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Gait Based Human Identification in Bad Illumination

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Abstract

Vision–based human identification in bad illumination is one of the challenge. Gait based human identification is an important biometric feature. In order to study and analyze Gait recognition in bad illumination conditions a framework is proposed. Kinect sensor is used for signal extraction, which has the capability to track human in bad illumination. Database is created using 5 persons by considering good illumination conditions and bad illumination conditions. The features of each individual are extracted using skeleton information. Mean value of distance between centroid of left leg lower part and centroid of right leg lower part is proposed as a new feature for Gait recognition. Training and classification is performed using Levenberg-Marquardt back propagation algorithm and SVM algorithm. Mean value of distance between centroid of left leg lower part and centroid of right leg lower part provides good distinguishing values between different persons. Results obtained for both algorithms are tabulated. 82.66% recognition rate achieved with Levenberg-Marquardt back propagation algorithm where as 92% recognition rate achieved with SVM for 5 persons in bad illumination conditions, with fixed Kinect sensor set up. From results it is revealed that the proposed framework performs the gait based human identification in bad illumination.

Keywords: Bad Illumination, Feature Extraction, Gait Recognition, Recognition Rate, Skeleton Information, SVM

1. Introduction

Gait denotes to the manner of walking of a person. An exclusive benefit of gait by means of a biometric is that it proposals possible for human identification at a distance or at truncated resolution or at bad illumination or when other biometrics might not be suitable. it has been saw in literature that people can be acknowledged by the manner they walk. Author in[1] created typical movement configurations for pathologically usual persons which be there used to relate the gait configurations intended for pathologically unusual patients[2]. These revisions once more recommended that gait seemed exclusive to every single subject. When individual walks or runs the right leg and left arm exchange direction of strike with the left leg and right arm, and vice versa, with half a period phase shift. Specified individual will carry out his or her walking pattern in a legitimately repeatable as well as specific manner, adequately exclusive that the aforementioned is potential to identify a individual at a distance by means of their Gait. Close-fitting clothing will have an effect on gait; loose-fitting clothing will have an effect on the observation of gait by video. Instinctively, gait will vary with age as do the majority biometrics, excluding ears. In requisites of recognition, the objective in biometrics is to obtain a set of measurements for single subject for which the difference for that subject is less than the variation between subjects.

Motion based[3] and Model-based[4] methodologies have been used in Gait Recognition. Gait recognition in bad illumination, e.g., night is not discussed more in previous research work on Gait, Gait recognition in bad illumination is not possible using vision based methods as the sequence of images does not contain useful information, this challenge can be overcome by using other methods for signal extraction. Proposed work uses a Kinect sensor for signal extraction, which gives the depth information as well as color information, Kinect sensor has a skeleton tracking tool, which is having the ability to track 20 joint points of human in bad illumination, even in dark light it will track the human and gives the information about the 20 joint points.

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Close-fitting clothing will affect gait, loose-fitting clothing will affect the observation of gait by video. Proposed work tried to address this problem. In my proposed work i used the skeleton information acquired by making use of Kinect sensor, the aforementioned has various advantages associated to additional signal extraction techniques for instance not sensitive to kind of clothes, so tight clothing, loose clothing does not affect performance of Gait recognition.

In this proposed work height or tallness of a person, step distance, variation of centroids, and a new feature, variation of distance between centroid of left leg lower part and centroid of right leg lower part, and other features are employed for gait recognition. Only one value intended for every single feature carefully chosen over a series of frames in a video[5].

Training and classification is accomplished by means of two dissimilar algorithms such as Levenberg-Marquardt back

Propagation algorithm and SVM algorithm. Results obtained with two algorithms in good illumination, bad illumination are tabulated.

The most important contributions of this paper are

- Gait recognition in bad illumination condition e.g. dark light, is proposed, different conditions have been discussed.
- Mean value of distance between centroid of left leg lower part and centroid of right leg lower part is proposed as a new feature for Gait recognition.
- This paper tried to address the challenge of gait recognition at different clothing conditions.

2. Proposed Method

The proposed method is represented in Figure 1 this method consists of four most important steps: data acquisition, data processing, feature extraction and human Gait recognition.

In data acquisition step, sensor acquires color (RGB), depth and skeleton information. Data processing step objectives on doing a small number of processing if required like data normalization. Feature extraction step objectives on calculating appropriate features intended for human detection. Training and classification performed for Gait recognition.

