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Gait Recognition using Hough Transform and DWT

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Abstract: The process of verifying a person's identity, also called authentication, plays an important role in various areas of everyday life. More important, by the early recognition of suspicious individuals who may pose security threats, the system would be able to reduce future crime. Biometric methods for verifying, i.e. authenticating, someone's identity are increasingly being used. Today's commercially available biometric systems show good reliability. However, they generally lack user acceptance. Users show an antipathy touching a fingerprint scanner and they dislike looking into an iris scanner that might eventually malfunction and impair their vision. In general, they favour systems with the least amount of interaction. Using gait as a biometric feature would lessen such problems since it requires no subject interaction other than walking by. Consequently, this would increase user acceptance. And since highly motivated users achieve higher recognition scores, it increases the overall recognition rate as well. Gait recognition has the potential to overcome most of the limitations that other biometrics suffer from such as face, fingerprints, and iris recognition etc.

I. INTRODUCTION

Gait is a new biometric technique, to classify individuals by the way they walk. In order to achieve a high recognition rate, discriminative features must be extracted from the available data. It seems obvious to try to recognise people through their stride length, walking cadence, body weight, body height, and so forth. However tempting the aforementioned features might be, they are not ideal for a biometric system. In fact, they are highly insecure due to their static nature, that allows an impostor to easily mimic them; e.g. an impostor can easily adjust his body weight, stride length, and cadence to match that of a legitimate user and try to gain access to a restricted area. Conversely, the dynamic properties of human gait are far more difficult to imitate, since they depend on physiological properties of the user's body, such as bone structure. The use of dynamic properties of human gait is therefore considered in this paper.

In my work as stated above dynamic features are used for gait analysis. Three or four extracted features are sufficient to determine human gait. So in this paper the mostly used gait feature knee angle of left and right knee is used. The foot distance is another feature as whether the human is injured at feet, drunk or in other circumstances in which his/her normal walking is changed; the foot distance between toe of one leg to other leg's ankle will remain same in major cases. One more important feature that is left untouched even in literature as per my knowledge is palm angle. The hand movement is also unique body gesture of every human.

.II. PROCESS FLOW FOR GAIT

RECOGINITION

The complete proposed algorithm for gait analysis is shown in the form of flow chart.

