

# Identification of People Using Gait Biometrics

Sanjeev Sharma, Ritu Tiwari, Anupam shukla and Vikas Singh

**Abstract-** Gait shows a particular way or manner of moving on foot and gait recognition is the process of identifying an individual by the manner in which they walk. Gait is less unobtrusive biometric, which offers the possibility to identify people at a distance, without any interaction or co-operation from the subject; this is the property which makes it so attractive. This paper proposed new method for gait recognition. In this method, firstly binary silhouette of a walking person is detected from each frame. Secondly, feature from each frame is extracted using image processing operation. Here center of mass, step size length, and cycle length are talking as key feature. At last neural network is used for training and testing purpose. We have created different model of neural network based on hidden layer, selection of training algorithm and setting the different parameter for training. Here all experiments are done on CASIA gait database. Different groups of training and testing dataset give different results. The best recognition result for our method is 96.32%.

Gait recognition is one kind of biometric technology that can be used to monitor people without their cooperation. Controlled environments such as banks, military installations and even airports need to be able to quickly detect threats and provide differing levels of access to different user groups.

**Index Terms-** Center of mass, Feature extraction, Gait recognition, Human identification, Neural network.

## I. INTRODUCTION

Recognition of an individual is an important task to identify people. Identification through biometric is a better way because it associate with individual not with information passing from one place to another. Biometrics is a physiological or behavioral characteristic, which can be used to identify and verify the identity of an individual. There are numerous biometric measures which can be used to help derive an individual identity. They are physiological, like fingerprints, face recognition, iris-scans and hand scans and behavioral, like keystroke-scan and speech patterns. Gait recognition is relatively new biometric identification technology which aims to identify people at a distance by the way they walk. It has the advantage of being unobtrusive, difficult to conceal, noninvasive and effective from a distance. Human gait recognition as a new biometric aimed to

recognize person via the style of people walking, which contain the physiological or behavioral characteristics of human.

In [1], the literature describes the general method and development actuality of gait recognition, they describe three methods of gait recognition, which include statistical based method, model based method and fusion based method. The statistical based method characterizes body movement by the statistic of the space temporal pattern generated in the image sequence by the locomotive person. The advantages of this method are low computational cost and less time consuming. Model based method constructs human model to recover explicit features describing gait dynamics such as stride dimensions and the kinematics, of joint angle. The advantage of this method is the ability to drive gait signature from model parameter and free from the effect of the different clothing and view point. However, it is time consuming and costly [5]. Fusion is combination of both statistical and model based method.

In the previous work many method has been proposed for solving gait analysis. Which include analysis of subject trajectory, velocity movements, discrete symmetric operator, continuous HMM [2] and some other approach based on kinematics and dynamics model.

Han and Bhanu [3] use gait energy image for gait analysis. They used statistical feature extraction approach for learning effective feature and feature fusion strategy is used to improve recognition. In [4], Eigenspace transformation based on Principal Component Analysis (PCA) is applied to reduce the dimensionality of the input feature space. Then supervised pattern classification techniques are finally performed in the lower-dimensional eigenspace for recognition. Su and Zanga [5] use fuzzy principal component for recognition. Firstly they processed the original gait sequence and gait energy image is obtained then Eigen value and Eigen vector are extracted by fuzzy principal component analysis, which are called fuzzy logic. Finally NN classier is utilized in feature classification. In [6], proposed low resolution method used manifold sampling, back projection and multi linear tensor based learning without tuning parameter. Davrondzhon proposed important gait recognition using cycle matching in which they use wearable accelerometer, to record ankle motion for measuring cycle [7].

In [17], presents an original 3D approach for automatic gait recognition based on analyzing image sequences captured by stereo vision. Contour matching is done after binarized silhouette of a moving individual is firstly achieved in order to get 3D contour. Then, stereo gait feature (SGF) which is the norm of stereo silhouette vector (SSV) is extracted from

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3D contour Principal Component Analysis (PCA) is adopted for dimensionality reduction. Finally, NN and ENN is applied for classifying and distinguishing.

In order for the biometrics to be ultra secure and to provide more than average accuracy more than one form of biometrics requires. Hence the need arises for the use of multimodal biometrics. This uses a combination of different biometrics recognition technologies. Multimodal biometrics technology uses more than one biometric identifier to compare the identity of the person. When designing a multimodal biometrics system, two factors should be considered: (a) the choice of biometric traits; (b) the level at which information should be fused [19].

