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Survey on Human Gait Recognition

1Prerna Arora, 2 Rajni

1Research Scholar, 2Asst. Professor, ECE Department, JCDM College of Engineering, Sirsa, India

PRERNA1993ARORA@GMAIL.COM , ER.RAJNI08@GMAIL.COM

Abstract- Gait recognition is the process of identifying an individual by the way in which they walk. This is less unobtrusive biometric, which offers the possibility to identify people at a distance. Moreover, gait recognition offers great potential for recognition of low-resolution videos, where other biometrics technologies may be invalid because of insufficient pixels to identify the human subjects. Gait can be used in situations where other biometrics such as iris, face and finger print info do not have sufficient resolution for recognition.

KEYWORDS- BIOMETRICS, GAIT, GAIT RECOGNITION APPROACHES [1], PCA, LDA[6],CASIA DATABASE, CMU MOBO DATABASE

INTRODUCTION

One of the first most important step towards preventing unauthorized access is user authentication. User authentication is the process of verifying claimed identity. Conventionally user authentication is grouped into three classes:

- Knowledge based
- Object(token) based
- Biometric based

The knowledge based authentication is based on something one knows and is characterized by secrecy. The knowledge based basically includes passwords and pin codes. The object based relies on something one has and is characterized by possession. Traditional keys to the doors can be assigned to be object based authentication .Biometric based authentication is based on something one IS. In knowledge based and object based approaches, passwords and tokens can be forgotten, lost or stolen .There are also usability limitations associated with them. Biometric based authentication [3] lacks above mentioned difficulties. Biometrics refers to the metrics related to human characteristics and traits. The identification through biometrics is a better way because it associates with individual not with information passing from one place to another. The term biometric is derived from a Greek word "BIO" means life and "METRICS" means measure. Thus biometric is science and technology of measuring and analyzing biological data.
Biometrics is classified into two categories:

❖ Physiological :
Fingerprint recognition
Iris recognition
Face recognition
DNA recognition

❖ Behavioral :
Typing rhythm
Gait recognition
Voice recognition

Physiological characteristics [13] are related to the shape of body. Behavioral characteristics are related to the pattern of behavior of an individual and pay attention to the actions of a person. Many biometric technologies have emerged for identifying and verifying individuals by analyzing face, fingerprint, palm print, iris, gait or a combination of these traits. Compared to other biometric methods, gait recognition offers several unique characteristics. The most attractive characteristic is its unobtrusiveness, which does not require observed subjects attention and cooperation. Also, human gait can be captured at a far distance without requiring physical information from subjects. This favorable characteristic has great advantages, especially when individual information such as face image is confidential. Moreover, gait recognition offers great potential for recognition of low-resolution videos, where other biometrics technologies may be invalid because of insufficient pixels to identify the human subjects.

Gait recognition approaches employ both static and dynamic features for recognition. Static features of body are above the waist i.e head , neck and shoulder etc. . Dynamic features parts are below the waist i.e foot, legs etc. Most of the methods adopt both the features and some adopt only dynamic features. Gait can be used in situations where other biometrics such as iris ,face and finger print info do not have sufficient resolution for recognition. Gait is an individual's style of walking . Any intentional movement, which is associated with the human body such as walking, is regulated by a very complex process involving the nervous and musculo-skeleton

system such as brain, spinal cord, peripheral nerves, muscles, bones and joints. Normal person's walk is cyclic in nature and one cycle is decomposed in two phases and each phase divided in several sub-events , as shown in figure 1.

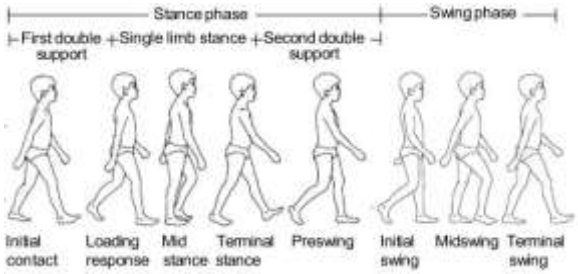

Figure 1.1: Gait of a child. In stance phase, one of the two feet is on the ground and during swing phase that same foot is no longer on the ground.

