International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2015): 6.391

Human Gait Recognition Based on Gait Energy Image

Mayur Popade[1], Anita Thengade[2]

[1]Project Engineer, Wipro Technologies, Pune, India

[2]Prof., Department of Computer Engineering, MIT College of Engineering, Pune University, Pune, India

Abstract: ***Biometrics is a dynamic industry resulting in sustained evolution of numerous new technologies. The biometric system is needed in many key areas such as banking, airport, criminal cases, security purpose etc. Gait is an important biometric technology to recognize a human by the manner, they walk. Biometric identification based on body movements as gait recognition has gained new motivation over the past few years due to the launch of low cost depth cameras. Here, we propose a model to identify the human without coordination using gait images. In this paper we propose the biometric system to distinguish human from others through gait images based on principal component analysis algorithm and K nearest neighbor classifier. Principal component analysis is used to extract gait features. K nearest neighbor classifier is used to compute human id. Experimental analyses on CASIA A dataset show a significant performance gain in terms of accuracy. We create our own dataset for experiment using camera that provide a good view of entire human body. Furthermore, proposed approach has been experimented on our own dataset.***

Keywords: Gait recognition, PCA, KNN, CASIA dataset

1. Introduction

Human biometric identification systems are used in many fields such as banking, airport, criminal cases, security purpose etc. Biometric is divided into two parts namely physiological and behavioral characteristics. Biometric can be used to recognize and authenticate individual person based on physiological and behavioral characteristics. As shown in figure 1. Physiological characteristics area associated to the structure of the body. These have few examples like fingerprint, Iris scan, footprint etc. Behavioral characteristics are associated to behavior patterns of a person. These have few examples like gait, speech patterns, signature etc. In this paper, we used behavioral characteristics as gait for human biometric identification. Gait recognition is add-on technique for recognize person at a distance by the way they walk.

Gait recognition has several advantages over other biometric methods. It does not require subject as person in contact.

Gait recognition methods are divided into two types namely model based method and model free or appearance based method. Model based method is aim to model human body structure for recognition. Computation cost of model based methods is relatively high. They generally have lower performance. While model free or appearance based method can perform classification regardless of underlying body structure. It has higher performance. Mainly make use of silhouette information of human body. Here, we used model free method for gait recognition. We have proposed human gait recognition for different viewing angles (45, 90 degree) using Principal Component Analysis (PCA) and K Nearest Neighbor (KNN). In this Paper section 2 covers literature survey. We will present proposed architecture in section 3.After that section 4 explain experimental results and section 5 explain existing research lab of gait recognition and gait product available today in market. Conclusion and future scope of this paper is given in section 6.

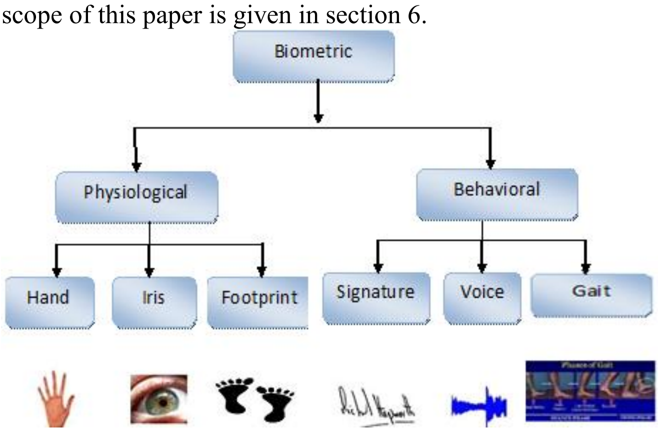


Figure 1: Types of Biometric System

2. Literature Survey

A variety of techniques have been used by researchers to recognize the gait. To introduces a few techniques of gait recognition. In the recent literature of gait recognition can be grouped into two categories, i.e. model- based and appearance based method.

Kshitiz Varma,Sanjeev Sharma(2015) used the front view silhouette data for gait recognition using PCA algorithms. Worapan Kusakunniran, Qiang Wu, Jian Zhang(2013) proposes a new framework to construct a new view-invariant feature for cross-view gait recognition. Procrustes Shape Analysis (PSA) is proposed and applied on a sequence of the normalized gait silhouettes. It is used to extract a new view-invariant gait feature.