In this paper special signature like center of mass, cycle length and step size length of individual from each frame are used as feature vector of person that represents pattern in a concise way and that are particularly well suited for recognition of gait. Different group of data is taking as training and testing. Neural network is using as recognition tool.

The rest of the paper is organized as follows. Section II describes the proposed method in which silhouette extraction, feature extraction process is explained. Section III explains the overall gait recognition system. Network structure is explained in section IV. Section V introduces the training and testing procedure. In section VI, experimental result is presented, finally, we conclude in section VII.

## II. THE PROPOSED METHOD

Biometrics recognition system involves the preprocessing task. In biometric gait recognition system the database to be collected is in video form, so frame of walking person to be created. These frame to be converted into silhouette. Major preprocessing tasks in gait recognition system are silhouette extraction and features extraction. Silhouette from frame can be extracted using the image processing operation. These processes are described follows:

### A. Silhouette extraction

The motional individual silhouette must be detected before getting the gait feature. Back ground subtraction is the relatively simple and new approach to find silhouette from image.

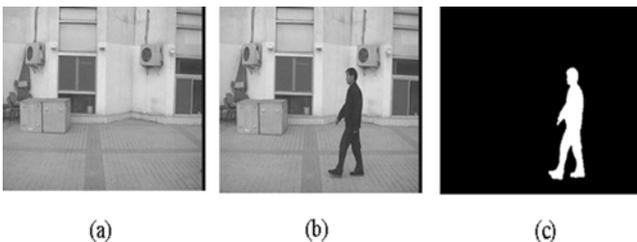


Fig. 1. Example of gait detection. (a) Background image; (b) Original image; and (c) Extracted silhouette

In our experiment the camera is assumed to be static and that body in the field of view is not occluded from each frame. The whole process of silhouette extraction is described as follows:

- To obtain an approximate background from the image sequence of a walking people, first mean image is computed by averaging the gray-level at each pixel over the entire image sequence (in Fig.1 (b)). Let  $I_k(x,y)$ ,  $k=1,2,\dots, N$ , represent sequence of  $N$  images. Background images  $b(x,y)$  can be computed by

$$b(x,y) = \text{median} ( I_k(x,y) ), \quad k = 1,2, \dots, N \quad (1)$$

- Moving object is extracted by back ground subtraction.
- Image processing operation likes Erosion, dilation are applied to improve the quality of extracted silhouette, and reduce noise.

### B. Feature extraction

Feature is defined as a function of one or more quality of objects that are capable to distinguish object from each other. Our gait image feature vector is comprised of parameters of moment features in image regions containing the walking person. Gait feature extraction is the very important tasks in human gait recognition. It must be reasonably robust to the varying conditions, and should be capable of describe the quality of individuals. Intuitively, the silhouette appears to be a good feature to utilize since it captures the motion of most of the body parts and also encodes structural as well as transitional information. Particularly, it is independent of the clothing, illumination and textures etc. Since now we have database in silhouette form, silhouette show most of the body part so we can extract feature from this silhouette.

Two basic feature extraction techniques are classified as feature based and holistic method [18]. Feature based method select individual features and characterization of geometrical relationship. Holistic method such as principal component, linear discriminant analysis and independent component analysis used appearance information extracted from entire image. Holistic feature extraction methods find feature with reduced dimensionality by projecting and original data onto the basic vectors. These extracted features can improve classification performance by reducing irrelevant feature from the data set. Selection of important features and eliminate irrelevant features play important role in recognition and computation process.

A feature vector is one method to represent feature of image, or part of an image (an object), by carrying out measurements on a set of features. The feature vector is an  $n$  dimensional vector that contains these measurements. This vector can be used to classify an object or to provide us with condensed higher-level image information. A feature is robust if it will provide consistent results across the entire application domain.