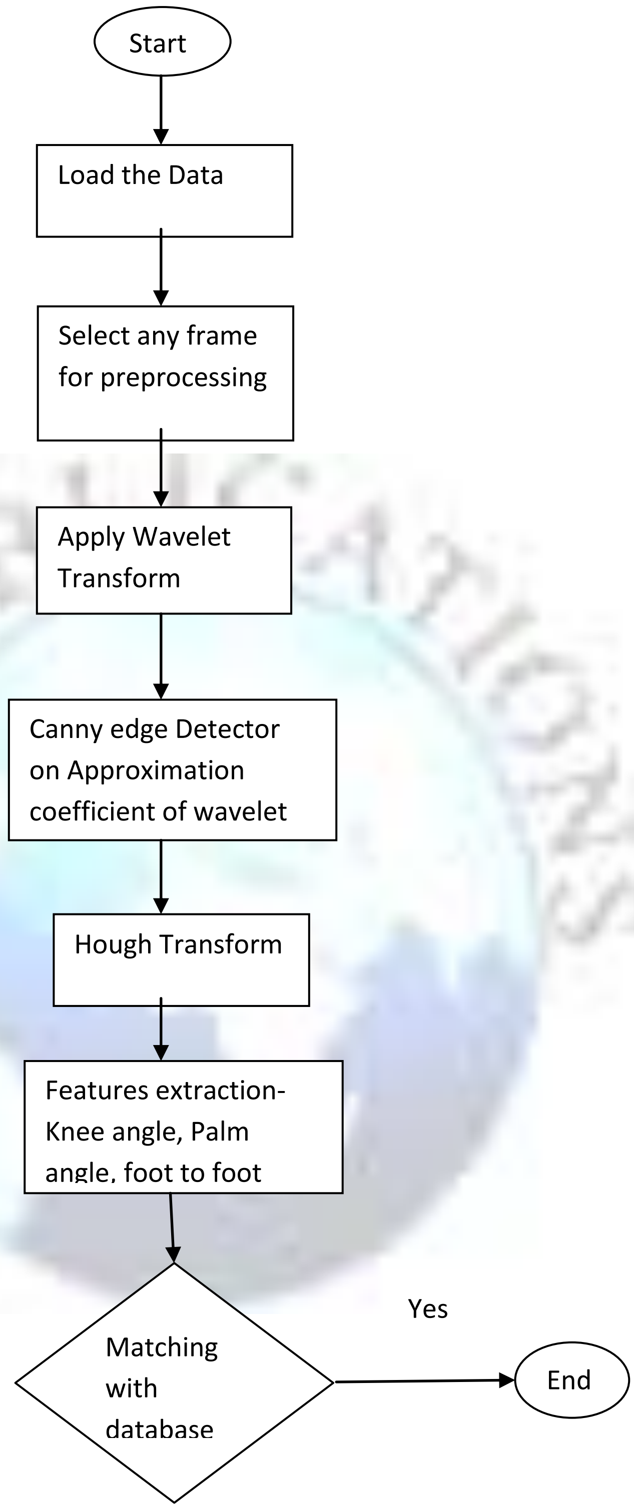

Figure-1

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III. DISCRETE WAVELET TRANSFOM

Discrete Wavelet transform detects the exact instant when signal changes. The DWT of images is a transform based on the tree structure with D levels that can be implemented by using an appropriate bank of filters. It consists of alternating one decomposition by rows and another one by columns, iterating only on the low-pass sub-image. The resulting decomposition is visible in the figure 4.3

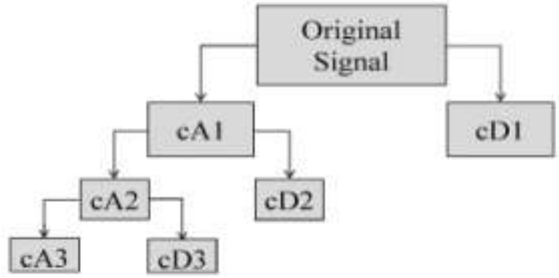

Figure 2: Decomposition of Wavelet transform

The DWT of a signal x is calculated by passing it through a series of filters. First the samples are passed through a low pass filter with impulse response g resulting in a convolution of the two:

$$y[n] = (x * g)[n] = \sum_{k=-\infty}^{\infty} x[k]g[n-k].$$

The signal is also decomposed simultaneously using a high-pass filter h. The outputs giving the detail coefficients (from the high-pass filter) and approximation coefficients (from the low-pass). It is important that the two filters are related to each other and they are known as a quadrature mirror filter.

However, since half the frequencies of the signal have now been removed, half the samples can be discarded according sssss Nyquist's rule. The filter outputs are then subsample by 2 (Mallat's and the common notation is the opposite, g- high pass and h- low pass):

$$y_{\mathrm{low}}[n] = \sum_{k=-\infty}^{\infty} x[k]h[2n-k]$$
$$y_{\mathrm{high}}[n] = \sum_{k=-\infty}^{\infty} x[k]g[2n-k]$$

This decomposition has halved the time resolution since only half of each filter output characterises the signal. However, each output has half the frequency band of the input so the frequency resolution has been doubled.

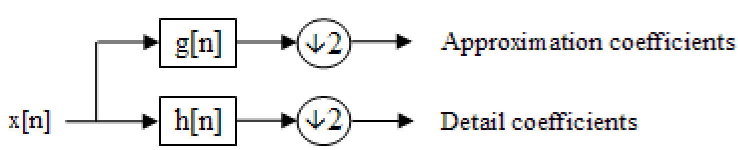

Figure 2.1: Block diagram of DWT filter analysis

With the sub sampling operator $\downarrow$
$$(y \downarrow k)[n] = y[kn]$$
the above summation can be written more concisely.
$$y_{\mathrm{low}} = (x * g) \downarrow 2$$
$$y_{\mathrm{high}} = (x * h) \downarrow 2$$

However computing a complete convolution $x * g$ with subsequent downsampling would waste computation time.

