CHAPTER 7
SUMMARY OF THE THESIS AND SUGGESTIONS FOR FUTURE WORK

7.1 SUMMARY OF THE THESIS

The overall summary points of the framework developed for diagnosis of diabetic retinopathy using digital fundus images and briefed in this thesis are consolidated and presented in the following sections.

The success of the framework was achieved, mostly, by utilization of hybrid segmentation methods, the introduction of novel morphological feature extraction methods and classification with the aid of artificial intelligence techniques.

7.1.1 Design of CAD system for DR diagnosis

- The methods used for segmenting anatomical structures such as optic disk, blood vessels and outer border along with exudates have been presented and promising results were shown.

- The proposed CAD system can identify DR cases with an average accuracy of more than 91%, a sensitivity of more than 91%, and a specificity of 90.5%.

7.1.2 Statistical comparison of SVM outcomes

- Automatic methods for screening exudates for DR diagnosis have been developed based on image processing methods which utilize a color component, morphology and intensity values in retinal digital fundus images.

- The extracted morphological parameters exhibit significant differences between normal and DR groups at p<0.001, whereas, the age and BMI values depicted no such significance.
The proposed system has achieved 93% segmentation accuracy of the exudates region form digital fundus images when ground truth (hand drawn) results were considered as standard. In addition, the traditional F-score, precession and recall values were 88.2%, 93.1% and 89.3% respectively.

7.1.3 Performance analysis of CAD system with standard database

- The CAD system proposed in this work is fast and accurate for the analysis of diabetic retinopathy detection using fundus images.
- The developed DR screening system has been validated with publicly available fundus image databases such as DIARETDB1, DRIVE and STARE, containing the ground truth collected from several experts and comparison with our database images.
- The proposed CAD system gives a higher rate of sensitivity, specificity and accuracy as 92%, 91% and 92% with own private dataset.

7.1.4 Detection of diabetic Maculopathy

- The detection of diabetic Maculopathy, which is the severe stage of diabetic retinopathy, is obtained using morphological operation.
- The overall sensitivity, specificity and accuracy are obtained as 70.4%, 98.4% and 94.7% respectively.
- This system is very useful in detecting the severe as well as early stage of diabetic retinopathy.

7.2 SUGGESTIONS FOR FUTURE WORK

This thesis presents a framework for automatic detection of diabetic retinopathy and Maculopathy from retinal fundus images. Certainly, this framework has few limitations, mainly, in the performance space as well as computation of depth related information. Hence, this work can be extended in the following areas:
7.2.1 Embedding the algorithm with imaging modality

- The proposed framework (programs) must be brought into real time processors such as digital signal processors (DSP) and further, which will be integrated with the fundus imaging modality (camera). Thus, it makes out a comprehensive independent system to detect retinal disorders automatically during the image acquisition phase.

7.2.2 Development of web and mobile based application

- With the introduction or advancement of technologies, retinal images can be captured by using a smart phone and hence, diagnosis can be done by the patients on themselves at home provided these disease detecting image processing algorithms are loaded into the cell phones.

7.2.3 Advancement in image processing algorithms

- The study of principal component analysis to exclude features those are least influential in the classification process, with the aim of decreasing the network complexity their by increasing its efficiency (improved performance).

- Generally, in fundus images, the depth related information is missing and hence it influence in the accuracy in the classification. Therefore, depth map extraction using probabilistic models can be considered for improving the accuracy.