European Journal of Academic Essays 1(3): 33-38, 2014
ISSN: 2183-1904
www.euroessays.org

Analysis of Gait of a Person for Individual Authentication

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Abstract: Gait analysis have been performed in various fields, this comes under biometrics. Biometrics has been used in a wide range of applications, this makes it a precise definition difficult to establish. There are various biometric measures which can be used to help derive an individual's identity. In this paper Gait recognition is done in order to identify an individual. This method or analysis is a marker less unobtrusive biometric method. This helps in location of an individual; rather it helps in identification of a person at a distance. This paper aims to develop methods for extracting discriminate gait features automatically and passively from low-resolution video. Gait analysis does not require any physical contact; this property helps its use in surveillance application. Two phases have been used in which firstly features of an individual are extracted and stored and then in the recognition phase the stored features are compared with the new features of a new individual. If match is found then the identification is success else rejection is made.

Keywords: Gait recognition, Genetic Algorithm, Image Processing, Segmentation

1. Introduction

There are numerous biometric measures which can be used to help derive an individual's identity. Biometric is: "A physiological or behavioral characteristic, which can be used to identify and verify the identity of an individual" They can be classified into two distinct categories-Physiological which is derived from a direct measurement of a part of a human body. The most prominent and successful of these types of measures to date are fingerprints, face recognition, iris-scans and hand scans and the second category is Behavioral which extracts characteristics based on an action performed by an individual, they are an indirect measure of the characteristic of the human form. Jain et al [1], describes the definition of biometric as the task of biometric (from Greek bios-life, metron-measure) systems consists of determining the individual identity found on his or her differentiating physiological and/or behavioral features in the majority of cases both properties are addressed. The main feature of a behavioral biometric is the use of time as a metric. Established measures include keystroke-scan and speech patterns. Biometric identification should be an automated process. Manual feature extraction would be both undesirable and time consuming, due to the large amount of data that must be acquired and processed in order to produce a biometric signature. Inability to automatically extract the desired characteristics which would render the process infeasible on realistic size data sets, in a real-world application. With a biometric a unique signature for an individual does not exist, each time the data from an individual is acquired it will generate a slightly different signature, there is simply no such
thing as a 100% match. This does not mean that the systems are inherently insecure, as very high rates of recognition have been achieved. The recognition is done through a process of correlation and thresholding.

The use of gait as a biometric is a new area of study. Its growing interest within the computer vision community is being received and development of many gait metrics is done. Previous studies about gait suggest that it was an individual characteristic which is unique, with cadence and also it has cyclic nature. Gait recognition term is used to signify the identification of an individual from a sequence of video of motion of a subject. This does not mean that gait can be limited to walking only; it can also be applied to any means of movement on foot or running. Gait as a biometric can be seen as advantageous over other forms of biometric identification techniques for the following reasons

Unobtrusive –The gait of a walking person can be extracted without the knowledge of the user being analyzed that is no cooperation from the user is required.

Distance recognition – The gait of an individual can be captured at a distance unlike other biometrics such as fingerprint recognition.

Reduced detail – Gait recognition does not require images that have been captured to be of a very high quality unlike other biometrics such as face recognition, which can be easily affected by low resolution images.

Difficult to conceal – The gait of an individual is difficult to

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disguise, by trying to do so the individual will probably appear more suspicious. Use of other techniques of biometrics for example face recognition, the face of the person can be altered easily or can be hidden.

2. GAIT RECOGNITION

2.1 Identification Using Gait

Gait Analysis comes under a Biometrical study, which is a very important research problem with respect to security and recognition of medical problem for diagnosis. Gait recognition is the process in which an individual is identified by the manner in which they walk. This is a marker less unobtrusive biometric, which offers the possibility to identify people at a distance, without any interaction or co-operation from the subject (no physical contact is required); this is the property which makes it as attractive as a method of identification. Gait is also one of the few biometrics that can be measured at a distance, which makes it useful in surveillance applications as well.