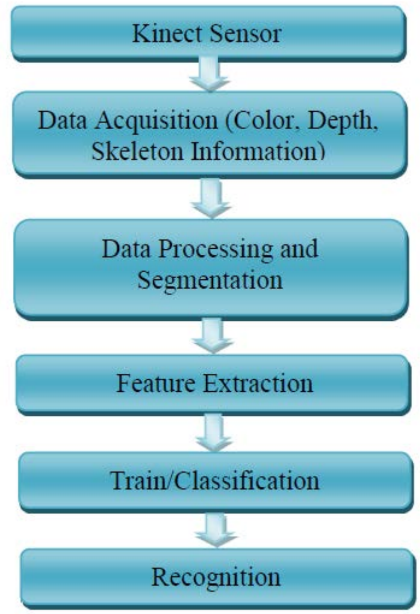

Figure 1. Flow graph of proposed method.

2.1 Gait Pattern Extraction

Gait pattern extraction is performed using Kinect sensor[6], which records data by 30 frames per second and make available real time human skeleton information of twenty joint points. Joint information is collected intended for every single frame. Positions of twenty joint points be there assessed as well as collected intended for every single frame. The 20 joints which are in use by means of reference points are revealed in Figure 2.

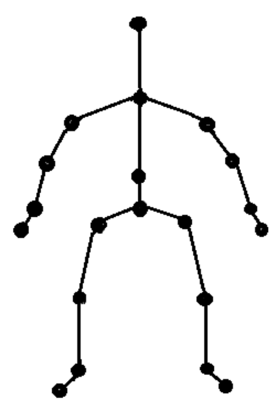

Figure 2. Important joints taken as reference points.

Every single joint point has a distinctive index value and every single joint position be there stated in (x,y,z) coordinates, x, y and z axes be present the body axes of the depth sensor. As of skeleton traced by means of Kinect first it excerpts values of joint positions, Figure 3 displays 3 coordinates of joint position. Figure 4 displays an illustration of Skeleton data abstraction by means of Kinect sensor. Kinect sensor provides the color image, depth image and skeleton information.

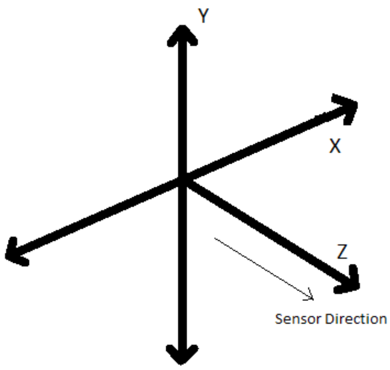

Figure 3. 3 coordinates of joint position.

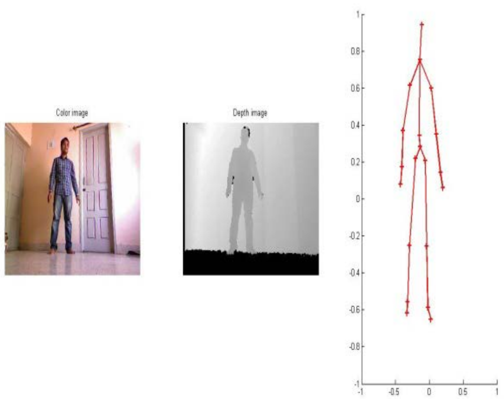

Figure 4. Skeleton data abstraction for forward-facing interpretation of the person by means of Kinect.

Database is created using Kinect sensor. Database consists of 5 persons, for each person 5 video sequences are taken, out of 5 video sequences, 3 are taken in bad illumination, i.e., Dark light, 2 are taken in good illumination, i.e., Day light. In bad illumination, due to depth sensor Kinect is able to track the 20 joint points of a human.

2.2 Feature Extraction

Static features such as height, length of both hands and length of both legs of a person be present calculated by Equation (1).

$$D = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2 + (z_i - z_j)^2} \quad (1)$$

Where x_i as well as x_j be present x coordinate value of i and j points correspondingly, y_i as well as y_j be present y coordinate value of i and j points correspondingly, z_i as well as z_j be present z coordinate value of i and j points correspondingly.

