A Survey of Human Gait Recognition for Model Free Approach

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Abstract--Human gait recognition is a second era biometrics which is unpretentious and distance based. Human gait recognition is only distinguishing an individual from its strolling style. Human Cooperation is not needed in this biometric framework. There are two methodologies of gait recognition which are model based and model free methodologies. This paper gives a late exhaustive study of just model free gait recognition approach. This overview concentrates on model free gait image representation, dimensionality decrease of concentrated feature and characterization. Openly accessible gait dataset are likewise talked about. The paper is finished up by posting the examination challenges and by giving future work in model free gait recognition approach.

Keyword: Classification, Human gait, Feature Extraction, Model Free, Silhouette.

1. Introduction

Human Gait recognition system is an unobtrusive biometric feature, which had attracted many researchers in recent years [9]. In video surveillance based application identifying the human gait is an important feature because it captures the human from a distance [1]. Human gait recognition have advantages like without knowing the person its gait can be captured and also high quality of videos are not required unlike face recognition. It is very difficult to conceal someone's gait. On the other hand factors like fillips, physical changes, clothing and psychology of human affects the individual's gait. Human gait recognition approaches are divided into two types: model free and model based. Model based approach typically uses a stick representation for modeling human. The person model is fit to the person in each frame of the walking sequence and parameters are measured with the constraints on the body model of walking sequence [2]. An advantage of model based approach is it is robust to occlusion and noise. Disadvantage of model based approach is it requires high computational cost [3].

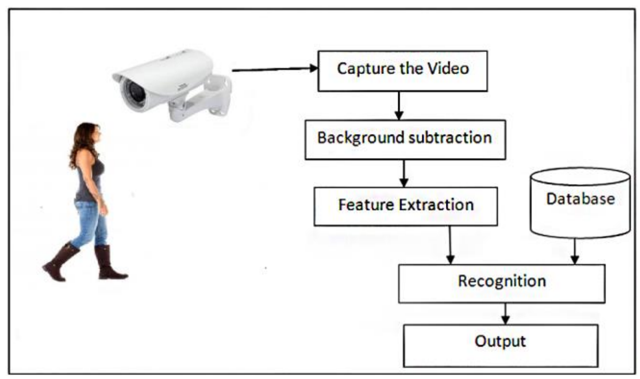

Fig. 1: Human Gait Recognition Process

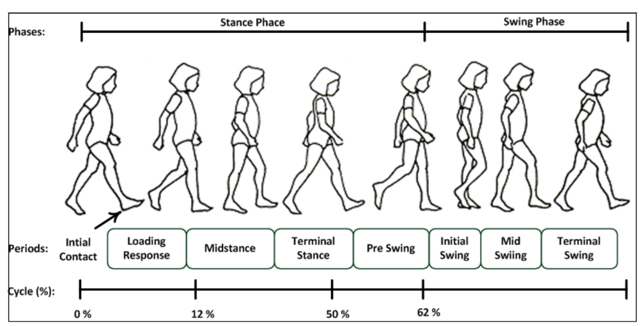

Fig. 2: Gait Cycle [29]

Model free approach is also called as holistic approach, which analyze the motion of the walking subject and then distinct features are extracted from the motion. The model free human gait recognition approach consists of detection of subject, extraction of the silhouette, extraction of the

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feature and classification. Once the walking subject is captured from a distance, then background subtraction is performed on the image by using background subtraction techniques (Running Gaussian Average, Temporal Median Filter, Kernel density estimation (KDE), Sequential KD approximation, Concurrence of image variations, Mixture of Gaussians, Eigen backgrounds) [24]. Human gait recognition process is depicted in Fig 1. The Video is captured by the CCTV camera, and then the video is divided into frames. Preprocessing step consists of detection of human from the image and background subtraction. Then the gait features are extracted by using either model-based approach or model free approach. Features extracted from the video are of high dimensionality so as to reduce the dimensionality and many dimensionality reduction methods are used (e.g. PCA, DCT, LDA). Recognition phase consists of matching the extracted features with the features which are stored within the database. The time interval between the exact same repetitive events of walking is known as gait cycle [31]. Gait cycle is depicted in Fig. 2, which shows the stance and the swing phase. In initial swing phase, subject moves the foot off the floor to take a stride. Two continuous stride makes a gait cycle. We will review dimensionality reduction techniques in section 3. Classification is done lastly which we will be discussed section 4.Some publically available and recently introduced datasets are discussed in section 5 followed by conclusion and the future work. For previous literature review of model free approach as well as model based approach readers can refer paper [19].