2.2 Gait Cycle

The Gait cycle comprises of two basic stages; these are Stance stage and Swing stage. The stance begins with the heel of the forward limb making contact with the ground and ends with the toe of the same limb leaving the ground. In the swing stage the foot is no longer in contact with the ground. During the swing stage the body weight is totally transferred and no portion of the leg is touching the ground surface. A Gait cycle is the time interval between successive instances of initial foot-to-floor contact ‘heal strike’ for the same foot. Each leg has two distinct periods as explained above; the stance phase and the swing phase. Thus these two phases comprises the Gait cycle. The gait cycle is demonstrated in figure 1.

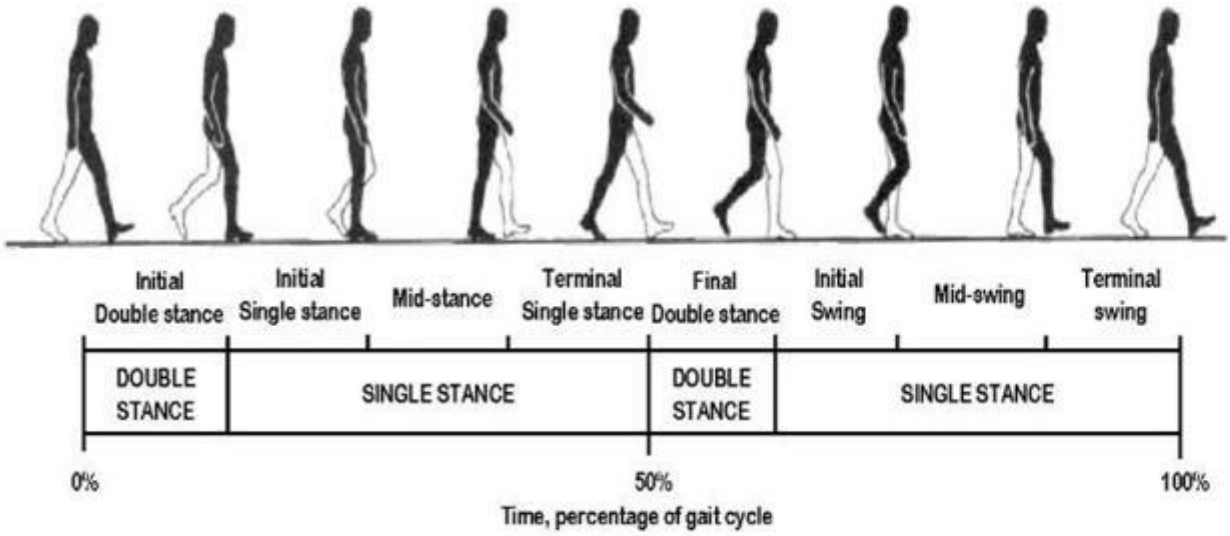

Figure 1: Gait Cycle.

