

Research on Human Skeleton Modeling and Anthropometric Parameters Modeling for Online Examination



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Abstract. Detection and identification of abnormal behavior is an important technology which can be applied in many cases. In this paper, an improved algorithm of positioning key points is proposed. It models the human skeleton parametrically based on the key points and converts the problem of human behavior trend analysis into the parametrical problem. It reduces the amount of calculation and storage in human behavior analysis greatly. The algorithm can deal with most body postures and the experiment shows that extracting results are more accurate and can be the base data for detection and identification of abnormal behavior for online examination.

Keywords: abnormal behavior detection, anthropometric parameters modeling, human skeleton modeling

1 Introduction

With the development of video information processing technology and high-speed video equipments, the research on intelligent real-time video monitoring system develops rapidly. In the system, detecting, seizing and following the objects can be realized easily without manual intervention. The terminal aim is to analyze the behaviour of those objects [1].

In 1999, Gavrilu applied the motion trend analysis to the visual surveillance system and combined it with computer vision for the first time [2]. Piyarat recognized human behavior with ANFIS (Actual Neuro-Fuzzy Network) model combining with various feature information, such as image background, body configuration, lothes texture and the sensor distance. The identification accuracy rate in standing, lying, sitting and bowing can be 70%~80%.

Many scholars began to devote themselves to the research of intelligent video monitoring system in China. CBSR (Center for Biometrics and Security Research) developed a suit of such system which can realize the object detecting, mobile objects following and classifying. Meanwhile, it also can detect and identify the abnormal behavior of moving objects.

2 Human Skeleton Modeling

2.1 Definition and Characteristic of Skeleton

Skeleton is defined as the axis part in the picture, which is the center black line remained after peeling the marginal image. Pavlidis and Ali put forward the standard definition about skeleton in 1975 [3]:

Suppose in a polygon, R is a point set and T is the side set. For the random point $P \in R$, P_m is the nearest point to P in set T , that mans $|PP_m| < |PP_t|$. If $\left\{ \left| \frac{P_m}{|PP_m|} \right| < |PP_t| \right\} < 1$, that is there are several points(over than one point) which are the nearest to point P , we can call P is the skeleton point in the area R . All the skeleton points comprise the skeleton of the polygon.

There are several basic characters in a good picture skeleton as follows [4]:

- (1) Connectedness: the picture skeleton must be connected as the original picture.
- (2) Refinement: the picture skeleton should be only one pixel width.
- (3) Axial: the picture skeleton should approach to the axle wire of the original picture.
- (4) Retentivity: the picture skeleton should be in keeping with the original picture in detail characteristic.
5. Speedability: the extracting algorithm should be speedy and effective.

2.2 Zhang-Suen fast parallel thinning algorithm

Zhang-Suen fast parallel thinning algorithm [5] consists of removing all the contour points of the picture except those points that belong to the skeleton. It divides the iteration into two iterative procedures. In the first iterative procedure, if point P satisfies all the four conditions, it will be deleted from the digital pattern.

$$2 \leq B(P) \leq 6 \tag{1}$$

$$A(P) = 1 \tag{2}$$

$$P_2 * P_4 * P_6 = 0 \tag{3}$$

$$P_0 * P_4 * P_6 = 0 \tag{4}$$

Where $A(P)$ is the number of 01 pattern in the ordered set $\{P_0, P_1, \dots, P_7\}$ that is the neighbors of P and $B(P)$ is the number of nonzero neighbors of P.

In the second iterative procedure, only conditions (3) and (4) are changed as follows:

$$P_0 * P_2 * P_4 = 0 \tag{3'}$$

$$P_2 * P_4 * P_6 = 0 \tag{4'}$$

Repeat the two iterative procedures until all the points that match conditions are deleted. The algorithm adopts logical operation to judge those points. The number of iterative procedures are fewer, the judging rate are rapid and it is accurate for the straight line, break point and T type cross point.

2.3 Experiment results

Zhang-Suen fast parallel thinning algorithm is adopted to extract the skeleton in the environment in which the abnormal behaviors need to be detected and identified. The experiment results are shown as Fig.1.

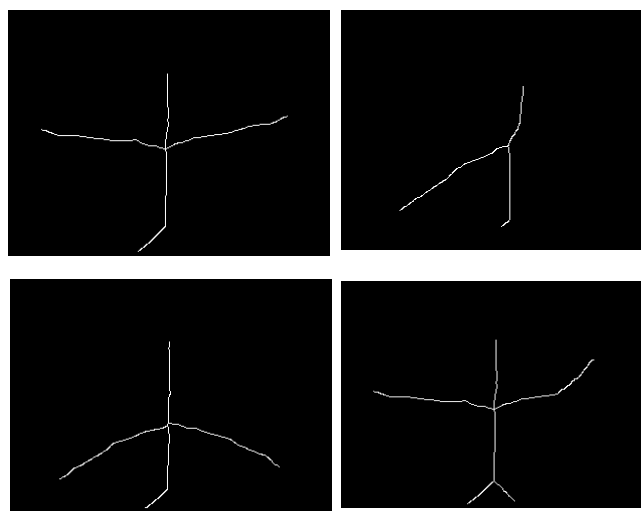


Fig. 1. The results of skeleton extracting

3 Anthropometric parameters modeling

3.1 Human skeleton model based on body joint

According to the results of the skeleton modeling and the characteristic of detection and identification of abnormal behavior, the skeleton model can be simplified as Fig.2.

