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Modeling Body Motion Posture Recognition Using 2D-Skeleton Angle Feature

Gang Xu, Ding Huang +, Qi Zhou and Dong Zhao

North China Electric Power University

Abstract. This paper proposed a method of human motion posture recognition using the angle characteristics of each branch. The coordinates of skeleton intersection and endpoint is extracted from the skeleton of human body image so as to calculate the branch angle parameters of head, hands and feet in human skeleton. In order to realize the matching identification of the series traffic command gestures, the method combined with SVM and template matching is used to classify and recognize the static human skeleton angle parameters. The method takes the effect on experiment of the resolution of the image and different size of human body into account, and the recognition rate can reach 93%, the recognition speed is 0.273s. This method also offers the theory and technology foundation in human body, pattern recognition and artificial intelligence field.

Keywords: feature extraction, skeleton feature, angle parameters, matching identification.

1. Introduction

The human body movement visual analysis is an important research direction in computer visual field. This study aims to analysis the static image or image sequence, so as to achieve some parameters of the human body gestures and movements, and further to recognize the gesture, analyze the semanteme, understand the behavior. The human body movement visual analysis uses motion segmentation, tracking, identification, semantic representation and inference theory and technology to solve problems, which covers the human recognition, gesture identification, human tracking and some other related areas. This research method also involves pattern recognition, image processing, computer vision, artificial intelligence, graphics, and other disciplines. The human body shape description is not only the foundation of human movement gesture recognition, but also the key problems of proximity measurement. Finding a method which can describe the human body shape integrality and exactly is the first step to analyze and recognize the human body effectively.

The description method must meet the following three properties: (1) Uniqueness. Namely, every object has its own shape descriptions, and it`s different from others. (2) Translation and rotation invariant. Namely, the objects won`t change its shape description when it moves or rotates in space. (3) Effectiveness. Namely the description should contain the shape of objects completely and easy to match. [1][2] . In the document [3] and [4], R.P lankers and P.Fua from Swiss federal sciences academy use video sequence of stereo vision to go along human body modeling and calculate the motion parameters with outline of video images. In the document [5] and [6], R.Urtasun and D.Fleet from Brown University extract the human regional feature and outline through monocular or more video images in effort to study the human movement based on model. This method compares the characteristics achieved to the projection model in similarity, and tracks them with annealed particle filter or graph model. At present, the research group is available to researchers for tracking real data of human motion, which make human body motion tracking research comparable.

+ Corresponding author. Tel.: + 13811711547.
E-mail address: 415644647@qq.com.

On the one hand, the framework in mathematical morphology can blend in the outline and region information of object as a description method of pattern. On the other hand, it is liable for itself to change its linear connected structure into the form of tree or graph so that it is convenient to match properties. Therefore, the target representation and recognition technology based on skeleton becomes a major subject in pattern recognition and computer vision and is widely used in the field of fingerprint recognition, character recognition and medical image analysis. This paper extracts skeleton from paragraph of traffic control static posture sequence, and get the angle parameter eigenvectors through analysis and calculations of skeleton. Then, the traffic control position can be analyzed by the method of SVM statistical classification. Finally, every posture is recognized using the method of SVM and template matching.

2. Identification method based on 2D-skeleton

2.1. Implementation framework

Fig.1 is an implementation frame diagram about movement posture recognition method of traffic control gestures based on 2D skeleton angle characteristics. The image sequences of traffic control gestures movement posture should go through a pretreatment. The pretreatment first get a character image of solid color background which is picked up from character under complex ground. Afterwards, the colored image is conducted with gray transformation and binarization processing so as to extract skeleton. The ultimate course is to find out intersection point and endpoint of the skeleton and calculate the angle parameters of the head, hands and feet.