3. Research works done on Gait analysis

A lot of work and researches have been carried out in the field of Gait recognition and analysis. According to the works carried out by Mrs.D.Sharmila and Dr.E.Kirubakaran [2] used two methods, firstly Image based gait recognition (spatio temporal sequence of images) and secondly, gait recognition using formulas i.e. (cadence, stride length, height and vertical displacement). Matlab software is used for image processing in this technique and in case of formula consists of computing mid- feet point, estimating period of gait, estimating 3D trajectory, estimating stride and height parameters. Dr.A.Venkataramana [3] et al makes use of DCT, Radon transform and PCA based method for better results. Gait recognition method using DCT, Randon Transform and PCA is proposed in this paper. DCT captures the features of an image by reducing the redundant information present in the image. Radon Transform provides mapping from Cartesian co-ordinates to polar co-ordinates. Finally PCA is applied on the DCT and Radon transformed image to reduce the dimensionality. The use of DCT and Radon Transform provides better representation of the given silhouette sequences. From the simulation results it is observed that the recognition rate is higher. Further work in this direction will be to identify algorithm for faster computation. Further the same experiment is to be repeated by taking real time gait images. Ju Han [4] et al proposes a new spatio-temporal gait representation, called the Gait Energy Image (GEI), for individual recognition by gait. Unlike other gait representations which consider gait as a sequence of templates (poses), GEI represents human motion sequence in a single image while preserving temporal information. To overcome the limitation of training templates, they propose a simple model for simulating distortion in synthetic templates and a statistical gait feature fusion approach for human recognition by gait. This paper presents a systematic and comprehensive gait recognition approach, which can work just as fine as other complex published techniques in terms of effectiveness of performance while providing all the advantages associated with the computational efficiency for real-world applications. Huma Khan and Yogesh Rathod[5] proposes a system in which works with the assumption that the video sequence to be processed is captured by a static camera, and the only moving object in video sequence is the subject (person). Given a video sequence from a static camera, this module detects and tracks the moving silhouettes. This process comprises of two sub modules; Foreground Modeling and Human tracking using skeletonization operation. Qiong Cheng [6] et al proposes a new gait recognition method using Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA). PCA is first applied to1D time-varying distance signals derived from a sequence of silhouette images to reduce its dimensionality. Then, LDA is performed to optimize the pattern classification and Spatiotemporal Correlation (STC) and Normalized Euclidean Distance (NED) are respectively used to measure the two different sequences and K nearest neighbor classification (KNN) finally performed for recognition. The experimental results show the PCA and LDA based gait recognition algorithm is better than that based on PCA. According to Ben-Abdelkader et al [7] the interpretation of human gait is the synchronized, integrated movements of hundreds of muscles and joints in the body. All humans follow the same basic walking pattern, but their gaits are influenced by functions of their entire musculo-skeletal structure. Limb length, body mass, stride length and several other factors affect the walking of a person. Many researchers from engineering field till 1970 have not carried out the work for Gait analysis. In the year 1980, Nasher [8] further continued the concepts made in previous work done by Harris and Beath [9].He carried out the work in detecting the problems while walking for the cardiac patients. The errors have been investigated in the work done by Nasher [10].Later, Garrett and Luckwill [11] carried the work for maintaining the speech of walking through EMG and Gait analysis. Grabiner et al [12] investigated the time taken to recover the normal walking of a subject when it hits an obstacle placed in its path. Although much research has been done in the field of computer vision for the analysis of human gait, very little work has been done in the area of global gait analysis for the detection of gait abnormalities like flat foot problems. The majority of the work done in the area utilizes motion capture data, or is very limited in scope and effectiveness in order to classify a limited number of grossly different human motions.

Tang et al [13] carried out works on slip simulation which is another usefulness of the topic Gait analysis. Paval and his colleges [14] extracted some features and characteristics using Gait analysis for finding maximum likelihood of falling after a very long journey.Bobick and Johnson [15] performed researches and developed a good method of Gait recognition which was based on static body and stride parameters which are measured during the persons walking phase. Kale et al [16] performed experiments on appearance based approach to the problem of gait recognition. Cunado [17] and his colleges proposed a method of evidence gathering technique. This technique has been developed for a moving model, representing human thighs and to get gait signatures automatically from the motion of thighs. Sarkar et al [18] proposed simple method that is combination of baseline algorithm and a dataset to establish a minimum model for performance evaluation. Simeesters et al [19] calculated the trip duration and threshold value by using Gait analysis. These are only some of the basic works that have been done in the field of GAIT

