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Gait Authentication Based on Fusion of Wavelet and Hough Transform

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ABSTRACT

Recognition is a process of identifying a subject's identity from a set of already known identities. Gait recognition is the process of identifying a subject by the manner in which he walks. It identifies a person from the database consisting walking sequences of images. The gait of a person walking can be extracted without requiring the prior consent of the observed subject and the gait of an individual can be captured at a distance unlike other biometric techniques. In this paper, wavelet decomposition and hough transformations are applied on the walking image sequences and also the height and width of the silhouette are considered. The experimentation results indicate that the proposed system works efficiently by combining both the transformations. The experiments are tested on CASIA Dataset A and Real time data set.

Keywords: *Gait recognition, Wavelet transform, Hough transform.*

1. INTRODUCTION

Gait Recognition is the term typically used to refer to the automatic extraction of visual cues that characterize the motion of a walking person in video for identification process. Gait recognition techniques are divided into model free and model-based. Model free also known as appearance based is a holistic approach and the advantage of using model free approach is that it is not linked to one object. Model-based approaches extract the motion of the human body by means of fitting their models to the input images. Models used are typically stick representations either surrounded by ribbons or blobs.

Gait recognition is a multistage process [8]. Initially the walking sequence of a subject is captured, the walking subject is separated from its background using a process called background subtraction. A critical step in gait recognition is feature extraction, which is the extraction of signals from video sequences of the walking persons that can be used for recognition. This step is very important since there are numerous conceivable ways to extract signals from a gait video sequence, e.g., spatial, temporal, spatiotemporal, and frequency-domain feature extraction. Therefore, one must ensure that the feature extraction process compacts as much discriminatory information as possible. Finally, there is a recognition step, which aims to compare the extracted gait signals with gait signals that are stored in a database.

In this paper, we present an efficient approach for gait recognition by extracting the hough peak by applying hough transformation, wavelet approximation coefficients are extracted by applying wavelet decomposition and both these extracted features are combined for gait recognition and also the height and width of the extracted silhouette are considered for recognition. The remainder of this paper is organized as follows. In section 2, we will review some of the previous work related to gait recognition. Then in section 3 we discuss about the preprocessing part and section 4 consist of the feature extraction techniques used. Section 5 describes the proposed algorithm. Section 6 discusses the experimental results and conclusions are drawn in section 7.

2. PREVIOUS WORK

D.Sharmila and E.Kirubakaran [11] have proposed a robust method for extracting discriminate gait features automatically and passively from low-resolution video. Two gait recognition techniques were proposed which are Image based gait recognition and Formula based gait recognition. Both methods characterize and recognize gait by computing correspondence-free motion features from the video sequence. Haitao Liu *et al.* [3] have proposed an algorithm for Automatic Gait Recognition from a Distance based on analyzing image sequences captured by stereo vision. Contour matching is done after binarized silhouette of a moving individual is firstly achieved in order to get 3D contour. Stereo gait feature which is the norm of stereo silhouette vector is extracted from 3D contour. In addition, Principal Component Analysis is adopted for dimensionality reduction. Finally, Nearest Neighbor Classifier and Nearest Neighbor Classifier about Exemplar are applied for classifying and distinguishing. Yi-Bo Li and Qin Yang [14] have presented the use of lower leg and ankle for gait feature extraction where the silhouette was divided into three consecutive parts and Discrete Cosine Transform was used to transform the amplitude angle sequences. Hu Ng *et al.* [5] have presented a new approach for extracting human gait features from a walking human based on the silhouette image. The approach consists of five stages, clearing the background noise of image by morphological opening, measuring the width and height of the human silhouette, dividing the enhanced human silhouette into six body segments based on anatomical knowledge, applying morphological skeleton to obtain the body skeleton and applying Hough transform to obtain the joint angles from the body segment skeletons. Shi Chen *et al.* [12] have proposed wavelet moments for gait recognition by motion templates. In the proposed approach changes of pedestrian silhouettes covering one stride are decomposed into disappear and emergent image area, from which motion history is cumulated into static grey scale images as motion templates. These motion templates are employed to characterize human walking properties. In order to reduce the feature space, the cubic B-spline wavelet moments are computed from the motion templates and extract discriminating features for identification.