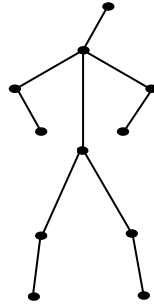


Fig. 2. Simplified human skeleton model

3.2 Improved key points extracting algorithm

There are two kinds of traditional location algorithms based on the key points of the skeleton model. In the first one, the human skeleton is divided based on the human body proportion, but it is affected by the body posture. In the other algorithm, the position information of skeleton points and connection state are mapped into body joint so that the key points can be extracted. The latter can only extract key points in some behaviors, so it can not satisfy all the postures in this research.

The improved key points extracting algorithm is put forward in this paper, which includes coordinate setting algorithm and body position mapping algorithm. It can extract the key points of human skeleton model based on many postures.

3.2.1 Key points coordinate setting algorithm

The key points include head, neck, waist, left hand, right hand, left foot, right foot, left elbow, right elbow, left knee and right knee. There are eight adjoining areas in traditional algorithm for each point. Because the thinning skeleton lines are not straight and they may be dislocation, it extends three pixel points from the eight adjoining areas in this improved algorithm. The structure is shown as Fig.3.

P_0	P_1	P_2
P_3	1	P_4
P_5	P_6	P_7
P_8	P_9	P_{10}

Fig. 3. 11 adjoining areas of the center pixel

The improved key points extracting algorithm is described as follows:

- (1) Define arrays a_1, a_2, a_3, a_4 . They are used to store the pixel points' position whose number is from 1 to 4 in the eight adjoining areas.
- (2) Scan the original image from top to bottom and from left to right. If the value of the pixel point is 1, record the number of value 1 in the eight adjoining areas.
- (3) If the number of value 1 in the eight adjoining areas is 1, store it into array a_1 .
- (4) If the number of value 1 in the eight adjoining areas is 2, and the pixel values of P_1 and P_6 are not 1, store it into array a_2 .

- (5) If the number of value 1 in the eight adjoining areas is 3, it should be discussed as follows:
- (a) If the pixel value of P1 is 1, and $P5 * P7 = 1$ or $P4 * P5 = 1$ or $P3 * P7 = 1$, store it into array a3. Otherwise it will go to (b).
 - (b) If a4 is null and the pixel value of P9 is 1, store it into array a4. Otherwise it will go to (c).
 - (c) If the pixel value of P1 and P6 are both not 1, store it into array a2.
- (6) If the number of value 1 in the eight adjoining areas is 4 and the pixel value of P9 is 1 and a4 is null, store it into a4.

3.2.2 The body position mapping algorithm

By analyzing the arrays a1, a2, a3 and a4, we can extract the key points which correspond with the body positions. The algorithm is described as follows:

- (1) If the length of a3 is 1, the points in a3 are waist key points.
- (2) If the length of a4 is 1, the points in a4 are neck key points.
- (3) If the length of a1 is more than 0, the two points whose values of y are maximal are foot key points. The point whose value of x is greater is right foot and the other point is left foot. The other points will be discussed as follows:
 - (a) The point whose distance is the nearest from the neck point is head point.
 - (b) If there are only two points in the array, the point whose x value is greater is right hand and the other point is left hand.
 - (c) If there is only one point left in the array and its x value is smaller than the value of neck point, it will be the left hand, otherwise it will be right hand.
- (4) If the neck point has been recognized and the length of array a2 is more than 0, compute the distance from hand to neck and sign it as Lt. Compute each distance from all the elements to neck point in array a2 and sign it as L. If $L_t - T < L < L_t + T$ (T is the deviation threshold, we assume its value is 3), it will be store into array ae.
 - (a) If the left hand has been recognized, the first point whose x value is smaller than neck's x value in array ae will be left elbow.
 - (b) If the right hand has been recognized, the first point whose x value is greater than neck's x value in array ae will be right elbow.

3.3 The body parameterization model based on key points coordinate matrix

It is the simplest model in many body parameterization models. After extracting key points, body parameterization model can be established by some simple data. The point whose coordinate value is (0, 0) will be regarded as the original point and the coordinate system will be established as Fig.4.

