Biometric System using Gait Feature Analysis and Comparison

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***Abstract*:- The world today is making rapid progress in its quest to realize the dream of a creating a user friendly, customer caring ambience. With every new dream comes the nightmare of a security of the system lapse which may allow the misuse of the system. A major success in trying to bridge the advent of a security lapse is the use of biometrics. Biometric systems are becoming increasingly important, since they provide more reliable and efficient means of identity verification. Biometric gait recognition (i.e. recognizing people from the way they walk) is one of the recent attractive topics in biometric research. This paper presents biometric user recognition based on gait.**

Most real-life biometric systems are still unimodal. Unimodal biometric systems perform person recognition based on a single source of biometric information. Such systems are often affected by some problems such as noisy sensor data, non universality and spoof attacks. Multi biometrics overcomes these problems. Multi biometric systems represent the fusion of two or more unimodal biometric systems. Such systems are expected to be more reliable due to the presence of multiple independent pieces of evidence. So , gait can be used alone as a biometric identification or it can be used with many other biometric trait .

Keywords : Gait , Biometrics , Biometric Fusion, Matching score, Multi biometric.

INTRODUCTION

Biometric basically refers to the identification system based on the human characteristics . A biometric system is a pattern recognition system that performs recognition based on some features derived from measurements of physiological or behavioural characteristics that an individual has [1]. Biometrics form a strong tool for authentication and security applications also as it is difficult to hide and fake such traits. The key advantage over card based or password based authentication is that biometrics cannot be forgotten or lost. Biometric characteristics, including fingerprint, facial features, iris, voice, signature, and palm print , finger-knuckle, gait, finger knuckle etc. are now widely used in security applications.

Gait analysis is the systematic study of animal locomotion, more specifically the study of human motion, using the eye and the brain of observers, augmented by instrumentation for measuring body movements, body mechanics, and the activity of the muscles[1]. Gait analysis is used to assess, plan, and treat individuals with conditions affecting their ability to walk. It is also commonly used in sports biomechanics to help athletes run more efficiently and to identify posture-related or movement-related problems in people with injuries.

The study encompasses quantification (i.e., introduction and analysis of measurable parameters of gaits), as well as interpretation, i.e., drawing various conclusions about the animal (health, age, size, weight, speed etc.) from its gait pattern. Gait analysis and recognition can form the basis of unobtrusive technologies for the detection of individuals who represent a security threat or behave suspiciously.

GAIT VERSUS OTHER BIOMETRIC TRAITS

Compared to other biometrics, gait has some unique characteristics. The most attractive feature of gait as a biometric trait is its unobtrusiveness, i.e., the fact that, unlike other biometrics, it can be captured at a distance and without requiring the prior consent of the observed subject. Most other biometrics such as fingerprints [2], face [3], hand geometry [4], iris [5], voice [6], and signature [7] can be captured only by physical contact or at a close distance from the recording probe. Gait also has the advantage of being difficult to hide, steal, or fake.

Although the study of kinesiological parameters that define human gait can form a basis for identification, there are apparent limitations in gait capturing that make it extremely difficult to identify and record all parameters that affect gait. Instead, gait recognition has to rely on a video sequence taken in controlled or uncontrolled environments. Even if the accuracy with which we are able to measure certain gait parameters improves, we still do not know if the knowledge of these parameters provides adequate discrimination power to enable large scale deployment of gait recognition technologies. Moreover, studies report both that gait changes over time and that it is affected by clothes, footwear, walking surface, walking speed, and emotional condition [8]. The above facts impose limitations on the inherent accuracy of gait and question its deployment as a discriminative biometric.

The ambiguity regarding the efficiency of gait-assisted identification differentiates gait from other biometrics whose uniqueness and invariability, and therefore appropriateness for use in identification applications, can be more conclusively determined by the study of the similarities and differences between biometrics captured from several subjects under varying conditions. This is why, at present, gait is not generally expected to be used as a sole means of identification of individuals in large databases; instead, it is seen as a potentially valuable component in a multimodal biometric system.

