LITERATURE REVIEW ON HUMAN IDENTIFICATION USING GAIT

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***Abstract*—Human gait recognition is a distance based second generation biometrics, which is unobtrusive. Human gait recognition is nothing but identifying a person from its walking style. Human cooperation is not required in this biometric system. There are two approaches of gait recognition, which are model based and model free approaches. This paper provides a recent comprehensive survey of only model free gait recognition approach. This survey focuses on motion free gait image representation, dimensionality reduction of extracted feature and classification. Publicly available gait dataset are also discussed. The paper is concluded by listing the research challenges and by giving future direction in model free gait recognition approach.**

Key words: ***Human gait, biometrics, machine learning techniques, feature extraction.***

1. INTRODUCTION

Gait recognition system is an unobtrusive biometric feature, which had attracted many researchers in recent years. 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 it's 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 stimulants, 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 approaches. Model based approach typically uses a stick representation for modeling human.

The model free human gait recognition approach consists of detection of subject, silhouette extraction, feature extraction 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, Mixture of Gaussians, Kernel density estimation (KDE), Sequential KD approximation, Concurrence of image variations, Eigen backgrounds). So the preprocessing step consists of detection of human in the image and background subtraction. After that gait features are extracted by using either model based approach or model free approach. Features extracted from the video are of high dimensionality, so to reduce the dimensionality many dimensionality reduction methods are used (e.g. PCA, DCT, LDA).

The simple human gait base human classification is shown in figure 1.

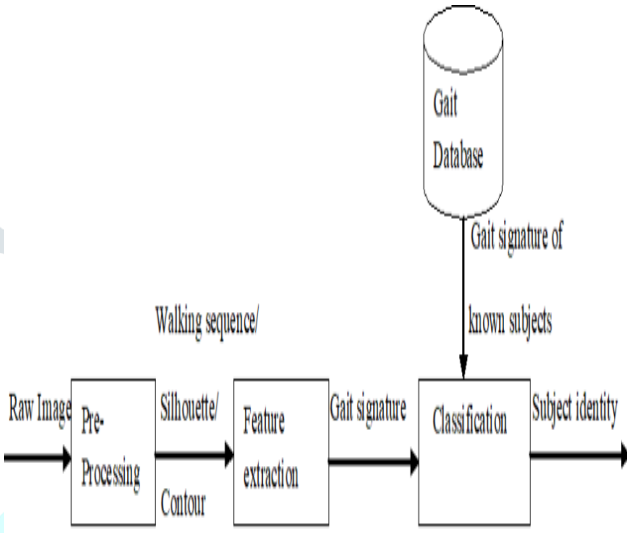

Figure 1: General block diagram of gait recognition system

The input to the gait recognition system is the video or the image captured from the camera. If video is the input then the video is subdivided into various frames and used as input to the gait recognition system. From the obtained image or video frame, the background is eliminated by means of some background subtraction methods. From that image Silhouette is extracted.

2. RELATED WORK

The related work involves the study of various works carried out by the authors. Different methods are proposed by different authors for gait recognition.

Othman O. Khalifa et. al[2] provided human Gait recognition which works on the gait of walking subjects to identify people without them knowing or without their permission. The initial step in this kind of system is to generate silhouette frames of walking human. A number of features could be extracted from these frames such as centroid ratio, height, width and orientation. The Principal Component Analysis (PCA) is used for the extracted features to condense the information and produces the main components that can represent the gait sequences for each walking human.

Muhammad Hassan Khan et. al[9], proposes a gait recognition algorithm which uses the spatial and temporal motion characteristics of human gait for individual identification without needing the silhouette extraction. This algorithm extracts a set of spatiotemporal local descriptors from the gait video sequences. The extracted descriptors are encoded using the Fisher vector encoding and Gaussian mixture model-based

codebook. The encoded features are classified using a simple linear support vector machine to recognize the individuals. The proposed gait recognition method is evaluated on five widely used gait databases, including indoor (CMU MoBo, CASIA-B) and outdoor (NLPR, CASIA-C, TUM GAID) gait databases.

Waqar Tariq, Muhammad Lutfi Othman, Shameem Akhtar Fareeha Tariq[11] proposed Gait Feature Based on Human Identification & Classification by Using Artificial Neural Network and Project Management Approaches for Its Implementation. This proposed system is primarily a real time human classification and monitoring system using gait recognition. The final deliverable of the proposed system is a functional visual application that captures a real time image of human and classifies it based on Gender, Group using Ann, moreover the application detects an alarm any anomaly in human gait for security purpose without getting in contact with suspected human and implementing the respective ICT project with Project management principles and approaches made it cost effective and an well implemented project Management is a valuable discipline that allows developers to meet their clients' goals/targets.

