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ABNORMAL GAIT CLASSIFICATION USING SILHOUETTES

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ABSTRACT

This paper proposes a new methodology to classify the person with normal walk or abnormal walk for surveillance purposes. Recognizing human walk is emerging as a critically important biometrics, challenging computer vision problem. However, the inclusion of abnormal gait dataset with normal gait databases has to be very useful to classify the normal and abnormal walking style of a person. The silhouettes are trained and tested with K nearest neighbor classifier. We introduce a more challenging abnormal walk patterns like Antalgic gait, Charlie chaplin gait, steppage gait, scissor gait, circumduction gait, inclusive with normal gait data base. The database consists of about 5000 frames with 5 different walk styles. Manual selection of persons with different walking styles resulted in high degree of variability in pose and illumination. The method starts with the extraction of human silhouettes from input videos. Initially the continuous input videos are converted into frame-by-frame by means of conversion algorithm. Each frame consists of noises and shadows. Then silhouettes are removed from noises and discontinuities to produce an abnormal gait database. From the gait data base, parameters are measured by segmenting into six portions from head to neck, neck to torso, hip to knee of both right and left leg, knee to toe of both legs, height of the blob and width has also taken as features for training. The same features extracted with test data has to be compared with trained data for classification. The proposed methodology achieves 77% classification rate for abnormal gait.

Keywords: abnormal walking style, abnormal gait classification, KNN classifier, recognition rate.

1. INTRODUCTION

Due to ever-increasing crime rate, identification using biometrics has turn out to be a significant field of study. When a person wears helmet, spectacles, cloves and mask then it is impossible to capture face, iris, figerprints etc., and then identification using gait may be a suitable and an effective tool to identify a person from a long distance. This paper presents a method which makes a distinction between normal walk and abnormal walk. A person having abnormal gait may be categorize as suspicious and alarming actions may be taken. There are so many experiments have been done on realistic data and system has been trained mostly for normal walk patterns and particular conditions like walk with luggage carrying conditions, walk with different dress codes, different speeds, different walking surfaces and illumination changes with respect to subjects. Experiments have been done on the significance about recognition and identification about the person. In general gait analysis can be categorized as clinical gait analysis and biometric gait analysis. Clinical gait analysis uses collection of kinematic data in controlled environments using motion analysis systems. Motion analysis provides information regarding gait cycle, speed, walking events etc. Biometric gait analysis can be used for authentication purposes because reliable authorization and authentication has become an integral part of every individual’s life for a number of routine applications. Biometric is an automated method of recognizing a person based on a physiological or behavioral characteristic. Gait is a vision-based human identification at a distance and has recently gained wider interest from the computer vision community due to day by day increasing crime rate and intimidation. In the present scenario, Banks, shopping malls, ATM centers, railway stations, airports, bus stands etc, requires protection from unwanted activities. Every person posses his own walking style. Gait cycle of a person is unique, which made gait as one of the biometric. It is the only biometric does not require any nearness sensors. It is the only biometric does not give up any cue to suspected person, like other biometrics, which gives an alert over measuring person.

2. LITERATURE REVIEW

In general gait analysis techniques are classified into two group, they are three dimension model and two dimension model. In two dimensional model approaches, the gait is again classified into two types, one is model based approach and the other is model free (holistic) approach. Various algorithms and parameters are applied into these two types of approaches to recognize the human. Principal Component Analysis uses Eigen values and Eigen vectors to construct the 3D linear model from a set of Fourier coefficients derived from projecting 2D motion sequences on to 3D.

In the Sixteenth century, the person can be identified from a long distance by his walking style itself. In the nineteenth century initially gait and its patterns are analysed only for various medical reasoning and their rehabilitation alone. Gait pattern was used to analyse the mental, physical health of a person. After that gait recognition mainly used for the analysis of health monitoring of athletic and sports men. In recent era gait is a new biometric aimed at recognizing persons by the way they walk. Based on static visual features, swing distances and joint angles of human limbs, the system identifies the patient with Parkinson diseases [4]. The concept of perceived exertion was introduced in the late 1950s with