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IV. Hough Transform

The Hough transform is a feature extraction technique used in image analysis, computer vision, and digital image processing. The purpose of the technique is to find imperfect instances of objects within a certain class of shapes by a voting procedure. This voting procedure is carried out in a parameter space, from which object candidates are obtained as local maxima in a so-called accumulator space that is explicitly constructed by the algorithm for computing the Hough transform. Hough performs groupings of edge points into object candidates by performing an explicit voting procedure over a set of parameterized image objects.

The simplest case of Hough transform is the linear transform for detecting straight lines. In the image space, the straight line can be described as $y = mx + b$ and can be graphically plotted for each pair of image points (x, y) [6]. In the Hough transform the characteristics of the straight line is considered in terms of its parameters, i.e., the slope parameter m and the intercept parameter b. Based on that fact, the straight line $y = mx + b$ can be represented as a point (b, m) in the parameter space. However, one faces the problem that vertical lines give rise to unbounded values of the parameters m and b. For computational reasons, it is therefore better to use a different pair of parameters, denoted r and θ (theta), for the lines in the Hough transform. The parameter r represents the distance between the line and the origin, while θ is the angle of the vector from the origin to this closest point. Using this parameterization, the equation of the line can be written as which can be rearranged to;

$$r = x\cos\theta + y\sin\theta$$

The (r,θ) plane is sometimes referred to as Hough space for the set of straight lines in two dimensions where r (the distance between the line and the origin) is determined by θ. This corresponds to a sinusoidal curve in the (r,θ) plane, which is unique to that point. In our approach, the output of the Hough transform rho(r) is used as another feature extraction technique. This value of r is found to be unique and hence could be used directly for matching.

V. RESULTS AND DISCUSSION

A toolbox for gait analysis is designed in MATLAB. It allows selecting desired frame from database. Database for our work is imported from the home page of Shuai Zheng, a DPhil student at University of Oxford. We have selected frames captured of a man moving from left to right and from right to left

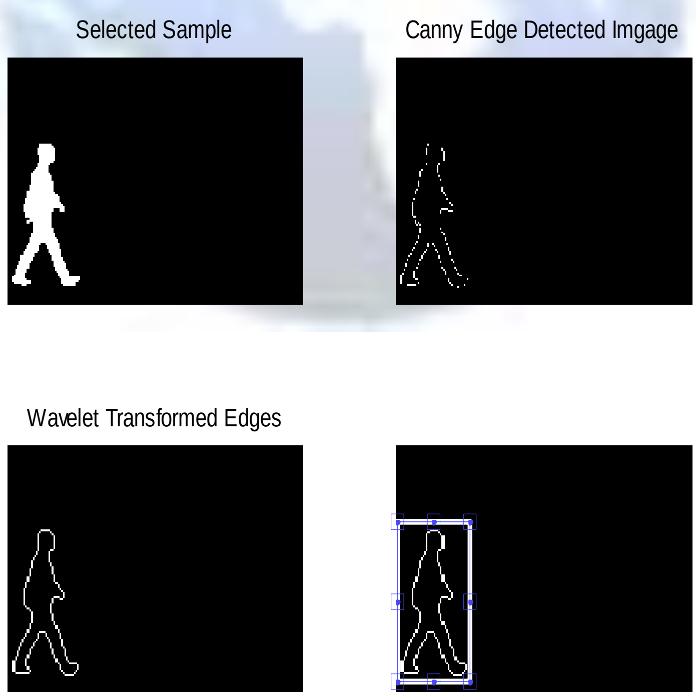

Figure 3: Skeleton part selected for Hough Transform

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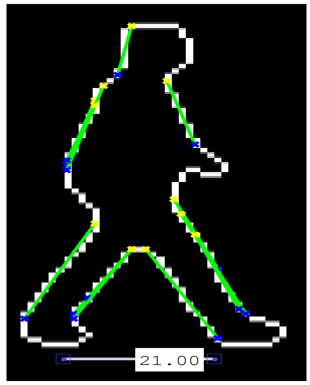

