

A Study on Multi-Feature of Gait Recognition Algorithm

Hui Wang, Taijun Li*, Haoli Zhou & Zezhong Yang

College of Information Science & Technology Hainan University, Haikou, Hainan, China

**Corresponding author: Taijun Li*

ABSTRACT: Gait recognition has become one of the hottest directions in study of long-range identification. Joint angle feature is an important gait feature, but extracting joint angle feature using traditional skeleton model is too idealistic. Therefore, a method of extracting joint angle feature based on skeleton model to remove the ending points was put forward. Given the low recognition rate of single feature, the paper would the joint angle feature, GEI and discrete Hu moment invariants weighted feature fusion. The experimental results show that the new joint angle feature extraction and feature weighted fusion algorithm improves gait recognition performance.

Keywords: skeleton model; joint angle feature; feature fusion; SVM

1 INTRODUCTION

Gait recognition compared to other biometric identification technology has many advantages, for example the hidden poor, ease of collection, suitable for long-range identification. Because of it has the strong application value, so that, it became a research hotspot, and emerged a large number of algorithms in recently years. These methods can be divided into two categories, a recognition method based on the model, such as skeleton movement model is established by Cunado (Cunado et al. 1999). Another based on statistical methods (Wang Liang et al. 2003). Above all, in spite of the joint Angle feature extraction method was put forward by Lv Yanting (Lv Yanting 2009), as a representative of the traditional method, but the paper considered that the method is too idealistic, therefore, a method of extracting joint angle feature based on skeleton model to remove the ending points was put forward. Secondly, in order to improve the recognition rate, this paper fused joint angle feature, gait energy image (GEI) and discrete Hu moment invariants, and a method of weighted multi-feature fusion recognition algorithm based on single feature recognition was put forward.

2 FEATURE EXTRACTION

2.1 Pretreatment

Moving target detection is the first step in gait recognition, and the processing results directly affect

the follow-up work. This paper analyzed the main moving target detection algorithm and decided to use Gaussian mixture background modeling which is often used in background subtraction method. But this method is based on the pixel, so that ignores the role of regional information in the background modeling. Therefore, the paper proposes a method which is Gaussian Mixture Background Modeling based on image segmentation (Zhou Haoli et al. 2015). Finally, in order to facilitate feature extraction, the detected foreground object had been dealt with morphological operation and unitization processing.

2.2 Joint Angle Feature

Skeleton model was first proposed and defined by burning grass model, in 1967 (Yuan Lei et al. 2008). There are two kinds of methods are used to extract skeletons, a kind is based on thinning (Cutler 2000), Another method is based on the distance transformation (Li et al. 2008). After analysis of skeleton extraction method based on distance that a partial contour metrics of skeleton point was proposed (Hu Rong 2010), which not only can fully express the importance of partial contour, overcome a shortcoming which the traditional standards tend to ignore tubular object contour. At first, this paper adopted improvement of skeleton extraction method based on distance. As shown in figure 1.

Although according to method of Hu Rong to extract the skeleton can suppress contour noise to some degree, but this method extracts skeleton where exists ending point, so it cannot be directly as the gait

model. The paper adopted Erosion or dilation action that removed the skeleton ending point (Wang et al. 2002). At discrete states, Hu Rong analyzed the human skeleton ending points and expressed by neighborhood coefficient sets, as shown below:
 $EPS=\{1,2,3,4,6,12,14,16,24,32,45,56,64,96,128,131,192,224\}$



Figure 1 obtained skeleton in the paper

The skeleton was eroded operation according to definition of EPS, and gradually removed the ending point of skeleton. Specific operation as follows:

- 1) Set the number of iterations ($n = 1$);
- 2) According to EPS, calculated all the skeleton ending point;
- 3) Recorded the ending point position, and removed these points;
- 4) $n+1$, and repeated steps 2) & 3), When $n = M$ (degree of corrosion), began to restore operation.

When eroded operation, used an array of X recorded all deleted ending point, Set $X(i)$ recorded the i -th iteration delete the ending point. Skeleton restore operation is as follows:

- 1) The initial value of M (degree of corrosion) set as i ;
- 2) In the array of $X(i)$, found and restore some points, which meet EPS relationships with existing skeleton ending point;
- 3) $i--$ & Repeat Step 2), when $i = 0$, the restore process was ended.

Corrosion and restore operations got the skeleton which was removed ending points, figure 2 shown on the right.