4. Methodology

4.1 Flowchart demonstrating the methodology

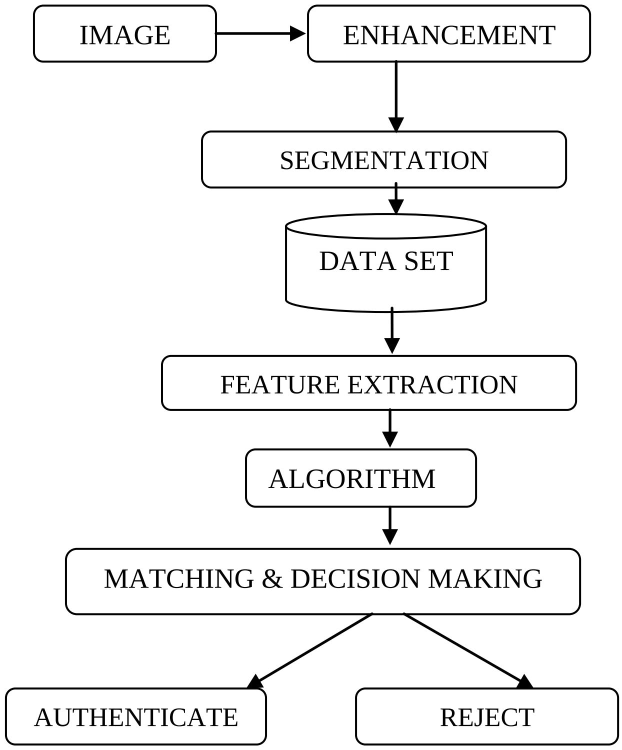

Figure 2: Flowchart of method used.

4.2. Mathematical Analysis

Based on the assumption that the original image is additive with noise. To compute the approximate shape of the wavelet (i.e., any real valued function of time possessing some structure), in a noisy image and also to estimate its time of occurrence, two methods are available, first one is a simple structural analysis and the second one is the template matching technique.

For the detection of wavelets in noisy image, assume a class of wavelets, Si(t), I = 0.... N-1 .All having some common structure. Based on this assumption that noise is additive, then the corrupted image has been modeled by the equation –

$$X(m,n) = i(m,n) + Gd(m,n) \qquad (1.1)$$

where,

i(m,n) is the clean image, d(m,n) is the noise and G is the term for signal-to-noise ratio control. To de-noise this image, wavelet transform has been applied. Let the mother wavelet or basic wavelet be y(t), which yields to,

$$\omega(t) = \exp(j2\pi ft - t^2/2) \qquad (1.2)$$

Further as per the definition of Continuous Wavelet transform CWT (a,ti), the relation yields to,

$$CWVT(a,\tau) = (1/\sqrt{a}) \int x(t)\, \omega\{(t-\tau)/a\}\, dt \qquad (1.3)$$

The parameters obtained in equation (1.3) has been discretized, using Discrete Parameter Wavelet transform, Thus equation (4.3) in discrete form results to equation

$$DPWT(m,n) = 2^{-m/n} \sum_k \sum_l x(k,l)\, \omega(2^{-m}k - n) \qquad (1.4)$$

where \`m' and \`n' are the integers, ao and o are the sampling intervals for \`a' and \`i', x(k,l) is the enhanced image. The wavelet coefficient has been computed from equation (1.4) by substituting ao = 2 and = 1. Data compression has been performed by using Discrete cosine transform (DCT)

$$DCT(u,v) = \sum_{m=0}^{M-1}\sum_{n=0}^{N-1} I(m,n)\cos\left(\frac{2\pi T(m+n)}{MN}\right) \quad (1.5)$$

Principal component is computed using covariance method:

$$Cov(X,Y) = \frac{\sum_{i=1}^{n}(Xi-X')(Yi-Y')}{N-1} \quad (1.6)$$

Where, X and Y are data sets; X' and Y' are mean

Eigen vectors and Eigen values of covariance matrix are calculated. Segmentation of image is done using connected component method. After image processing an algorithm is implemented for the further process of the method used. The algorithm for gait recognition for individual identification is as shown below.

4.3. Algorithm

STEP-1 Read the number of unknown Gait image frames.
STEP-2 Set the frame counter, fcount=1.
STEP-3 Do while fcount <= NF
STEP-4 Read the gait image [fcount]
STEP-5 Enhance the image
STEP-6 Apply loss-less Compression
STEP-7 Compute the connected components for segmenting the image
STEP-8 Crop the image for locating the Region of Interest
STEP-9 Compute the step length, K -A (Knee to Ankle) distance, Foot length, Shank width, Foot angle and Walking Speed
STEP-10 Compute the genetic parameters using the relation as,

UB= (((mmax-mmean)/2)*A) + mmean
LB= (((mmean-mmin)/2) *A) + mmin

where `A' is the pre-emphasis coefficient, mmax is the max value and mmean is mean value and mmin is minimum value. UB is upper bound and LB is lower bound value.