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methods measuring local fatigue or breathlessness. Perceived exertion is defined by sensations of effort, constraints, uncomforted and fatigue felt by a person when exercising. However, the relevance of measuring perceived exertion in obese patients is still poorly known. So verification of exhaustion and exercise safety and rehabilitation programs for obese patients is required. Genu recurvatum affects between 40 and 68% of hemiparetic stroke patients [6]. From a biomechanical point of view, it occurs during the stance phase. In patients with quadriceps weakness, this phenomenon generates a knee extensor moment which avoids collapse during the stance phase. Fibromyalgia (FM) is an impairment disease that involves systemic chronic pain and its pathogenesis and etiology are still not fully understood. Functionally, FM is a condition frequently accompanied by diminished physical work capacity and muscular fatigue [7]. Indeed, when compared to a control group, subjects with FM show altered gait parameters, characterized by reduced walking speed, cycle frequency, and stride length which are also observed in the elderly. Kinematic deviations are observed in swing phase include decreased peak hip flexion, decreased peak knee flexion throughout swing. Based on static visual, early research was motivated by Johansson's [11] and Barclay's [2] psychological experiments, where participants were able to recognize the type of movement of pedestrians simply from observing the 2D motion pattern generated by light bulbs attached to several joints over their body. The earliest research into computer-vision based gait analysis techniques was published by Sourabh A *et al*. [8], which were based on spatio-temporal analysis and model fitting. Later that year, Yan Guo *et al*. [9] published an algorithm based upon a 10 stick model and neural network classification. James J *et al*. [10] published a gait analysis technique based upon the spatial distribution of optical flow and how it varied over time. Hiroshi Murase *et al*. [14] proposed a technique that compared the Eigen space trajectories between subjects. This concept was later extended by Huang *et al*. [3]. Cunado *et al*. [16] published a model based technique that used the Hough transform to a model to the video frames; results were published on a small dataset recorded indoors, which was to become the first gait dataset widely used by others. James J *et al*. [12] published results of their previous algorithm, James J *et al*. [10] applied to a new dataset recorded outdoors, and this dataset also became very popular in the research community. Other significant milestones include the release of the Gait Challenge dataset and baseline algorithm, provided by south Ampton University (the University of South Ampton's Human ID dataset), Jamie D. Shutler *et al* [13] publicly available datasets and are still used extensively by researchers around the world. Recently CASIA database for gait (china), OU-ISIR gait data base (Osaka university-Japan) are also utilized. This paper includes abnormal gait database combined with normal gait database.

A. Data acquisition

We have considered subjects for our experimentation, having ages 18 and above. The purpose and the necessity about the experiments were explained to individual person who have taken into experiments. All are of male candidates. During experiments subjects were wearing different types of clothes like pant, shirt. The candidates wore shoes and slippers during experiments. They were told to walk on the track shown in Figure-1. The Process Video has been recorded using SONY Handy cam HDR-CX240.It has CMOS sensor with size of 1/5.8 inch. Resolution of "1920 x 1080", "1440 x 1080", frame rate of 60 pixels. The distance between camera and track was around 25 feet and length of track was 20 feet. Every person's walk was recorded. Gait cycle of different walk pattern also calculated. It is calculated by identifying the duration from toe on to toe on of same leg.

Video to frame conversion

Three minutes of continuous walk converted around1200 frames in JPEG (. jpg) format with frame size of 1920x1080. The background model has subtracted from original frame. The resultant frame consist only the foreground object. Then the foreground image is converted into silhouettes. The silhouettes are consisting of noises and shadows. Real time challenges in the real video sequences, we have faced the difficulties with shadows, illumination changes.

B. Research gap

In real time emotions of different persons may be different. So the requirement about the real time should adopt the real time conditions like various speed of walk, various dress code, and different walking conditions. But still there is a gap between how system will categorize the gait of an identified person as abnormal or dubious person.

3. PROPOSED METHOD

A. Background subtraction

a. Aim

In order to perform the gait analysis from the real time video frames, the subject needs to be taking out from the video sequence. Image segmentation is the process which is used to separate dynamic objects such as people.

One of the most common and easiest methods for performing segmentation is to perform image subtraction technique .The known background image is subtracted from the current picture frame which initially compare the intensities of connecting pixels, then threshold is applied into this. A pixel is considered as a part of the foreground when the current pixel value differs from its mean value by more than a pre defined threshold valueφ.

$$f(x,y)=\begin{cases} background, & if \quad abs(I_{current}(x,y)-I_{known}(x,y))\le \phi \\ foreground, & otherwise \end{cases}$$

b. Feature extraction

The proposed methodology uses height and width; six angles such as head to neck, neck to torso, hip

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to knee of both legs, knee to foot angle of both legs were computed.

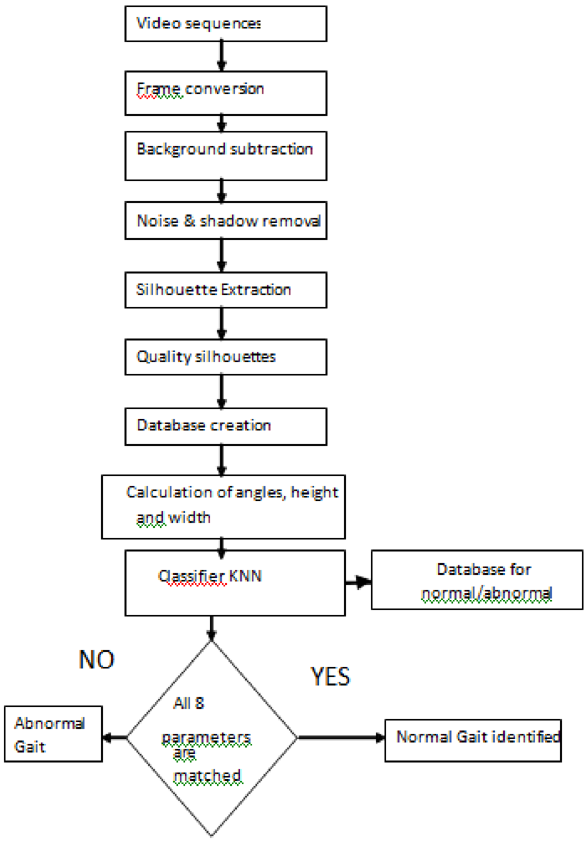

Figure-1. Flow chart for normal and abnormal gait classification.