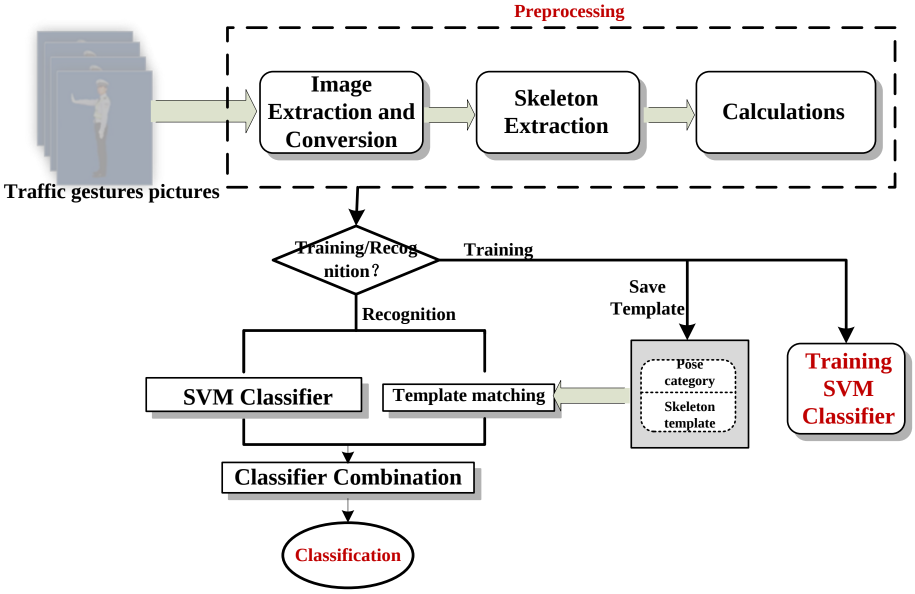


Fig. 1: Implementation frame diagram of movement gesture recognition based on 2D skeleton angle features

3. Human Body Image Skeleton Extraction

3.1. Skeleton Extraction

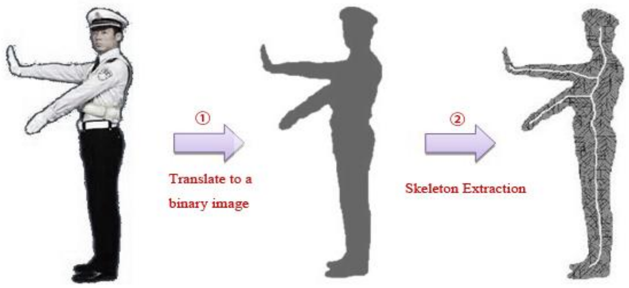


Fig. 2: Process diagram of skeleton extraction

Figure.2 shows the process of body image skeleton extraction which is established on Matlab using programming. The original RGB sequence image is transformed to binary image and the maximum circle method is used to get skeleton model of binary body image. The recognition feature of body image skeleton such as endpoint, intersection and other eigenvalues is all derive from refined image. Therefore, the refined algorithm and implementation method has direct influence on the accuracy and rate of recognition. This paper use the algorithm of skeleton extraction and skeleton burr removed described in document [7] to extract skeleton and eliminate the burr from five body posture. Fig.3 shows the effective result of the algorithm which lays a good foundation for the next step.

