A Study on Gait Analysis for Human Identification

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***Abstract* --** Gait refers to the style of walking of an individual [18]. Human identification by gait has become a key area of interest in cyber world due to its advantage of inconspicuous recognition at a relatively far distance. Biometric systems are gaining importance, as they provide a more efficient and reliable means for identity verification. Gait analysis is one of the behavioral biometric technologies that is becoming an attractive topic in biometric research. Segmentation and tracking humans is a challenging problem in complex situations [6]. In Gait biometric research there are various gait recognition approaches available. The problem of human identity from gait sequences is investigated with arbitrary walking directions [2]. In this paper, the literature survey, gait categories, approaches for gait identification, gait recognition system is been discussed.

Keywords—*gait analysis, gait recognition system, human silhouette, spacio-temporal*

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I. INTRODUCTION

A person can be identified or verified on the basis of different physiological and behavioral attributes like fingerprints, live scans, faces, iris, hand geometry, gait, ear pattern, voice recognition, keystroke pattern and thermal signature etc. Among them, gait recognition, as a relatively new biometric technique, aims to recognize individuals by the way they walk. The advantage of identification using gait recognition is that features can be extracted from the image without the co-operation of the person [23].

The term gait recognition is typically used in the computer community to refer the automatic extraction of visual cues that characterize the motion of a walking person in video. It is also used for identification purposes in surveillance systems. Often in surveillance applications, it is difficult to get face or iris information at the resolution required for recognition. Studies in psychophysics indicate that humans have the capability of recognizing people by their gait even when their face is not clearly visible, thus indicating the presence of identity information in gait.

Substantial research has been done on segmentation algorithms that extract objects and people from the environment. Research into human recognition has also been gaining popularity by utilizing the existing methods of image understanding. This task of human recognition combines both the spatial information of the target subjects within the video frames, as well as the temporal information of the target subjects as they move over time. This allows human identification research to draw on a wide variety of approaches and algorithms in order to devise an optimal recognition system for a given set of circumstances. Offline analysis of data would facilitate the usage of more complex and computationally intensive algorithms which may not be feasible in a real-time environment. A method must be used to separate the human figure from the environment so as to indicate what part of each video frame is significant. Then, the position and motion data of the figure can then be extracted.

The aim is to establish an automatic gait recognition method based upon spatio-temporal silhouette analysis measured during walking. Gait includes both the body appearance and dynamics of human walking motion. Recognizing people by gait intuitively depends on how the silhouette shape of an individual changes over time in an image sequence. Since human gait analysis is known to be sensitive to the varying views human identification from gait sequences with arbitrary walking directions are difficult. For this, we first collect a new gait dataset, where people are asked to walk freely in a given scene, and the walking directions are arbitrary and time-varying throughout the sequence. Fig. 1 shows some frames of a gait sequence from the dataset which was captured with arbitrary walking direction, as well as the segmented and aligned human silhouettes. By background subtraction method we obtain the silhouettes. It is then broken into several clusters to obtain gait feature [2].

Fig. 1. From top to bottom are the original gait images, binary segmented silhouette images, and normalized and aligned silhouette images of one gait sequence, respectively.

The paper is organized as follows. The Literature Survey is discussed in section II. Section III, IV summaries gait categories and factors and parameters affecting gait. Section V gives approaches for gait recognition and Steps of Gait Recognition System are presented in section VI. Application of human identification using gait is given in section VII. The paper is concluded in section VIII.