II. Model Free Approach

Model free approach different types of features are extracted like whole motion of human bodies, silhouette width vector or Fourier descriptors. It also focuses on silhouette shape and the dynamic information, which is used for pattern matching. Dynamic information is collected by using temporal alignment techniques [4] [5]. Khalid Bashir et al[17] uses height of the outermost counter of the silhouette and the right most pixel and the left most pixel of each row of the normalized silhouette belongs to the outermost counter. This method is easy to implement and having lower computational cost. This method ignores the space between the two legs but, if imperfect segmentation is there it gives the shadow of the legs which is good for recognition. Dong Xu et al [5] proposed a new patch distribution feature (PDF) where each gait energy image(GEI) is presented as a set of local augmented Gabor feature in concatenation with Gabor features extracted from different scales and different orientations(40 D Gabor features extracted from 5 different scales and 8 different orientations) together with 2D x-y coordinate. Recently, Haifeng Hu [6] proposed combination of enhanced Gabor (EG) and representation of GEI and regularized locally tensor discriminant analysis (RLTDA). To cope with the variation EG extract the gait features which are characterized by spatial frequency, orientation and spatial locality . EG considers statistical property of gait features as well as nonlinear mapping to emphasize those important feature points. Daigo Muramatsu et al [8] used GEI as gait feature. Silhouette sequence is extracted from normalized image sequences using graph cut based algorithm and background subtraction. Silhouette sequence is normalized into 88*128 pixel sized silhouette sequence and finally GEI is computed. For gait analysis silhouette is required and most of the work requires silhouette extracted from background subtraction (tracking and detection). Maodi Hu et al [9] apply optical flow motion feature which provides richer details than silhouette .Local binary pattern (LBP) is used for tracking and modeling and it is also used to describe texture information of optical flow. Daigo Muramatsu et al [10] create silhouette image sequence by background subtraction and graph cut method. Yasushi Makhihara et al [11] assess silhouette by background subtraction and graph cut segmentation and for silhouette sequence a bounding box segment is computed and by scaling height of boundary box and by registering silhouette centre a size normalized silhouette sequence is generated. Haruyuki Iwama et al [12] has used Gait energy image (GEI). Ryo Kawai et al [13] assess gait features which contain shape and motion with color information and spatio temporal histogram of oriented gradient (STHOG) features are employed as gait feature by containing shape and motion movers shape morphing (EMM)for extracting the inner silhouette motion. Recently, Yasushi Makhihara et al [18] uses multiple gait features like gait energy image (GEI), frequency domain feature (FDF), gait entropy image (GEnI), chronogait image (CGI), gait flow image (GFI) in concurrence with score level fusion. GEI,FDF and GEnI are silhouette regionbased gait features and CGI and GFI are silhouette contour based gait features and capture more dynamic components for more information about previous work done on motion based approach readers can refer paper [19]. Negin K. [26] applied gait cycle extraction,average silhouette calculation and the feature extraction by using PCA. Gyan C. et. al. proposed a sub window extraction calculation for feature extraction and back propagation calculation for recognition. Here all the pictures they have taken are caught from distinctive edges and pictures are upgraded by utilizing cutting, separating and histogram leveling. Investigations are performed on distinctive datasets. At that point stack the silhouette picture and hunt the upper left, upper-right, lower-left and lower-right pixels for each one column and every segment. With the assistance of these pixels, concentrate sub-window from the silhouette picture. Presently figure the mean of the concentrated sub-window. On the off chance that the mean of the concentrated window is zero then

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concentrated sub-window will be considered as a background picture and skipped else will be considered as sub-window. The given calculation is connected at each one column and segment for concentrating the sub-window [28].