Jwu-Sheng Hu, Kuan-Chun Sun, and Chi-Yuan Cheng(2013) proposed a human kinematic walking model for normal gait speed estimation using tri-axial acceleration signals at waist location.

Chen Wang, Junping Zhang, Liang Wang, Jian Pu, and Xiaoru Yuan(2012) develop a novel temporal template, named Chrono-Gait Image (CGI). Author proposed new method of human identification using temporal information preserving gait template.

Hu Ng , Hau-Lee Tong, Wooi-Haw Tan, Timothy Tzen-Vun Yap,Pei-Fen Chong, Junaidi Abdullah(2011) construct the human identification system based on automatically extracted gait features. Author used Gaussian filter, covariate factors for experiment. The proposed approach has been applied on SOTON covariate database.

Hu Ng, Hau-Lee Tong and Wooi-Haw Tan (2011) construct a novel model free approach for extracting gait features from human silhouette image. Here, he used three different classification techniques namely fuzzy k nearest neighbor, linear discriminate analysis and linear support vector machine. Apply these techniques on SOTON database, which analysis 11 subjects walking patterns.

Ju Han and Bir Bhanu(2006) proposed the concept of GEI, and constructed the real and synthetic gait templates to improve the accuracy of gait recognition.

Liang Wang, Huazhong Ning and Tieniu Tin(2004) proposed efficient algorithm which is based on fusion of static and dynamic body biometrics for gait recognition. Procrustes shape analysis method is used for experiment. It is model based approach.

Liang Wang, Tieniu Tan, Huazhong Ning, and Weiming Hu (2003) proposed human identification using silhouette image based on gait recognition. Principal Component Analysis (PCA) is applied to silhouette images to reduce the dimensionality of the input feature space.

Anita Thengade and Rucha Dondal(2012) proposed the new system that recognize human gait model using genetic fuzzy finite state machine.

Nivedita Gunale and Anita Thengade (2014) proposed the new system that identifies human using integration of gait and footprint.

3. Proposed Work

Our study aim to establish automatic human identification method based on gait recognition. The work is explained in three parts as follows:

3.1 System Design
3.2 Feature Extraction using PCA
3.3 Methods and Materials

3.1 System Design

The overview of proposed method is shown in figure 2.
This proposed architecture consists of five different modules which are as follows:
1) User input
2) Feature extraction
3)Trained dataset
4) Classifier
5) Decision module.

All these modules are described as below. Human gait recognition is carried out by converge the outline of human walking pattern individual in a feature. We have proposed model free gait recognition approaches.

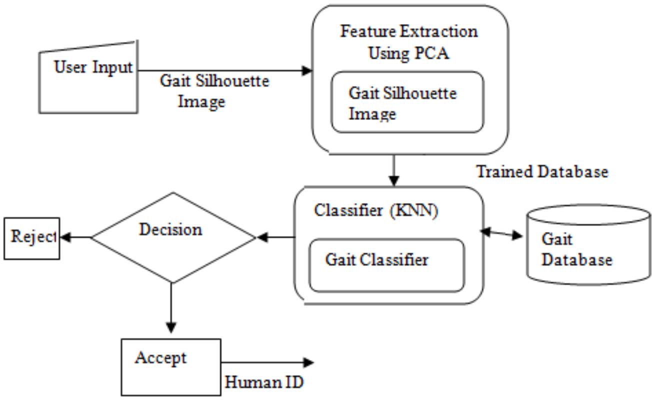


Figure 2: Overview of Proposed System

1) User Input Module
User Input module contains gait images. Gait images look like a Gait Energy Images (GEI). Gait Energy Image (GEI) is the sum of images of the walking silhouette divided by the number of images. GEI is very efficient and effective way of gait representation. It has main advantages is it's save storage space and it is less sensitive to noise. When person walks in front of camera at that time camera captures the human walking style pictures. Using these images, we can get GEI images of human gait .We used these GEI images as an input of system. The following equation presents the pre-processed binary gait silhouette images Bt(x, y) at time t in a sequence, GEI is computed by,

$$G(x,y) = 1/N \sum_{t=1}^{N} Bt(x,y)$$

Where N is the number of frames in the complete gait cycle(s) of a silhouette sequence, x and y are corresponding pixel coordinate in image frame Bt of gait sequence. t is frame number.

