International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 07 | July 2018 www.irjet.net p-ISSN: 2395-0072

Analysis of Unique Gait patterns by extraction of salient features

Satarupa Bhattacharyya[1], Jaba Nayana Laskar[2], Shanwavi Sharma[3], Bidisha Kashyap[4]

[1,2,3,4]*Dept. of Electronics and Telecommunication, Jorhat Institute of Science and Technology, Assam, India.*

Abstract – *Gait based human identification is a type of behavioral biometrics which is used to identify a person based on automatically extracted gait features. Biometric verification is becoming increasingly common in corporate and public security systems, consumer electronics etc. as biometrics are unique and one will not lose or forget them over time. Gait of a person means the style of his/her walking. A person can be identified from distance through their walking pattern and this can be considered as a unique feature for biometric. As such gait has become one of the latest promising biometric and can be used for identifying the person accurately. At first a gait video is recorded and pre-processing is done to extract the silhouette images from that video in the proposed system. This proposed system consists of extracting human gait features from enhanced human silhouette, smoothing process on extracted gait features and classification by k-nearest neighbor (k-NN) algorithm. The gait features are extracted by Principal Component Analysis (P.C.A) and Discrete Cosine Transform (D.C.T) methods. The results show that the proposed system is effective and it is 100% accurate in human identification process.*

Key Words: Gait based human identification, Biometric, Human silhouette, k-Nearest Neighbour algorithm (k-NN), Principal Component Analysis (P.C.A), Discrete Cosine Transform (D.C.T).

1. INTRODUCTION

Biometric is a technological and scientific authentication method based on biology and used in information assurance (IA). Biometric is the measurement and statistical analysis of people's unique physical and behavioral traits. The basic principle of biometric authentication is that every person can be accurately identified according to the physical or behavioral traits. There are two types of biometric identifiers that depend on either physiological characteristics or behavioral characteristics. Physiological identifiers include facial recognition, fingerprints, finger geometry, iris recognition, voice recognition and DNA matching. Behavioral identifiers include the unique ways in which individuals act, including recognition of typing patterns, walking gait and other gestures. Advantage of biometric verification is its convenience as there are no passwords to remember or security tokens to carry. Identification of a person based on gait [1] is becoming popular and can be used in high security applications like smart rooms, health care and military applications. Human identification [2] based on gait is the ability to identify people at a distance when other biometrics are obscured. Gait is a complex locomotion pattern [3] which involves synchronized movements of body parts, joints and the interaction among them. In 1973 psychological research from Johannson [4] has proved that human can easily recognize walking friends based on the light makers that are attached to them. Even since then, much research much research has been carried out on gait analysis and it has been proven that gait can be used to identify people. Furthermore, it does not require any intervention from the user and can be captured by hidden cameras or synchronized closed-circuit television (CCTV) cameras. This is also motivated by the increasing number of CCTV cameras that have been installed in many major cities, in order to monitor and prevent crime by identifying the criminal or suspect [5]. The performance of gait as biometric can be affected by covariate factors, such as light illumination [6] during video capturing, imperfect object segmentation from background [7], changes in the subject appearance, nature of ground and different camera viewing angle with respect to the subjects.

1.1 Review of literature

Various attempts were made for the task of recognizing the Gait of a person. Some methods are discussed below:

