, on the basis of the principle of region growing, we go on trade-offs connectivity of pixels of curve and go on detection and tracking by chain code. As we know that chain code has eight chains and four chain code [12]. For a point P (x, y) on the contour curve, we define its eight Freeman chain code, of which the direction of the chain code with the number 0 to 7, respectively, whose number represent the eight directions.

Gray value of these adjacent pixels representing chain code direction are denoted by Grayn, where $0 \le n \le N-1$, n is the n + 1 point on the contour. The algorithm makes Counterclockwise traversal starting from 0 as shown in Fig. 3. We treat Point P as vertices the directed graph to go on deep traversal. If there is loop, we tag the loop, and store it in a linked list and return point P continue to traverse. Without loop, return the point P to clip, then continue to traverse. Until return to the starting point P (x, y).

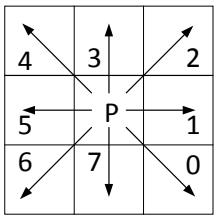


Fig. 3. Eight Freeman chain code.

2.3.1. Contour Curve Feature Point Selection

Operator steps:

1) M(x,y),a point on the contour, is treated as a starting point.

2) Along the contour from the starting point ,on the basis of counterclockwise, deep traversal can be gone on as shown 1-5 sequence in Fig. 3.

3) If traversal vertices forms a loop, the loop can be retained, and then the algorithm goes back to the specified vertices on the contour and chooses the next vertex adjacent, goes back to Step2.

4) Otherwise, clip the closed curve, return (2).

In the process of traversal, to the n point, we calculate the pixel gray value of eight neighborhood CD_r,

We assuming δ is a value of gray. δ expresses background pixel gray value after image edge detection. $C\,Dn$ and $C\,Dr$ is the connected vertices and $C\,D_r \neq \delta$ .Take the vertex of the r pixel search eight field adjacent vertices, until the algorithm find the last adjacent vertices

If the last vertex is the initial vertex, i.e. adjacency connected vertices form a loop, then mark it and store circuit pixels in a linked list.

3. Contour Extraction Algorithm Process

From the above, the result of image segmentation is made up of a series of closed curve C_1, $C_2 \ldots C_r$, every curve is subset of contour, the outer contour curve pixel set I is:

$$I = C_1 \cup C_2 \cup \ldots \cup C_r \tag{4}$$

If user gives an initial vertex P , $p \in c$, c is a curve set. The point P is closed curve in the closed curve collection C_1, C_2... C_r is a subset of the set C, P collection points in contour pixels as follows:

$$\begin{aligned} I_p = C - (C_1 + C_2 + \ldots + C_r) \\ + C \cap C_1 + C \cap C_2 + \ldots + C \cap C_r \end{aligned} \tag{5}$$

1) Input image I(x, y);

2) Filter and reduce noise, convert color image to grey image;

3) Fuzzy c-means clustering algorithm is used to make image edge detection;

4) Given initial point, filter curve feature points;

5) According to the list, calculate the curve contour.

4. Experimental Results and Analysis

In order to prove the performance of the algorithm in this paper, we choose several pictures of variety of data sources to do experiment. In this paper, the experimental platform is Windows 7 operating system. The computer configuration for this experiment is as follows: Inter core2 Quad CPU Q8300, 2 GB memory and Matlab2010a. Our algorithms in this paper compare with Level set contour extraction algorithm. The experimental results are shown in Fig. 4.

(a) original image

(b) Result of level set method

(c) Result of our algorithm

Fig. 4. Comparison of experiment results.

The experimental results show that the traditional level set method for contour extraction is seriously affected by noise, for image with the strong noise, the result of image segmentation is worse, and our method can very accurately determine all sorts of closed contour feature points. In the region consistency (NU), contrast (GC) [13], our method is superior to the traditional level set method for contour extraction.

5. Conclusions

In this paper, the biggest advantage is that the algorithm introduces the user's prior knowledge on the basis of image edge detection algorithm, independently choice the starting point, and independently choose the contour curve. The algorithm makes contour vertex information in dynamic linked list and produces continuous uncross and deformational object contour. The algorithm can well reduce the noise disturbance to the contour extraction and can get high quality image contour.

Acknowledgements

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