II. LITERATURE SURVEY

Presently there are several methods available on gait analysis to identify humans. Xianglei Xing [1] proposed a fusion method for people identification at a distance by coupling gait feature along with facial feature. The proposed method maps the heterogeneous features from gait and face into a unified subspace to minimize the distance between the two features extracted from the same individual. The fusion features are acquired by computing the mean of two projecting features from a given individual in the coupled subspace. L.Q.Shen et al [7], introduces to integrate information from gait and face for recognizing individuals at a distance in video. Gait energy image and side face image both of which integrate information over multiple frames in video. JiwenLu [2], proposed a sparse reconstruction based metric learning method to learn a distance metric to minimizethe errors in intra-class sparse reconstruction while simultaneously maximizing the errors in inter-class sparse reconstruction, sothat distinctive information can be exploited for recognition. Qiang Fang [4], proposed a gait analysis system based on 6-axis inertiamotion measurement. The system is specificallydeveloped for hemiplegic gait analysis application and utilizeda set of non-visual based wireless body sensor network for datacollection which is considerably less expensive and easier to setup and operate compared to its visual based counterpart. Xiaoli Zhou et al [5], introduced a new video-based recognition method to recognize non-cooperating individuals at a distance who expose their side views to the camera. Information from two biometrics sources, side face and gait, was utilized and integrated for recognition. For side face, an enhanced side-face image (ESFI). For gait, the gait energy image (GEI). Hemalatha, M [6], introduced a motion template approach that can successfully handle shadow, reflection, multiple human in one moving blob, and occlusion. They have contributed in the employment of appropriate models and knowledge to robustly solve a difficult and useful problem. They use a background appearance model to focus interest by throwing away the static regions. Alice J. O'Toole et al [8], presented the database containing a variety of still images and videos of large number of individuals taken in a variety of contexts. Milica D [3], proposed a method based on processing of data obtained from an inertial sensor mounted on shank. The method proposed by her separates normal from abnormal gait using Pearson's correlation and describes each stride by duration, shank displacement, and spectral components. This wasused to compare between a healthy person and an unhealthy person which further helped in recognition of any diseases.

III. GAIT CATEGORIES

The current approach to human gait identification can be divided into two categories: model-based methods and motion-based methods.

Model-based methods aim to describe human movement using a mathematical model, for example, Cunado et al. [9] used Hough translation to extract arms, legs, torso etc. and use an articulated pendulum to match these moving body parts. Yoo et al. [10] divided the body into head, neck, waist, leg, and arm by image segmentation and then obtained the moving curve of these body parts. Lee and Grimson [11] applied 7 ellipses to model the human body and applied the elliptical movement based features to identify humans.Tafazzoli and Safabakhsh [12] constructed movements' model based on anatomical proportions wherein Fourier transform was used to analysis human walking style. Dupuis et al. [13] used probability based approach for gait modeling to describe the human walking.

Motion-based methods consider the human gait as a sequence of images and extract features from them. Cheng et al. [14] employed Hidden Markov Models (HMM) to analyze the relationship among these images. Chen et al. [15] used parallel HMMs to describe the features of human gait. Yu et al. [16] overlapped all the images to get Gait Energy Image (GEI). GEI was used as the feature to identify humans in his approach.Fan et al. [17] took Chrono-Gait Image (similar to GEI) to characterize the gait features. Kale et al. [18] used "frieze" patterns to extract features from image sequence and used these features to identify humans.

The raw features extracted by motion-based methods usually contained several cures or images, hence Gabor Transform, Random Forest algorithm, and Fourier Transform were used to reduce the dimensions of these features.

IV. FACTORS AND PARAMETERS FOR GAIT ANALYSIS

The gait analysis is manipulated or modified by many factors, and changes in the normal gait pattern can be temporary or permanent [19]. The factors can be of various types:

- Extrinsic: such as terrain, footwear, clothing, cargo
- Intrinsic: gender (male or female), height, weight, age, etc.
- Physical: such as weight, height, physique
- Psychological: personality type, emotions
- Physiological: anthropometric characteristics, i.e., measurement and proportions of body
- Pathological: for example, trauma, neurological diseases, musculoskeletal anomalies, psychiatric disorders

The parameters considered for the gait analysis are as follows [20]:

- Step length
- Stride length
- Cadence
- Speed
- Dynamic Base
- Progression Line
- Foot Angle
- Hip Angle

V. APPROACHES FOR GAIT RECOGNITION

Some basic methods or approaches for gait recognition are [21]

1. **Gait Recognition using Moving Video** In this method, imagesare captured using a video-camera from distance. Video and image processing techniques are then employed to extract features that are used for identifying gait. Most of the M-V based gait recognition algorithms are based on the human silhouette like stride, cadence, static body parametersetc.
2. **Gait Recognition using Floor Sensor** In this approach, a set of sensors or force plates are installed on the floor thatcan measure gait related features whenever a person walks over them, e.g. maximum heel strike time value, maximum heel strike amplitude value.
3. **Gait Recognition using Wearable Sensor** In this method, gait is collected using motion recording (MR) Sensors worn on the body. The MR sensors can be worn at different locations on the human body. The acceleration of gait, recorded by the MR sensor is then utilized for authentication.