In [3] the authors (D.Cunado, M.S. Nixon and J.N Carter) describe a new model-based moving feature extraction analysis that automatically extracts and describes human gait for recognition. This is done using a Fourier series to describe the motion of the upper leg and apply temporal evidence gathering techniques to extract the moving model from a sequence of images. Classification uses the k-nearest neighbour rule applied to the Fourier components of the motion of upper leg. Experimental analysis demonstrates that an improved classification rate is given by the phase-weighted Fourier magnitude information over the use of magnitude information alone. The disadvantage was that it would no longer uniquely identify an individual. In [5] the authors (T.Kobayashi and N.Otsu) proposed a method to identify multiple person using cubic higher order local autocorrelation (CHLAC) to address three-way data analysis. This method is a natural extension of higher order local autocorrelation (HLAC). Both methods use "correlation" to summarize relative positions or motions with some local data regions and can be calculated simply with a low computational load. However, CHLAC is sensitive to scale and the approach is not able to identify a person at a time. In [8] (A.Nandy, P.Chakraborty, G.Nandi, et al.) attempted to use the computer vision technique to derive the gait signature of a person which is a major criterion for gait based recognition system. The gait signature has been obtained from the sequence of silhouette images at various gait speeds varying from 2km/hr to 7km/hr. The major concept behind the making gait recognition speed invariant is that the human can walk in finite speed so instead of training the classifier for a single speed the classifier is to be trained for multiple speeds. The problem was that this approach is computationally very complex to evaluate the parameters while constructing the human model. (L. Wang, T.Tan, W.Hu and H.Ning), in [9] introduced a brief history of gait-based human identification and the challenges has been listed out that lie in this field, such as cross-view and cross walking condition gait recognition. This proved that the single gait recognition performance drops when computing similarity measurement of gait appearances in different viewing angles. In [10] (S.Sarkar, P.J. Philips, Z.Liu, I.R. Vega, P.Grother and K.W. Bowyer) analyzed the human identification gait challenge problem. The challenge problem consists of baseline algorithm, a set of 12 experiments silhouettes by background subtraction and performs recognition by temporal correlation of silhouettes. The drawback is that the deviation of gait representation in practical visual surveillance scenario often gets out of control due to the viewing angle variation, large intraclass variations.

2. PROPOSED METHODOLOGY

The proposed system encompasses the following functional blocks: -

1. The elemental function is detection of the human from a frame.

2. The succeeding block is to acquire the features using Principal Component Analysis (PCA) descriptor on the human (detected, as in step (1)).

3. Then we apply Discrete Cosine Transform (DCT) operator on the features extracted by PCA.

4. Finally, we create training and a testing dataset. The k-NN classifier trained on training dataset is then used for evaluating the performance on the test dataset.

Fig. 1 shows schematic overview of our proposed system for recognition of Human Gait.

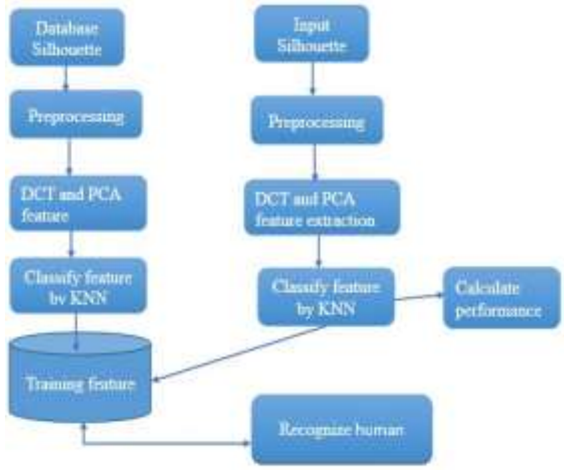

Figure 1: Block Diagram of the proposed method

The following table shows the time taken to extract features by Principal Component Analysis (PCA), Discrete Cosine Transform (DCT), and visual appearance of the person and the classification of the proposed method:

Table 1: Performance Analysis of the proposed system

IMAGE NUMBER	TIME TAKEN TO EXTRACT FEATURES BY PCA	TIME TAKEN TO EXTRACT FEATURES BY DCT	VISUAL APPEARENCE OF THE PERSON	CLASSIFICATION OF THE PROPOSED METHOD
1	0.0023914	0.0028293	Man carried a bag in shoulder	100%
2	0.0035371	0.0042472	Man carried a bag in shoulder	100%
3	0.0025218	0.0030534	Man carried a bag in shoulder	100%
4	0.0023371	0.0027857	Man carried a bag in shoulder	100%
5	0.0024273	0.0052045	Man carried a bag in shoulder	100%
6	0.0023208	0.0027733	Man carried a bag in shoulder	100%
7	0.0017016	0.0020865	Man carried a bag in shoulder	100%
8	0.0027985	0.0038156	Man carried a bag in shoulder	100%
9	0.0024863	0.002997	Man carried a bag in shoulder	100%
10	0.0026518	0.003127	Man carried a bag in shoulder	100%
11	0.0028024	0.0033074	Man carried a bag in shoulder	100%
12	0.0023546	0.0027994	Man wearing coat	100%
13	0.0037022	0.0041332	Man wearing coat	100%
14	0.0025099	0.0029452	Man wearing coat	100%
15	0.0024483	0.0029178	Man wearing coat	100%
16	0.0024154	0.0028575	Man wearing coat	100%
17	0.0025334	0.0030243	Man wearing coat	100%
18	0.0030915	0.0036196	Man wearing coat	100%
19	0.003316	0.003857	Man wearing coat	100%
20	0.0029491	0.0033874	Man wearing coat	100%
21	0.0023546	0.0027917	Man wearing coat	100%
22	0.0017008	0.0020783	Man wearing coat	100%

23	0.0031261	0.0035572	Man wearing coat	100%
24	0.0026571	0.003381	Man wearing coat	100%
25	0.0023529	0.002799	Man wearing coat	100%
26	0.00456	0.0087262	NOT VALID	100%
27	0.00325	0.006125	NOT VALID	100%
28	0.00261	0.0059832	NOT VALID	100%
29	0.002673	0.0041276	NOT VALID	100%
30	0.00316	0.007789	NOT VALID	100%
31	0.00281	0.003654	NOT VALID	100%
32	0.00239	0.003523	Women carried a bag in hand	100%
33	0.00261	0.003548	Women carried a bag in hand	100%
34	0.00262	0.0034009	Women carried a bag in hand	100%
35	0.00251	0.003287	Women carried a bag in hand	100%
36	0.00250	0.003292	Women carried a bag in hand	100%
37	0.00253	0.003297	Women carried a bag in hand	100%
38	0.00254	0.0033193	Women carried a bag in hand	100%
39	0.00255	0.0034229	Women carried a bag in hand	100%
40	0.00265	0.003975	Women carried a bag in hand	100%
41	0.002470	0.003205	Women carried a bag in hand	100%
42	0.00310	0.004132	Women carried a bag in hand	100%
43	0.002383	0.003537	Women carried a bag in shoulder	100%
44	0.00258	0.00332	Women carried a bag in shoulder	100%
45	0.00249	0.003296	Women carried a bag in shoulder	100%
46	0.00249	0.003639	Women carried a bag in shoulder	100%
47	0.00256	0.003240	Women carried a bag in shoulder	100%
48	0.00246	0.003256	Women carried a bag in shoulder	100%
49	0.00248	0.003223	Women carried a bag in shoulder	100%
50	0.00270	0.005634	Women carried a bag in shoulder	100%
51	0.00252	0.003619	Women carried a bag in shoulder	100%
52	0.00254	0.001303	Women carried a bag in shoulder	100%
53	0.00256	0.003332	Women carried a bag in shoulder	100%

Here we first took 53 images from the SOTON database. At first an input image is given. That input image is then pre-processed to get a smooth silhouette image. On that silhouette image we applied Principal Component Analysis (PCA) and Discrete Cosine Transform (DCT) to extract the gait features. After extracting the gait features, we classified the images using k-Nearest Neighbor (k-NN) classifier. The time taken to extract the gait features by PCA and DCT are recorded and shown in column 2 & 3 respectively in table 1.

The visual appearances of person as classified by k-NN classifier are recorded in column 4 of table 1. We have seen that the performance of the proposed system is 100%.