STEP-11 Store the features.
STEP-12 Perform best fit matching.
STEP-13 Perform classification and make decision.
STEP-14 End do.
STEP-15 Display result.

5. Discussions

In this paper I have used two phases – Training phase and Recognition phase. In the Training phase a knowledge-based data set has to be formed using Artificial Neural Network (ANN). In the Recognition phase, this model will be used for understanding of an unknown Gait for Gait analysis. The Enhancement phase has been used to obtain the distortion free and compressed image for further processing. The noise free image has been obtained by using filters. The compression of the noise free image has been obtained by using some compression techniques such that the information should not be lost. In this present work the Discrete Cosine Transform (DCT) [7] has been used to compress the noise free image. After obtaining the compressed image the various parameters have been extracted that is required for the present work. The output of the enhancement phase that is the compressed image has been provided to the segmentation phase. By using segmentation methods the various parameters such as lines and points of the image has been detected. The next step in formation of the Gait Model (knowledge-based model) is Feature Selection and Extraction. The expected result is to develop an algorithm that will calculate basic features in human walking and match it with the results in the database and help us in recognition of Gait of the person. Region of interest is that area of images which are useful in analysis of Gait.

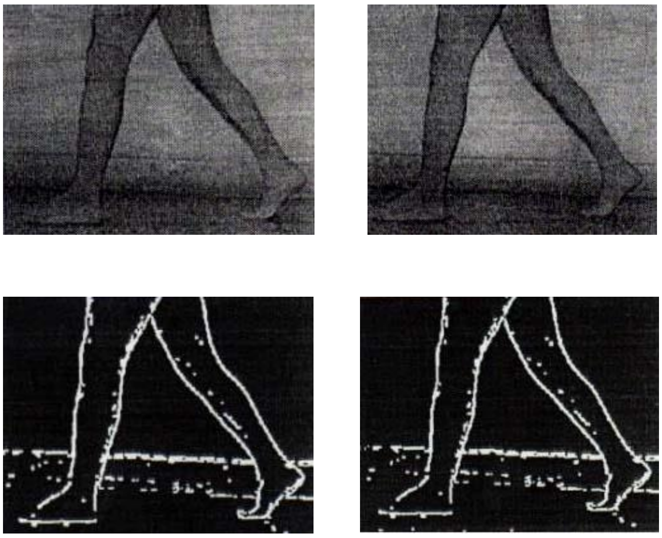

Figure 3: Figure showing original, enhanced and segmented images.

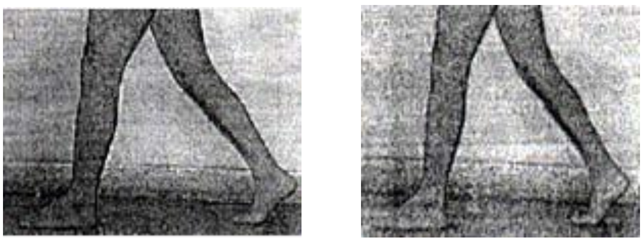

Figure 4: Figure showing original and sharpened images.

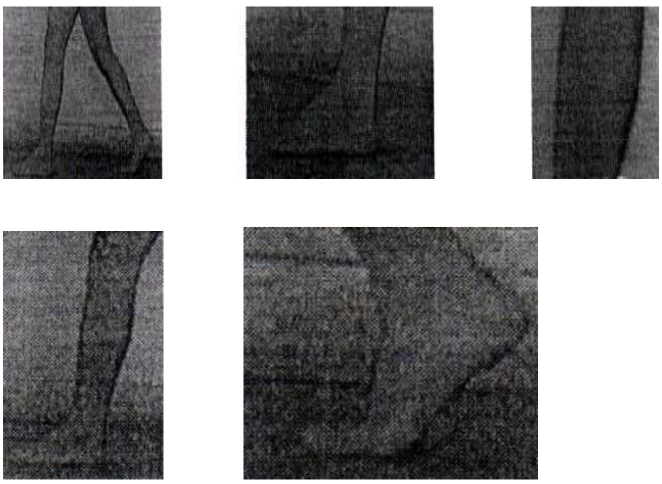

Figure 5: Figure showing region of interest.