3. PRE-PROCESSING

The video of the subject walking is captured and then the captured video is cut into frames and the walking subject is separated from its background using background subtraction algorithm. To extract the foreground object from background we have compared each frame that is |frame – background| with a pre-defined threshold Th. If the difference of a pixel is larger than Th, then classify it as foreground; otherwise, claim that it is background. The assumption behind this algorithm is that the foreground is constantly moving while the background remains static. The implementation of this background subtraction is very fast. However, it works only if the static background is known or can be estimated.

The captured background image is as shown in Fig. 1, Fig. 2. shows the frame of a person walking captured from the camera and Fig. 3. shows the silhouette after performing background subtraction.

Fig. 1. Background

Fig. 2. Original image

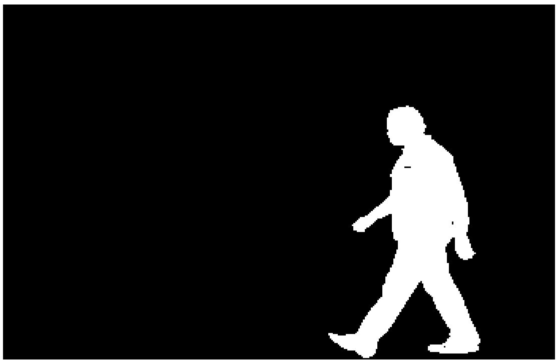

Fig. 3. Silhouette extraction

4. FEATURE EXTRACTION

4.1 Wavelet Transform

Mathematical transformations are applied to signals to obtain further information from that signal that is not readily available in the raw signal. The Wavelet transform provides the time-frequency representation. In case of discrete wavelet transform (DWT), filters of different cutoff frequencies are used to analyze the signal at different scales [9]. The signal is passed through a series of high pass filters to analyze the high frequencies, and it is passed through a series of low pass filters to analyze the low frequencies. Wavelet decomposition involves a pair of waveforms, the wavelet function and the scaling function. The wavelet function represents high frequencies corresponding to the detailed parts of an image. The scaling function represents the low frequencies or smooth parts of an image. The DWT analyzes the signal by decomposing the signal into a coarse approximation and detail information. The approximation component represents the coarser information of the input image. The detail information is contained in the horizontal, vertical and diagonal coefficients. The scaled and translated basis functions in 2D DWT [1] is given by Eq. (1) and Eq. (2).

$$\phi_{j,m,n}(x,y) = 2^{j/2}\phi(2^j x - m, 2^j y - n) \quad (1)$$

$$\psi^i_{j,m,n}(x,y) = 2^{j/2}\psi^i(2^j x - m, 2^j y - n) \quad (2)$$

where *i* is the index to identify the directional wavelets in terms of horizontal, vertical and diagonal components.

A single level decomposition can be performed resulting in four different frequency bands namely the upper left quadrant is the approximation of the source image. The upper right, lower left and lower right represent vertical, horizontal and diagonal details of the source. At each level of decomposition, the image is split into the approximation, horizontal detail, vertical detail and diagonal detail. The approximation coefficients are further decomposed into four components in the next level.

The Haar basis is obtained with a multiresolution of piecewise constant functions. It is a square pulse and captures sharp edges in an input image.

The Haar wavelet's mother wavelet function ψ (t) can be described as

$$\psi(t) = \begin{cases} 1 & 0 \le t < 1/2, \\ -1 & 1/2 \le t < 1, \\ 0 & \text{otherwise.} \end{cases} \quad (3)$$

Its scaling function φ(t) can be described as

$$\phi(t) = \begin{cases} 1 & 0 \le t < 1, \\ 0 & \text{otherwise.} \end{cases} \quad (4)$$

The wavelet descriptors are better than fourier, since they are able to catch small differences between patterns and the decomposition level four is considered to be the best compromise between compactness of representation and preservation of shape information [10]. In the proposed approach Haar wavelet of level four is applied on the image and approximation coefficients are extracted from the image and stored.

4.2 Hough Transform

The Hough transform is a feature extraction technique used in image analysis, computer vision, and digital image processing. The purpose of the technique is to find imperfect instances of objects within a certain class of shapes by a voting procedure. This voting procedure is carried out in a parameter space, from which object candidates are obtained as local maxima in a so-called accumulator space that is explicitly constructed by the algorithm for computing the Hough transform. Hough performs groupings of edge points into object candidates by performing an explicit voting procedure over a set of parameterized image objects.