3. PREPROCESSING

A non-linear digital morphological technique, morphological opening is used to enhance the input image. Morphological opening was applied using diamond shape of radius 3 to separate the shadow into isolated regions, while morphological closing is used to close the small gaps in the foreground object. The basic proposition of the operation is to move over each entry of a signal, and then replacing every entry with the opening entries.

3.1. Dilation and Erosion

Dilation and Erosion [11] are two fundamental morphological operations. Dilation adds pixels to the boundaries of object in an image while erosion removes pixels on object boundaries. The number of pixels added or removed from the objects in an image depends on the size and shape of the structuring element used to process the image. In the morphological dilation and erosion operations, the state of any given pixel in the output image is determined by applying a rule to the corresponding pixel and its neighbours in the input image. The rule used to process the pixel defines the operation as dilation or erosion.

Dilation rule: The value of the output pixel is the maximum value of all the pixels in the input pixel's neighbourhood. In a binary image, if any of the pixels is set to the value 1, the output pixel is set to 1.

Erosion rule: The value of the output pixel is the minimum value of all the pixels in the input pixel's neighbourhood. In a binary image, if any of the pixels is set to 0, the output pixel is set to 0.

4. PRINCIPAL COMPONENT ANALYSIS (PCA)

Principal Component Analysis is a technique which uses sophisticated under-lying mathematical principles to transform a number of possibly correlated variables called principal components. PCA is defined by transformation of a high dimensional vector space into a low dimensional space. It provides an efficient way to reduce dimensionality, so it is much easier to visualize the shape of data distribution.

4.1 EIGEN VECTORS, EIGEN VALUES AND SINGULAR VECTOR DECOMPOSITION

Let us define an n X n matrix A and a non-zero vector ~x which belongs to R^n. If there exist a scalar value λ which satisfies the vector equation -

$$A(\tilde{x}) = \lambda \tilde{x}$$

We define λ as an Eigen value of matrix A, and the corresponding non-zero vector $\hat{x}$ is called an Eigen vector of the matrix A. To determine Eigen values and eigenvectors a characteristics equation is used.

$D(\lambda) = \det(A - \lambda I)$

4.2 SINGULAR VECTOR DECOMPOSITION (SVD)

In the implementation of PCA, SVD is used to extract principal components (eigenvectors) from a given dataset. Given an n-by-m matrix A, a singular vector decomposition of A is given by-

$A = U \sum V^T$

Where U belongs to $R^{m \times n}$ V belongs to $R^{m \times n}$. The matrix U and V are orthogonal matrices and consist of left and right singular vectors respectively. The matrix $\sum V^T$ is diagonal and consist of non-negative singular values α. The singular values are placed in the matrix in descending order such as

$\alpha_1 \geq \alpha_2 \geq \ldots \geq \alpha_p \geq 0$ where p = min (n, m).

4.3 2D DATA ANALYSIS

In this example, PCA is implemented to project one hundred of 2-D data; X belongs to R (2 X 100) on 1-D space. Figure 2 shows elliptical distribution of X with principal component direction $\widetilde{u_1}$ and $\widetilde{u_2}$. The principal directions are extracted from the covariant matrix of original data set using SVD method: V = **[** $\widetilde{u_1}, \widetilde{u_2}$ **]** belongs to R (2 X 2). As shown in the Figure 3, the data matrix X can be rotated to align principal axis with x and y axis: $X' = V^T X$ Where X' represents rotated data matrix. In figure 4 and 5, the matrix X is projected on the primary and secondary principal direction. Euclidean distances between original and projected 2-D points are computed and summed up to quantitatively show reliability in data representation.

