CHAPTER-9

9 Conclusion and Future Scope

9.1 Conclusion

The development of an intelligent and efficient off-line handwritten character recognition system has been an active area for research for many years. A critical literature review of existing techniques and comparative study of recent achievements in this area has been thoroughly investigated and it is observed that the research is almost matured in area of numeral recognition however the same accuracy level is not met with alphabets. Therefore, the problem of cursive character recognition remains very much an open problem. To handle this type of problems new character segmentation techniques, preprocessing techniques, feature extraction / selection techniques and robust classifiers are desired.

The focus of this thesis is to explore preprocessing, untouched and touched character segmentation and feature extraction techniques for off-line cursive handwritten words recognition. MLP and RBF network classifiers are employed for the recognition task and various techniques are suggested to optimize the neural network classifier for further improvement in the recognition accuracy.

The first character segmentation technique proposed in this thesis is based on the connected component analysis and is used to segment untouched characters. This technique can be extensively used in a variety of applications where the extracted character images are used to train and test a character recognition system like a car number plate recognition system etc. Some shortcomings are identified in cases where a character image is not completely connected.

The second character segmentation technique proposed in this thesis is basically a vertical dissection based segmentation technique used to segment touching characters in a
word. It guaranteed correct segmentation when characters in a word image are not touching each other. This technique also delivered excellent results in case of segmentation of ligatures present between consecutive Closed Characters. It also minimized the problem of over-segmentation that appeared during segmentation of Open Characters.

The use of binarization features along with back-propagation feed forward neural network yielded the excellent recognition accuracy of 85.62%. Whereas the use of projection profile features in all the four directions of the digit image along with RBF neural network yielded the excellent recognition accuracy of 100% for the recognition of handwritten digits.

The character recognition performance of the two neural network classifiers, MLP and RBF Network, has also been evaluated using the hybrid features obtained from fusion of binarization and projection profile features. The binarization and projection profile feature vectors of each character image are concatenated to form the hybrid features for the training sample. The samples thus created are trained and tested by both the classifiers and it has been observed that in case of training with hybrid features, back-propagation MLP delivers better recognition accuracy (88.76%) as compared to training with only binarization features (85.62%). The recognition accuracy is found to be further improved (93.46%) when RBF neural network classifier is used for the recognition of samples prepared by using hybrid features.

Various techniques are evaluated which are used to optimize the architecture and the training parameters of a back-propagation MLP network. Some common situations during back-propagation learning with possible causes and potential remedies are also presented and based on these theories and strategies, some performance tests has been conducted by changing the various training parameters (by trial and error method) and the recognition accuracy and speed has been found to be improved considerably.
9.2 Future Scope

Preprocessing, feature extraction/selection techniques and the methodology used to select the neural network training parameters can be improved to get promising results. In future, the character images which are rotated at a certain angle can also be included in the character recognition experiment.

Some intelligent technique to validate the correct segmentation points (e.g. a neural-based validation) may be developed to further improve the segmentation accuracy in future work.

Performance of pattern classifiers can be improved further if the best features are selected from all the extracted features by using various Soft Computing techniques such as Genetic Algorithms, Fuzzy Systems or their combination. Genetic algorithm is based on "the survival of the fittest" and is the most efficient feature selection technique to select best features from the extracted feature set of the character/digit image. It can also be investigated for optimal weight initialization during Neural Network Training. Fuzzy Set theory can be involved for the recognition of noisy, broken or incomplete character patterns having imprecise information.

Apart from MLP and RBF networks, other potential neural network classifiers such as Hopfield Network, Hidden Markov Model (HMM) and Support Vector Machine (SVM) can be examined in this domain of research. Different classifiers have their own advantages and disadvantages. Therefore, the advantages of each individual method can be inherited in a single classifier system built by the fusion of various other classifiers working at different stages in this system.

Hence, Genetic Algorithms and Fuzzy Set Theory for extraction and selection of features along with the fusion of classifiers may become an interesting research direction for future.