The images we analyze are stored in the form of a two-

dimensional data array, in which each datum is referred to as a pixel (picture element). We refer an individual pixel located at row  $i$  and column  $j$  by the notation [8]:

$B(i, j)$  = the brightness of the image at the point  $(i, j)$

At the time of walking, the human body center of mass change from instance to instance so we are using center of mass as a feature this center of mass show the brighted weighted average of  $x$  and  $y$  coordinates pixels in the frame. Center of mass of the white pixels area for binary images is the same as the center of mass if we consider the intensity at a point as the mass of that point. In binary image we can calculate center of mass coordinate by using following formula.

$$\bar{x} = \frac{\sum_{i=0}^n \sum_{j=0}^m j * B(i, j)}{A} \quad (2)$$

$$\bar{y} = \frac{\sum_{i=0}^n \sum_{j=0}^m i * B(i, j)}{A} \quad (3)$$

Here  $\bar{x}$  and  $\bar{y}$  are center of mass points in image.

Here  $m$  and  $n$  is dimension of matrix which store image in matrix form,  $A$  is the area of region, it can be calculated by following formula:

$$A = \sum_{i=0}^n \sum_{j=0}^m B(i, j) \quad (4)$$

Another feature of gait is its periodicity [10]. By observing, the width of the silhouette was changing periodically with the time-lapse. The width of the silhouette will reach a maximum when the two legs are farthest apart (full stride stance) and drop to a minimum when the legs overlap (heels together stance). At the same time, the height of silhouette has slight change in the procedure. Consequently, we can get the estimation of gait cycle.

For calculating step size length and cycle length, we are using boundary box technique. In silhouette boundary box is created, so that cover whole object from outside and its right edge boundary touches the back foot back end and left edge touches the front foot front end [9], this boundary box width recorded as step size length.

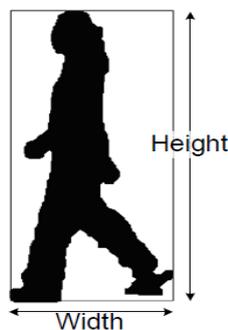


Fig. 2. Boundary box to measure width

Gait cycle is one way to specify people. For particular person it begins when one foot contacts the ground and ends when that foot contacts the ground again. Thus, each cycle begins at initial contact with a stance phase and proceeds through a swing phase until the cycle ends with the limb's next initial contact. Stance phase accounts for approximately 60 percent, and swing phase for approximately 40 percent, of a single gait cycle.

For calculating cycle length we are created stack of frame. Fig 3 shows the complete gait cycle.