Dynamic feature for example step distance is computed by means of Equation (1). Velocity is computed as distance by sum of frames taken on the way to cover the distance. Centroid of the upper body part bounded by hip right, hip left, shoulder right, shoulder left, shoulder center be there intended by means of (2). Centroid X_c of M points can be computed as

$$Xc = \frac{1}{M}\sum_{i=0}^{M} M(x_i, y_i, z_i) \quad (2)$$

Where x_i, y_i and z_i are x, y, z coordinate values of the i point. Centroid of left hand bounded by wrist left, elbow left, shoulder left is computed by means of Equation (2). Centroid of right hand bounded by wrist right, elbow right, shoulder right is computed by means of (2). Centroid of left leg bounded by ankle left, knee left, hip left is computed by means of Equation (2). Centroid of right leg bounded by ankle right, knee right, hip right is computed by means of Equation (2). Distance between upper body centroid (x_c, y_c, z_c), and other centroids (x_j, y_j, z_j) are calculated for each and every frame by means of (1). Centroid of left leg lower part bounded by foot left, ankle left, and knee left is calculated by means of Equation (2). Centroid of right leg lower part bounded by foot right, ankle right, knee right is calculated by means of (2). Variation of distance between centroid of left leg lower part and centroid of right leg lower part while walking is calculated by means of Equation (1).

Angle between left leg upper part consisting of hip left, knee left, and lower part consisting of knee left, foot left, by taking knee left as origin is calculated by using Equation (3). Angle between right leg upper part consisting of hip right, knee right, and lower part consisting of knee right, foot right, by taking knee right as origin is calculated by using Equation (3). The angle between the two points U and L in 3D space is calculated by means of Equation (3).

$$\theta = \cos^{-1}\left[\frac{u_x l_x + u_y l_y + u_z l_z}{|U|\,|L|}\right] \quad (3)$$

Where u_x and l_x are the x coordinate value of U as well as L points correspondingly. u_y, l_y be there y coordinate value of U as well as L points correspondingly. u_z, l_z be there z coordinate value of U as well as L points correspondingly. The magnitude of the two points |U| and |L| are given by Equation (4) and Equation (5) respectively.

$$|U| = \sqrt{u_x^2 + u_y^2 + u_z^2} \quad (4)$$

$$|L| = \sqrt{l_x^2 + l_y^2 + l_z^2} \quad (5)$$

Figure 5 shows the flow graph of the feature value selection process. Database consists of 5 persons, 5 video sequences for each person. In overall Database be made up of twenty five video sequences. Features values are computed for every single frame of video sequence. Measures are in use to choice single or particular value for every single feature in a video sequence. For height, step distance of a individual extreme value over series of frames is designated. For length of left hand, right hand, left leg, right leg mean value over the series of frames is designated. For distance between upper bodies centroid to other four centroids extreme value over series of frames is selected. For distance between centroid of left leg lower part and centroid of right leg lower part mean value over series of frames is selected. For angle between left leg upper part as well as lower part, angle between right leg upper part as well as lower part standard deviation value over the array of frames is designated. Velocity is calculated as distance by number of frames taken to cover the distance. Velocity feature contains a single value over the series of frames.

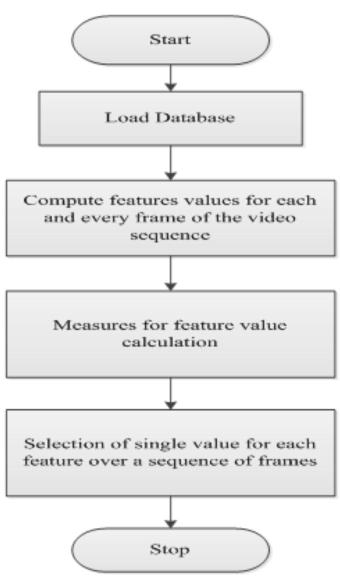

Figure 5. Flow graph of the feature value selection process.

Feature value selection results in distinct value for every single feature in a video sequence. Since the database consists of 5 video sequences for every single person, every single feature will have the 5 values, single value for every single video sequence. Selection of single value for every single feature decreases the computation time and there is no need to find the gait cycle.

3. Gait Recognition

3.1 Gait Recognition using Levenberg-Marquardt Back Propagation Algorithm

Levenberg-Marquardt back-propagation algorithm[7] is chosen aimed at training as well as classification which is an iterative process that obligate three steps in every single iteration: Forward, Backward, Weight adjustment. In back-propagation training progression Equation (6) is used as error function.

$$E = \frac{1}{2}\sum_p \sum_j (t_{pj} - o_{pj})^2 \quad (6)$$

Where t_{pj} and o_{pj} are target output as well as actual output j intended on behalf of input p correspondingly. Arrangement will recognize given input if input is accorded if not once more it will checked for the error by means of Equation (6).