2) Feature Extraction Module
PCA is used for gait feature extraction.PCA is a linear technique and used for feature extraction and recognition.PCA is adopted for dimensionality reduction. Dimension reduction is the process of reducing the number of random variables under consideration via obtaining a set of principal variables. It can be divided into feature selection and feature extraction. It produce compact low dimensional encoding of a given high dimensional dataset.PCA calculate eigen vector and eigen values of images. Features like height and weight of silhouette are concentrated throughout feature extraction in PCA.

3) Trained Dataset
Trained database contains gait silhouette images. We have utilized CASIA-A data set, which contains binary silhouette so preprocessing step is avoided. Also we create our own

dataset for experiment using canon S25 camera. It has 13 megapixel camera feature and 32 optical zoom moss sensor. We captured 45 and 90 view degree images from this camera. We used gimp2 software for creating silhouette images.

4) Classifier Module

Classifier module contains K nearest neighbor classifier. It is used to match the similarities between given samples

5) Decision module

Decision module takes the decision, given image are valid or not. If valid, show the human id.

3.2 Feature Extraction using PCA

Principal component analysis is a linear technique and used for feature extraction and for recognition.PCA does a linear mapping of high dimensional space to low dimensional space in such a way that first it centralizes the data by subtracting the mean. It is a way of identifying patterns in data, and expressing the data in such a way as to highlight their similarities and differences. Since patterns in data can be hard to find in data of high dimension, where the luxury of graphical representation is not available, PCA is a powerful tool for analyzing data. The other main advantage of PCA is that once you have found these patterns in the data, and you compress the data, ie. by reducing the number of dimensions, without much loss of information. This technique used in image compression.

3.3 Methods and Materials

Gait Recognition

Gait is a new biometric field to determine person. Gait is nothing but a particular way or manner of moving on foot. Gait recognition dataset mostly provide gait energy images. Which are the average silhouettes along the temporal dimension. For example, some GEI of one subject in CASIA A gait dataset are shown in figure 3.

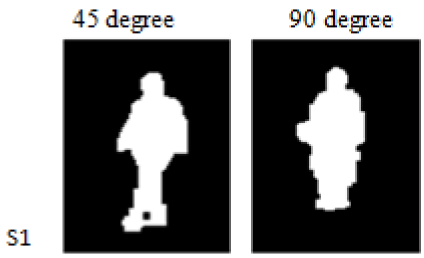
For our experiment, we used the CASIA A dataset and our own created dataset. The gallery set contains N= 21 subjects. Training set of m images of size $N*N$ are represented by vectors of size N^2

$$\Gamma_1,\Gamma_2,\Gamma_3,\ldots,\Gamma_M .$$

A covariance matrix is constructed as:

$C = AA^T$, where $A=[\Phi_1,\ldots,\Phi_M]$ of size N^2 x N^2.

Covariance matrix generalizes the notion of covariance to multiple dimensions.



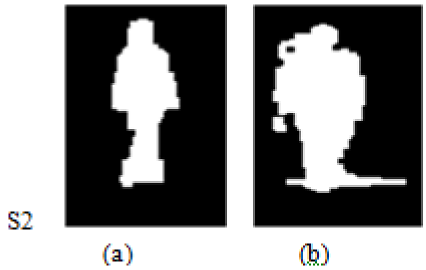


Figure 3: Example GEIs of two subjects (s1-s2) in CASIA-A gait dataset. Column (a):GEI of 45 degree .Column(b) :GEI of 90 degree

Finding eigenvectors of N^2 x N^2 matrix is intractable. Hence, use the matrix A^TA of size M x M and find eigenvectors of this small matrix using following formula (using equation(1))

If v is a nonzero vector and λ is a number such that

Av = λv, …………..(1) then

v is said to be an *eigenvector* of A with *eigenvalue* λ.

Finally we get the sorted eigen values of covariance matrix of eigen vector.

3) K –Nearest Neighbor

The idea behind the k-Nearest Neighbor algorithm is to build a classification method using no assumptions about the form of the function, y = f(x1,x2,...xp) that relates the dependent (or response) variable, y, to the independent (or predictor) variables x1,x2,...xp. The only assumption we make is that it is a smooth function. This is a non-parametric method because it does not involve estimation of parameters in an assumed function form such as the linear form that we encountered in linear regression.

KNN is calculating k neighbors around the unknown sample, and classifies the unknown sample to the category that majority neighbors belongs to. Considering the problem of classifying N entities into M classes, which can be formulated as n = {WI' W 2" "' W M }, where Wi denotes the ith class.