Fig. 3. Gait cycle

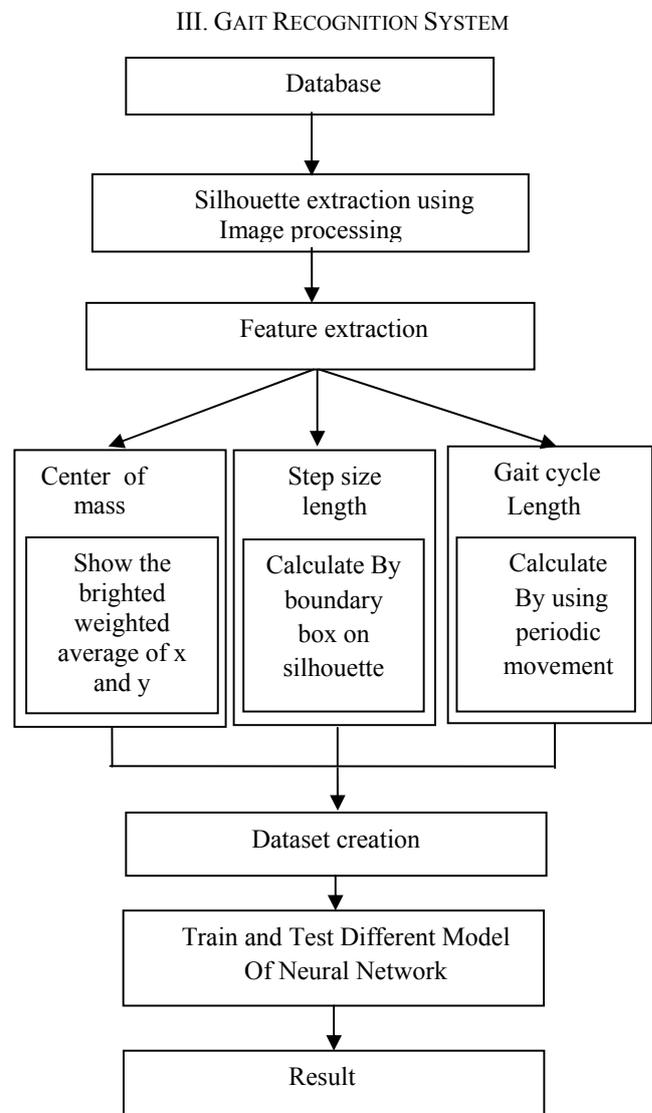


Fig. 4. Block diagram of training and testing phase

Gait recognition for our algorithm is shown in figure 4. Firstly video database is captured by a camera. After that motion detection and segmentation methods are applied to detect and segment walking person in video and silhouette is created for segmented image. Image processing operations are applied to extract the feature for each silhouette. These features represent the special characteristic of walking person. This shows the feature vector. Dataset is created for extracted feature. This paper adopts the neural network for classification. Here feed forward back propagation neural network is created. Many neural networks are created for different group of data set, and check the performance of each created networks. Highest recognition rate is 96.32%.

#### IV. NETWORK STRUCTURE

A neural network can be seen as machine that is designed to model the way in which the brain perform a particular task or function of interest. By offering useful properties and capabilities, i. e. nonlinearity, input output mapping, neural network can be applied in many field. Neural networks have been used among others to identify system as well as data classification techniques with significant success rate.

In this paper neural network is used as a classifier. It is capable of forming arbitrarily decision boundaries but its performance depends on the network architecture. Using neural network as classifier gives some advantage. First, neural network are data driven self adaptive methods in that they can adjust themselves to the data without any explicit function. Second, it is function approximation technique in that network can approximate any function. Third, it is nonlinear model, which can model real world problem. Finally, neural networks are able to estimate the posterior probability, which provides the basic of estimating classification rule. Neural network composes of input layer, hidden layer and output layer [11, 15, 16]. Particular network architecture defined two things, first is the number of hidden layer and second is the number of neuron in each layer. Based on these two things we can create many network architecture, other than these two we can also define different network model and also use different training algorithm. Good architecture determined by experiment result.

Design of neural network involves the selection of its model, architecture, learning algorithm, and activation function. For Gait recognition problem Back propagation neural network can be used with one or more hidden layer. Hidden layer is use to reduce complexity and increase computational efficiency.

##### A. Input layer

This layer takes the inputs (the values we pass) and forwards it to hidden layer. Input layer for created neural network is determined by characteristics of inputs. We have four attribute feature vector. So number of neuron in input layer is four.

##### B. Hidden layer

Hidden layer automatically extracts the feature of the input pattern [12]. There is no definite rule to find the number of neuron in hidden layer. So, it is hit and trial method. Where network to be tested with different neuron in hidden layer. We were found that 40 neuron hidden layer could accomplish the task with good recognition rate.

For hidden layer hyperbolic tangent sigmoid transfer function is used. At the hidden layer it is used to calculate network output from its input. The tangent hyperbolic function and its fast approximation is given by following equation.

$$a_{i1} = \text{tansig}(n_{i1}) = \frac{2}{\exp(-2 n_{i1}) + 1} - 1 \quad (5)$$

where  $a_{i1}$  is  $i^{\text{th}}$  element of  $a_1$  vector contains output from the hidden neurons.  $n_{i1}$  is the  $i^{\text{th}}$  element of  $n_1$  vector containing net input going into the hidden units.  $n_1$  is calculated by using the following formula.

$$n_1 = w_{10} p + b_1 \quad (6)$$

where  $p$  is input pattern  $b_1$  is the vector of bias.  $w_{10}$  is the weight matrix between hidden layer and output layer.

##### C. Output layer

Output layer is designed based on the required output of neural network. Here we are talking 25 subject data, so number of neuron in outputs layer is 25. Pure linear activation function is selected for output, given by following equation.

$$a_2 = n_2 \quad (7)$$

where  $a_2$  is the column vector coming from output layer.  $n_2$  is the output net inputs going into the output layer can be calculated by using following formula:

$$n_2 = w_{21} a_1 + b_2 \quad (8)$$

where  $b_2$  is the bias at second layer,  $w_{21}$  is the synaptic weights at hidden layer and output layer,  $a_1$  is the column vector.

