Human Gait Recognition Using Bezier Curves

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Abstract-- **Gait recognition refers to automatic identification of an individual based on the style of walking. It is a new biometrics recognition technology. It has accomplished a series of achievements in scientific research in recent years. This paper proposed a new algorithm which is based on Bezier curves. Bezier curves are generated according to person's walk and recognition is achieved by matching those curves by calculating the mean and variance, and used for recognition. Only the side-view of the person is considered, since this viewing angle provide the richest information of the gait of the waking person. The experimental result shows that the proposed approach has a good recognition performance.**

Keywords- Gait recognition; Biometrics; Bezier Curves; Control points; Database; Mean; Variance.

Introduction

Gait recognition is a kind of biometrics using the manner of walking to recognize an individual. More formal definition of biometrics is given by [1], "Gait recognition refers to automatic identification of an individual based on the style of walking".

Many studies have now shown that it is possible to recognize people by the way they walk. It is well-known that biometrics is a powerful tool for reliable automated person identification, but at present, none of the conventional biometrics like fingerprint recognition, iris recognition can work well from a large distance [7]. In visual surveillance, the distances between the cameras and the people under surveillance are often large. In these situations, it is almost impossible to acquire the detailed conventional biometric information. Unlike other biometrics, gait can be captured from a distant camera, without drawing the attention of the observed subject [1].

While gait is a novel biometrics, the performance of image-based gait recognition is not very good because features extracted from image sequences have a little difference with the original information included in the gait. There is no efficient algorithm proposed yet to minimize the difference between the three dimensional information and features extracted from projected images [3].

In this paper, a novel algorithm for human gait recognition is presented, which is based on Bezier curve. Features are selected by choosing definite number of coordinate points on the grayscale image at some specific locations i.e. ankle, toe, knee, palm and shoulder. These coordinate points will be the control points of Bezier curve. Through these selected coordinate points, original coordinates of Bezier curve are calculated and are used to calculate variance and mean. Recognition is achieved by matching the mean and variance.
The rest of this paper is organized as follows: Section 2 presents some related works on human gait recognition. Section 3 gives the overview of proposed human gait recognition algorithm based on Bezier curves. Section 4 discusses the experimental results and finally, Section 5 concludes the paper.

Related works

Yanmei Chai Jinchang Ren, Rongchun Zhao and Jingping Jia [5] proposed a statistical approach for dynamic gait signature extraction. The DVS on each of the pixel position for a full gait sequence is extracted firstly, and then compute their variance features respectively to construct a dynamic variance matrix as gait signature for identification.

Alam and Hama [9] presented an approach to typify object contours in a database by a reduced number of data points and to match object shapes in occluded conditions. For simplicity, contours are approximated by a set of quadratic Bezier curves and all control points are stored in the database. Distance matrix is introduced, which is constructed from curve to curve distance measurement between the test and database contours.

Hong, Lee, Oh, Park, and Kim [4] have proposed a new feature vector, sampled point vector, for gait recognition based on model-free method. The mean and variance of value of pixels are chosen which are sampled along to central axis of silhouette image for several frames.

Wang and Liu [2] presented a simple and efficient gait recognition method based on positioning body joints. The coordinates of joints are computed according to the geometrical characteristics shown while walking. The limbs angles are computed based on the coordinates of joints and then made discrete Fourier transform. The amplitude-frequency and phase-frequency of angles are chosen as gait feature. At last the nearest neighbor classifier is used to classify subjects.

Proposed Algorithm

In this paper, we have proposed a new algorithm for recognizing gait system. This algorithm is based on Bezier curves. The proposed gait recognition system consists of three units: image preprocessing, feature extraction, and gait recognition.