Shamna A, Ranjith et. al[10] described Automatic Human Identification via CCTV Using Gait Analysis. Author suggests a cost effective way to make the existing system to automatically identify a person using face and motion detection. Here author have used CCTV camera for input sequence of images and gait recognition for identify of person. Here author have created a processing module using raspberry pi 3 for this purpose and connect all existing surveillance systems to a single network. This module is connected to cloud server and it processes the CCTV video to detect the person. A single surveillance system requires only one module. If information of a person is provided to the server, whenever the person appear on any of CCTV connected to the network an automatic detection of corresponding person is done.

S. Joul Monisha, G. Merlin Sheeba[12] proposed Gait Based Authentication with Hog Feature Extraction. Authors have proposed a method for people behavior recognition based on people walk. A set of video samples are used and the features are extracted using Histogram of Gradient (HOG) feature flow, where a Gait Energy Image (GEI) is developed for each frame of an individual person. Here KNN classifiers are used to classify the features extracted from the videos. HOG feature based analysis has achieved 93% accuracy.

Mohammed Hussein Ahmed, Azhin Tahir Sabir, Halgur Sarhang Maghdid[13] proposed Kinect-based Human Gait Recognition using Triangular Gird Feature.
Here database consisting of the data from 49 participants is created to present the performance of this work. In this database, each participant has 5 records. TGF feature set was created based on a set of triangles which have been generated in each frame using all the 20 joint points of the human body. Four different statistical moments are applied to the generated triangle measurements (the three angles and the triangle area) for the sequence of frames during one gait cycle. The statistical moments led to the generation of 4 different sets of features for TGF (Mean TGF, Std TGF, Skew TGF and Slop TGF). Since the TGF is a high dimension feature set, the PCA and LDA feature vectors have been used to reduce the high dimensionality of the TGF. To evaluate the proposed method, two different classification methods have been used in the form of LDC and k-NN (where k=5). In this method author have got recognition accuracy by 90%.

Marg Yi Chiew Han [14] proposed Gait Phase Detection for Normal and Abnormal Gaits using IMU to detect normal/abnormal heel strike, toe strike, and toe off using a single IMU attached to the shank and validated against FSRs. The mean absolute error of the heel strike, toe strike and toe off detections is low at around 2 sample differences, equivalent to 20ms difference. Some unique and common waveform patterns of the shank's angular velocity and acceleration for normal/abnormal gaits were observed to classify the heel strike and toe strike as normal/abnormal. This provides insights into the shank's angular velocity waveform patterns that are human-understandable to assist clinicians to evaluate the patients' gaits.

The survey on the gait based human recognition can be summarized as the gait monitoring system is a promising system in the field of biometric. As the available systems uses fingerprint, iris, DNA and face as the biometric parameter. The consideration of gait for biometric would be advantageous compared to the existing one as the gait cannot be forged and it is unique for each individual. Gait detection can play a major role in the criminal and terrorist activities monitoring as they operate from far places. Since the gait detection doesn't involve any human contact and it can be analyzed from considerable distance. Other than these the gait recognition would help in gender classification, age classification, fall detection and monitoring the elderly person.

3. PHASES of the GAIT CYCLE

Gait analysis is the study of human locomotion. In order to analyze and quantify how someone walks, it is necessary to isolate the shortest, unique, repeatable task during gait. This task is called the gait cycle. A single gait cycle can be measured from any gait event to the same subsequent event on the same foot, but the conventional tacit model considers gait cycle is measured from one foot strike to the subsequent foot strike of the same foot.

Quantifying aspects of the gait cycle, such as time and spatial measures, allow for analysis of gait symmetry, variability and quality.
The gait cycle can be broken down into two primary phases, the stance and swing phases, which alternate for each lower limb.

Stance phase: Consists of the entire time that a foot is on the ground.
Swing phase: Consists of the entire time that the foot is in the air.
The observation of both the spatial and temporal characteristics of the two lower limbs makes it possible to introduce complementary phases. When both members are simultaneously in the stance phase, we speak of bipedal

support or double support (2 times 10%); when only one is in the support phase, one speaks of unipedal support or single support (40%), the second then being in oscillating phase.

The most accurate approach is based on the functional interpretation of events and identifies eight phases that capture three tasks related to walking.