III. Dimensionality Reduction of Features

Dimensionality reduction techniques transform the original high dimensional data into consequential description of reduced data. The process of assuming that the data will be placed on or near a linear subspace of higher dimensional space is termed as linear technique. Classification algorithm does not work properly due to the higher dimensionality features extracted from the gait sequences. Feature reduction algorithms reduced the dimensionality of the features extracted from the gait sequences. The dimensionality reduction techniques are mainly classified as linear and non-linear techniques with various types, it is depicted in figure 1 [12]. C.Murukesh et al [25] Used PCA method to reduce the dimensionality of the image silhouette. 1-D image vectors are formed by concatenating 2-D gait images and then the zero mean 1D training images are obtained. Afterwards PCA is applied on the collection of 1-D zero-mean image set vector which further produce a low-dimensional features vector.

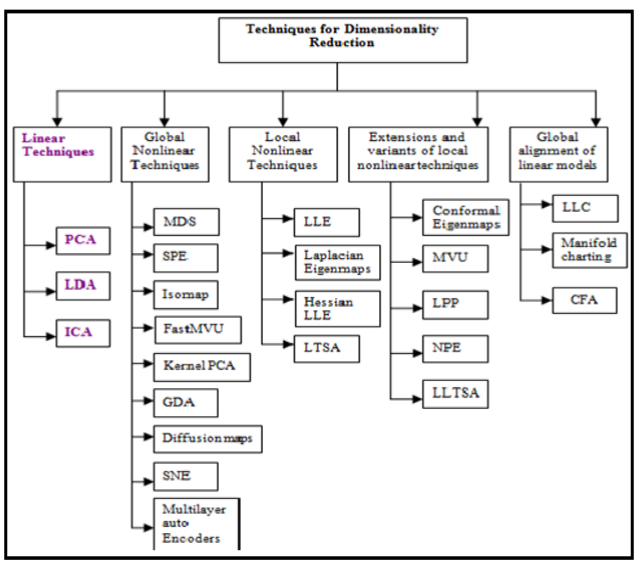

Fig. 3: Dimensionality Reduction Techniques [12]

Dong Xu et al [5] uses bilinear and tensor subspace methods. In this one gray level GEI is presented as second order tensor and one set of Gabor filtered images characterized as high order tensor. Haiheng Hu [6] used RLTDA which obtains the set of locally optimal tensor eigenvectors and captures nonlinear variations of gait features that shows changes due to variable viewing angles. RLTDA method obtains nonlinear gait structure therefore it is suitable for multiclass tensor discrimination.

Yi Huang et al [26] use principal component Analysis (PCA) or linear discriminant analysis (LDA) to extract the most representative and discriminant features. Recently Md. Zia Uddin et.al [30] used local directional patterns (LDPs) for local feature extraction from depth silhouettes and for recognition hidden Markov models (HMMs) was used. First the LDP features were extracted from the depth Silhouettes of a human body from each frame of a video containing human gait. Then the dimensions of the LDP features were reduced by principal component analysis.

VI. Classification

Classification is done by using three methods which are direct classification, similarity of temporal sequences classification and state space model classification. Temporal information of gait sequences is ignored in direct classification. Direct classification is based on the key frames which are extracted from the sequence of gait features. State space model classification method makes use of both similarity of shapes and the probabilities of the shape appearing. Dong Xu et al [5] has introduced Locality-constrained group sparse representation (LGSR) classification method. First the optimal reconstruction coefficient is obtained and the probe videos are classified by minimizing the reconstruction error and maximizing weighted inverse reconstruction error. Haifeng Hu [6] has used enhanced Gabor feature based classification using regularized locally tensor discriminant model (RLTDA). In this features are extracted from averaged gait image using Gabor wavelets. Then, to emphasize features with higher statistical probabilities and spatial importance, nonlinear mapping is defined and applied. Dimensionality of EEG features then further reduced by RLTDA to obtain nonlinear gait structure. RLTDA results in different features hence aggregation scheme is applied to combine these features at matching score level. Maodi Hu et al [9] has used and compares two classification methods AVG and DTW. Where, similarity between averages of different sequences is compared AVG and Dynamic time wrapping (DTW) calculate the distance between the gallery set and the probe. Khalid Bshir et al [18] used adaptive component and discriminant analysis (ACDA) where, they have done direct template matching and used GEI+CDA approach.