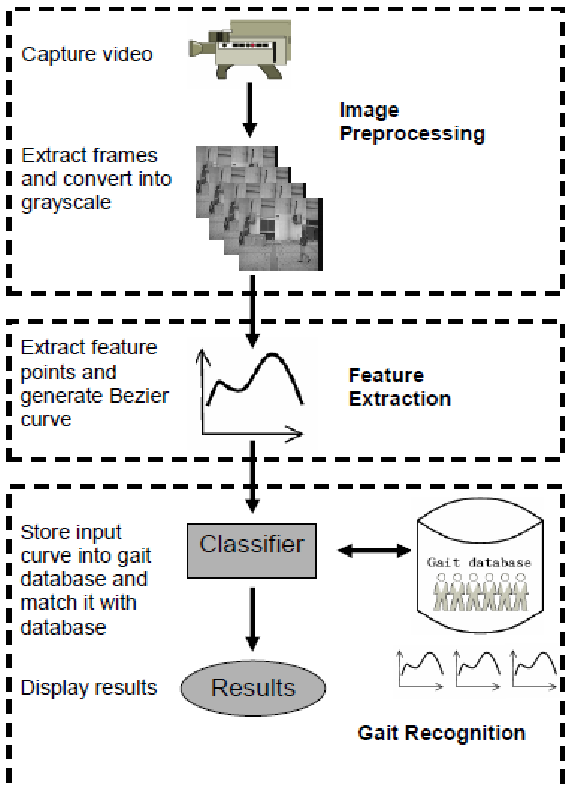


Figure 1. Proposed Algorithm

Image Preprocessing

In our experiments, there are two assumptions for the human walking sequences: (1) the camera is static and the body in the field of view is not occluded, (2) the image sequence of side-view is used.

The gait of a person is best brought out in the side-view [5]. Video of a walking individual is captured by camera and sequence frames are extracted from that video. Each frame is converted into grayscale if it is a color image. Grayscale images are used in this work because these images are entirely sufficient for our tasks and so there is no need to use more complicated and harder-to-process color images.

(a) (b)

Figure 2. a) Original image [5]. b) Corresponding grayscale image.

Gait Feature Selection

An important issue in gait is the extraction of appropriate salient features that will effectively capture the gait characteristics. The features must be reasonably robust to operating conditions and should yield good discriminability across individuals. A fast and efficient method is adopted to select only most discriminative features.

Key Frames Generation

We determine the key frames of a walking gait by observing the different phases of a human walk cycle as shown in Figure-3. The first key is defined at the pose where front leg is standing straight while the back leg is bend and slight above the ground. The second key is at the location where the front leg's foot is flat on the ground and back leg's toe touches the ground. The third key is defined as the pose where the back leg's foot if flat on the ground and front leg's ankle touches the ground. The fourth key will return back to the first key and complete the cycle [8].

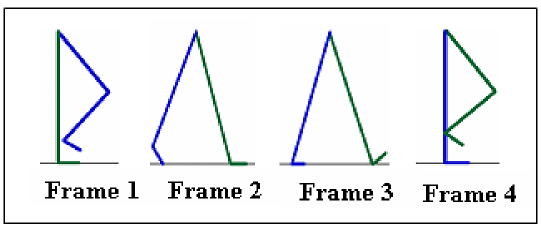
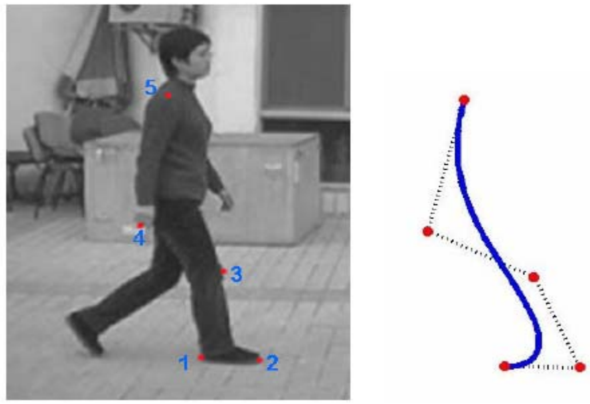


Figure-3. Key Frames

Computation of Bezier Curves

Bezier curves, different than other curve modeling techniques (e.g. spline curves), are not constrained to pass through all the specified points, instead they only approximate the given points (called control points), as shown in Figure 3(b). Once the control points are given, the curve shape is determined.



(a) (b)

Figure 4. a) Sequence of selecting control points of Bezier curve. b) Corresponding Bezier curve.