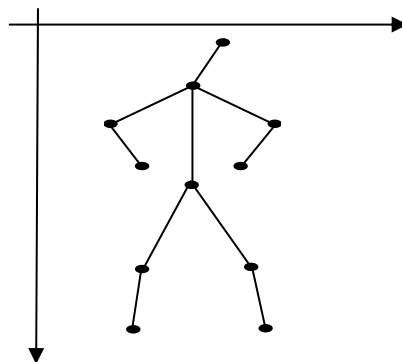


Fig. 4. The body parameterization model based on key points coordinate matrix

The parameterization model is defined as formula (5).

$$M = \begin{pmatrix} x_H & y_H \\ x_N & y_N \\ x_W & y_W \\ x_{LH} & y_{LH} \\ x_{RH} & y_{RH} \\ x_{LF} & y_{LF} \\ x_{RF} & y_{RF} \\ x_{J1} & y_{J1} \\ x_{J2} & y_{J2} \\ x_{J3} & y_{J3} \\ x_{J4} & y_{J4} \end{pmatrix} \quad (5)$$

3.4 Experiment results

In this experiment, the research object is only the upper part of the body, include different arm and hand postures. The original images and the extracting results are shown from Fig.5 to Fig.8.

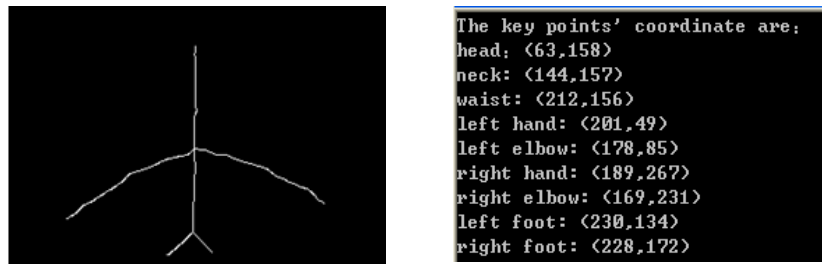


Fig. 5. The original images and the extracting results (1)

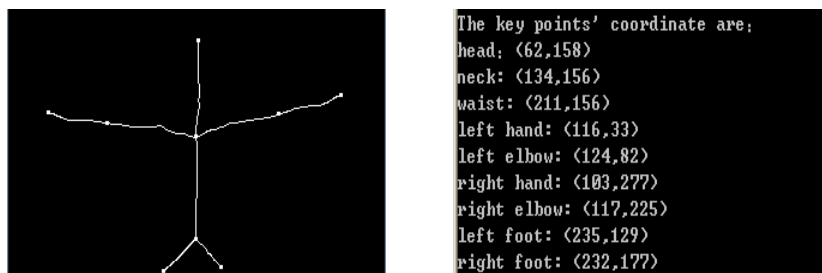


Fig. 6. The original images and the extracting results (2)

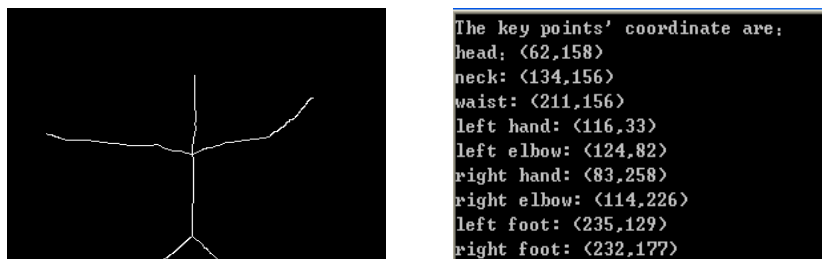


Fig. 7. The original images and the extracting results (3)

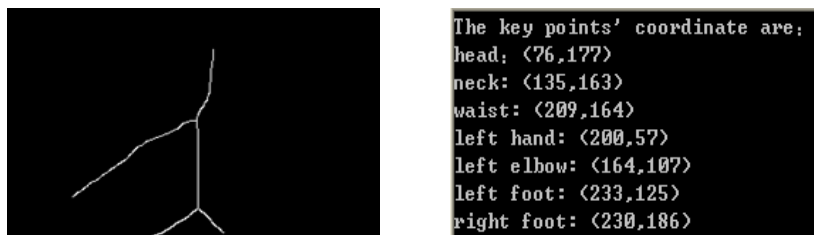


Fig. 8. The original images and the extracting results (4)

The body has two arms and the elbows are not obviously bent in Fig.5 and Fig.6. But in Fig.7, one elbow is bent and there is only one arm in Fig.8. Although these four postures have different features, the algorithm still can more accurately extract the key points and output the coordinate values according to body features.

4 Conclusion

This article sets the human skeleton model based on body joint and put forwards an improved key points extracting algorithm. After adopting Zhang-Suen fast parallel thinning algorithm to extract the body skeleton, the body parameterization model based on key points coordinate matrix is built. The algorithm can deal with most body postures and the experiment shows that extracting results are more accurately and can be the base data for detection of abnormal behavior for online examination.

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