The available information is assumed to consist in a training dataset T = {(XI,CI), ... ,(XN,CN)} of N patternsX;(i = 1,2, . .. ,N) and their corresponding class labels ci (i = 1,2, .. . , N) taking values in n. K -nearest neighbor(KNN) rule [8] is well known in the pattern recognition literature. According to this rule, an unclassified pattern X is assigned to the class represented by a majority of its K nearest neighbors in T. This rule is usually called "voting KNN rule." KNN is popular in pattern recognition community due mainly to its good performance and its simple-to-use feature. Since the inception of KNN some

Simple KNN Algorithm:

1) Determine parameter k=no of nearest neighbor.
2) Calculate the distance between query instance and all training sample.
3) Sort the distance and determine nearest neighbor based on k th mininmum distance.
4) Gather the category Y of nearest neighbor.

5)Use simple majority of category of nearest neighbor as the predication value of query instance.

4. Experiments and Discussion

4.1 Experiment Data

CASIA A dataset is used for this experiment. It consists of human normal walking images. It consists of 20 people. Each person has 12 image sequences, 4 sequences for each of the three directions, i.e. parallel, 45 degrees and 90 degrees to the image plane. Here we used 20 people's data for experiment. We considered each person has 4 image sequences .2 sequence for each of two directions i.e. 45, 90 degree.

Here we also create our own dataset for experiment using canon s25 13 megapixel cameras. We used GIMP software for silhouette images. There are 6 steps to create silhouette images as follow:

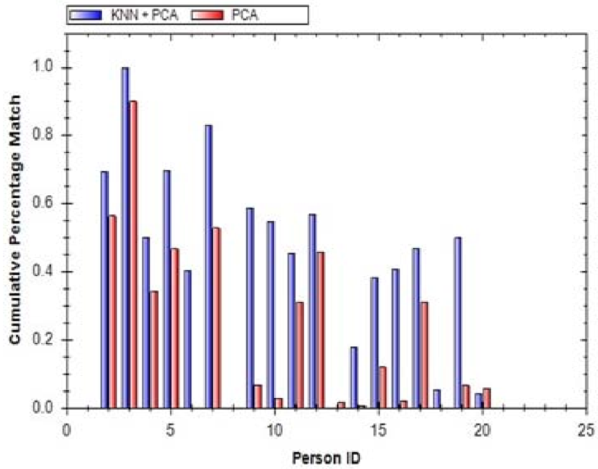
1*)* Open your image with Gimp. 2*)* Select your foreground object. (Click on the "Scissors Select Tool" located in the main toolbar.) 3*)*. Remove the background (Go to "Select" menu and click "Invert". This will change your selection from the foreground to the background so you can delete the background.). 4*)* Optionally Fill the image in black (Choose the Bucket fill tool from the menu. Make sure that "fg color fill" is selected) .5) Touch ups and saving(Go to File->Export As->Select file type and save your image, png files will preserve transparency). 6) You are done!

4.2 Experiment Result and Analysis

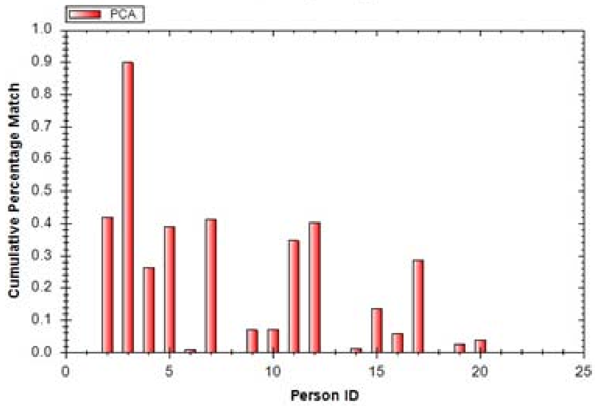
After computing the similarity differences between the test sample and the training data, the KNN is then applied for classification. Figure 4 show the cumulative match scores for 20 human, where Figure. 4a show recognition result using PCA plus KNN and figure 3b show recognition result using PCA.

From figure. 4, we can draw the following conclusions:

- The identification performance using PCA plus KNN is, better than that using PCA. PCA plus KNN can better capture spatiotemporal characteristics of gait motion than PCA, and it is expected to obtain better recognition accuracy.
- Recognition accuracy of PCA plus KNN is always above 95% under any view angle condition. But Recognition accuracy of PCA is 90%.