We select five control points from every frame of an individual according to Figure. 4. Here, first point is selected to locate ankle; next is selected to locate the toe; next is selected to indicate the knee; next is selected to indicate palm and last one is selected to locate shoulder. (x_i, y_i) denotes i-th selected point.
A Bezier curve is represented by the function [6]:

$$P(t) = \sum_{i=0}^{N} P_i B_{i,N}(t) \tag{1}$$

where N is the degree of curve (total number of control points), $P_i = (x_i, y_i)$ and $B_{i,N}(t)$, for $i = 0, 1, \ldots, N$, are the Bernstein polynomials of degree N, and $t \in [0, 1]$.

Without ambiguity the control points can be treated as vectors and the corresponding Bernstein polynomials as scalars. Thus the above formula can be represented parametrically as $P(t) = (x(t), y(t))$, where,

$$x(t) = \sum_{i=0}^{N} x_i B_{i,N}(t) \tag{2}$$

And,

$$y(t) = \sum_{i=0}^{N} y_i B_{i,N}(t) \tag{3}$$

where, $0 \le t \le 1$. From each frame, we construct a Bezier curve by calculating x- and y- coordinates for Bezier curve using equations (2) and (3).

Gait Recognition

We adopted a simple and straightforward way in order to test the recognition capability of our proposed method. First we calculate the variance of x- and y- coordinates of Bezier curve of all frames of an individual separately and then finally calculate the mean of x- coordinate with its corresponding y- coordinate. In contrast to other system, proposed features are very simple and require low storages.
Variances of x- and y- coordinates are calculated in the following manner [5]:

$$\sigma_x^2 = \frac{1}{n} \sum_{i=0}^{n-1} \left[x_i - \overline{x} \right]^2 \tag{4}$$

And,

$$\sigma_y^2 = \frac{1}{n} \sum_{i=0}^{n-1} \left[y_i - \overline{y} \right]^2 \tag{5}$$

where x_i and y_i are the i-th coordinates of the Bezier curve, for $i=1,2,\ldots.n$, and are the mean values of x- and y- coordinates of Bezier curve, respectively, and n is the total number of x- (or y-) coordinates in Bezier curve.

Finally, mean calculated in following manner:

$$M_{xy} = \frac{1}{2}\left(\sigma_x^2 + \sigma_y^2\right) \quad (6)$$

These variances and mean of an individual are matched with those of stored in database in order to find similarity between input frames (probe sequences) and database frames (gallery).

Experimental Results

For the evaluation of our proposed method using the mean and variance method for people identification, a gallery dataset of 80 video sequences is taken from the CASIA gait database [10]. The set consists of 20 different subjects with 4 sequences for every individual. The results are obtained for Rank 1 and Rank 2. Rank 1 results report the percentage of subjects in a test set that were identified exactly. Rank 5 results report the percentage of test subjects whose actual match in the reference database was in the top 5 matches [1].
In this section, we present the results generated by the proposed method.

TABLE 1. Rank 1 and Rank 5 match results for 20 different inputs

S. No.	**INPUT IMAGE**	**RANK 1** *(Match found or not)*	**RANK 5** *(Match found or not)*
1.	A	YES	YES
2.	B	YES	YES
3.	C	YES	YES
4.	D	YES	YES
5.	E	NO	NO
6.	F	NO	YES
7.	G	YES	YES
8.	H	YES	YES
9.	I	YES	YES
10.	J	YES	YES
11.	K	NO	YES
12.	L	YES	YES
13.	M	YES	YES
14.	N	YES	YES
15.	O	YES	YES
16.	P	YES	YES
17.	Q	YES	YES
18.	R	YES	YES
19.	S	YES	YES
20.	T	YES	YES

TABLE 2. Experimental result compared with others

S. No.	Name of Methods	Database	CCR *Rank 1*	CCR *Rank 5*
1.	Our method	20 subjects, 80 sequences	85%	95%
2.	Dynamic Variance Features [5]	6 subjects, 42 sequences	76%	-
3.	Positioning Human Body Joints [2]	10 subjects, 40 sequences	78%	-