METHODS

There are some basic methods [1] for gait recognition:

- Moving Video Based gait recognition : In this approach ,gait is captured using a video camera from a distance . Video and image processing techniques are employed to extract gait features for recognition purpose. For example stride, cadence, static body parameters etc.

- Floor Sensor Based gait recognition : In this approach ,a set of floor sensors or force plates are installed on the floor and such sensors enable to measure gait related features, when a person walks on them, e.g. maximum time value of heel strike, maximum amplitude value of heel strike, etc.

- Wearable Sensor Based gait recognition: In this approach, gait is collected using body worn motion recording sensors. The MR sensors can be worn at different locations on the human body. The acceleration of gait, which is recorded by the MR sensor, is utilized for authentication. Among these, video based approach has unique advantage that it can be captured from a distance without subject's willingness or without any physical contact. Once the video is captured, some distinct gait features are extracted form the video. These features are then saved as templates and used for the identification.

COVARIATE FACTORS

There are some factors which affects the human gait and consequently on recognition. They can be categorized in two types:

1. External Factors: Such factors mostly impose challenges to the recognition approach (or algorithm). For example, viewing angles(e.g. frontal view, side view), lightning conditions(e.g. sunny day, rainy day etc), clothes, walking surface conditions(e.g. hard/soft, dry/wet, grass/concrete etc), shoe types(e.g. mountain boots, sandals etc), object carrying(e.g. backpack, briefcase etc.).

2. Internal Factors: Such factors cause changes of the natural gait due to sickness(e.g. foot injury, lower limb disorder, Parkinson disease etc) or other physiological changes in the body due to aging , drunkenness, pregnancy, gaining or loosing weight etc.

APPROACHES

Basically, gait analysis can be divided into two major categories, namely model-based approach and model-free approach.

- Model-Based Approach

Model-based approach generally models the human body structure or motion and extracts the features to match them to the model components. It incorporates knowledge of the human shape and dynamics of human gait into an extraction process. The gait dynamics are extracted directly by determining joint positions from model components, rather than inferring dynamics from other measures (such as movement of other objects). Thus, the effect of background noise can be eliminated. Research examples of this approach are static body parameters, thigh joint trajectories, dual oscillator, articulated model, 2D stick figure and elliptic Fourier descriptors. The advantages of this approach are the ability to derive dynamic gait features directly from model parameters. It is free from background noise as well as the effect of different subject's apparel or camera shooting viewpoint. However, it creates many parameters from

extracted gait features and hence resulting in a complex model. Due to that reason, the computational time, date storage and cost are extremely high due to its complex searching and matching procedures.

- Model-Free Approach

Model-free approach generally differentiates the whole motion pattern of the human body by a concise representation such as silhouette without considering the underlying structure. Normally, its parameters are obtained from the static gait features like centroid, width and height of the silhouette. Research examples of this approach are self-similarity Eigen gait, key frames analysis, spatial-temporal distribution characterization, kinematic features, unwrapped silhouette, higher order correlation, video oscillations and gait sequences. The advantages of this approach are speedy processing, low computational cost and small data storage. However, the performance of this approach is highly affected by the background noise and the changes of the subject's apparel.

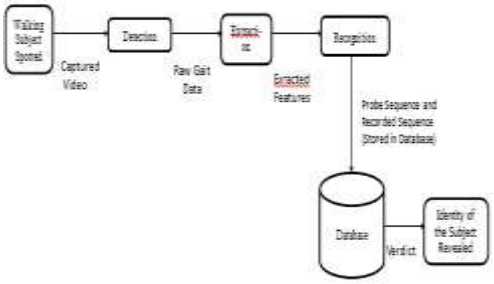

Figure1.2: Basic gait recognition process

RELATED WORK

In [1] use the width of the outer contour of silhouette to encode the information of silhouettes. The width is defined as the horizontal distance between the leftmost pixel and the rightmost pixel of the contour. The width of the outer contour may be unreliable due to the poor quality of silhouettes. However, the silhouette itself as features may be more suitable for low quality and low resolution data.