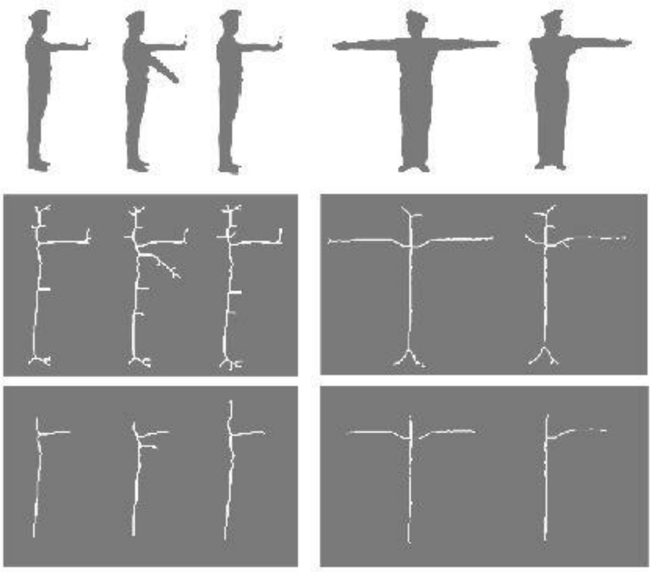
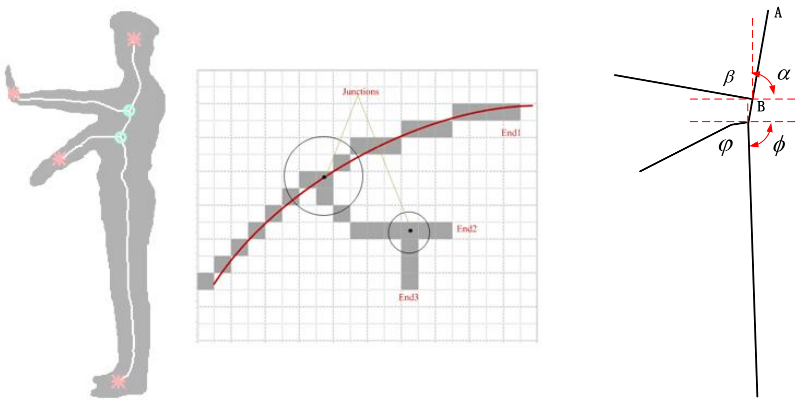


Fig. 3: Result of skeleton burr removed

3.2. Endpoints and intersections

This paper is designed to get the angle eigenvalues of human skeleton (including the hand, feet and head). Consequently, the operation after skeleton is to look for the coordinate of endpoint and intersection so as to calculate the skeleton branch angle. The red fork signs the endpoint and the green circle signs the intersection of skeleton branch shown in the Fig. 4(a).



(a) (b)

Fig. 4: (a)The elementary diagram of endpoint and intersection,(b)Skeleton angle calculation model.

In the environment of Matlab, this article use the Hit/Miss Transform to find junctions and endpoints of the skeleton. In the morphology , the Hit/Miss Transform of image I and the reference image C is defined as follow:

$$X \otimes C = (X \oplus C_{f}) \cap (\vec{X} \oplus C_{b}) \quad (1)$$

Where $\oplus$ is Corrosion， $\bar{X}$ is the complementary operator of image X. $C(C_f, C_b)$ is defined as $C_f = C, C_b = \bar{C}$. According to the equation (1), corrosion is the basic operation to realize Hit/Miss Transform, the two images it can realize through the correlation of two image.

$$I \oplus C = (I * C)|_{T=N} = (I \Delta C)|_{T=N} \tag{2}$$

According to the equation (2), Hit/Miss Transform can be shown as equation (3):

$$I \otimes C = (I \Delta C_f)|_{T=N_1} \bigcap (I \Delta C_b)|_{T=N_2} \tag{3}$$

Where * is convolution, Δ is correlation, T is the threshold, N is the total number of the foreground points.

In order to calculate the Angle of each branch, not only to find out the endpoint of intersection and coordinate, but also to find out the mapping relationship of endpoints and intersections. If E for endpoint set, J for intersection set, its mapping function is:

$$f(E_i) = J_j \text{ (where I is the number of endpoints, j is the number of intersections)} \tag{4}$$

Through finding out the corresponding relation of intersections and endpoints , we can ensure the point of view of the branch through two coordinates.

3.3. Angle Calculation

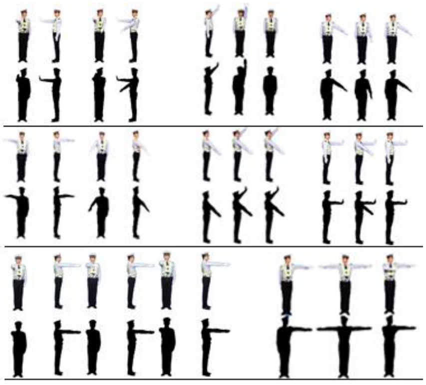
Figure.4(b) is skeleton angle calculation model. The angle of each skeleton branch is obtained by set E, J and their mapping relation. For example, the angle α between the branch endpoint A placed and the branch intersection B related with A placed in Fig. 4 is calculated as the formula (5). The coordinate of A is (x1, y1) and the coordinate of B is (x2, y2).