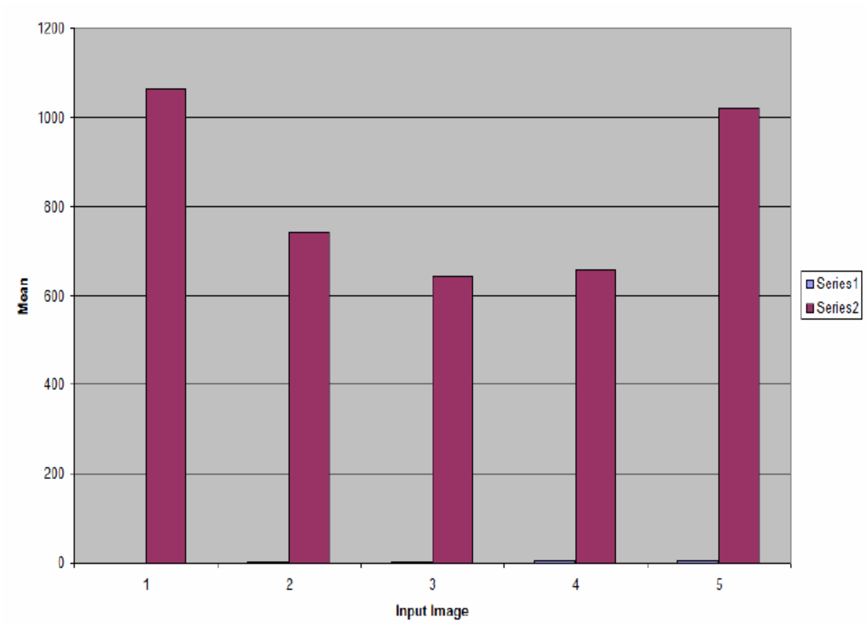


Figure 5. Graph for Rank 1 (five input images Vs their corresponding mean)

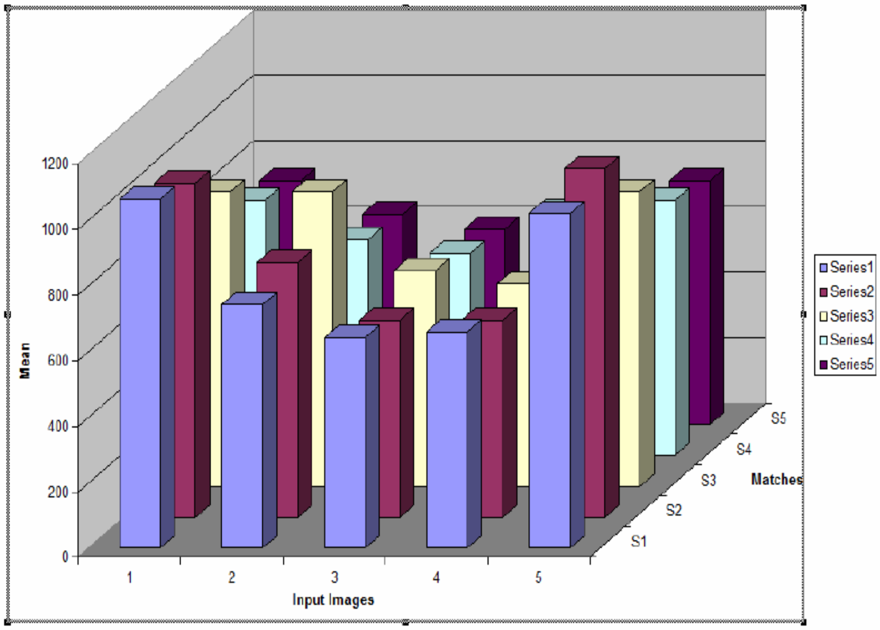


Figure 6. Graph for Rank 5 (five input images Vs corresponding mean of five nearest matches)

Advantages of Proposed Method:

1. Recognition is much higher than other methods.
2. It does not require silhouette images and GEI images.
3. Computational speed becomes high due to use of simple mathematical calculations like mean and variance.
4. It requires less memory space because of comparison of numeric values.

So, it is efficient in terms of execution time and memory space both.

Conclusion

In this paper, we proposed a novel gait recognition method based on the Bezier curves. First we select the points on sequence frames, calculate the coordinates of Bezier curve from those points, draw the Bezier curves and finally, calculate the variance and mean from Bezier curve coordinates. These variance and mean are used to fulfill the person identification. The experiments results on real sequences have obtained the CCR 100% for rank 5 and 85% for rank 1 on CASIA database, respectively. Experimental results demonstrate that our proposed algorithm achieves higher recognition rate with the advantages of simple computation and high processing speed.

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