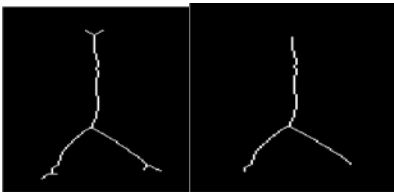


Figure 2 Removal skeleton view of ending point

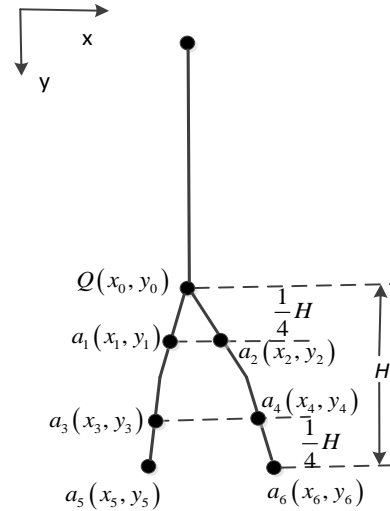
By the method described above can be obtained skeleton model in five key frames of a gait cycle, Figure. 3 is a skeleton model five key frames obtained herein.



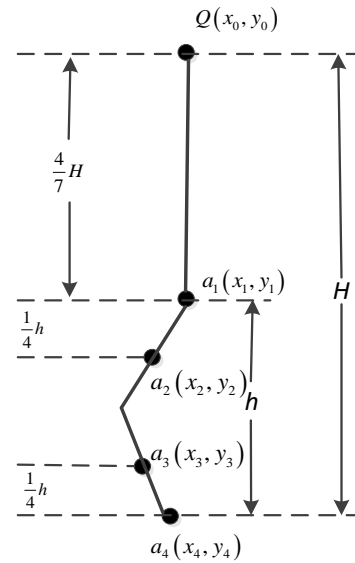
Figure 3 A skeleton model key frames gait cycle

By observing figure 3, There are two kind of skeleton model : One is the lower half of the skeleton model have two branches, another is only one branch, so that need to be extracted joint angle feature in two different conditions.

When the lower part of the skeleton model into two branches, because people walking the intersection between the upper body and thighs move down a distance, the paper combined with the ratio relationship between height and limb in human anatomy, and proposed an improved method, as shown in figure 4a. Steps of the method is as follows:



(a) Two branches



(b) A branch

Figure 4 Improved skeleton model

(1) From left to right, top to bottom scanned skeleton model, set scanning counter of line as i , $i++$ representative continued to scanned down, When the $i+1$ row there are two pixel value of 255, Is the i -th row position is located $Q(x_0, y_0)$;

(2) From left to right, bottom to top scanned skeleton model, set scanning counter of line as i , $i++$ representative continued to scanned up, When the $i+1$ row there are two pixel value of 255, to the point from left to right, respectively $a_5(x_5, y_5)$ and $a_6(x_6, y_6)$, $H = y_6 - y_0$;

(3) Between the Q and $a_6, 1/4H$ position from the point Q , intersection skeleton as $a_1(x_1, y_1)$ and $a_2(x_2, y_2)$; $3/4H$ position from the point Q , intersection skeleton as $a_3(x_3, y_3)$ and $a_4(x_4, y_4)$;

(4) Obtaining four limbs angle feature values:

$$\theta_1 = \frac{|x_1 - x_0|}{|y_1 - y_0|} \quad \theta_2 = \frac{|x_2 - x_0|}{|y_2 - y_0|} \quad \theta_3 = \frac{|x_5 - x_3|}{|y_5 - y_3|} \quad \theta_4 = \frac{|x_6 - x_4|}{|y_6 - y_4|}$$

When the lower half of the skeleton model have one branch, at this extraction method shown in Fig. 4b. The specific steps are as follows:

(1) From left to right, top to bottom scanned skeleton model, set scanning counter of line as i , $i++$ representative continued to scanned down, When scanning to have a pixel value is 255, Is the i -th row position is located $Q(x_0, y_0)$;

(2) From left to right, bottom to top scanned skeleton model, set scanning counter of line as i , $i++$ representative continued scanned up, When scanning to have a pixel value is 255, the i -th row position is located $a_4(x_4, y_4)$ and $H = y_4 - y_0$, $h = 5/7H$;

(3) Between the Q and a_4 , h position from the point a_4 , intersection skeleton as $a_1(x_1, y_1)$; $3/4H$ position from the point Q , intersection skeleton as $a_3(x_3, y_3)$;

(4) Obtaining two limbs angle feature values:

$$\theta_1 = \frac{|x_2 - x_1|}{|y_2 - y_1|} \quad \theta_2 = 0 \quad \theta_3 = \frac{|x_4 - x_3|}{|y_4 - y_3|} \quad \theta_4 = 0$$

Using the above method to obtain a character identified gait cycle joint angle five key frames, resulting in 5×4 dimensional feature matrix.

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2.3 Gait energy image (GEI)

Gait energy image (GEI) is a kind of space-time expression of gait. As shown in figure 5, It is contains information about human silhouette, exercise frequency & phase information, and there is not difficult to find everyone's gait energy image are obviously different. Therefore, in the gait recognition, GEI can be used as gait feature. Allowed for the correlation between the ranks of the gait energy image,

the paper uses bi-directional compressed two-dimensional principal component analysis algorithm (RL2DPCA) (Yang et al. 2004) of the gait energy image is processed and extracted 16×161 dimensional feature matrix.