GAIT AS MULTIBIOMETRIC COMPONENT

Research conducted thus far in the area of gait recognition has shown that gait can be reliable in combination with other biometrics. If we assume that palm, fingerprint, and iris methods belong to a different (obtrusive) class of biometrics, additional biometrics that could be used in conjunction with gait in a multi biometric system would be face and foot pressure [9] (the latter requiring some specialized equipment for measuring the ground reaction force).

In a multi biometric system, gait and foot pressure could be used to narrow down the database of subjects. Subsequently, face recognition could be used for identification of a test subject

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 05, May - 2017

among the reduced set of candidate subjects. Otherwise, the three biometrics could be combined altogether, e.g., using the techniques described in [10].

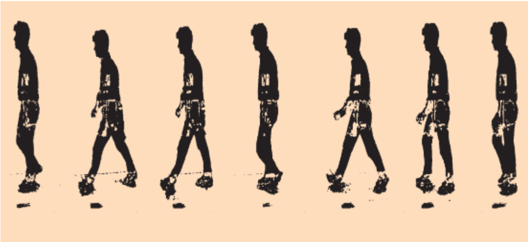

FIGURE 1. Several stances during a gait cycle. The silhouettes are from CMU database [11].

Despite the differences among walking styles, the process of walking is similar for all humans. A typical sequence of stances in a gait cycle is shown in Figure 1.
It is interesting to notice that in case of face recognition, there is more information in the frontal face than that in the side face. Thus, recognition of the frontal face is generally easier than that of the side face. However, the situation happens to be the reverse in case of gait. Usually it is easier to recognize the side view gait than the frontal view gait due to the fact that there are more motion characteristics in the side view of a walking person. Up to the present, most reported experiments are performed on the side view gaits [12]. However, it is not realistic to expect only side view gait in real applications. These complementary properties of face and gait inspire fusion of them to get more accurate results.In previous paper ,there is fusion at feature level which follows the following methodology.

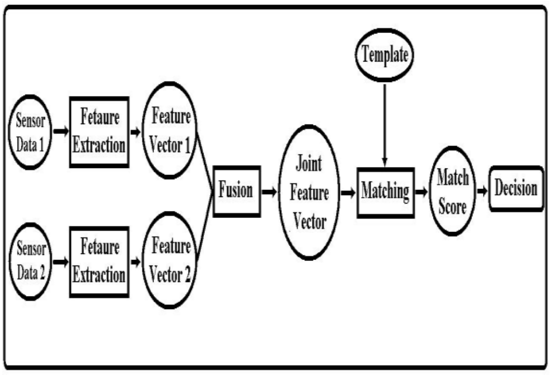

Figure 2. Fusion at the feature extraction level [13]

BASIC PROCESS OF GAIT RECOGNITION

It is a multistage process in which the gait of the person is captured with the uniform background . Moreover, since gait recognition algorithms are not , in general, invariant to the capturing viewpoint, care must be taken to conduct capturing from an appropriate viewpoint. After capturing the gait from the correct viewpoint that is the side view point which is mainly used in many algorithms developed than there will be a background separation process. A background is separated than the feature (gait viewpoint) will be extracted by a processing called feature extraction . Finally, there is a recognition step, which aims to compare the extracted gait signals with gait signals that are stored in a database. There are many applications of gait recognition in biometric and non biometric field .

Fig3. represent the generalized process :-

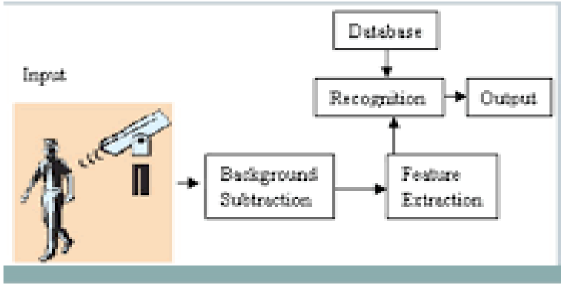

FIGURE 3 . GENARILIZED GAIT RECOGNITION SYTEM

The parameters taken into account for the gait analysis are as follows[16]:

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

PREVIOUS WORK

The study of gait as a discriminating trait was first attempted a few decades ago from a medical/ behavioural viewpoint [14]. Later, several attempts were made to investigate the gait recognition problem from the perspective of capturing and analyzing gait signals . Most recent work investigating the appropriateness of gait as a biometric for human identification has taken place in the context of the Human ID project sponsored by the U.S. Defence Advanced Research Project Agency (DARPA). Each of the participating institutions has established its own database of sequences depicting humans walking.

