CHAPTER 6

CONCLUSIONS AND FUTURE WORK

6.1 CONCLUSIONS ON THE RESEARCH CONTRIBUTIONS

This research work develops the basis for decisions on choice of efficient multimodal biometric authentication system needed for providing highly secured access to resources. Initially, three feature extraction methods were developed using unimodal biometric systems (based on iris, retina and ear) which provide better authentication accuracy/ high processing speed compared to existing results. Next, five different multimodal biometric systems were implemented by employing various score normalization and fusion techniques to give enhanced performance. Finally, a PSO based method was developed to ensure the use of optimal threshold for maximizing accuracy of the developed biometric system. Specific conclusions/ results obtained from the above mentioned methods are summarized below:

- Iris based authentication

  A new feature extraction algorithm was developed which makes use of the best bits in the middle portion of iris code, excluding the inconsistent bits near the pupil and limbic boundaries of iris. Feature matching was then performed by computing hamming distance between the compared iris images. The result shows that the proposed best bit method gives comparable recognition rate with Daugman’s method (97.3% against 100%). In addition, the time taken for computing hamming distance was found to be reduced by 50% as the best bit method uses only 2/3rd of the bits of the original iris code. To enhance further the authentication accuracy, a multi-unit iris recognition system was proposed that uses the left and right irises of users. Score level fusion of hamming distances obtained
from left and right irises was computed using SVM, min, max and weighted sum methods. It was found that SVM gives the highest recognition rate of 98.9% compared to other fusion rules employed in this work.

- **Retina based authentication**

  The method involves blood vessel segmentation, feature template generation based on retinal minutiae (bifurcation points), which is insensitive to translational and rotational displacements of retinal images and finally matching of these points. Performance of the method was analyzed by using three publicly available retina databases. It was observed that there was a large inter-class distance for DRIVE images than STARE and VARIA images. The method gives 100%, 98.3% and 87.1% recognition rates for images of DRIVE, VARIA and STARE databases respectively. As retinal template size and the effort involved in processing retina images are much less, this method is computationally efficient.

- **Ear based authentication**

  A new way of feature extraction was proposed by removing the occluded parts of ear (top and bottom portions) and using only the middle part of ear. This method involves two stages of feature extraction from the cropped portion of ear. The extracted feature points from each of the two stages of different ear images were then compared and the matching scores were computed. The final score was computed by combining the matching scores obtained from the two stages by means of weighted sum fusion. Performance analysis of this system was made by using USTB ear database and the experimental results showed that the method gives 98.3% recognition accuracy with partial ears. This result is even better than that of conventional methods based on complete ear images. The computation time also reduces by 40% as the size of ear image used in authentication process is $2/3^{rd}$ of its original size.
• **Authentication by fusion of multimodal biometric scores**

Five different multimodal biometric systems were implemented and their performances were compared with respect to accuracy and error rate. The results showed the effectiveness of min-max fusion approach in combination with the modified QQ and QLQ normalization methods resulting in 100% accuracy. It may be mentioned that the method chosen for normalization has a significant impact on the resulting fusion performance. It is also found that fusion of more traits increases recognition rate while decreasing the error rate, which ultimately raises the complexity of the biometric authentication system. Hence use of optimal number of traits is recommended which enhances performance of the system while keeping complexity within the limits. It is also observed that there is no specific method of normalization or fusion that can be quoted as the best one. Performance varies with different traits and fusion methods employed in the biometric system.

• **Performance enhancement by PSO**

One of the key problems in adaptive multimodal biometric systems pertains to the selection of optimal threshold value for maximizing accuracy and minimizing error rates while employing different modalities. Selection of threshold plays a crucial role in any biometric authentication system as it directly affects the system performance. Hence an optimization approach based on PSO was proposed for proper selection of threshold in a multimodal system based on iris and palm print. The experimental results obtained show that the application of PSO for threshold optimization improves accuracy of the system. In particular, weighted sum fusion gives the best results in terms of lower EER and higher recognition rates compared to other fusion methods.

6.2 **FUTURE WORK**

As biometrics is widely used nowadays in almost all security related automation applications, its scope and performance need constant upgradation. In
this regard, the following issues can be taken up as potential extensions of existing research:

- Designing biometric systems that automatically recognizes the working environment (outdoor / indoor / lighting etc) is needed which adjusts its settings to deliver robust data.
- Scalability enhancements along with quality measures can be included in the experimentation to assist decision making in the matching process.
- Iris, ear and retina templates generated by the biometric systems need to be secured for maintaining the privacy of users’ information.
- The number of samples per image can be increased for making stronger comments about different biometric systems that is being developed.
- In adaptive multimodal systems, algorithms can be developed to adaptively select the best set of biometric modalities from the available inputs to ensure the desired level of security.
- Open standards for biometric data interchange formats, file formats, application interfaces, testing methodology and framework for integration can be developed.

Successful pursuit of these biometric challenges will generate significant advances to improve safety and security in future missions.