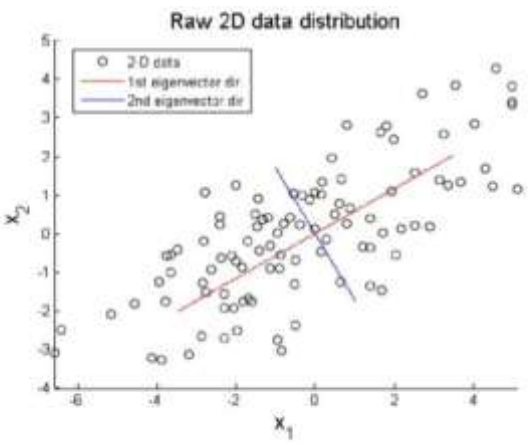

Fig-2: Raw 2D data distribution

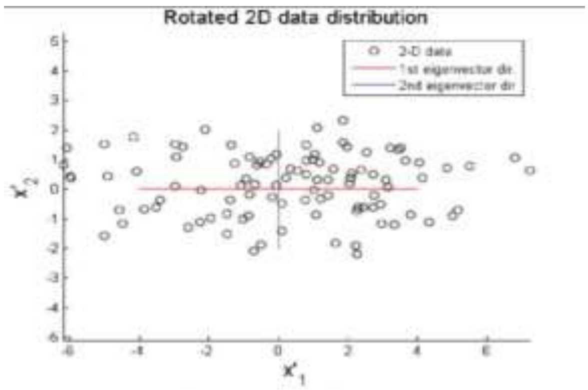

Fig-3: Rotated 2D data distribution

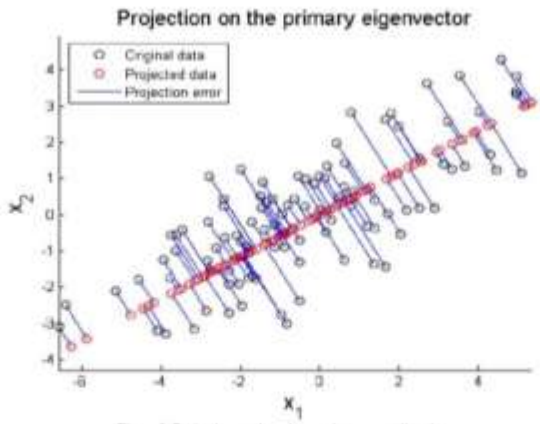

Fig-4: Projection on the primary Eigen vector

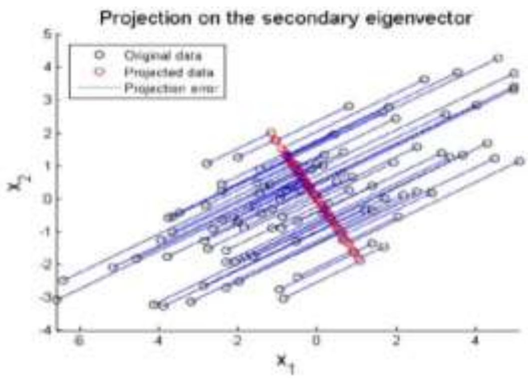

Fig-5: Projection on the secondary Eigen vector

5. DISCRETE COSINE TRANSFORM

The discrete Fourier transform (DFT) transforms a complex signal into its complex spectrum. However, if signal is real as in most of the application, half of the data is redundant. In time domain, the imaginary part of the signal is all zero; in frequency domain, the real part of the spectrum is even symmetric and imaginary part is odd. In comparison, Discrete Cosine transform (DCT) is a real transform that transforms a sequence of real data points into its real spectrum and therefore avoids the problem of redundancy.

Also, as DCT is derived from DFT all the desirable properties of DFT (such as the fast algorithm) are preserved.

- **Algorithm of DCT**

1. The first step of DCT descriptor modeling is converting the image to the binary image.

2. Pixel matrix of the image is created and divided it into blocks of size 8x8 DCT blocks.

3. FDCT (Forward Discrete Cosine Transform) is applied on each 8x8 block of pixel matrix to get equivalent 8x8 DCT blocks.

