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Study on Fur Cutting Path Method Based on Contour Radius Increment Constraint

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Abstract: This paper takes the fur edge contour as the research object, and proposes a cutting algorithm based on the incremental constraint of contour radius. The algorithm uses the centroid of the fur contour as the starting point to make rays at the same interval angle, and the distance between the intersection of the ray and the contour point is calculated by the ratio of the radius of the adjacent intersection points. By setting the maximum and minimum thresholds of the growth rate, the intersections exceed the threshold are processed to meet the threshold conditions. Finally, the connection of all the remaining intersections is the cutting path. The experimental results show that the cutting method proposed in this paper can realize the image cutting and give the cutting path, which can meet the industrial production requirements of automatic fur cutting.

1. Introduction

The research on automatic fur edge cleaning technology is of great significance to improve the automation level of the leather industry. Since the initial cutting part is mainly concentrated in the edge area, it is necessary to extract the local features [1]. By identifying the contour features at the local target, the edge skin is cut off by the cutting algorithm based on the extracted features. The extraction methods of features mainly include continuous contour description method [2] and discrete contour description method. Continuous contour description is to describe directly using the feature variables derived from the law of edge contour points [3], while discrete contour description uses specific criteria to describe each sub-segment [4]. Lou proposed an automatic threshold selection method for image segmentation [5]. The above algorithms are not ideal for extracting local information of the target, and an adaptive cutting algorithm that can accurately identify the waste edge features and optimize the cutting path is required.

Aiming at the complexity and disorder of the fur edge region, this paper proposes an algorithm that can be used for large-scale fur feature detection and cutting line planning. By this method, waste parts such as the head, hoof and tail of the fur can be cut off effectively.

2. Materials and Methods

The collected data are preprocessed to obtain the binarized contour image of the fur image. The typical 9 contour extraction results are shown in Figure 1.

It can be seen from Figure 2 that the target contour area that needs to be cut is mainly concentrated in the hoof area and the sharper part of the fur, and most of the contour points in the marked area are far away from the contour centroid. A cutting algorithm based on contour radius increment constraint is proposed in this paper. The core idea of the algorithm takes the centroid of the fur contour as the center, divides the entire fur edge contour around the contour centroid and divides it into corresponding parts according to the same angle, traverses the contour points on each angle, and observes the distance between the contour point and the centroid and the previous one. The rate of the distance between the contour point and the centroid exceeds a certain threshold, according to the setting and adjustment of the threshold, the cut part can be extracted.

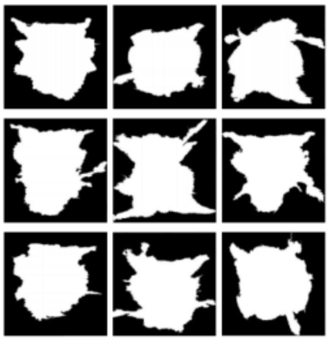

Fig.1 Extracted Contour Image

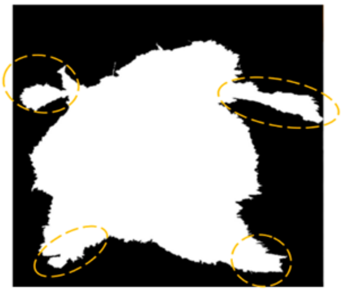

Fig.2 Schematic Diagram of Fur Cutting Area

3. Cutting Algorithm Based on Radius Incremental Constraint

3.1 Establishment of Coordinate System

A two-dimensional plane rectangular coordinate system is established, and the abscissa and ordinate of the centroid of the fur outline are obtained according to formula (1),

$$\begin{cases} X = \dfrac{\sum_{i=0}^{n-1} X_i}{N} \\ Y = \dfrac{\sum_{i=0}^{n-1} Y_i}{N} \end{cases} \quad (1)$$

In the formula, X is the abscissa of the contour centroid, Y is the ordinate of the contour centroid, Xi is the abscissa of the contour point i, Y_i is the ordinate of the contour point i, and N is the total number of contour points.

3.2 Contour Discretization Extraction

Taking the origin of the coordinates as the starting point, a ray is drawn clockwise along the positive direction of the X-axis to intersect with the first contour line in contact at a point, the Euclidean distance between this point and the contour centroid is defined as the contour radius length, r. The angle between the ray and the positive direction of the X-axis is θ. The second ray in the clockwise direction intersects the first contour line in contact at a point, and the angle between the two rays is denoted as Δθ.

Record the length of the contour radius formed by each ray according to formula (2),

$$r_i = \sqrt{(X - X_i)^2 + (Y - Y_i)^2} \tag{2}$$

In the formula, r_i is the length of the contour radius of the contour point i, and the angle θ between each ray and the X axis is constrained according to formula (3),

$$\theta = \theta_0 + i \cdot \Delta\theta \tag{3}$$

In the formula, θ is the angle between the current ray and the positive direction of the X-axis, θ_0 is the initial angle, and Δθ is the angle increment of two adjacent rays.

Traverse the entire space 0°~360° clockwise, let θ_0=0°, that is, the first ray direction is the positive direction of the X-axis, set the angle increment △θ=5°, emit the ray and the first contour line touches intersects at one point, and marks these points. At this time, the ray divides the contour into 72 equal parts, and the angle of each equal part is 5°. Note that the coordinates of all initial points are P_i, i is the current initial point number, i=1, 2, 3...72.