1) Height and width calculation

Maximum height (H) and maximum width (W) can be measured from silhouettes. When a person moves towards the camera, the height value is increased. Similarly, when a person is away from the camera, the frame height continuously decreases. Variation of height and width can be evaluated by defining the bounding box and the centroid point for each observed body is calculated. The height and width of box alters in a gait cycle.

Let $H_1, H_2, \ldots H_N$ be the height of skeleton in a gait cycle. Then the maximum height of the person in the entire silhouettes is denoted as $H_{max} = \max(H_1, H_2 \ldots H_N)$. The variation of the width is important cue for gait analysis, as it contains structural and dynamical information about the gait. When the person is in middle stance position, the space between the two legs is small and hence the width is minimum. The maximum width is attained, when a person walks by swinging his arms. Let $W1, W_2 \ldots W_N$ be the width of skeleton in a gait cycle. Then the maximum spacing between two legs for a person is denoted as

$W_{max} = \max(W_1, W_2, \ldots W_N)$.

The centroid (X_c, Y_c) of the human silhouette is calculated by using the following equations

$$X_c = \frac{1}{N}\sum_{i=1}^{N} X_i \quad (1)$$

$$Y_c = \frac{1}{N}\sum_{j=1}^{N} Y_i \quad (2)$$

where (X_c, Y_c) represents the average contour pixel position. (X_i, Y_i) represents points on the human blob, N- Total number of points on the contour.

2) Angle calculation

The angles are calculated by the following procedure. The input silhouettes are applied into Fourier transform. The resultant Fourier coefficients are given to Radon transform, to produce a rotation invariant image features. Applying Radon transform, it is possible to create a mapping between (x, y) domain to the radon domain of (r, θ). During human walking, a large variation exists at leg portion. Since the variation is higher, the output of the Radon coefficients is also higher in its value, and it is very suitable for feature vectors. The radon transform of a skeleton image $f(x, y)$ denoted as $R(r, \theta)$ where r defined by a normal distance from the origin, θ as a normal angle. Radon transform point

$$R(r,\theta)[f(x,y)] = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x,y)\delta(r - x\cos\theta - y\sin\theta)dxdy \quad (3)$$

Where $-\infty < r < \infty, 0 < \theta < \pi$

The angles from head to neck, neck to torso, hip to knee of both legs, knee to toe of two legs were calculated as feature vectors for each person. It has been calculated and stored in database. Nearest neighbor technique has been

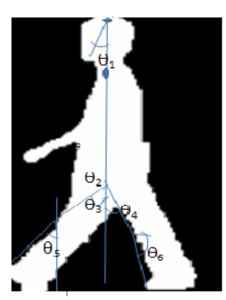

Figure-2. exhaustive angle from head to neck -θ_1, neck to torso - θ_2, hip to knee (θ_3, θ_4), knee to toe (θ_5, θ_6).

used to classify the image belongs to class1 (person with normal walk), class 2 (person with abnormal walk) or other one (a doubtful person). MATLAB programming

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has been used to simulate the process. The Figure-2. Shows separation of six angles process has been shown in Figure-2

Figure-3. Background.

C. Pattern classification

Once the gait feature has been extracted from the person, it will be projected into a feature space and then classified.

A classifier defines boundaries in a feature space which are used to separate different sample classes from each other in the data. The simplest type of classifier is a linear classifier. This is a straight line which is defined in the feature space, points above the line are in one class, and points below the line are placed into another class. This is a simple method and unable to provide the best results due to small non-linear fluctuations around the boundary region which result in poor classification results. An improvement on this method is called the K-Nearest Neighbour (KNN) classification.

D. K-Nearest Neighbour classifier

A feature vector of unknown class can be classified as belonging to a class by using the k-nearest neighbour rule. A training set of points (i.e. feature vectors projected in eigenspace) T is used to determine the classification of feature vector X, by the following method: 1. Calculate the k-nearest points to the unclassified feature vector X in the feature vector set T. There are a number of distance measures which can be used to calculate the separation of two points in n-dimensional space.

2) Determine the class which has the most points in the k selected points, from set T

4. RESULTS AND DISCUSSION

A. Antalgic Gait

B. Charlie chaplin

C. Circumduction Gait

D. Scissors Gait

E. Steppage Gait

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Table-1. Classification rate.

Person	Classification rate (KNN)
Normal gait	90
Abnormal gait	77

5. CONCLUSIONS

In this proposed work we introduce the abnormal gait database. The gait pattern was classified as normal or abnormal using KNN classifier. The classifier recognizes walk with 77% classification rate. Lower classification rate was obtained because of irregularity made by the two legs.

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