$$\alpha = \begin{cases} \arctan\left(\left|\frac{y1-y2}{x1-x2}\right|\right) & (y1-y2)>0, (x-x2)>0 \\ \pi - \arctan\left(\left|\frac{y1-y2}{x1-x2}\right|\right) & (y1-y2)>0, (x-x2)<0 \\ \pi + \arctan\left(\left|\frac{y1-y2}{x1-x2}\right|\right) & (y1-y2)<0, (x-x2)<0 \\ 2\pi - \arctan\left(\left|\frac{y1-y2}{x1-x2}\right|\right) & (y1-y2)<0, (x-x2)>0 \end{cases} \tag{5}$$

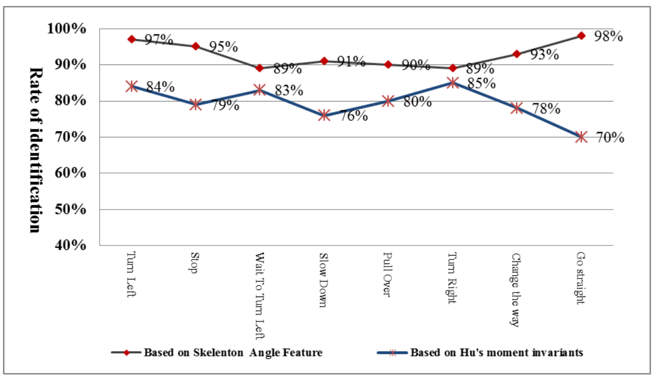
The angle set $A = \overbrace{\{\alpha, \beta, \phi, \varphi.....\}}^{n}$ (where n is the number of branches) is calculated from formula (5) and arranging the element in A from small to large can get the vector $A_n = \overbrace{\{\alpha_1, \ \alpha_2, \ \alpha_3, \ \alpha_4.....\}}^{n}$ which is the eigenvector for matching and classifying the sample.

4. Experimental Result

The 8 gestures of turn left, stop, wait to turn left, slow down, pull over, turn right, change the way and go straight are trained and classified with 50 samples, and the left 100 samples are used for matching. The match result is shown in Fig.5(b) and Table.1.



(a)



(b)

Fig. 5 : (a) Traffic command gestures in experiment,(b) Comparison between Skeleton and Hu's moment invariants

Figure.5 (b) is the accuracy contrast diagram between Skeleton and Hu's moment invariants for 8 kinds of traffic command gestures, as can be seen from the graph the former is higher than the latter. The following Table.1 shows the detailed identification results of 8 traffic command gestures.

Table. 1: The experimental results data

	Turn Left	**Stop**	**Wait to turn left**	**Slow Down**	**Pull Over**	**Turn Right**	**Change The Way**	**Go Straight**
Turn Left	**97**	0	0	1	1	1	0	0
Stop	0	**95**	0	0	0	2	0	0
Wait to turn left	0	0	**89**	6	1	1	0	0
Slow Down	2	3	5	**91**	1	0	1	0
Pull Over	0	0	5	2	**90**	6	0	0
Turn Right	1	0	0	0	7	**89**	0	0
Change The Way	0	1	0	0	0	1	**93**	2
Go Straight	0	1	1	0	0	0	6	**98**
Accuracy rate	**97%**	**95%**	**89%**	**91%**	**90%**	**89%**	**93%**	**98%**

5. Conclusions

The research of traffic movement gesture recognition indicates that the method in this paper can recognize and distinguish the various gesture of traffic command under the circumstance that left turn posture is similar with slow down posture. The new method is combined with skeleton angle eigenvalue extraction and a classification method which contains both SVM and template match theory. The recognition rate of 8 motion postures have all exceeded 85%. Although the method could not meet the requirements of the high recognition rate in practical application, this research offers the theory and technology foundation in human body and pattern recognition field.

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