1. Weight acceptance (0-12%):
The objectives of weight acceptance are to stabilize the limb, absorb shock and preserve the progression of the body. This phase can be broken down further into initial contact and loading response. Initial contact consists of the first 3% of the gait cycle. In typical gait, the heel strikes the ground and initiates the rotation over the heel to foot flat to preserve progression. This motion is the first rocker of the gait cycle. Loading response goes from 3-12% of the gait cycle. In this portion, the knee flexes slightly in order to absorb shock as the foot falls flat on the ground, stabilizing in advance of single limb support.

2. Single limb support (12-50%):
Single limb support involves progression of the body over the foot and weight-bearing stability. The first sub-phase of single limb support is mid-stance, which is seen during the 12-31% of the gait cycle. During mid-stance, the shank rotates forward over the supporting foot, creating the second rocker motion of the cycle. This maintains the forward progression of gait. The second stage of single support is terminal stance which goes from 31-50% of the gait cycle. During terminal stance, the center of mass advances out in front of the supporting foot. The heel raises of the ground as you roll onto the ball of the foot, creating the third rocker motion of the cycle.

3. Swing phase (50-100%):
The objectives of the swing phase of gait

- Foot clearance over the ground
- Forward swing of the limb
- Preparation of limb for stance
- The swing phase can be broken down into 4 sub-phases.

Pre-swing takes place during 50-62% of the gait cycle. Pre-swing is the transition phase between stance and swing, in which the foot is pushed and lifted off of the ground.
Initial swing goes from 62-75% of the gait cycle. During initial swing, the hip, knee, and ankle are flexed to begin advancement of the limb forward and create clearance of the foot over the ground.
Mid-swing goes from 75-87% of the gait cycle. During mid-swing, limb advancement continues and the thigh reaches its peak advancement.
Terminal swing is the final phase of the gait cycle going from 87-100% of the cycle. During terminal swing, the final advancement of the shank takes place and the foot is positioned for initial foot contact to start the next gait cycle.

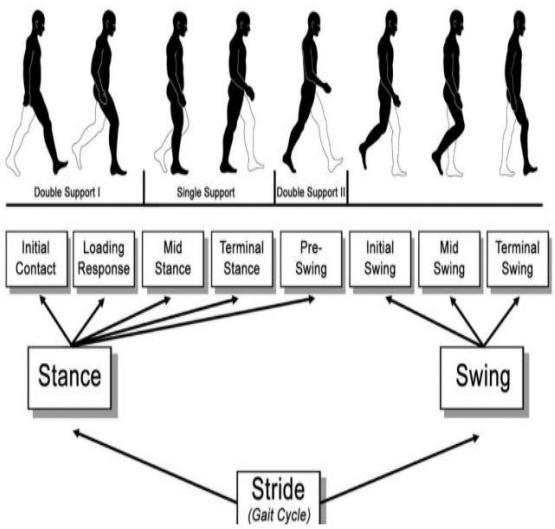

Figure 2: Breakdown of the gait cycle into phases based on the work of Perry and Burnfield (2010) [1].

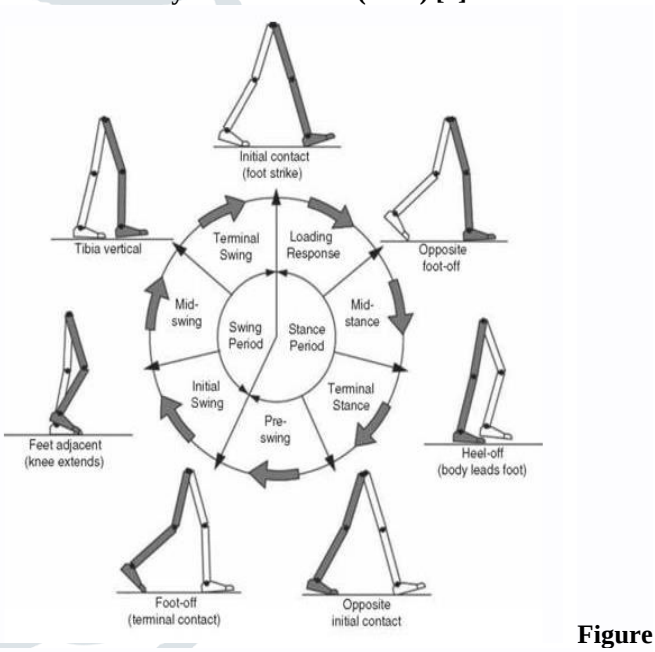

Figure 3: Typical gait cycle wrapped around a unit circle and subdivided into eight gait phases that have functional significance[15].
The first phase is initial contact, and is equivalent to the temporal event by the same name. The phases are drawn in sequence and are equally spaced for clarity, but do not represent their usual duration. Refer to the text for a complete description of the phases and their functional significance.