[2] In this paper, a simple but efficient gait recognition algorithm using spatial-temporal silhouette analysis is proposed. For each image sequence, a background subtraction algorithm and a simple correspondence procedure are first used to segment and track the moving silhouettes of a walking figure. Then, eigen space transformation based on Principal Component Analysis (PCA) is applied to time-varying distance signals derived from a sequence of silhouette images to reduce the dimensionality of the input feature space. Supervised pattern classification techniques are finally performed in the lower-dimensional eigen space for recognition. This method implicitly captures the structural and transitional characteristics of gait. For side view, oblique view, and frontal view, the correct classification rates are, respectively, 65, 63.75, and 77.5 percent with NN and STC, 65, 66.25, and 85 percent with NN and NED, and 75, 81.25, and 93.75 percent with ENN and NED.

In [3] suitable feature considered for gait recognition is width of silhouette. The width of silhouette is nothing but the horizontal distance between the leftmost and the rightmost foreground pixels of the silhouette. Experimental results showed that the side-view gave the optimal result to capture the characteristics of gait. By using the frontal-view the proposed method can recognize gait but the result is low accuracy as compared to the side-view. Two different approaches are used in order to gain observation vector .Indirect approach and Direct Approach. In, Indirect Approach the extracted features that have high-dimensions are transformed into Frame to Exemplar Distance(FED) vector that have low-dimensions. FED vector is capable of capturing Structure and dynamics of gait. This FED vector is fed to HMM (Hidden Markov Model) for training. In, Direct Approach the extracted features are represented as vectors and are directly fed to HMM for training. In this manner the distance between exemplars and image features is found and compared for Reference and test image for Recognition.

In [4], a baseline algorithm for gait recognition is proposed, which uses spatial-temporal correlation of silhouettes. 12 experiments were conducted on large data sets in order to test the effects of five covariates on performance. The five covariates considered are: change in viewing angle, change in shoe type, change in walking surface, carrying or not carrying a briefcase and elapsed time between sequences being compared. Two condition were selected for each covariate : 1) Two Camera angles viz., Left and Right. 2) Two Shoe Types viz., A and B. 3) Two Surfaces viz., Grass (G) and Concrete(C). 4) Not Carrying a Brief case (NB) and Carrying a Brief case (BF). 5) Two Different Dates, six months apart i.e Acquisition time May(M)and November(N).Identification/Recognition rates for the 12 experiments range from 78% on the easiest experiment to 3% on the hardest. All five covariates had noteworthy effect on performance, but the walking surface and time difference had more noteworthy impact.

In [5], proposed method is Radon transform of binary silhouettes. The speed is considered to be constant for any particular gait sequence. First of all, input to the system is sequences of binary silhouettes that are obtained using background subtraction process. These, silhouettes are used to calculate walking cycle. Then after silhouettes are aligned and subjected to Radon Transform and thus Radon template is obtained. This, Radon template is subjected to LDA(Linear Discriminant Analysis) for extraction of the features. Then, these features are represented as single feature vector scribes entire gait sequence. Lastly, gait recognition is achieved by comparing it the feature vectors of reference sequences with the feature vectors of given test/ probe sequence.

[6] This paper proposes a new gait recognition method using Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA). PCA is first applied to 1D time-varying distance signals derived from a sequence of silhouette images to reduce it's dimensionality. Then, LDA is performed to optimize the pattern class ..And, Spatio temporal Correlation (STC) and Normalized Euclidean Distance (NED) are respectively used to measur the two different sequences and K nearest neighbor classification (KNN) are finally performed for recognition. The experimental results show the PCA and LDA based gait recognition algorithm is better than that based on PCA.

[7] This paper, propose an efficient self-similarity based gait recognition system for human identification using modified Independent Component Analysis (MICA). Initially the background modeling is done from a video sequence. Subsequently, the moving foreground objects in the individual image frames are segmented using the background subtraction algorithm. Then, the morphological skeleton operator is used to track the moving silhouettes of a walking figure. The MICA based on Eigen space transformation is then trained using the sequence of silhouette images. Finally, when a video sequence is fed, the proposed system recognizes the gait features and thereby humans, based on self-similarity measure. The proposed system is evaluated using gait databases and the experimentation on outdoor video sequences demonstrates that the proposed algorithm achieves a pleasing recognition performance.