5.1. Geometrical feature calculation

Various geometric features of the region of interest are calculated which is helpful in analyzing the persons gait .The images shown below shows the geometric feature extraction from the images obtained.

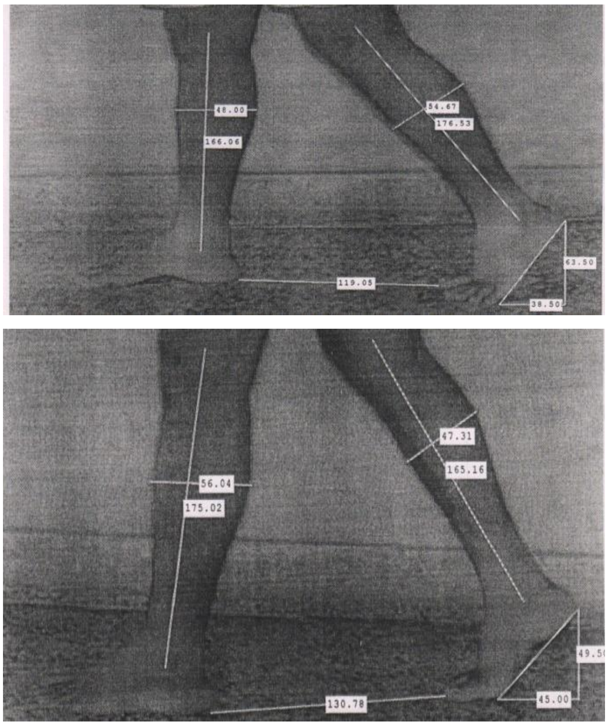

Figure 6: Figure showing two frames for geometric calculation of features of region of interest.

6. Observations

The below calculated values are stored in the database and then same values are calculated for unknown person and matching is performed using algorithms. Matching is done and thus individual's identity is found out.

Table 1: Geometrical features of Gait image.

Image	Gait	Foot angle in degrees	Step Length in pixels	Foot Length in pixel
Img1	Standing	0	0	105
Img2	Walking(Left leg)	61.5	122.5	102
Img3	Walking(Right leg)	46	119.4	103
Img4	Walking(Left leg)	57.4	118	101
Img5	Walking(Right leg)	47	129.8	103

In the above table foot angle, foot step length and foot length is calculated and stored

Table 2: Extracted Parameters.

Image	Gait	LB	UB	Eigen value	Eigen Vector
Img1	Standing	-269.412	2620.24	130.115	0.0016273
Img2	Walking(Left leg)	-290.525	2637.19	69.34	0.0019628
Img3	Walking(Right leg)	-430.764	2548.69	62.8651	0.0001926
Img4	Walking(Left leg)	-412.331	2658.6	64.6354	0.0003645
Img5	Walking(Right leg)	-365.698	2650.6	64.5754	0.0007164

7. Limitations

Some of the limitations of my study are that, the subject taken into consideration is a fit person that is consumption of alcohol; drugs etc. may change the subject's gait. The background selected for image capturing is white background, still images are used. The surface used for walking is basically considered as smooth one.

8. Conclusion and Future Scope:

The present work has been done in order to identify a person by storing his gait features. The work can be extended further for motion images (video).Work can also be extended to identify a person who is carrying some weight also. Foot abnormalities (flat foot problem) can also be found out using this technique; this is helpful in army recruitments etc. Other environments such as rough surface, slippery surface etc. so on has to be considered for further study.

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