3.2 Gait Recognition using SVM

SVM depend on statistical learning concept and purposes to conclude the position of judgment boundaries that turn out the optimum disengagement of categories. Intended for training data from the jth as well as kth classes, the fallowing 2-class classification problem represented by Equation (7) is solved .

$$\min_{w^{jk}, b^{jk}, \xi^{jk}} \frac{1}{2}(w^{jk})^T w^{jk} + C\sum_t (\xi^{jk})t \quad (7)$$

Subject to $(w^{jk})^T \emptyset(x_t) + b^{jk} \geq 1 - \xi_t^{jk}$, if x_t in the jth class

$(w^{jk})^T \emptyset(x_t) + b^{jk} \leq -1 + \xi_t^{jk}$, if x_t in the kth class

$\xi_t^{jk} \geq 0$

SVM can give probability estimations. Specified n classes of data, aimed at any x, objective is towards estimation of

$p_i = P(y = i \mid x), i = 1,.....,n$

Subsequent the set of one-against-one technique intended aimed at multi-class classification, earliest in order estimate couple wise class probabilities

$m_{ij} \approx p(y = i \mid y = i \text{ or } j, x)$

By means of an enhanced enactment, if f stands decision value at x, at that time adopts Equation (8).

$$m_{ij} \approx \frac{1}{1 + e^{Gf+H}} \tag{8}$$

Where G and H are assessed by means of lessening the undesirable log possibility of training data.

After collecting all m_{ij} values, solve the optimization problem represented by Equation (9)

$$\min_{p} \frac{1}{2}\sum_{i=1}^{n} \sum_{j:j\neq i} (m_{ji}p_i - m_{ij}p_j)^2 \tag{9}$$

subject to $p_i \geq 0, \forall i, \sum_{i=1}^{k} p_i = 1$

objective function in problematic originates as of the equality

$P(y = j \mid y = i \text{ or } j, x) \cdot P(y = i \mid x) = P(y = i \mid y = i \text{ or } j, x) \cdot P(y = j \mid x)$

then can remain reformulated by means of Equation (10)

$$\min_{p} \frac{1}{2} p^T Q p \tag{10}$$

Where $Q_{ij} = \begin{cases} \sum_{s:s\neq i} r_{si}^2 & if\ i = j \\ -r_{ji} r_{ij} & if\ i \neq j \end{cases}$

Gait database is used to train the Multi-class SVM, classification is performed to identify the human based on the gait features.

4. Results

Results are attained for the database contains 5 individuals and 5 sequences meant for every single individual. Figure 6 shows the graph of features versus feature value. x axis represents the features used in the gait recognition and y axis represents the feature value corresponds to each feature. Each color represents the plot for single person consists of 5 video sequences. In x axis each point represents as follows. Point 1 represents step distance. Point 2 represents length of left hand, Point 3 represents length of right hand, Point 4 represents length of left leg. Point 5 represents length of right leg, Point 6 represents distance between centroid of left leg lower part and centroid of right leg lower part, Point 7 represents height of a person, Point 8 represents distance between upper body centroid to left hand centroid, Point 9 represents distance between upper body centroid to right hand centroid, Point 10 represents distance between upper body centroid to left leg centroid. Point 11 represents distance between upper body centroid to right leg centroid. Point 12 represents angle between left upper part of the leg and lower part of the leg. Point 13 represents angle between right upper part of the leg and lower part of the leg. Point 14 represents velocity.

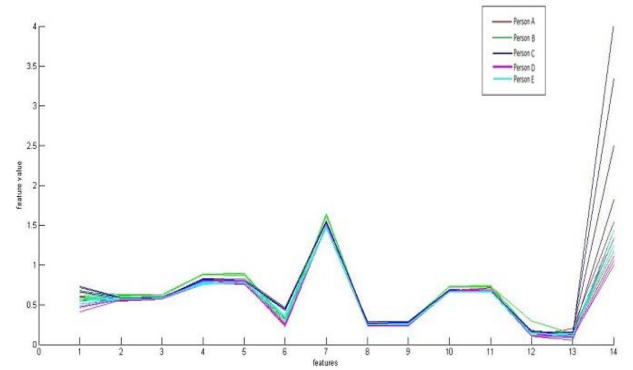

Figure 6. Graph of features versus feature value.

