Chapter 8

CONCLUSION AND FUTURE WORK

8.1 SUMMARY OF THE WORK

The goal of this thesis is to investigate the information contained in the video sequences of human gait and how to extract and represent that information in ways that facilitate human authentication. The attractiveness of gait as a biometric arises from the fact that it is non-intrusive and can be detected and measured even in low resolution video. Furthermore, it is harder to disguise and it does not require a cooperating subject. Unlike traditional biometrics like face, fingerprints, iris, etc., gait is a spatiotemporal signature, which contains a structural component and dynamic component.

In this thesis, a machine vision based, model free approach is presented in which features are extracted from silhouettes for implementing a gait based authentication system. Given the video of an individual, the moving object is segmented out by a background subtraction technique. Gait representing spatiotemporal, anatomical and part based binary moment features are extracted from human silhouette and classified using standard pattern classifiers such as PNN, kNN, SVM and with the proposed kNN-SVM classifier.

The theoretical background for the development of a biometric system using human gait as the discriminating feature, basic characteristics of human gait, techniques used to
recognize human gait, challenges of gait recognition and methodologies of Motion Vision based gait recognition available in the literature are presented.

Implementation details of the steps before feature extraction such as background modeling, foreground segmentation, silhouette generation and gait cycle estimation are described. Three background modeling techniques namely Change Detection Mask, Median value based and Histogram based and two foreground segmentation techniques namely Frame difference and Approximate Median are tested with various video sequences. These algorithms are evaluated in terms of execution time, MSE, PSNR and SC. Experimental results showed that frame difference with median value based background modeling algorithm is simple and efficient.

The proposed framework for authentication and its block diagram is given in Figure 7.2. Since the efficiency of a system depends on size of search space, an efficient method is proposed to reduce the search space by splitting the database into two based on gender. Then the search is restricted in the identified gender database for authentication. The objective of the proposed approach is successfully achieved in the confined space and the experimental results on the benchmark CASIA-B database showed superior performance.

Extraction of different types of features namely spatiotemporal features (height, width, aspect-ratio, diagonal angle, steplength, stridelength, cadence, velocity), anatomical features (Pixel-wise height, width and all possible ratios of body parts based on anatomical division) and binary moment features (area, centroid, orientation, length of
major and minor axis, aspect ratio and eccentricity) to represent gait for gender discrimination and classification are described. Sequential Forward feature selection algorithm is used to select appropriate features and to remove redundant and irrelevant features based on misclassification rate.

Two methods for gender discrimination are outlined in this thesis. In the first method, full body binary silhouette to determine gender is considered and extracted six features namely height, width, xmean, ymean, aspectratio and angle of inclination. Three different cases of images namely upper body, lower body and whole body region are used to compare the classification performance. In this work experiments are conducted with kNN and SVM models, and NLPR database is used to evaluate the effectiveness of the proposed approach. Conducting a leave-one-out recognition experiment on NLPR dataset revealed excellent results, with a correct classification rate of 100% for both kNN and SVM. This showed the discriminatory ability of the extracted features. But this feature set did not work well for the dataset with covariates.

In the second work, binary silhouettes of lateral view videos of human gait with two covariates carrying bag and wearing coats from CASIA-B database are considered, and extracted 9 different features. In this method, features are extracted based on binary moments and anatomical division. A total of 26 parameters are considered as gait features initially and removed irrelevant and redundant features. As a result, 9 important features are selected from all the frames in one gait cycle and then calculated the average of each
feature for gender discrimination. The selected features are area, centroid(x,y), aspect ratio, angle of inclination, shoulder width, head width, chest width and hip_chest ratio.