4. To get the original image IDCT (Inverse Discrete Cosine Transform) is applied on each 8x8 block DCT and obtains its equivalent 8x8 IDCT block.

5. Using the 8x8 IDCT we create original pixel matrix to get original image

6. K- NEAREST NEIGHBOUR CLASSIFIER

K-NN is a popular classifier in pattern recognition. It stores all available cases and classifies new cases based on similarity measure. K-NN makes prediction by using training data directly. Predictions are made for new instance(y) by searching throughout the whole training data and for the K and determine the most similar instance. To determine similarity between new inputs to the K instance in training data a distance is considered. There are many distance functions such as Euclidean, Hamming, Cosine etc. In our work we have considered Euclidean distance. If new input point is y and existing point is y_i then Euclidean distance is given by:

$$D_e = \sqrt{(y - y_i)}$$

The value of K varies as per types of data and in general the value of K is chosen as odd number to avoid tie. In our work we have chosen K value as 1.

7. RESULTS AND DISCUSSION

7.1 Result

After the process of feature extraction is carried out for all the 53 silhouette images of the SOTON database, the extracted features are grouped into some classes using k-NN classifier for recognition purpose. During recognition, when an image from the test set is entered, after pre-processing its, features are extracted using PCA and DCT. These extracted features of this particular silhouette image are analyzed by the k-NN classifier and finally the original class of the test image is recognized. Finally, we obtain our result of identifying a human using extracted gait features.

The following fig.6 shows the result of our proposed work-

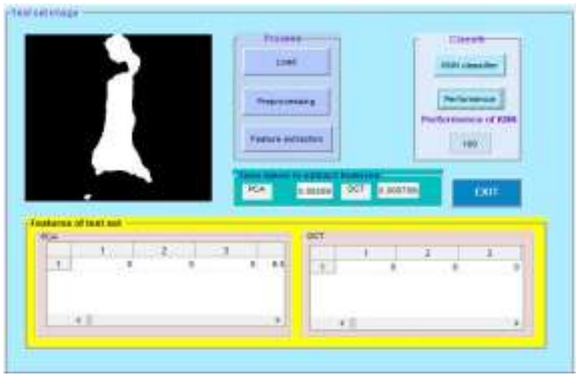

Fig-6: System performance and execution time

Thus, it is seen that the performance of k-NN classifier is 100%. Therefore, the proposed system is 100% efficient in identifying a person based on its gait features.

7.2 Discussion

This project basically deals with recognition with the help of Feature Extraction. In this project, first we took 53 silhouette images from the SOTON database. First of all, the silhouette images from the SOTON database are pre-processed. The pre-processing is done by using the method of Erosion followed by Dilation operation (opening) leading to image restoration. This is followed by feature extraction which consists of two methods- PCA (Principal Component Analysis) and DCT (Discrete Cosine Transform). PCA extracts the features of a person's gait with help of Eigen vectors and DCT deals with angles involving the gait. Subsequently all the extracted features of the database are classified into some classes by the k-NN classifier. Recognition part of this project deals with comparison of the test set with the training set. This comparison is done by the k-NN classifier by investigating out which class the tested image belongs to and finally we obtain our objective to recognize a person on the basis of gait by means of feature extraction. This project tries to enhance biometrics by introducing the process of recognizing but without touch sensing.

8. CONCLUSION AND FUTURE SCOPE

8.1. Conclusion

With the principal focus on being on the feature extraction, we also aimed at low-cost computational solutions that are feasible for applications in real life. The modeled method is implemented using Mat Lab 2017 (a) on a 64-bit Computer with Pentium (5thgeneration) Processor and 4GB Memory on the Silhouette database and the above results are obtained. The method proposes a computationally efficient novel technique for extracting the gait features from enhanced human silhouette image. The gait features are extracted from human and the silhouette has been smoothened before their average values were applied for classification by k-NN. The results show that the proposed

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 07 | July 2018 www.irjet.net p-ISSN: 2395-0072

method can perform well regardless of walking speed, carrying objects and apparel of subject. In addition, it performs consistently well on classification techniques.