From the graph it is observed that the step distance for different persons is having different values and is providing good distinguishing values between each person hence step distance is one of the main feature for Gait recognition. Length of left hand, right hand, left leg, right leg aimed at different persons varies by small values. Variation of distance between centroid of left leg lower part and centroid of right leg lower part while walking provides decent distinctive feature value among different individuals. Distance between upper body centroid to other four body centroids provides decent distinctive feature values among different individuals hence distance between centroids is good candidate of feature for Gait recognition. Angle between left upper part of the leg and lower part of the leg, angle between right upper part of the leg and lower part of the leg provides somewhat good distinguishing values between persons. Velocity also provides good distinguishing values between persons and it provides information weather the person is walking slow or fast.

Features for instance step distance or step length, height of a person, distance between upper body centroid to other four centroids provides good distinctive feature values compared to the length of left hand, right hand, left leg, right leg.

Figure 7 displays the performance plot intended for Levenberg-Marquardt back propagation algorithm. Performance is plotted by means of mean square error contrasted with numeral of epochs, finest training performance value attained is 5.4116e^{-30} at epoch 5.

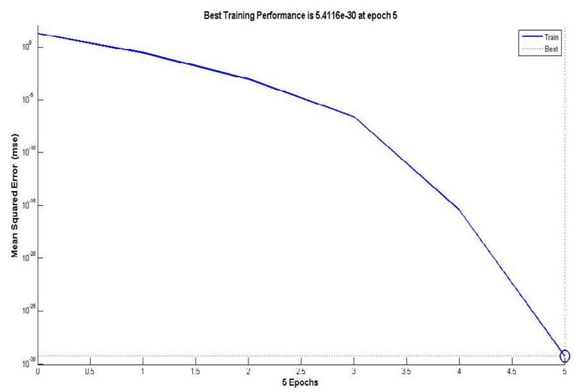

Figure 7. Performance plot.

Figure 8 displays the Training State Plot obtained in Levenberg-Marquardt back propagation algorithm. Epochs are sampled up to 5 iterations.

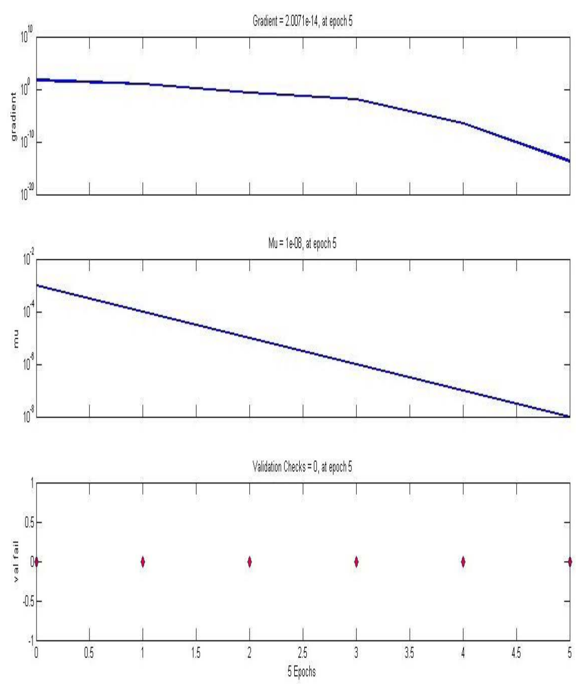

Figure 8. Training state plot.

Figure 9 displays the regression plot intended for 5 people, by means of Levenberg-Marquardt back propagation algorithm and this one is plotted aimed at output versus target.

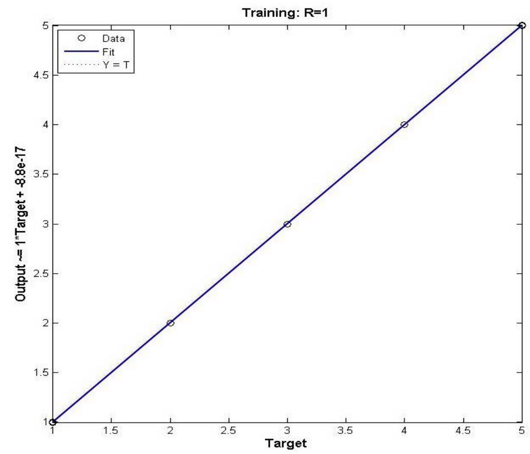

Figure 9. Regression plot.