In [8], an original 3D approach for automatic gait recognition based on analyzing image sequences captured by stereo vision is proposed. Contour matching is done after binarized silhouette of a moving individual is firstly achieved in order to get 3D contour. Then, stereo gait feature (SGF) which is the norm of stereo silhouette vector (SSV) is extracted from 3D contour Principal Component Analysis (PCA) is adopted for dimensionality reduction. Finally, NN and ENN is applied for classifying and distinguishing.

In [9] use fuzzy principal component for recognition. Firstly they processed the original gait sequence and gait energy image is obtained then Eigen value and Eigen vector are extracted by fuzzy principal component analysis, which are called fuzzy logic. Finally NN classier is utilized in feature classification.

[10]Gait is an emergent biometric aimed essentially to recognize people by the way they walk. Gait's advantages are that it requires no contact like automatic face recognition, and that it is less likely to be obscured than other biometrics. Gait has allied subjects including medical studies, psychology, human body modeling and motion tracking. These lend support to view that gait has clear potential as a biometric. To identify a person using their distinct Gait, the publicly available database is being taken in the video sequence format. By applying PCA analysis the gait points are extracted and trained. To obtain the false positive points LDA and a combined approach of LDA and Radon is used. The performance of the usage of LDA separately and LDA Radon are being compared and the results are being produced as the graph.

In [11] this paper, proposed a new method for gait recognition, firstly binary silhouette of a walking person is detected from each frame. Secondly, feature from each frame is extracted using image processing operation. Here center of mass, step size length, and cycle length are talking as key feature. At last neural network is used for training and testing purpose Here all experiments are done on CASIA gait database .The recognition rate for method results 96.32%.

[12] In this paper, a simple but effective gait recognition method based on outermost contour is proposed. For each gait image sequence, an adaptive silhouette extraction algorithm is firstly used to segment the frames of the sequence and a series of post processing is applied to obtain the normalized silhouette images with less noise. Then a novel feature extraction method based on outermost contour is performed. Principal Component Analysis (PCA) is adopted to reduce the dimensionality of the distance signals derived from the outermost contours of silhouette images. Then Multiple Discriminant Analysis (MDA) is used to optimize the separability of gait features belonging to different classes. Nearest Neighbor (NN) classifier and Nearest Neighbor classifier with respect to class Exemplars (ENN) are used to classify the final feature vectors produced by MDA. In order to verify the efectiveness and robustness of feature extraction algorithm, two other classifiers – Back propagation Neural Network (BPNN) and Support Vector Machine (SVM) are used for recognition. Experimental results on a gait database of 100 people show the accuracy of using MDA, BPNN and SVM can achieve 97.67%, 94.33% and 94.67%, respectively.

[13] In this paper, Principal Component Analysis (PCA) with and without Radon Transform (RT) are applied for gait recognition purposes. The Radon Transform is used to detect features within an image and PCA is used to the reduce dimension of the images without much loss of information. The side view of slow walk , fast walk and carrying a ball walk have been selected from the CMU MoBo database for experimental purposes. The two techniques experimental result achieved equal recognition rates (EER) of 85.40%, 78.07% and 90.05% for RT with PCA and 85.18%, 80%, and 89.90% for PCA only for slow walk, fast walk and carrying a ball walk respectively.

In [14], the approach was done using angle at intersecting points and Fuzzy inference system. This was tested on a database of video sequence corresponding 17 people. The aim was to increase the matching accuracy using two components i.e. hand and feet. The proposed method increased the accuracy which lies between 75 to 86 percent.

[15] This paper proposed new methods i.e accelerometer-based biometric gait recognition which achieve sufficient low error rates, as well as to demonstrate that their computational effort is low and allows for an execution on current smart phones. Because the basis of existing methods is the extraction of gait cycles.. This method uses raw data of the gait cycles as feature vectors and accomplishes the classification using distance functions. In addition, a further approach was selected, which does not need the time-costly and error-prone gait cycle extraction. Instead, it is using overlapping segments of a fixed time length. Several features are extracted from these segments and combined to feature vectors. Machine learning algorithms are used for classification. A benchmark of the approaches on a challenging database showed that these methods yield low equal error rates between 6% and 7% and are outperforming the cycle-based methods. These error rates were achieved under the realistic conditions that training and probe data are

not collected on the same day. It was shown that five minutes of gait data are sufficient to thoroughly train the modelsTo obtain low false rejection rates, the classification should be based on around three minutes walk data. Two of the developed methods were implemented on a smartphone. It was shown that both methods are able to perform the classification fast enough to allow for an authentication without delay for the user.