3.3 Threshold Constraint Rules

The contour radius length changes sharply with the angle. According to the contour radius length, the ratio of the contour radius length of the current initial point to the previous initial point is defined as the current point contour radius growth rate, which is calculated by formula (4). The growth rate of the contour radius of two adjacent initial points is:

$$\eta = \frac{r_i}{r_{i-1}} \times 100\% \tag{4}$$

In the formula, η is the growth rate of the contour radius of the current point, r_i is the length of the contour radius of the current initial point, and r_{i-1} is the length of the contour radius of the previous initial point. The initial points of the contour are detected in turn, and the maximum threshold of the radius growth rate is set to 110% and the minimum to 90%, that is, when the radius growth rate of the contour point is greater than 110% or less than 90%, it is determined as a point that does not meet the threshold constraints. In order to make points meet the threshold rules, they are processed as follows:

(1) When the growth rate of the contour radius is fast, a new contour point is re-determined at the current angle, and this point is marked and recorded as the selection point. The Euclidean distance between the selection point and the centroid is the new contour radius length, and the ratio of the contour radius length of the current selection point to the previous selection point is 110%. The coordinates of the selection point are determined by the formula (5):

$$\begin{cases} p_i^{'} = [r^{'}, 0] \cdot \begin{bmatrix} cos\theta & -sin\theta \\ sin\theta & cos\theta \end{bmatrix} \\ r^{'} = r_{i\text{-}1} \times \eta_{\max} \end{cases} \tag{5}$$

In the formula, P_i' is the coordinates of the selected point, the matrix is the transformation matrix rotated clockwise by the angle θ, r' is the contour radius of the selected point to be determined, and r_{i-1} is the previous selected point (or the initial point that meets the requirements reserved) Contour radius, η_{max} is the maximum threshold set. This formula can replace the current initial point with a new selection point that satisfies the threshold condition. The growth rate of the contour radius of the selected point is obtained by formula (6).

$$\eta = \frac{r^{'}}{r_i} \times 100\% \tag{6}$$

(2)When the growth rate of the contour radius is slow, the contour point at the previous angle of the current contour point is re-determined and recorded as the selection point, which is the same as the selection point. The Euclidean distance of the centroid is the new contour radius length, and the ratio of the current initial point to the contour radius length of the selected point is 90%. The new selection point can be determined by equation (7).

$$\begin{cases} p_{i-j} = [r^{'}, 0] \cdot \begin{bmatrix} cos(\theta - j \cdot \Delta\theta) & -sin(\theta - j \cdot \Delta\theta) \\ sin(\theta - j \cdot \Delta\theta) & cos(\theta - j \cdot \Delta\theta) \end{bmatrix} \\ r^{'} = r_{i-j\text{-}1} \times \eta_{\min} \end{cases} \tag{7}$$

In the formula, P_{i-j} is the coordinates of the first j contour points of the current contour point, j is a cyclically increasing variable with an initial value of 1, the matrix is a clockwise rotation (θ-j•Δθ) angle transformation matrix, r_{i-j-1} is the radius length of j_{+1} contour points before contour point i. This formula can replace the previous initial point of the current initial point with a new selection point, and make it meet the threshold condition. And the contour radius growth rate at this time is calculated by formula (8).

$$\eta = \frac{r_{i-j}}{r_{i-j-1}} \times 100\% \tag{8}$$

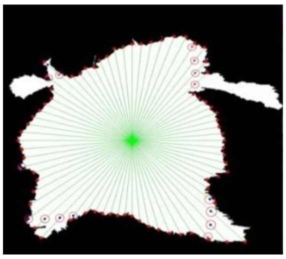

Fig.3 Threshold Constraint Diagram

Figure 3 Shows the Plane View of the Contour Points after Threshold Constraint Adjustment.

3.4 Target Cutting Line Connection

Through the contour radius increment threshold constraint rule, the intersection points that exceed the threshold value are processed to meet the threshold value conditions, and all the final intersection points meet the threshold value conditions are the final cutting points. The initial points and selection points meet the requirements are marked is the final point, and the cutting path is obtained by connecting a clockwise line, which is the final target cutting line. Figure 4 is a schematic diagram of the contour cutting line based on the final point.

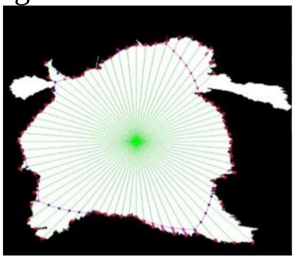

Fig.4 Fur Cutting Line

4. Experimental Results and Analysis

According to a large number of experiments, an appropriate interval angle of 5° and a growth rate threshold of 8% were selected, and the boundary contour extracted in the early stage was simulated and verified, and the obtained image cutting effect is shown in Figure 5. Although the shape and size of fur (a~i) are different, the method in this paper can effectively identify these features and perform effective cutting line, so the algorithm in this paper has an adaptability and can adapt to different shape and size. The cutting line can optimize the extraction route according to the change of the growth rate, the segmentation effect is better, and the false segmentation rate of the fur is reduced.

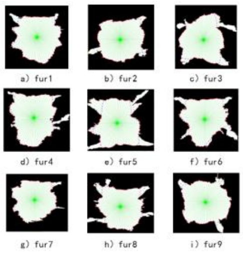

Fig.5 Final Extraction Results

5. Conclusion

In this paper, based on computer vision technology, a cutting algorithm based on radius increment constraint is proposed. The algorithm is mainly to find the characteristics of the cutting area, so as to plan the cutting path and cut off the discarded part. The optimal growth rate and angle range are determined by experiments of setting different growth rate thresholds and different interval angles. This method can adjust parameters according to the characteristics of fur to optimize the cutting results which provides a new solution for contour recognition and feature extraction for automatic fur cutting.

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