During training, with SVM algorithm for person A minimization finished at 55 iterations, objective value is equal to -14.942557, and nSV (number of support vectors) is equal to 25. For person B minimization finished at 57 iterations, objective value is equal to -14.375834, and nSV is equal to 21. For person C minimization finished at 53 iterations, objective value is equal to -3.813362, and nSV is equal to 12. For person D minimization finished at 53 iterations, objective value is equal to -12.741918, and nSV is equal to 20. For person E minimization finished at 81 iterations, objective value is equal to -14.956963, and nSV is equal to 24.

Proposed method tested in two cases, during bad illumination and good illumination. Different clothing colors, close-fitting clothing and tight-fitting clothing conditions have been tested. Table 1 shows the results obtained by means of Levenberg-Marquardt back propagation algorithm, in bad illumination conditions.

Table 1. Recognition accurateness for Levenberg-Marquardt back propagation algorithm, in bad illumination conditions

Person	Number of times tested	Number of times properly recognized	Recognition rate in %
A	15	11	73.33
B	15	13	86.66
C	15	14	93.33
D	15	11	73.33
E	15	13	86.66

Table 2. Recognition accurateness for SVM, in bad illumination conditions

Person	Number of times tested	Number of times properly recognized	Recognition rate in %
A	15	13	86.66
B	15	14	93.33
C	15	15	100
D	15	12	80
E	15	15	100

Table 3. Recognition accurateness for Levenberg-Marquardt back propagation algorithm, in good illumination conditions

Person	Number of times tested	Number of times properly recognized	Recognition rate in %
A	15	12	80
B	15	13	86.66
C	15	14	93.33
D	15	11	73.33
E	15	14	93.33

Table 4. Recognition accurateness for SVM, in good illumination conditions

Person	Number of times tested	Number of times properly recognized	Recognition rate in %
A	15	14	93.33
B	15	14	93.33
C	15	15	100
D	15	13	86.66
E	15	15	100

Table 2 shows the results obtained using SVM, in bad illumination conditions. Table 3 shows the results obtained using Levenberg-Marquardt back propagation algorithm, in good illumination conditions. Table 4 shows the results obtained using SVM, in good illumination conditions. From the outcomes it can be witnessed that the proposed method is able to identify the person in bad illumination, this is one of the unique contribution of the proposed method. From the results it is noticed that the clothing colors does not affect the Gait Recognition, close fitting clothing and tight fitting clothing conditions very less affects the Gait Recognition, due to the use of Kinect sensor for signal extraction which is insensitive to type of clothes. Proposed method is able to identify persons using Gait Recognition in bad illumination and good illumination.

The proposed method by means of Levenberg-Marquardt back propagation algorithm is capable to recognize the individuals efficiently and it attains the recognition rate of 82.66% in bad illumination conditions and 85.33% in good illumination conditions. By means of SVM proposed method is capable to recognize the individuals efficiently and it attains the recognition rate of 92% in bad illumination conditions and 94.66% in good illumination conditions.

5. Conclusion

Gait based human identification system using skeleton information is implemented. Database is created using stable Kinect sensor set up in indoor setting. Database consists of 5 persons, for every single person 5 video sequences are taken, out of 5 video sequences, 3 are taken in bad illumination, 2 are taken in good illumination. Database consists of the 5 persons and 5 sequences for each person. Mean value of distance between centroid of left leg lower part and centroid of right leg lower part is proposed as a new feature for gait recognition; proposed feature provides a good distinguishing feature value between different persons proposed method using Levenberg-Marquardt back propagation algorithm achieves a recognition rate of 82.66% in bad illumination conditions and 85.33% in good illumination conditions. By means of SVM proposed method achieves a recognition rate of 92% in bad illumination conditions and 94.66% in good illumination conditions. For the proposed method the clothing colors does not affect the Gait Recognition, close fitting clothing and tight fitting clothing conditions very less affects the Gait Recognition. Proposed method is able to identify persons using Gait Recognition in bad illumination conditions and good illumination conditions.

6. Future Work

In future there is a need to develop a large standard database consists of skeleton information for Gait Recognition, which comprises of all the conditions. Gait recognition and Face recognition can be combined to form an efficient human authentication system.

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