V. Publicly Available Gait Dataset

There are few datasets available publically for gait recognition. These gait databases are needed to fairly compare and evaluate the performance of the gait recognition algorithm [19]. The datasets which are popular and available publically are described below.

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A. USF Dataset

University of South Florida has collected the USF HumanID gait dataset. This dataset consist of 1870 video clips taken from the 122 subjects walking around the elliptical path in front of the camera. Five covariates are there for each person: two viewpoints that are left and right; two surface types grass and concrete; two shoe types; with or without surface; and two different times instance May and November to test the performance in different conditions [5] [6].

B. OU-ISIR Gait Dataset

The Institute of Scientific and Industrial Research (ISIR), Osaka University (OU) has collected this datasets. There are two datasets treadmill and large population dataset. Treadmill dataset contains gait images of subjects on a treadmill with the largest range of view variations: 25 views, 9 Speed variations between 2 and 10 km/h), and clothing variations up to 32 combinations, and as such, it can be used to evaluate view invariant, speed-invariant and clothing-invariant gait recognition. In addition, it is used to analyze gait features in gender and/or age-group classification. Large Population Dataset is released on 16 January 2013.The data set consists of subjects walking on the ground. The ground is surrounded by the 2 cameras at 30 fps, 640 by 480 pixels [22]. The datasets contains silhouette sequences registered and size-normalized to 88 by 128 pixels size. This gait database includes 4007 subjects (2135 males and 1872 females) with ages ranging from 1 to 94 years. There are two subsets of this database that are A and B. Dataset A is a set of two sequences (gallery and probe sequences) per subject. Dataset B is a set of one sequences per subject and each of the main subsets is further divided into 5 subsets based on the observation angles, 55[deg], 65[deg], 75[deg], 85 [deg], and including all four angles. Dataset B is a set of one sequence per subject and it is used for identifying gait based gender classification [7] [8] [13] [16].

C. The CMU Motion of Body (MoBo) Database

The CMU Motion of Body (MoBo) Database is collected by the robotics institute, Carniegie Mellon University. The CMU MoBo Dataset contains 25 subjects which are trained on treadmill. There are six cameras around the tread mill to capture the images in six different viewing angles. The provided database has four kinds of walking pattern which are slow walk, fast walk, incline walk and carrying a ball walk. It contains each subject walking pattern with six kinds of views in different angles where each view captured 340 frames that can be calculated minimum 14 gait cycles and each cycle has generally 18 to 20 frames.[23][24].

	Short Name	Description
Conf. 1	regular	Regular walking
Conf. 2	pocket	Walk with hands in pocket
Conf. 3	backpack	Walk with a backpack
Conf. 4	gown	Walk with gown
Conf. 5	dynamic occlu-sion	Occlusion by two walk-ing people
Conf. 6	static occlusion	Occlusion by two standing people

Fig. 4: Walking configurations of TUM-IITKGR Dataset [22]

D. CASIA Gait Dataset

The Institute of Automation Chinese Academy of Sciences has provided this dataset. In CASIA dataset there are 3 datasets A, B and C. Dataset A- Dataset A is having 20 persons. Each person has 12 image sequences and 4 sequences for each of the three directions. (Parallel, 45 degrees and 90 degrees to the image plane). The length of each sequence is not identical for the variation of the walkers speed, but it must ranges from 37 to 27.The CASIA dataset includes 19139 images and having size 2.2 GB [9]. Dataset B-Dataset B is a large multiview gait dataset. This dataset is created in January 2005.It contains 124 subjects and the gait data was captured from 11 views with three variations, namely view angle, Clothing and carrying condition [6] [9] [4]. Dataset C-Dataset C was collected by an infrared (thermal) camera in Jul.-Aug. 2005.It contains 153 subjects along with four walking conditions(normal walking with or without bag, slow walking and fast walking). These videos were all captured at night[4]. Dataset D- Dataset D was gathered synchronously by camera and Rescan Foot scan in Jul.-Aug. 2009. It holds 88 subjects and considers true observation scenes and wide age dissemination. This Dataset might be considered as the endeavors in misusing the relations between conduct biometrics and its relating prints. The videos and images are gathered indoor, while all the subjects are Chinese [4].

