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Human Gait Recognition Based on Principal Component Analysis

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***Abstract*— This paper represents a method to recognize the human walking individuals by their gait using Principal Component Analysis (PCA). Human Gait is used as principal identifying feature to generate the unique gait sequence for each individual. Gait is an important biometric feature which delineates the way of locomotion. The generation of binary silhouette frames of walking subjects is the initial step in this method. Some distinguishable gait features, *viz.*, centroid, aspect ratio, orientation, height and width are extracted from the silhouette frames to acquire feature vectors. Then, the PCA is employed over the generated feature vectors to condense the information contained and produces the principal components which are used as gait sequences or signatures to represent each walking individuals. Finally the generated gait sequences are recognized by using a minimum distance classifier based on eluclidean distance. A classification rate of 93% is achieved from the proposed human recognition method which is tested using CASIA dataset.**

Keywords— PCA, Gait, Silhouette, Feature Vector Human Recognition, CASIA dataset

I. INTRODUCTION

The human gait is an important biometric feature which offers the ability to recognition or identification or tracking of subjects at a distance. It is beneficial in certain aspects as gait does not require the subject corporation or subject contact unlike fingerprint, iris, Face, etc [2]. Gait is unique distinguishable biometric feature as each person has a distinctive walking style which is easily understood from biomechanical viewpoint. Different methods or techniques are currently used in some of the existing methods to recognize human locomotion or action and identify the person [1], [5], [6], [9], [15], [17]-[20], [22] [26].

In the last few years gait analysis and recognition attracts the interest of many researchers. Recently, Jianqiang [5] has proposed a methodology in order to do the recognition of gait fast and efficiently. This is based on $(2D)^2$ PCA and HMM. Initially with the help of adaptive background modeling, a stable background model is established and get the human actions using background subtraction algorithm. Features are extracted by using $(2D)^2$ PCA to reduce the dimensions so as to solve the curse of dimensionality, makes use of Hidden Markov Model for the classification.

With the advantage of gait recognition, it also have disadvantage of low recognition rate when the silhouette of the subject changes with their clothes. Kim Sa-Mun[6] has proposed a new method for Person Recognition using combination of gait energy image feature and thermal face feature. For extraction of features, Linear discriminant analysis is used which is also a very important algorithm for feature extraction. They have done the classification using nearest neighbor classification algorithm.

The first motion approach was examined by French physiologist and physician Étienne-Jules Marey [8] founding father of cinematographic technique which was used to capture and display high speed moving image. Marey filmed walking subjects with small markers. Gunnar Johansson coined the term PL animation, according to him a person is able to identify subjects walking with lights affixed to their body parts. In 1975, Gunnar Johansson [4] [16] reported that an observer can recognize person if walked with light affixed to joint of subject.

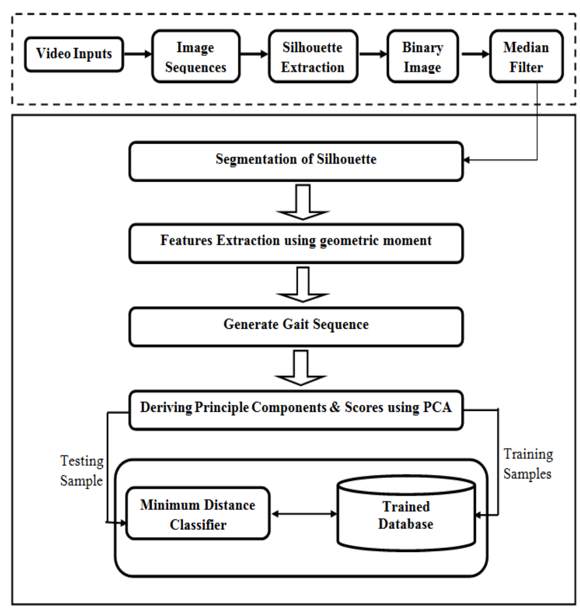

Fig.1. Block diagram of proposed Human Recognition system

In 2002, Lee and Grimson [9] conducted an experiment on gait recognition by dividing the silhouette into 7 segments and an ellipse was fitted into each of the segment and features were computed to classify pattern. Our initial steps are similar with this work. In our methodology, we have taken nine segments instead of