(a)



(b)

Figure 4: I dentification performance based on the cumulative match score (a) Recognition result using PCA plus KNN. (b) Recognition result using PCA.

Table 1 shows the correct cumulative match score of different methods measured on CASIA A dataset and our own created dataset.

Table 1: Correct Cumulative match score(CMS) of different methods measured on CASIA A dataset and our created dataset

Algorithms	Cumulative match score (CMS) (%)
PCA	90%
PCA plus KNN	Above 98%

5. Research Lab & GAIT Products

5.1 Research Lab

As the survey done by us, there are the four below mentioned research lab working in gait recognition.

1. The Center for Biometrics and Security Research (CBSR) is established by the Institute of Automation, Chinese Academy of Sciences (CASIA). CBSR focus to research and develop biometric standards and databases and protocols. Their current biometric researches are face recognition, iris recognition, gait recognition, handwriting recognition etc.

They provided different CASIA database for recognition purpose. For gait recognition they provided CASIA gait database. In the CASIA Gait Database there are three datasets:

Dataset A, Dataset B (multi view dataset) **and Dataset C**(infrared dataset).CASIA Dataset D provides gait and footprint data together.

2. Yogi Laboratory is established by Department of Intelligent Media ISIR (Institute of Scientific and Industrial Research), Osaka University, and Japan. This laboratory's main study focus is computer vision and media processing. Major research project are developed in biometrics fields including gait identification, video analysis for endoscopic diagnosis assistance etc. They provided OU-ISIR Gait Database.

3. ISIS (Information Signals Images Systems) research in image processing and computer vision. Main application domain is biometrics, in remote sensing and in medical image analysis. Their current work is to recognize people by their gait and by their ear.

4. Georgia Tech Research Institute : Here Researcher is developing ways to identify humans at a distance. One primary focus of their work is on gait recognition. They proposed a technique that recovers static body and stride parameters of subjects as they walk. This approach is an example of an activity-specific biometric: a method of extracting some identifying properties of an individual or of an individual's behavior that is only applicable when a person is performing that specific action. Researchers are also analyzing the ability of time-normalized joint angle trajectories in the walking plane as a means of gait recognition.

5.2 Existing Gait Products

Following are few examples of existing gait products.

Gait Scan: Gait Scan is a computerized pressure place that it attached to a computer. This technology assists us in analyzing your gait and detecting unusual foot function which may be affecting the rest of your body. This product is developed by Dr.Ken Fujinaka(Japan).

Gaitometer: The Gaitometer is a patented iPhone or iPod Touchapplication that is used to measure asymmetry in your gait and provide you with feedback about your gait. That way, you may be able to improve your walking ability.

RunwayScan: RunwayScan is a component of our NeurodegenScan Suite. RunwayScan system meets the needs for gait analysis of animals. Gait analysis allows highly sensitive, noninvasive detection and evaluation of many patho physiological conditions, such as those occurring in Spinal Cord injury, Parkinson's disease, Alzheimer's disease, ALS, arthritis, pain, neuromuscular and skeletal muscle diseases.

Tekscan: Tekscan offers two distinctive solutions for performing meaningful gait analyses: Platform-based walkway and in-shoe-based systems. Both systems provide objective, quantifiable data from heel contact to toe off during the full unique insights from these systems help you identify asymmetries and abnormalities which otherwise might go undetected.

It is a gait analysis system that uniquely provides spatial-temporal data from multiple sequential footsteps during the gait cycle. Walkway Systems are available in multiple sensor resolutions and multiple standard lengths that are sure to meet your needs.

LiteGait: LiteGait products meet the clinical gait therapy needs of patients of all ages in the clinic and in the home. The unique design of LiteGait provides benefits to the Patient, the facilityand to the therapist. LiteGait has three type namely Adult LiteGait , Pediatric LiteGait and Pariit.