VI. BASIC MODEL

In gait recognition, following steps are executed for verification [23]. The steps are explained through block diagram shown in Fig. 2.

1. Firstly, camera captures the video data.
2. Segmentation and detection are the two main aspects of silhouette representation which is used to calculate a walking person from the background. In segmentation, the foreground subject is extracted from the video-sequence, and then used to extractgait features.
3. After calculating the foreground and background image from segmentation and detection respectively, the relevant gait features are then extracted from the segmented images, to be used in fulfilling the classification purpose, i.e. gait features can be easily extracted after the segmentation of silhouettes is done from the background.
4. The similarity between the extracted gait feature and the features presented in the gait database or the difference between output image and actual image is measured for human identification thus giving usthe final outcome.

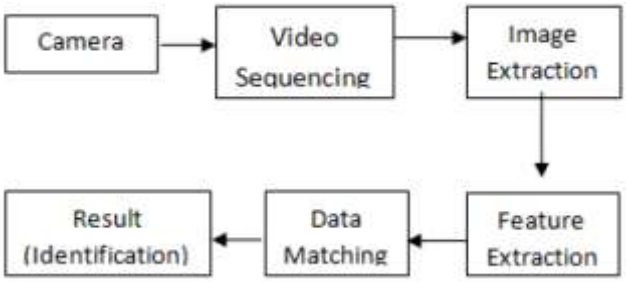

Figure 2. Block Diagram of Gait Recognition System

VII. APPLICATION

Real-time human identification systems are becoming increasingly important in the security industry, where it is important to identify suspicious actions and behaviors to avoid harm coming to others. People monitoring security videos may miss important occurrences and in such situations, it would be helpful for a computer system to flag suspicious actions and behaviors and alert to possible dangerous or criminal situations. Such real-time systems can beuseful not only to the security industry, but also for the medical industry. Motion patterns of humans could be used to help identifypeople experiencing a dangerous condition, such as a seizure, heart attack, or serious fall. Proper medical personnel can be alerted to provide care to such persons.

VIII. CONCLUSION

Human Motion Analysis is gaining wide attention across the world from the computer vision scholars. This wide interest is motivated by wide spectrum of its application such as in closed-circuit television (CCTV) surveillance,

dueto its high potential in unconstructive individual recognition from a distance. It's usability in commercial visual surveillance can be utilized in several areas like security systems, namely banks, airports, military-based areas, public transportation like railway- stations and bus-stations, shops and malls, and car-parking monitoring systems. One of the major reasons for increasing need of human identification is due to increasing number of piracy, theft and unauthorized access cases across the globe. Thus, it is paving a great achievement in technology field for the upcoming computer vision researchers. This paper mainly contributes towards the study of various approaches for gait analysis which can be used to identify humans.

REFERENCES

[1] Xianglei Xing, Kejun Wang, Zhuowen Lv, "Fusion of Gait and Facial Features using Coupled Projections for People Identification at a Distance"*IEEE Signal Processing Letters*, vol:22, pp: 2349 - 2353,2015

[2] Lu, Jiwen, Gang Wang, and Pierre Moulin. "Human identity and gender recognition from gait sequences with arbitrary walking directions." *IEEE Transactions on Information Forensics and Security* 9.1 (2014): 51-61.

[3] Milica D. Djurić-Jovičić; Nenad S. Jovičić; Saša M. Radovanović; Iva D. Stanković; Mirjana B. Popović; Vladimir S. Kostić, "Automatic Identification and Classification of Freezing of Gait Episod es in Parkinson's Disease Patients" *IEEE Transactions on Neural Systems and Rehabilitation Engineering* , vol: 22, ,pp: 685 - 694, 2014 Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, "Electron spectroscopy studies on magneto-optical media and plastic substrate interface," IEEE Transl. J. Magn. Japan, vol. 2, pp. 740-741, August 1987 [Digests 9th Annual Conf. Magnetics Japan, p. 301, 1982].