Figure 4: Hough transform lines displayed over skeleton

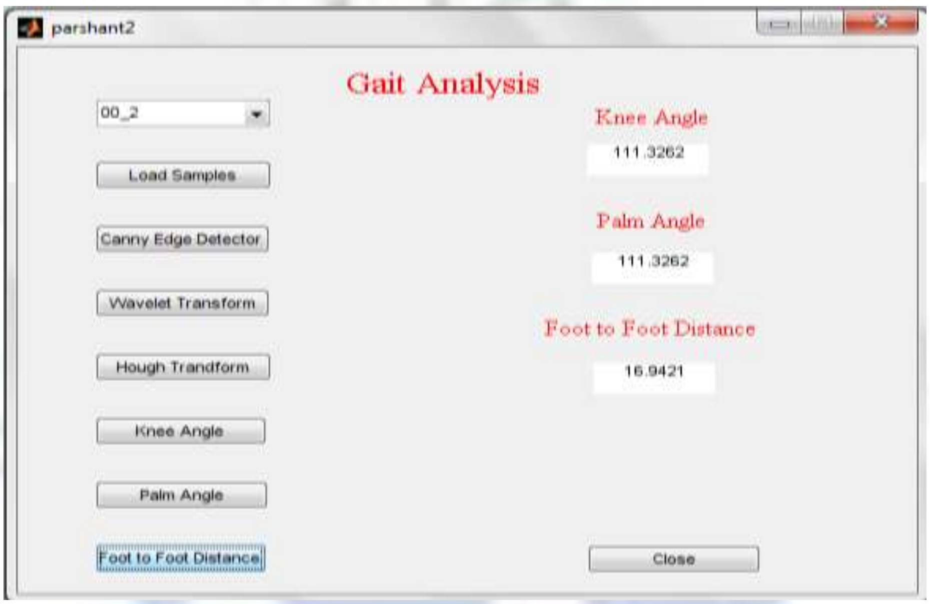

Figure 5: Toolbox GUI showing foot to foot distance

Table 1: Knee angle in different frames

Frame No.	Front Knee Angle	Frame No.	Back Knee Angle
1	89.8629	5	56.9761
2	103.6658	6	45.3031
3	116.4625	7	38.3867
4	123.0667	8	30.5826

Table 2: Palm angle in different frames

Frame No.	Palm Angle
1	121.9642
2	132.1136
3	125.8195
4	135.9392

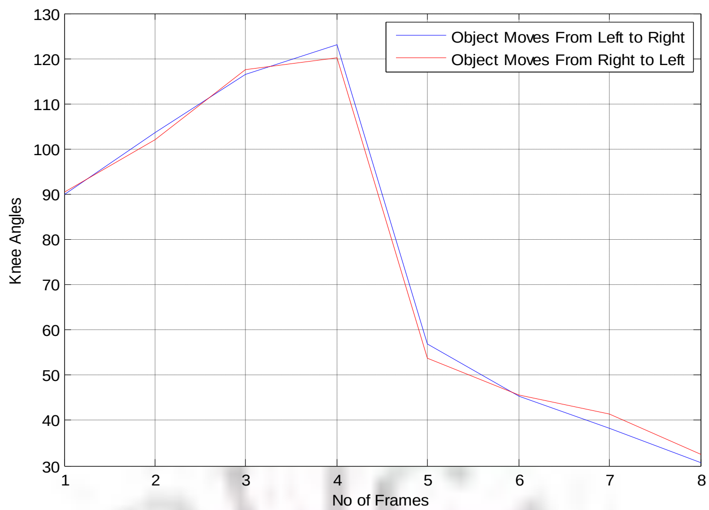

Figure 6: Graph showing comparison of knee angles in case of two moving directions of a same object

The aim of this paper is to extract human gaits correctly. For this purpose the first problem is to identify the gait features which are can be captured from at a distance and which are more secure which means which are difficult to follow by imposter. It was found that knee angle, palm angle and foot to foot distance are such features which are unique to every human and very difficult to copy. In literature canny edge detection was used for image pre processing but it was giving errorneous edges. To extract features correctly errorneous results wavelet transform is applied on captured frame and then canny edge detection is applied as wavelet transform detects the exact instant when the signal changes and categorise that into different energy coefficients. The limitations of canny edge detection were removed by this step. Hough transform successfully extracted features form the edges. I previous work till now no one has given freedom to user to select the joint angles which are to be extracted. But here in my work it is made customised. User can select the which knee angle is to be measured and by drawing a reference line along the hough line, that can be measured. Frame data of a same person is captured when he moves form right to left and vice versa. The foot to foot distance in both cases was almost equal. That proves at least foot to foot distance is the feature that can't be varied in many conditions.

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