E. TUM-IITKGP Dataset

The TUMIITKGP Database is having 840 sequences of 35 individuals. Each person is captured in six different configurations. Furthermore, each of the configurations is repeated two times (right-to-left motion, in a left-to-right motion), which results in a total of 840 sequences. There are six configurations for each person. Each person was primarily recorded in a regular walking configuration and three degenerated configurations including hands in pocket, backpack and gown, static and dynamic occlusion. The configurations are applied to evaluate recognition

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methods if different kinds of gait variations are present [21] [22] [26].

F. *The AVA Multi-View Dataset(AVAMVG)*

This gait recognition dataset is introduced in year 2013. In this dataset there are 20 persons, out of which 4 are females and 16 are male and each is having 10 recording sessions. The dataset consist of 200 recorded videos or we can say 6* 200 single view video. Before recording the sessions first ten gait sequences are designed.

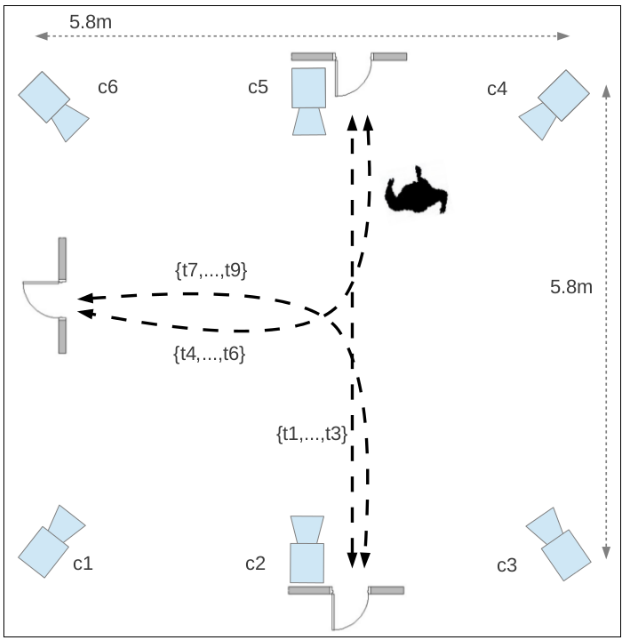

Fig. 5: Workspace Setup for Dataset Recording [27]

All persons depict three straight walking sequences (t1... t3), and six curved gait sequences (t4... t9), as if they had to rounding a corner. The curved paths are created by a first area in straight line, then a slight turn, lastly a last straight portion. In the last sequence on-screen characters portray a figure-eight way (t10) [27].

VI. Conclusion

The paper has presented the review of recent developments in model free gait recognition and identification approach. We observed that Model free approaches do not require high quality images. There are two dimensionality reduction techniques: linear and nonlinear. On concluding these methods recently researchers are focusing on nonlinear dimensionality reduction techniques for good quality of gait features. On the other hand linear dimensionality techniques are not optimal for classification. Concluding the gait classification, a direct classification technique loses the temporal information. Similarity based methods takes into account both temporal and dynamic information over the sequence of images is suitable for gait recognition. State space based models are robust.

VII. Future Work

Researchers have worked on so many approaches for the gait recognition of an individual. But practically they are very far. Some further research work is outlined as follows.

1] Maximum system in forensics operates on verification mode. So, researchers are planning to operate the system for identification mode [10]. 2] Till today maximum researchers work with the videos taken by the still cameras. Researchers have proposed new research direction for broad variety of data which serve temporary actions, occlusion and moving cameras [9].

3] Researchers are also trying to fuse the gait recognition method with more feature oriented methods and also want larger test population (20-100) people and images taken from multiple views [6].

4] Covariates like tilt angle and speed affects the accuracy of the gait recognition so, this can also be a future work proposed by researchers [7].

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