In previous year the gait was been used for gender classification . Psychological experiments were carried out. These experiments showed that humans can recognize gender based on gait information, and that contributions of different body components vary. The prior knowledge extracted from the psychological experiments can be combined with an automatic method to further improve classification accuracy[17]. The proposed method which combines human knowledge achieves higher performance than some other methods, and is even more accurate than human observers. They also present a numerical analysis of the contributions of different human components, which shows that head and hair, back, chest and thigh are more discriminative than other components. In the paper they perform challenging cross-race experiments that used Asian gait data to classify the gender of Europeans, and vice versa[17]. Encouraging results were obtained. All the above prove that gait-based gender classification is feasible in controlled environments. In real applications, it still suffers from many difficulties, such as view variation, clothing and shoes changes, or carrying objects[17]. An early gait-based-gender classification is developed by Kozlowski and Cutting [18]. In their experiments, point-light displays are attached to the major joints of persons. Human observers can classify the gender from the displays with 63% accuracy. They also found that point-lights from dynamic sequences were sufficient for gender classification, but static point-lights are insufficient.

In previous year there was an appearance based approach for gait identification using infrared imaging [19] . This paper gait recognition system, which is insensitive to view, clothing and lightning conditions. In the proposed work, an infrared camera is used to capture videos of moving objects. After that background subtraction is performed i.e. foreground objects (moving objects) like human, vehicles and animals are extracted by estimating background information. This is achieved using Gaussian Mixture Model (GMM) followed by morphological median filtering operation to remove noise in the background subtracted image. A classification metric is used to separate human being from other foreground objects. Shape and boundary information is used in the moving target classification. Subsequently, width vector of the outer contour of binary silhouette and the MPEG-7 Angular Radial Transform coefficients are taken as the feature vector. Binary silhouette obtained is used to produce gait features of a person. Independent Component Analysis (ICA) applied to reduce dimensionality of the features vectors. These feature vectors used to train Support Vector Machine (SVM) for recognition of some individual. Length of gait cycle, maximum feet and hands distance, contour height, centre of mass and colour are taken as key feature. Proposed approach is tested over a self created database of thirteen different people with different resolution conditions. In indoor environment an average recognition percentage upto 97.73% and for outdoor conditions recognition is upto 86.28% (daylight) and 78.32% recognition at night hours is observed. Use of infrared cameras makes it quite advantageous to be used at night.

There was also an silhouette analysis-based gait recognition for human identification [20]. 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, eigenspace 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 eigenspace for recognition. This method implicitly captures the structural and transitional characteristics of gait. Extensive experimental results on outdoor image sequences demonstrate that the proposed algorithm has an encouraging recognition performance with relatively low computational cost.

In [21], a comparison is provided of several techniques for improving the quality of silhouettes extracted from video sequences depicting humans walking. The silhouettes were extracted using a model-based method that produces silhouettes that have fewer noise pixels and missing parts. The resulting sequences were tested with the model-based algorithm in , and the overall system was shown to improve on the baseline system in.

There is also an novel signal processing approach for gait based human identification system [22]. In this paper, they propose a novel set of features extracted from a walking sequence of a person, which include the varying leg spread, the motion of centroid, the number of pixels
on the vertical line through centroid, and the sum of foreground pixels as the dynamic features, and the height and maximum leg spread as the static features for gait identification. These features are very easy to obtain, but contain significant information about the gait of the person. To reduce the size of data, the dynamic features are represented by their respective line spectral pairs. Match scores obtained using Euclidean distance measure on these features are combined with match scores obtained by comparing the horizontal and vertical projection vectors. Nearest neighbour classifier is used and the performance of our recognition algorithm is tested on CASIA A dataset.