[4] Qiang Fang; Zhe Zhang; Yinjun Tu, "Application of Gait Analysis for Hemiplegic Patients using Six-axis Wearable Inertia Sensors", *IECON 2014 - 40th Annual Conference of the IEEE Industrial Electronics Society* ,pp: 3993 - 3996,2014

[5] Xiaoli Zhou , Bir Bhanu, "Integrating Face and Gait for Human Recognition at a Distance in Video*" IEEE Transactions on Systems*, Man, and Cybernetics, Part B (Cybernetics), vol: 37, pp:1119 1137, 2007

[6] Hemalatha, M., V. Vinodhini, and B. Sivaranjani. "A System for Dissecting the Video for Tracing Multiple Humans in Multifaceted Situation." International Journal of Computer Applications 77.5 (2013).

[7] L. Q. Shen, L. Z. Tian and Z. D. Dan, "Integration of Gait and Side Face for Human Recognition in Video," 2009 Second Int. Symposium on Electronic Commerce and Security, pp. 65-69, 2009.

[8] "A Video Database of Moving Faces and People" Alice J. O'Toole, Joshua Harms,Sarah L. Snow, Dawn R. Hurst, Matthew R. Pappas, Janet H. Ayyad, and Herve´ Abdi,May 2005

[9] Cunado D, Nixon MS, Carter JN. Automatic extraction and description of human gait models for recognition purposes. Computer Vision and Image Understanding. 2003;90(1):1–41.

[10] Yoo JH, Hwang D, Nixon MS. Gender classification in human gait using support vector machine. Proceedings of the 7th International Conference on Advanced Concepts for Intelligent Vision Systems (ACIVS '05); September 2005; Antwerp, Belgium. Springer; pp. 138–145.

[11] Lee L, Grimson WEL. Gait analysis for recognition and classification. Proceedings of the 5th IEEE International Conference on Automatic Face and Gesture Recognition (FGR '02); May 2004; IEEE; pp. 148–155.

[12] Tafazzoli F, Safabakhsh R. Model-based human gait recognition using leg and arm movements. Engineering Applications of Artificial Intelligence. 2010;23(8):1237–1246

[13] Dupuis Y, Savatier X, Vasseur P. Feature subset selection applied to model-free gait recognition. Image and Vision Computing. 2013;31(8):580–591.

[14] Cheng MH, Ho MF, Huang CL. Gait analysis for human identification through manifold learning and HMM. Pattern Recognition. 2008;41(8):2541–2553.

[15] Chen C, Liang J, Zhao H, Hu H, Tian J. Factorial HMM and parallel HMM for gait recognition. IEEE Transactions on Systems, Man and Cybernetics C. 2009;39(1):114–123.

[16] Yu S, Tan T, Huang K, Jia K, Wu X. A study on gait-based gender classification. IEEE Transactions on Image Processing. 2009;18(8):1905–1910. [PubMed]

[17] Fan X, Li M, Ma J, Ren Y, Zhao H, Su Z. Behavior-based reputation management in P2P file-sharing networks. Journal of Computer and System Sciences. 2012;78(6):1737–1750.Kale A, Sundaresan A, Roychowdhury A, Chellappa R. Handbook on Pattern Recognition and Computer Vision. 2004. Gait-based human identification from a monocular video sequence.

[18] Kale, Amir, et al. "Gait analysis for human identification." *International Conference on Audio-and Video-Based Biometric Person Authentication*. Springer Berlin Heidelberg, 2003.

[19] S. Niyogi and E. Adelson, "Analyzing and Recognizing Walking Figures in XYT", Proc. IEEE CS Conf. Computer Vision and Pattern Recognition, 469-474, 1994.

[20] Jyoti Bharti, M. K. Gupta, "Gait Recognition with Geometric Characteristic and Fuzzy Logic", Journal on Image Processing and Computer Vision, Canada Vol. 3, Issue 1, 1 March, 2012.

[21] Pritpal Kaur And Gagandeep Singh Aujla, "Human identification using Gait Recognition Technique with PAL and PAL Entropy and NN", International Journal Of Computer Science And Information Technologies, Vol. 5, Issue 3, 3281-3285, 2014.

[22] Yi-Bo Li, Tian-Xiao "General Methods And Development Actuality Of Gait Recognition", International Conference on Wavelet Analysis and Pattern Recognition, Beijing, China, 2-4 November, 2007

[23] http://www.ijarse.com/images/fullpdf/1448362809_1308J.pdf

[24] https://en.wikipedia.org/wiki/Gait_analysis