4. Hog Feature Flow

Histogram of oriented gradients (HOG) is a Feature used to detect objects in computer vision and image processing. The HOG descriptor technique counts the occurrence of gradient orientation in localized portions of an image detection window, or region of interest (ROI)] [12].The flow diagram of Hog feature extraction is shown in Figure 4.
Implementation of the HOG descriptor algorithms as follows:
The converted GEI image is divided into small cells which are connected and it is also called scaled image.

- Edge orientation or HOG direction is computed within a cell for the pixels.

- Each cell is discredited into eight angular bins, in which each bin consists of angle of 45°.
- Cell pixel contributes weighted gradient to its corresponding angular bin.
- Gamma normalization is done to normalize the pixel values of 0-255 to the value of 0-1.
- Gradient calculation is done on both the x and direction and to obtain vertical gradient from dx and horizontal gradient from dy direction.
- From which the phase and magnitude is obtained, using these both vector calculation is done for single person

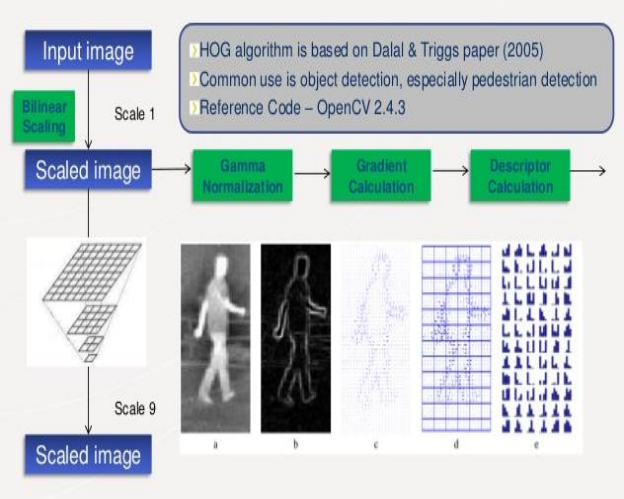

Figure 4: Hog feature flow [12].

HOG descriptor requires the following basic configuration parameters:

- Masks to compute derivatives and gradients
- Geometry of splitting an image into cells and grouping cells into a block
- Block overlapping
- Normalization parameters

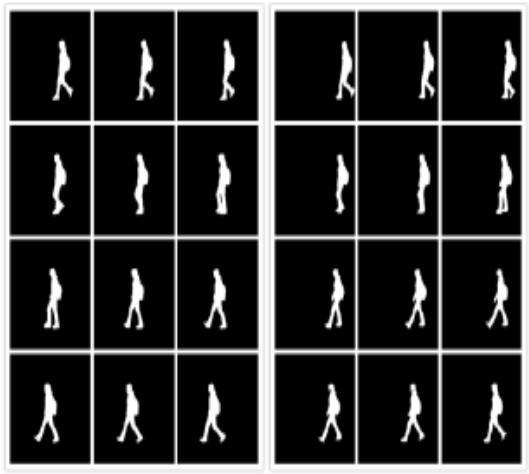

Figure 5: The period of human gait from CASIA-B dataset

Other human gait detection has applications in sport, computer games, physical rehabilitation, clinical assessment, surveillance, human recognition, modeling, and many other fields.

5. RESULTS AND DISCUSSION

The table 1 below shows the summary of the reviewed methodologies and their important parameters for gait analysis.

Sl. no	Author	Year	Accuracy	complexity	classifier	Data set
1	Mohammed Hussein Ahmed, Azhin Tahir Sabir, Halgur Sarhang Maghdid	2018	90%	High	KNN	Own
2	S.Joul Monisha ,G. Merlin Sheeba	2018	93%	High	KNN	Own
3	Muhammad Hassan Khan, Muhammad Shahid Farid, Marcin Grzegorzek	2018	96.5 %.	High	SVM	TUM GAID database
4	Waqar Tariq, Muhammad Lutfi Othman, Shameem Akhtar, Fareeha Tariq	2019	80%	Normal	ANN	CASIA Gait Database

6. CONCLUSION

With mounting demands for visual surveillance systems, human identification at a distance has recently emerged as an area of significant interest. Gait is being considered as an impending behavioral feature and many allied studies have illustrated that it can be used as a valuable biometric feature for human recognition. This paper has presented the review of recent developments in human identification based on human gait. The silhouette extraction, feature extraction and classification are the major steps involved in the gait recognition. The various methods are presented and reviewed.

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