TECHNIQUES OF BIOMETRIC GAIT RECOGNITION[15]

MV based technique - In this category, gait is captured using a video-camera from distance. Video and image processing techniques are employed to extract gait features for recognition purposes. Most of the MV based gait recognition algorithms are based on the human silhouette . That is the image background is removed and the silhouette of the person is extracted and analyzed for recognition. Most of the current gait recognition methods are MV-based. The primary advantage of MV-based gait biometric compared to other modalities is in being captured from the distance when other biometrics are not accessible. Application areas for MV-based gait recognition are usually surveillance and forensics.

FS based technique - In FS-based approach, a set of sensors or force plates are installed on the floor . Such sensors enable to measure gait related features, when a person walks on them. They used to analyze and store the features and matched it with database available . One of the main advantages of FS-based gait recognition is in its unobtrusive data collection. The FS-based gait recognition can be deployed in access control application and is usually installed in front of doors in the building.

WS based technique - In WS-based gait recognition, gait is collected using body worn motion recording (MR) 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. One of the main advantages of the WS-based gait recognition over several other biometric modalities is its unobtrusive data collection. The WS-based approach was proposed for protection and user authentication in mobile and portable electronic devices. With advances in miniaturization techniques it is feasible to integrate the MR sensor as one of the components in personal electronic devices.

CHALLENGES

Although the performance of all three biometric gait recognition approaches are encouraging, there are several factors that may negatively influence the accuracy of such approaches. We can group the factors that influence a biometric gait system into two classes (not necessarily disjoint):

• External factors. Such factors mostly impose challenges to the recognition approach (or algorithm). For example, viewing angles (e.g. frontal view, side view), lighting conditions (e.g. day/night), outdoor/indoor environments (e.g. sunny, rainy days), clothes (e.g. skirts in MV-based category), walking surface conditions (e.g. hard/soft, dry/wet grass/concrete, level/stairs, etc.), shoe types (e.g. mountain boots, sandals), object carrying (e.g. backpack, briefcase) and so on.

• 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 body due to aging, drunkenness, pregnancy, gaining or losing weight and so on. One of the public gait data set that was published by Sarkar et al. [15] includes five factors that may influence gait recognition. These factors include change in viewing angle, in shoe type, in walking surface, carrying or not carrying briefcase, and the elapsed time between samples being compared. For example, when the difference between the template and the test samples was in shoe type (A vs. B), view (right camera vs. left camera), briefcase (carrying vs. not carrying) and surface (grass vs. concrete), the recognition rates were 78%, 73%, 61% and 32%, respectively [13].

Some of the external factors may have various effects on different gait recognition approaches. For example, while carrying an object may influence the dynamics of gait both in WS-based and MV-based categories, it may also create additional difficulties in MV-based category during human silhouette extraction. The effect of carrying backpack from WS-based perspective is studied in [15]. When carrying backpack the EER increased from 7.3% to 9.3% and recognition rate dropped from 86.3% to 86.2% [15]. Although some of the external factors have been addressed, others are not investigated yet. Moreover, to our knowledge, so far internal factors of the gait have not studied in the context of biometric gait recognition. One needs to cope with such factors in order to develop robust gait recognition systems.

APPLICATIONS

Gait analysis is used to analyze the walking ability of humans and animals, so this technology can be used for the following applications[16]:

- **Medical diagnostics**

Pathological gait may reflect compensations for underlying pathologies, or be responsible for causation of symptoms in itself. Cerebral palsy and stroke patients are commonly seen in gait labs. The study of gait allows diagnoses and intervention strategies to be made, as well as permitting future developments in rehabilitation engineering. Aside from clinical applications, gait analysis is used in professional sports training to optimize and improve athletic performance.