Figure 5 shows the network structure with one input layer, one hidden layer, and one output layer. It is  $4 \times 40 \times 25$  network structure.  $x = [x_1, x_2, x_3, x_4]$  is the training sample and network input.  $y = [y_1, y_2, y_3, \dots, y_{25}]$  is the output vector.

Two important parameters are learning rate and weight range that can influence the performance the performance of neural networks.

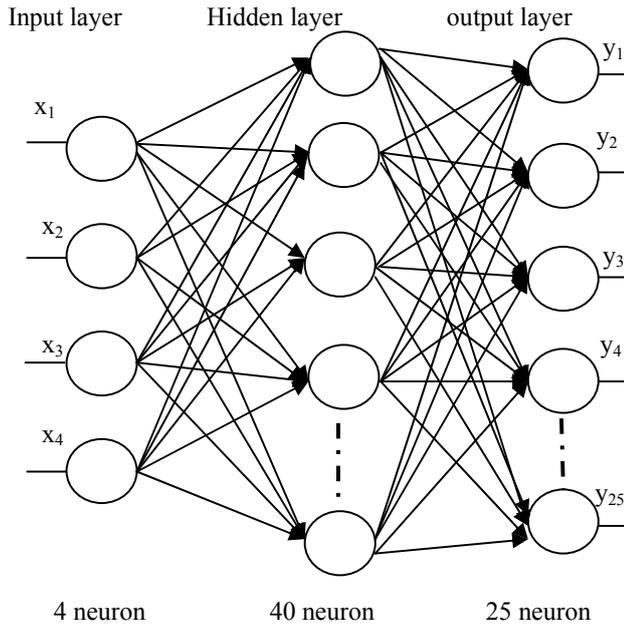


Fig. 5. structure of neural network

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#### D. Feed Forward Back Propagation Neural Network

One of the most commonly used supervised ANN model is back propagation network that uses back propagation learning algorithm. Back propagation was created by generalizing the Widrow – Hoff learning rule to multiple layer network and non linear differentiable transfer function. Input vectors and corresponding target vectors are used to train a network until it can approximate a function, associate input vectors with specific output vectors, or classify input vectors in an appropriate way as defined in this study. Networks with biases, a sigmoid layer and a linear output layer are capable of approximating any function with a finite number of discontinuities. The back propagation algorithm consists of two paths; forward path and backward path. Forward path contain creating a feed forward network, initializing weight, simulation and training the network. The network weights and biases are updated in backward path.

Before training a feed forward back propagation network [13], the weight and bias, must be initialized. Once weight and bias have been initialed the network is ready to train. For training of neural network, proper inputs and targets is needed as outputs. During training process, the weights and biases of network is to be adjusted, so network performance function to be minimized. Many algorithm are available for training neural network, these algorithm uses gradient of performance function to determine how to adjust weight to minimize

performance function. An iteration of this algorithm can be written

$$x_{k+1} = x_k - \alpha_k g_k \quad (9)$$

where,  $x_k$  is vector of current weights and biases,  $g_k$  is the current gradient, and  $\alpha_k$  is the learning rate.

Learning algorithm can be implemented in two modes either batch mode or incremental mode. In the batch mode all inputs are applied to the network before the weights are updated. In incremental mode, the gradient is computed and weights are updated after each input is applied to the network. In this paper Levenberg-Marquardt training (trainLm) algorithm is using to learn neural network. It is faster and more accurate than other. It is operate in batch mode.

#### V. TRAINING AND TESTING DATASETS

This paper uses the above ANN architecture, feed forward back propagation learning algorithm to create, train and test the neural network for gait recognition. In addition, MATLAB software with its neural network toolbox is used. The original data sets contains 1250 instance of 25 subjects where each subject has 50 sequence instances. This data is sets group into different data sets as shown in table I. Each set is portioned into two subsets, training set and testing set. In this analysis, the transfer function between input layer and hidden layer is tangent sigmoid function tensing, and one between hidden layer and output layer is linear function purelin.