The simplest case of Hough transform is the linear transform for detecting straight lines. In the image space, the straight line can be described as y = mx + b and can be graphically plotted for each pair of image points (x, y) [6]. In the Hough transform the characteristics of the straight line is considered in terms of its parameters, i.e., the slope parameter m and the intercept parameter b. Based on that fact, the straight line y = mx + b can be represented as a point (b, m) in the parameter space. However, one faces the problem that vertical lines give rise to unbounded values of the parameters m and b. For computational reasons, it is therefore better to use a different pair of parameters, denoted r and θ (theta), for the lines in the Hough transform.

The parameter r represents the distance between the line and the origin, while θ is the angle of the vector from the origin to this closest point. Using this parameterization, the equation of the line can be written as

$$y = \left(-\frac{\cos\theta}{\sin\theta}\right)x + \left(\frac{r}{\sin\theta}\right)$$

which can be rearranged to

$$r = x\cos\theta + y\sin\theta \quad (5)$$

The (r,θ) plane is sometimes referred to as Hough space for the set of straight lines in two dimensions where r (the distance between the line and the origin) is determined by θ. This corresponds to a sinusoidal curve in the (r,θ) plane, which is unique to that point. In our approach, the output of the hough transform rho(r) is used as another feature extraction technique. This value of r is found to be unique and hence could be used directly for matching.

5. PROPOSED ALGORITHM

5.1 Training Phase

The proposed approach for the training phase is,

Step 1: Read each frame of a person from the dataset.

Step 2: Hough Transform is applied on the skeleton of the human silhouette. The peak value rho (r) is extracted

Step 3: Apply wavelet transform on the image and obtain the approximation wavelet coefficients.

Step 4: Extract the geometrical features namely height and width of the person [7].

The features are computed for all the frames of the captured image using the above steps. The mean values of all the features is computed for all the people in the dataset and stored in the database.

5.2 Testing Phase

The proposed approach for the testing phase is,

Step 1: Step 1 to 4 in the training phase is repeated for the different input frames of a subject. (1)

Step 2: The extracted feature are compared with the training phase data by using k-nearest neighbor classifier.

For classification we have used k-nearest neighbour classifier (KNN) [13]. KNN is a classifier which distinguishes the different subjects based on the nearest training data in the feature space that is subjects are classified according to the majority of the nearest neighbours.

6. EXPERIMENTAL RESULTS

The proposed method is tested on CASIA Dataset A which contains walking style of 20 persons and also on real time dataset which had walking style of 10 persons. In CASIA Dataset A, each person has 12 image sequences of three directions i.e. parallel, 45 degrees and 90 degree to the image plane. The length of each sequence is not identical for the variation of the walker's speed and it ranges from 37 to 127. The real time dataset had subjects walking parallel to the camera and the walking sequence was cut into frames ranging from 50 to 80 frames.

The proposed system was tested on 19 subjects from the CASIA Dataset and 10 subjects from the real time dataset walking parallel to the camera and in both the directions left to right and right to left. The training data contained 3400 frames of subjects walking in both the sequence left to right and right to left and 3100 frames were used as our test data. Our proposed algorithm is highly efficient and has a recognition accuracy of 95%. Fig. 4 shows the haar wavelet decomposition at level 4 for a given subject, as shown in the figure the approximation coefficients are further decomposed at each level.

Fig. 4. Haar Wavelet Decomposition at Level 4

Experimental results observed on sample trained data set and test dataset are shown in table 1 and table 2 respectively which contain sample data of seven subjects. The table contains the values of all the four features extracted from the silhouette. During the testing phase has shown in table 2 it recognizes the respective subjects correctly expect row 2 where the subject was falsely accepted has subject 13.

Table 1. Sample Trained Dataset

Class	Height	Width	RHO	Approximation Coefficient
1	130.2619	56.44	27.4048	0.5837
2	139.6591	62.8333	32.3485	0.6927
3	131.3929	54.0071	16.9929	0.5356
4	152.5818	68.7636	25.5273	0.8327
5	177.7179	83.3718	35.7051	1.1207
6	125.1293	51.1497	21.5238	0.5584
7	149.4478	63.2388	29.8209	0.8107

Table 2. Sample Test Dataset

Height	Width	RHO	Approximation Coefficient	Result showing which class the subject belongs
132.600	55.5667	29.6167	0.5939	1
138.9565	61.8261	30.7536	0.7004	13 (falsely accepting)
133.1493	54.6866	18.1194	0.5525	3
132.5147	52.7206	15.2647	0.5254	3
179.0588	81.4902	26.4118	1.1243	5
124.1293	49.9710	26.0290	0.5523	6
124.6533	51.0667	20.8800	0.5454	6

Table 3 shows the comparison of the present approach with the existing methodologies. It can be observed that our present approach has got a higher recognition accuracy of 95% when compared to the other approaches.