[16] This project aims to develop a system capable of automatic gait recognition. A person's gait signature is created using a model based approach. Temporal and spatial metrics extracted from the modal, such as length of torso, shin and variation in angles of the limb or the amplitude of a person's walking pattern can all be used to create a "gait signature" of the individual which are transformed into a self similarity matrix. The use of spacio -temporal correlation method to identify the subject in subsequent video sequences.

[17]This paper proposed new method for gait recognition. . In this they presented the review of gait recognition system, different approaches and classification categories of Gait recognition like model free and model based approach, MDA, ENN, NN**.**

[18] In this paper, a modern gait recognition technique is proposed in Cell Phone-Based Biometrics by testing the technique outside of the laboratory on real users under everyday conditions. They propose how this technique can be applied to create an anti-theft system. The system proposed in this paper shows results as high as 91% for cross-fold accuracy for some users; however, the predictive accuracy for a single day's results ranged from 0.8% accuracy to 92.9% accuracy, showing an unreliability that makes such a system unlikely to be useful under the pressure of real-world conditions.

[19] This paper presents an approach to identify human gait patterns using features extracted from statistical moments. Post background subtraction, silhouette frames of walking subjects were segmented into 9-segments representing different human body parts. Statistical moments, viz., geometric moments, legendre moments and Krawtchouk moments were used individually to extract some distinguishable gait features namely centroid, aspect ratio and orientation from each segment of the silhouettes. In addition to these features, height and width of the person were also included. Each walking person was represented by a gait pattern ora feature vector, generated using 38 features extracted from silhouette. A minimum distance classifier based on Euclidean distance was used to recognize the input image sequence in testing phase. All the experiments were conducted on CASIA database. The performance of geometric moment based representation was the best among the three moments. From the proposed method, an encouraging recognition rate of 92.50% was achieved.

In [20] firstly binary silhouette of a walking person is detected from each frame of an image. Then the features from each frame are extracted using the image processing operation. The step size length, center of mass and cycle length are taken as key features. In end, SVM, K-Means, LDA are used for training and tracking purpose. Here every test is done on gait database. This technique gives recognition accuracy up to 99.79%.

DISCUSSIONS AND CONCLUSION

Gait is behavior characteristic that possess individual difference formed in course of human's growth. Gait is all external appearance that consists of human body structure, motion regulating system, behavioral and psychological activities when person is walking. Compared with other biometrics, Gait requires no object contact and is measured at a distance. Hence, it is applied to passive vision surveillance scenario such as ranks, airports and military departments. However, gait is affected by various physiological, psychological and external factors such as footwear, clothing, surface of walking, mood, illness, fatigue, and so on. Considerable work has been done in human gait recognition; still there are many challenges and scope to improve the system performance. Investigation is needed regarding various features which vary with individual. Correct classification rate is always being a problem with any biometric system. In gait recognition covariate factors can certainly bring down the recognition performance. Efficient methods to remove covariate factors and best discrimination
among classes are required. Recognition rate for outdoor video data is low as compared to indoor video data and hence significant efforts have to be made on robust segmentation in case of outdoor video data. Development of more flexible model based method to solve the conflicts between model complexity and model descriptive capability is required. Though model free approaches are more feasible than model based, fusion of model based and model free approaches can yield better results because of increased feature space and capability to fit model for feature extraction. Various method discussed in this paper for recognition are Baseline algorithm, SVM methods, K-method,Radon transform etc.

REFFERENCES:

[1] A. Kale, A. N. Rajagopalan, N. Cuntoor, and V. Kruger, "Gait-based recognition of humans using continuous HMMs," in Proceedings of the Fifth IEEE International Conference on Automatic Face and Gesture Recognition, (2002), pp. 336-341.