seven and central/ geometric moment is used to extract the features: centroid, aspect ratio and orientation from the pedestrian silhouette.
The silhouettes from the input image sequence are extracted by using Background subtraction method. Background subtraction method is very important method for extracting silhouette in gait recognition approaches. In the absence of any *a priori* knowledge about target and environment, the most widely adopted approach for moving object detection with fixed camera is based on *background subtraction* [7] [11] [12]. Finally these features are used to generate the feature vector and by using Principal Component Analysis, principal components are derived which represent gait signature for each individual. Our proposed methodology is shown in the Fig. 1.

II. Proposed Methodology

The Background Subtraction algorithm is used for extraction of silhouettes frames of each walking individual from the input image sequences. It is the initial step in our proposed method. Post background subtraction, silhouette frames are passed through a median filter which is a non lineal digital filtering technique, used to remove noise. The gait signatures for each individual are generated from these silhouette frames using gait features. The gait signatures are the basic building blocks, which are used in the proposed human recognition algorithm. The steps involves in the generation of gait signatures are: i) Segmentation of silhouette frames, ii) feature extraction, iii) Computing feature vectors and finally Principal Component Analysis is applied to generate the gait signatures.

A. Segmentation of Silhouette and Feature extraction

Post background subtraction, silhouette of walking individual is segmented into nine sections which represent different parts of the human body: head, upper torso, lower torso, thigh and calf. The segmentation is mainly done with respect to the centroid of the entire silhouette and it is computed by using geometric moment [10]:

$$\mathbf{m_{pq} = \sum_p \sum_q x^p y^q} f\mathbf{(x,y)} \quad \textbf{where,} \quad \mathbf{p,q = 0,1,2,3......} \tag{1}$$

$$\mathbf{x_0 = m_{10}/m_{00}\ ;\ y_0 = m_{01}/m_{00}} \tag{2}$$

Where, m_{pq} is the geometric moment and p, q are the order of the moment, f(x, y) is the silhouette image and (x_0, y_0) is the centroid of the silhouette image.

Initially, the parts above and below of the centroid are divided in horizontal direction with some ratios which are considered after analysis of several video samples of human of different heights and weights. Then, the vertical front and back sections are divided, except for the head portion, resulting in nine shown in the Fig 2. Some distinguishable gait features: Centroid (*x, y*), Aspect ratio (*l*) and orientation (α) from each segment of the silhouette and height of the person (*h*) and width(*w*) of the person, are extracted from the silhouette for the computation of feature vectors which result in 38 number of features for each subject. Geometric moment is used to extract the centroid, aspect ratio and orientation from each of the segments using geometric moment.

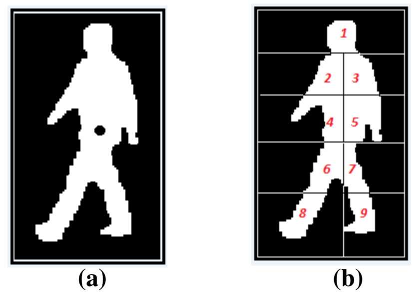

Fig.2. Segmentation of the human Silhouette: (a) Centroid of the Silhouette; (b) 9-segments of the silhouette of a foreground walking person [30].

B. Computation of Feature Vector

The features which are extracted from the silhouette are kept in the form of vector which indicates the feature vector. The feature extraction process is repeated in the entire image sequences of a video input to obtain the feature vectors for all images. The average mean of all the feature vectors generated from a single image sequence or a video represent the feature vector for that video input. Now each walking sample input video is represented by the obtained feature vector $[h\ \ w\ \ x_1\ \ y_1\ l_1\ \alpha_1\ \ ......]_{1x38}$.