TABLE I: DATA SETS GROUP

Data set Group name	Training %tage	Testing %tage	Training instances	Testing instances
Data set 1	80	20	1000	250
Data set 2	90	10	1125	125
Data set 3	60	40	750	500

#### VI. EXPERIMENT AND RESULT

We performed experiment on CASIA gait database [14]. This database is divided into 3 set, Dataset A, Dataset B (multiview dataset) and Dataset C (infrared dataset). Here we are using data set B. Data set B contain 124 subjects and the gait data was captured in 11 views. In this paper we are taking 25 subject gait database in which view angle is  $90^\circ$ , where people are walking from right to left. Here 50 frame of each subject is taking for training and testing. Experiments performed on Matlab. Feed forward back propagation neural network are used for training and testing. Training algorithm is Levenberg- Marquardt, performance is measure by mean square error, data division is random. Data set is divided in to groups DS1, DS2, and DS3 as shown in table II. Default values are taking for learning rate and weight range. Results

are marked as bold for the best performance. The results show that the best classification accuracy is 96.32% for dataset 1 with two hidden layers. Fig. 6, Fig 7, Fig. 8 respectively show performance plot, regression plot and training state graph for highest performance.

TABLE II: DATA SETS RESULTS FOR BACK PROPAGATION

Dataset name	Number of Hidden layer	Classification accuracy	epoch
Data set 1	1	69.9	71
	2	96.32	101
	3	94.32	34
Data set 2	1	90.84	50
	2	90.27	20
	3	74.14	51
Data set 3	1	78.8	25
	2	80.9	26
	3	90.26	42

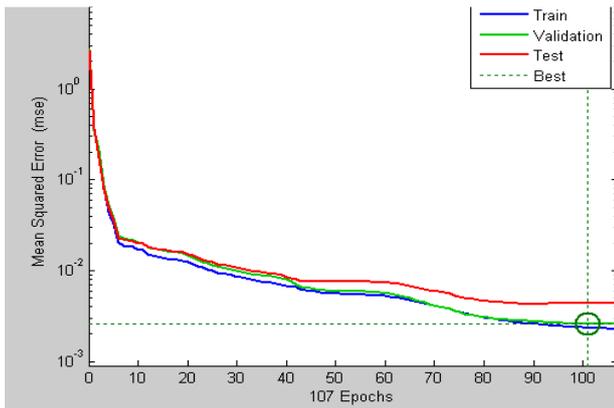


Fig. 6. performance plot

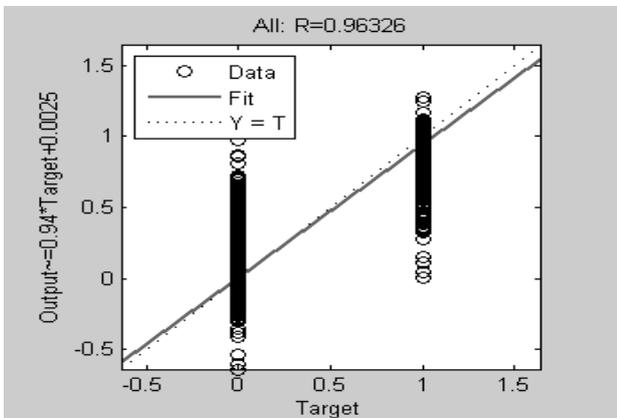


Fig. 7. Regression graph for highest performance

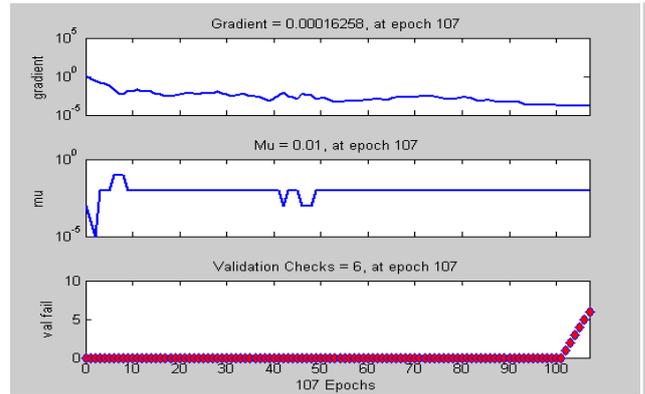


Fig. 8. Training state graph

### VII. CONCLUSION AND FUTURE WORK

This paper presents a gait recognition approach using specific features, like center of mass, step size length and cycle length. Here neural network is being used for recognizing people. Our results show that these features are more effective to identify people from distance. Recognition rate for our method is 96.32%.

The work can be extended to develop new multimodal biometric [20] system in which, gait can be combined with other biometrics system. So it can be use as one of the good reliable way of authentication.

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