[2] Liang Wang, Tieniu Tan, Huazhong Ning, and Weiming Hu, " Silhoutte Analysis- Based Gait Recognition for Human Identification", IEEE transactions on pattern analysis and machine intelligence, Vol.25, No. 12, December (2003).

[3] Amit Kale, Aravind Sundaresan, A.N.Rajagopaln, Naresh P.Cuntoor,Amit K. Roy-chowdhury, Volker Kruger and Rama Chellappa, "Identification of Humans Using Gait," IEEE Trans on Image Processing, Vol.13, no.9, September (2004).

[4] Sudeep Sarkar, P. Jonathon Philips, Zongyi Liu, Isidro Robledo Vega, Patrick Grother and Kevin W. Bowyer, " The HumanID Gait Challenge Problem: Data sets, Performance, and Analysis," IEEE Trans. Pattern Analysis and Machine Intelligence, Vol. 27, No.2, February (2005).

[5] Nikolaos V. Boulgouris, "Gait Recognition Using Radon Transform and Linear Discriminant Analysis," IEEE Transactions on Image Processing, Vol. 16, No 3, March (2007).

[6] Qiong Cheng, Bo Fu, Hui Chen, "Gait Recognition Based on PCA and LDA", ISBN 978-952-5726-07-7 (Print), 978-952-5726-08-4 (CD-ROM) in Proceedings of the Second Symposium International Computer Science and Computational Technology (ISCSCT '09) Huangshan , P.R. China, 26-28, Dec.(2009), pp. 124-12.

[7] M. Pushpa Rani and G.Arumugam "An Efficient Gait Recognition System For Human Identification Using Modified ICA", International Journal of Computer Science And Information Technology, 2010

[8] Haitao Liu; Yang Cao; Zengfu Wang; , "automatic gait recognition from a distance," Control and Decision Conference (CCDC), 2010 ,Chinese , vol., no., pp.2777-2782, 26-28 May 2010.

[9] Su-li XU, Qian-jin ZHANG, "Gait recognition using fuzzy principal component analysis", 2nd International Conference on e-business and information system security , IEEE, 27 may, 2010.

[10] M.Siva Sangari and B.Mathivanan; "Performance Evaluation of LDA & RADON in GAIT Recognition", International Journal of Computer Applications (0975 – 8887), Volume 13– No.8, pp: 1-5, January 2011.

[11] Sanjeev Sharma, Ritu Tiwari, Anupam shukla and Vikas Singh, " Identification of People using Gait Biometrics," in International Journal of Machine learning and Computing, Vol.1, No. 4, October 2011.

[12] Lili Liu , Yi long Yin Wei Qin , Ying Li, "Gait Recognition Based on Outermost Contour", in International Journal of Computational Intelligence Systems, Vol.4, No. 5 September,(2011),1090-1099.

[13] A. Hayder, J.Dargham , A.Chekima , and G.M.Ervin, " Person Identification using Gait", in International Journal of Computer and Electrical Engineering, Vol.3, No. 4, August (2011).

[14] Jyoti Bharti , M.K. Gupta, " Gait Recognition With Geometric Characterstics And Fuzzy Logic" in Canadian Journal on Image Processing And Computer Vision Vol. 3 No.1, March (2012).

[15] Claudia Nickel" Accelerometer-based Biometric Gait Recognition for Authentication on Smartphones", 2012.

[16] Alese, B. K., Mogaji, S. A., Adewale, O. S. and Daramola, O. "Design and Implementation of Gait Recognition System", International Journal of Engineering and Technology, (2012).

[17] Robindeep kaur Namita Kakkar" Person Tracking Using Gait ", International Journal of Advanced Research in Computer Science and Software Engineering , (2013).

[18] Cameron Stearns" A System for Cell Phone Anti-theft Through Gait Recognition", (2014).

[19] P. Das, D. Das, " Gait Analysis and Recognition for Human Identification" in International Journal of Electronics and Applied Research(IJEAR) (2014),1,45-54.

[20] Deepti Singh ,Dr. Amit Dixit, " Human Identification using Gait Recognition Technique with PAL and PAL Entropy ,SVM And K-Means with LDA" in IJCSIT International Journal of Computer Science and Information Technologies, Vol. 5(6), (2014), 7141-7145