Two classification models SVM and PNN are trained with the 9 features. For training, only normal walking sequences are used, while the normal walking scenario and the other two scenarios (carrying, clothing) are used for testing. Out of 6, 4 normal walking sequences of 31 males and 31 females are used for training. Hence, there are 248 video sequences for training. For testing 124 sequences are used from each test case (normal - 124, coat wearing -124 and bag carrying -124). 3 fold cross validation experiment was carried out with CASIA-B dataset. The performance of SVM model with quadratic kernel and PNN model is similar and is 100%, 100%, 82.5% classification rate for Normal/Normal, Normal/Bag and Normal/Cloth test cases respectively.

For authentication the proposed approach was applied on CASIA-B database. A total of 76 parameters are considered as gait features initially and removed irrelevant and indiscriminant features. As a result, 19 important features for male and 12 features for female are selected from all the frames in one gait cycle and then calculated the average of each feature for gait representation of a video.

Male feature set contains 11 binary moment features and 3 anatomical features and 5 spatiotemporal features. The binary moment features are 5 from head part (xmean, angle, minor axis length, eccentricity, standard deviation of ymean), 3 from shoulder part (angle, area and major axis length) and 3 from entire silhouette (xmean, standard
deviation of ymean and angle). The anatomical features are ratio of chest width to height, ratio of hip width to height and hip waist width ratio. The spatiotemporal features are standard deviation of height and width, mean height, step length and stride length.

Female feature set contains 10 binary moment features and 2 spatiotemporal features. The binary moment features are 5 from head part (xmean, angle, minor axis length, eccentricity, standard deviation of ymean), 3 from shoulder part (angle, area and major axis length) and 2 from entire silhouette (xmean and angle of inclination). The spatiotemporal features are height and steplength.

Three classification models SVM, kNN and the proposed combined classifier kNN-SVM are trained with 19 features for male and 12 features for female. The same testing strategy as in gender discrimination was applied in authentication also. Performance of SVM model with Radial Basis Function (RBF) kernel is 100%, 92.5% and 67.5% verification rate for Normal/Normal, Normal/Bag and Normal/Cloth test case respectively. Performance of kNN model with cityblock distance is 100%, 87.5% and 72.5% verification rate for Normal/Normal, Normal/Bag and Normal/Cloth test case respectively. Performance of kNN-SVM model is 100%, 92.74% and 80.64% verification rate for Normal/Normal, Normal/Bag and Normal/Cloth test case respectively.

Experimental results evaluated on the benchmark CASIA-B dataset show that this proposed method can effectively capture gait characteristics. Performance of the system
degrades significantly when the training and testing data differ in clothing and are least
affected by variation in carrying condition. False Acceptance Rate of the proposed
system is 0.032. Varying from other authentication systems, the probability of accepting
an imposter decreases with the increase of enrolled users in the proposed system. False
Rejection Rate of the system is 0%, 7.26%, 19.35% for Normal/Normal, Normal/Bag and
Normal/Cloth test cases respectively. Performance of the combined classifier
outperforms many gait classification approaches. Achievement of improved performance
with less processing time is due to the splitting of database based on gender and less
dimension feature set by the selection of significant gait features.

8.2 CONTRIBUTIONS OF THIS RESEARCH WORK

- Proposed an authentication system with reduced search space to increase the
efficiency of the system.
- Split the database into two based on gender, before performing matching.
- As the gait characteristics vary by intrapersonal variations, a representation which
  is stable and discriminant is created.
- Three classification models were developed for gender discrimination and
  authentication and their performances were evaluated.
- Combined classifier approach was applied for utilizing the decisions of both kNN
  and SVM.
- Performance of the combined classifier outperforms many gait recognition
  approaches.
8.3 DIRECTIONS FOR FUTURE RESEARCH

- Develop view transformation algorithms to make the system view invariant because in realistic surveillance scenarios, it is unreasonable to assume that a person could always present a lateral view to the camera. Therefore, further work is required to address the different viewpoint angles for gait recognition.

- Although the method brings closer to goal, we are still at a far distance because the real world data are very complex.

- Fusion of model free and model based approaches to yield better results.

- Consider other external factors varying gait.

- Create a real time system.