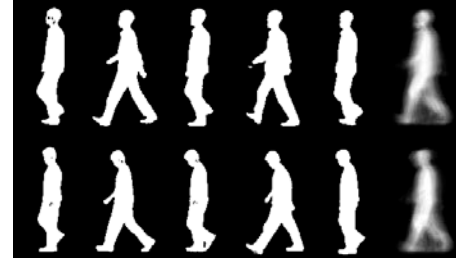


Figure 5 Gait energy image(GEI)

2.4 Discrete Hu moment invariants

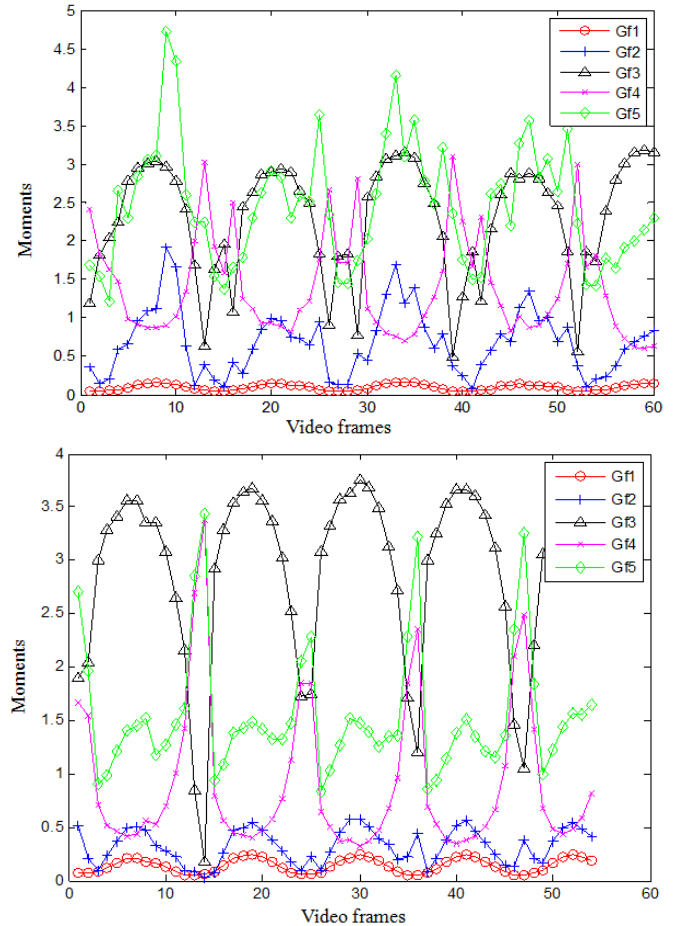


Figure 6 Moment gait sequence

Moment invariants is a shape description operator, Used to describe a single frame video image information, Static information this information on behalf of gait (Yuan Haijun 2007). Because under the condition of discrete Hu, seven invariant moment is not in conformity with the invariance of the scaling factor (Jian Liqiong et al. 2009). Gait and image acquisition in different situations can not be completely the

same scale, Feng Huili constructed five invariant moments, eliminate the influence of the scale factor on the results (Feng Huili 2010). In this paper, discrete Hu invariant moments experimental verification, the results shown in Figure 6.

Observe the figure 6 can be found, that discrete Hu invariant moments can simultaneously satisfy the scale, rotation and translation invariance, this article selects discrete Hu invariant moments of five key frames in a cycle. Featured by a single individual dimension ism 5×5 .

2.5 Feature normalization

In order to eliminate three kinds of properties ranging from gait characteristics are quite different on the fairness of the classification, T This article uses the maximum minimum normalization method to deal with the extraction of gait features. Specific mapping is calculated as

$$v' = \frac{v - \min_A}{\max_A - \min_A} (new_max_A - new_min_A) + new_min_A$$

3 GAIT FEATURE FUSION

After the analysis of feature of layer fusion method, put forward a kind of based on single feature without feedback which can adjust the weights of the weighted feature fusion algorithm.

Assuming that feature vector of Joint Angle feature is W , Weight is ω_W ; feature vector of GEI is Q , Weight is ω_Q ; feature vector of Discrete Hu moment invariants is E , weight is ω_E .