Gait analysis techniques allow for the assessment of gait disorders and the effects of corrective orthopedic surgery. Options for treatment of cerebral palsy include the artificial paralysis of spastic muscles using Botox or the lengthening, re-attachment or detachment of particular tendons. Corrections of distorted bony anatomy are also undertaken (osteotomy).

- **Chiropractic and Osteopathic Utilizations**

Observation of gait is also beneficial for diagnoses in chiropractic and osteopathic professions as hindrances in gait may be indicative of a misaligned pelvis or sacrum. As the sacrum and ilium biomechanically move in opposition to each other, adhesions between the two of them via the sacrospinous or sacrotuberous ligaments (among others) may suggest a rotated pelvis. Both doctors of chiropractic and osteopathy use gait to discern the listing of a pelvis and can employ various techniques in order to restore a full range of motion to areas involved in ambulatory movement. Chiropractic adjustment of the pelvis has shown a trend in helping restore gait patterns as has osteopathic manipulative therapy (OMT).

- **Biometric identification and forensics**

Minor variations in gait style can be used as a biometric identifier to identify individual people. The parameters are grouped to spatial-temporal (step length, step width, walking speed, cycle time) and kinematic (joint rotation of the hip, knee and ankle, mean joint angles of the hip/knee/ankle, and thigh/trunk/foot angles) classes. There is a high correlation between step length and height of a person. The approach above belongs to the model-based approach. Another appearance-based approach recognizes individuals through binary gait silhouette sequences. For example, silhouette sequences of full gait cycles can be treated as 3D tensor samples, and multi linear subspace learning, such as the multi linear principal component analysis, can be employed to learning features for classification.

- **Comparative biomechanics**

By studying the gait of non-human animals, more insight can be gained about the mechanics of locomotion, which has diverse implications for understanding the biology of the species in question as well as locomotion more broadly.

COMPARISON WITH OTHER BIOMETRIC FEATURES

The table 1 show the comparison with other biometric features and table 2 represent the list of biometric features [23].

BIOMETRIC	UNIQUENESS	UNIVERSALITY	PERMANANCE	CIRCUMVENTION	PERFORMANCE	COLLECTABILITY	DISTINCTIVNESS
signature	P	P	P	G	P	G	P
speaker	P	A	P	G	P	A	P
face	L	G	A	G	P	G	P
iris	G	G	G	P	G	A	G
keystroke	P	P	P	A	P	A	P
palmprint	A	A	G	M	G	A	A
retina	A	G	A	P	G	P	G
gait	A	A	P	A	P	G	P
fingerprint	G	A	G	A	G	A	G
ear	A	A	G	A	A	A	A
DNA	G	G	G	P	G	P	G
odour	G	G	G	A	P	P	P

Table 1. Comparison of trends based on various criteria P=poor, A=average, G=good. (Source: Biometric Wikipedia and paper. [23])

Table 2.List of biometric features

Biometric	Trait
Fingerprint	Finger lines, pore structure
Signature (dynamic)	Writing with pressure and speed differentials
Facial geometry	Distance of specific facial features (eyes, nose, mouth)
Iris	Iris pattern
Retina	Eye background (pattern of the vein structure)
Hand geometry	Measurements of fingers and palm
Finger geometry	Finger measurement
Vein structure of back of hand	Vein structure of the back of the hand
Ear form	Dimensions of the visible ear
Voice	Tone or timbre
DNA	DNA code as the carrier of human heredity features

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 05, May - 2017

CONCLUSION

This review paper was intended to provide an overview of the basic research directions in the field of gait analysis and recognition and its comparative study with other biometric features. The paper also provides the technique used for gait recognition ,its challenges and the comparison with other biometric technique .The recent developments in gait research indicate that gait technologies still need to mature and that limited practical applications should be expected in the immediate future. At present, there is a potential for initial deployment of gait for recognition in conjunction with other biometrics. However, future advances in gait analysis and recognition—an open, challenging research area—are expected to result in wide deployment of gait technologies not only in surveillance, but in many other applications as well. We hope that this article will expose the gait analysis and recognition problem to the signal processing community and that it will stimulate the involvement of more researchers in gait research in the future .

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