8.2 Future Scope

The task of recognition of diverse gait positions is very exacting. In Human Recognition the perfection is tough to achieve, specifically under uncontrolled natural conditions or in context of video surveillance. This system, characterized by low dimension features, improves the recognition accuracy. More efforts to improve the recognition accuracy are to be necessitated for vital applications. Our future work objective is improving the average performance accuracy of the structured method in the wild and also in the occluded images. The recognition of the structured method can also be evaluated with different classifiers as a future work. Further, we also aimed in reducing the feature size and to investigate the robustness in extreme adverse circumstances and also the accuracy and validity of the methodology proposed in real processing time recognition.

REFERENCES

[1] W.G. Bhargavas, K. Harsavardhan, G.C. Mohan, A.N. Sharma and C. Prathap, "Human identification using gait recognition," 2017 International Conference on Communication and Signal Processing (ICCSP), Chennai, 2017, pp.1510-1513.doi: 10.1109/ICCSP.2017.8286638

[2] H.Ng, H.-L. Ton, W.-H. Tan, T. T.-V. Yap, P.-F. Chong, and J.Abdullah," Human identification based on extracted gait features," International Journal of New Computer Architectures and their Applications(IJNCAA), vol. 1, no. 2, pp. 358-370, 2011.

[3] D. Cunado, M.S. Nixon and J.N. Carter, "Automatic extraction and description of human gait models for recognition purposes," Computer Vision and Image Understanding, vol.90, no.1, pp. 1-41, 2003.

[4] G. Jansson and G. Johansson, "Visual perception of bending motion," Perception, vol.2, no.3, pp. 321-326, 1973.

[5] T. Kobayashi and N. Otsu, "Action and simultaneous multiple-person identification using cubic higher-order local auto-correlation," in Pattern Recognition, 2004, ICPR 2004. Proceedings of the 17th International Conference on, vol.4, pp. 741-744, IEEE, 2004.

[6] I.Bouchrika and M. S. Nixon, "Exploratory factor analysis of gait recognition," in Automatic Face & Gesture Recognition, 2008. FG'08. 8th IEEE International Conference on, pp. 1-6, IEEE, 2008.

[7] B. Bhanu and J. Han, "Human recognition on combining kinematic and stationary features," in International Conference on Audio-and Video Based Biometric Person Authentication, pp. 600-608, Springer, 2003.

[8] A. Nandy, P. Chakraborty, G. Nandi, et al., "Speed invariant, human gait based recognition system for video surveillance security," in Intelligent interactive technologies and multimedia, pp. 325-335, Springer, 2013.

[9] L. Wang, T. Tan, W. Hu, and H. Ning, "Automatic gait recognition based on statistical shape analysis," IEEE transactions on image processing, vol. 12, no. 9, pp. 1120-1131, 2003.

[10] S. Sarkar, P. J. Phillips, Z. Liu, I. R. Vega, P. Grother, and K. W. Bowyer, "The human id gait challenge problem: Data sets, performance, and analysis," IEEE transactions on pattern analysis and machine intelligence, vol. 27, no. 2, pp. 162-177, 2005.

[11] S. A. Dar and S. A. Lone, "An application of morphological image processing to forensics," International Journal of Computer Engineering and Technology, vol. 6, no. 8, 2015.

BIOGRAPHIES

Satarupa Bhattacharyya
Department of Electronics and Telecommunication, Jorhat Institute of Science and Technology, Assam, India.

Jaba Nayana Laskar
Department of Electronics and Telecommunication, Jorhat Institute of Science and Technology, Assam, India.

Shanwavi Sharma
Department of Electronics and Telecommunication, Jorhat Institute of Science and Technology, Assam, India.

Bidisha Kashyap
Department of Electronics and Telecommunication, Jorhat Institute of Science and Technology, Assam, India.