(1) Simple Feature Fusion:

$$T = Q + W + E \quad (1)$$

$$\omega_W + \omega_Q + \omega_E = 1. \quad (2)$$

(2) The weighted feature fusion:

Above all, according to the recognition rate to calculate weight value. Assuming that Recognition rate is respectively P_Q , P_W , P_E . Then according to the formula(3) to calculated the weights, and according to the formula(4) &(5) to calculated the fusion feature.

$$P_Q \chi + P_W \chi + P_E \chi = 1 \quad (3)$$

$$\omega_Q = P_Q \chi \quad \omega_W = P_W \chi \quad \omega_E = P_E \chi \quad (4)$$

$$T = Q \omega_Q + W \omega_W + E \omega_E \quad (5)$$

4 EXPERIMENTAL ANALYSIS

This paper tested in DatasetA & DatasetB database.

Table 1 Sample selection

Database	viewing angle	sample size
DatasetA	90°	80
DatasetB	All	744

Table 2 comparison recognition rate

Database	sample	JAF	GEI	D-Hu	SFF	WFF
DatasetA	80	85.47	88.23	85.56	89.12	93.51
DatasetB	744	81.81	89.57	85.16	88.89	92.32

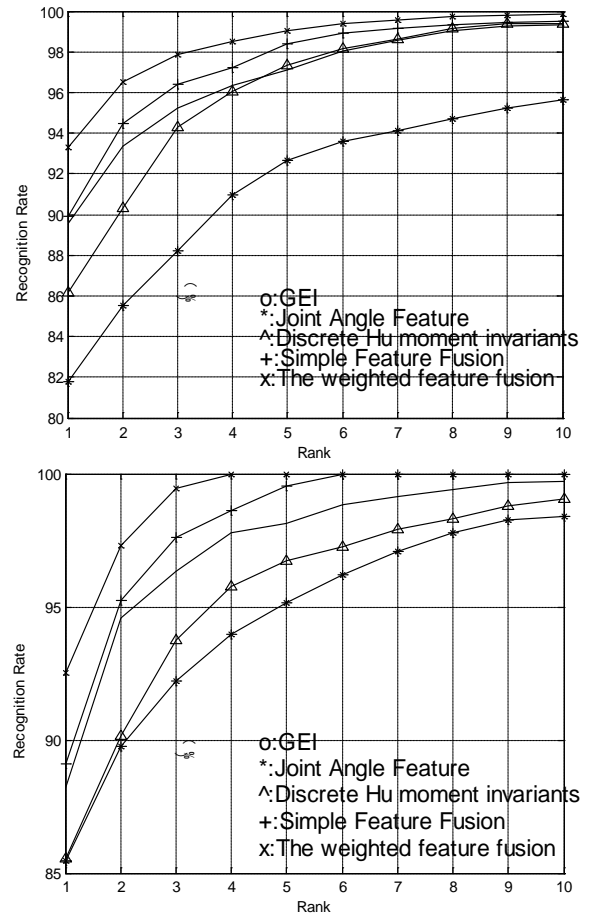


Figure 7 CMS Results (up: DatasetA, down: DatasetB)

Based on the test results, Used the three methods were compared to verify multi-feature fusion algorithm here in superiority. First, each of the three feature support vector machine classification to obtain recognition rate; Then, after three features simple integration, support vector machine classification to obtain recognition rate; Finally, the feature vector of each of the three characteristics based on the weight of the individual characteristics of the recognition rate is obtained, and fusion, and then SVM classification to obtain recognition rate. Recognition rate as shown in Table 2.

From the test results, it was found in terms of sigle feature, GEI is contains information about human silhouette, frequency & phase information, thus

the highest recognition rate. From Simple Feature Fusion and Single feature recognition rate results, simple feature fusion results than a single feature has improved recognition results, but recognition rate increase so little. Weighted Fusion features high recognition rate, in DatasetA database on a 4.39% increase, and in DatasetB database on a 3.43% increase. Therefore, in this paper, the improved fusion algorithm is effective.

In order to further evaluation algorithm of classification performance, this paper adopts the method of cumulative matching score (CMS) were evaluated. The results shown in Fig.7.

From figure7, due to factors interference joint Angle feature extraction, affect the joint point positioning, resulting in low recognition rate than the other two features. Simple features recognition higher than single feature, but the increase of the space is not large. In general, the weighted feature layer integration in the two databases has achieved higher recognition rate.

5 CONCLUSION

Skeleton model to remove the ending points can be obtain an ideal joint angle feature, and the feature and GEI, discrete Hu moment invariants weighted feature fusion, improved gait recognition rate. Feature fusion recognition method has a certain robustness, can improve the recognition rate of complex background. However, due to the influence of factors such as clothes keep out, joint angle feature recognition rate is low, further research is needed to improve.

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About the Author: Wang Hui (1989-), graduate students, research interests: image processing and information retrieval; Li Taijun* (1964-), master tutor, professor, main research directions for image processing and information retrieval, streaming media technology; Zhou Haoli (1989-), graduate students, research interests: image processing and information retrieval; Yang Zezhong (1990-), graduate students, research interests: image processing and information retrieval.

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