6. Conclusion and Future Work

In this paper we have proposed human identification system with hybridization of PCA and KNN techniques giving better result as compared to existing techniques. This system will be applicable to many surveillance areas i.e. in banking, in medical field, military etc. In future we are trying to add one more biometric field for human identification. We will work this experiment on dynamic data as a future work

References

[1] Kshitiz Varma, Sanjeev Sharma, "Front View Gait Recognition", International Journal of Advanced Engineering and Global Technology, 2015.
[2] Jyoti Bharti, Navneet Manjhi, M.K.Gupta and Bimi jain, "Gait using Moment of Gray Scale and Silhouette Image", International Journal on Soft Computing (IJSC) Vol.6, No. 1, February 2015.
[3] Robindeep Kaur ,Namita Kakkar ,"Person Tracking using Gait", International Journal of Advanced Research in Computer Science and Software Engineering ,Volume 3, Issue 8, August 2013.
[4] Avani P. Patel, 2Vaibhav C. Gandhi, "Survey on Human Gait Recognition", IJCST Vol. 5, Issue 4, Oct - Dec 2014 .
[5] Navneet Kaur, Samandee p Singh, "Review On: Gait Recognition for Human Identification using NN", International Journal of Computer Science and Information Technologies, Vol. 5 (3) , 2014, 3991-3993.
[6] Ju Han, Bir Bhanu, "Individual Recognition Using Gait Energy Image" , IEEE Transations on Pattern Analysis and Machine Intelligence, Vol. 28, No. 2, February 2006.
[7] Heesung Lee, Byungyun Lee, Jin-Woo Jung, Sungjun Hong, and Euntai Kim, "Human Biometric Identification through Integration of Footprint and Gait",International Journal of Control ,Automation ,and System. Springer, 2013,pp.826-833.
[8] Chen Wang, Junping Zhang, Liang Wang, Senior Member, Jian Pu, and Xiaoru Yuan, "Human

Identification Using Temporal Information Preserving Gait Template", IEEE transaction on Pattern and Analysis and Machine Intelligence,Vol.34,No.11, November2012.pp.2164-2176.

[9] Nivedita Gunale and Anita Thengade, " Human Identification using Integration of Gait and Footprint" Proceedings of Third Post Graduate Conference on Computer Engineering Cpgcon 2014 ISBN:9789351072928,ELSEVIER

[10] Anita Thengade and Nivedita Gunale,"Enhanced Biometric System using Gait and Footprint", in Processing of International Conference for Convergence of Technology(I2CT) 2014.

[11] G.V.Narasimhulu, Dr.S.A.K. Jilani(2012), "Fuzzy Principal Component Analysis based Gait Recognition", International Journal of Computer Science and Information Technologies, Vol. 3 (3), pp.4015 – 4020.

[12] Rohit Katiyar ,and Vinay Kumar Pathak(2013, February),"Gait Recognition Based on Energy Deviation Image Using Fuzzy Component Analysis ", International Journal of Innovation, Management and Technology, Vol. 4, No. 1,pp.43-46.

[13] Hu Ng, Hau-Lee Tong and Wooi-Haw Tan(2011), "Human Identification Based on Extracted Gait Features ", International Journal on New Computer Architectures and Their Applications (IJNCAA) pp.358-370.

[14] Liang Wang, Tieniu Tan, Huazhong Ning, and Weiming Hu(2003,December),"Silhouette Analysis Based Gait Recognition for Human Identification", IEEE Transactions on Patteren Analysis and Machine Intelligence, VOL.25,pp.1505-1517.

[15] Horia F.Pop (2001)," Principal Component Analysis Based on A Fuzzy Sets Approch ", Studia Univ. Babes–Bolyai, Informatica, Vol. 2, pp.45-52.

[16] Charles Elkan, "Nearest Neighbor Classification", elkan @ cs.ucsd.edu.pp.1-16 (2011,January11).

[17] Oren Boiman, Eli Shechtman and Michal Irani, "In Defense of Nearest-Neighbor Based Image Classification",pp.1-8.

[18] S. Sarkar, P. J. Phillips, Z. Liu, I. R. Vega, P. Grother, and K. W. Bowyer(2005, February), "The HumanID gait challenge problem: data sets, performance, and analysis," IEEE Trans. Pattern Analysis and Machine Intelligence,vol. 27, pp. 162-177.

[19] A. Kale, A. Sundaresan, A. N. Rajagopalan, N. P.Cuntoor, A. K. R. Chowdhury, V. Kruger, and R.Chellappa(2004), "Identification of humans using gait,"IEEE Transactions on Image Processing, vol. 13, no. 9,pp. 1163-1173.

[20] Anita Thengade and Rucha Dondal(2012), " Recognition of Human Gait Using Genetic Fuzzy Finite State Machine", International Journal of Engineering Research and Technology Vol. 1 (02), ISSN 2278 - 0181