C. Computation of Principal Components

The above steps are conducted over all the input training video samples to train the dataset. The derived feature vectors are used as gait pattern to represent each walking individual and all vectors are stored in a single matrix is known as Featured Matrix. Then PCA is employed over the generated feature vectors to compute the principal components with minimum loss of information.

(F × PC=Z)

Where, **F** is a feature matrix which contains feature vectors of **'n'** sample videos with'd' number of features. **'k' (k<n)** principal components which are used as gait signature of the patterns. **Z** is the matrix which obtains after PCA is employed over feature matrix. **PC** is the principal component oefficients matrix of size d-by-d in which each column containing coefficients for one principal component.

After Computation of principal components, classification is carried out on the derived gait signatures which are computed from training dataset. An unknown subject is compared with the train database to find the best match.

D. Human Recognition and Identifications

A new sample video input is processed through all the above steps to derive a new feature vector which represents the gait pattern of the unknown subject. Then, the new feature vector is transform to PCA (Principal Component Analysis) space.

(F × PC=Y)

Where **X** is the newly derived feature vector which includes‘d’ numbers of features, **PC** is the principal component coefficients matrix and the matrix **Y** includes **‘k’ (k<n)** principal components which are used as gait signature of the derived pattern.

The principal components which are derived from a new testing sample are used for the recognition. In order to recognize or verify the subject’s identity using gait, a minimum distance classifier is used which is based on eluclidean distance. The generated gait signature is compared with each gait signature stored in the trained dataset. The minimum Euclidean distance is compared with a threshold value. The person is considered as known (means gait signature present in the trained database); if the minimum distance is smaller than the threshold value otherwise it is considered as unknown.

III. Results and Disscussion

All the experiments of our proposed methodology are conducted on CASIA dataset. This is a well Known standard gait database provided by CASIA (Institute of Automation Chinese Academy of Sciences) for gait recognition and other related researchers.

In the initial step of our proposed methodology i.e. background subtraction, ‘45’ is set as the threshold value which is mandatory in the algorithm. The value is achieved by conducting the experiment several times with different manual values and the result obtained by this value is comparatively good. A set of silhouette frames for a walking subject is shown in Fig. 3.

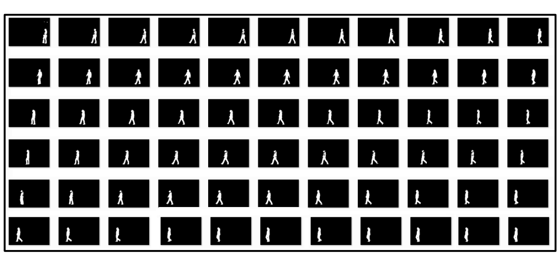

Fig.3. Set of binary frames to represent a silhouette image sequence of a walking subject [30].

Geometric moment is used for extracting the gait features like centroid, aspect ratio and orientation from the silhouette of the walking individual which are used to generate the unique gait signature for each subject. These gait features are distinguishable in nature and it helps to give a good recognition rate.

After extracting the gait features, principal component analysis is applied to vectors to condense the information contained in a large number of original variables into a smaller set of new composite dimensions i.e. principal components, with a minimum loss of information. These principal components used as signatures of the gait patterns. The number of principal components is less than or equal to the number of original variables [3].

IV. Conclusion

In the segmentation part of the proposed method, nine segments are considered. The proposed method is tested with both seven and nine segment. A recognition rate of 86 % is achieved with seven segments and 93% with nine segments which is relatively higher. This is might have been due to the features taken from the torso part of the silhouette is more distinct in the two extra segments. The extraction of gait feature and computation of principal scores become important steps in the proposed human recognition system. Finally the generated gait signature which are represented by the principal score are compared with the new subject‘s gait signature using Euclidean distance based minimum distance classifier. The performance of the proposed human recognition using PCA has been illustrated using CASIA dataset.

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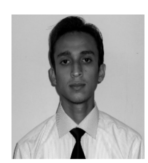

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