Table 3. Comparison with different approaches

Sl No.	Methodology	Recognition Accuracy
1.	Our earlier approach [6]	90%
2.	Wavelet Descriptors approach used by other researcher [10]	85% with MLP and 91% with KNN classifier
3.	Hough Transform approach used by other researcher [5]	72.07%

7. CONCLUSION

The proposed method is tested on CASIA Dataset A and the real time dataset, recognition rate of 95% is achieved. We have used KNN classifier for classification and the experimental results prove that our system has higher recognition rate. It is observed the recognition accuracy reduces when oriented images are given for testing. Since the proposed approach has extracted the features using the fourth level decomposition of haar wavelet approximation coefficients which contains only the low-frequency bands of the transform coefficients, the features are insensitive to the shape variations caused by the walking styles of different persons, together with the peak values of the hough transform output which contributed to the edge features has lead us to this increased accuracy of the overall system. The research continues in coming out with novel robust technique where in the real time datasets will be tested when the input frames are oriented and for cluttered background.

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REFERENCES

[1] Chun-Lin, Liu (2010), A Tutorial of the Wavelet Transform

[2] Dong Ming, Yanru Bai, Cong Zhang, Baikun Wan and Yong Hu, KDK Luk (2009), Novel Gait Recognition Technique Based on SVM Fusion of PCA-Processed Contour Projection and Skeleton Model Features, International Conference on Computational Intelligence for Measurement Systems and Applications.

[3] Haitao Liu, Yang Cao and Zengfu Wang(2010), Automatic Gait Recognition from a Distance, Chinese Control and Decision Conference.

[4] Han Su and Feng-Gang (2005), Human Gait Recognition based on Motion Analysis, Proceedings of Fourth International Conference on Machine Learning and Cybernetics.

[5] Hu Ng, Wooi-Haw Tan, Hau-Lee Tong, Junaidi Abdullah and Ryoichi Komiya (2009), Extraction of Human Gait Features from Enhanced Human Silhouette Images, IEEE International Conference on Signal and Image Processing Applications.

[6] Nandini.C, Pratul Mukhopadhyay, Tushar Tanmay, Saurabh Kumar Ranjan, Samvit Roy (2011), An Efficient Human Identification Using Gait Analysis, International Journal of Research and Reviews in Computing Engineering, Vol. 1, No. 2.

[7] Nandini.C, Sindhu.K, Ravi Kumar.C.N (2011), Gait Recognition by Combining Wavelets and Geometrical Features, IEEE Second International Conference on Intelligent Agent and Multi-Agent Systems, Chennai.

[8] Nikolaos V. Boulgouris, Dimitrios Hatzinakos, and Konstantinos N. Plataniotis (2005), Gait Recognition: A challenging signal processing technology for biometric Identification, IEEE Signal Processing Magazine.

[9] Robi Polikar (1999), The Wavelet T utorial.

[10] Saeid Rahati, Reihaneh Moravejian and Farhad Mohamad Kazemi (2008), Gait Recognition Using Wavelet Transform, Fifth International Conference on Information Technology: New Generations.

[11] Sharmila.D and Kirubakaran.E (2010), Image and Formula Based Gait Recognition Methods, International Journal of Computer and Electrical Engineering, Vol. 2, No. 2.

[12] Shi Chen , Wanhong Huang , Qiuli Guo and Laicang Dong (2010), Wavelet Moments for Gait recognition Represented by Motion Templates, Seventh International Conference on Fuzzy Systems and Knowledge Discovery.

[13] Theodoridis. S, Koutroumbas. K, Pattern Recognition, Academic Press, New York, 1999

[14] Yi-Bo Li and Qin Yang (2010), Gait extraction and recognition based on lower leg and ankle, International Conference on Intelligent Computation Technology and Automation.

[15] Yumi Iwashita and Ryo Kurazume (2009), Person identification from human walking sequences using affine moment invariants, IEEE International Conference on Robotics and Automation, Japan.

[16] http://www.cbsr.ia.ac.cn/english/Gait%20Databases.asp

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