CHAPTER 7

CONCLUSION AND FUTURE WORK

7.1 CONCLUSION

An automatic diagnosis system is developed to detect glaucoma and diabetic retinopathy at an early stage using digital fundus images. In this work, attempts are made to address the issues associated with the detection of two ocular diseases. Various detection algorithms found in the literature related to the detection of optic disc, optic cup and exudates identification are analyzed and the requirements for an efficient detection algorithm for glaucoma and DR are identified.

In the assessment of glaucoma, to overcome the drawbacks associated with the CDR parameter, rim to disc ratio an alternate optic nerve head parameter provides better identification of the stages of glaucoma. Optic disc is detected using DW technique to overcome the drawbacks of previous methods by analyzing the optic disc in the polar coordinate domain. The newly developed segmentation algorithm is capable of obtaining 100% OD localization and 100% accuracy in the identification of left and right eye. Representation of images in the polar coordinate domain facilitates description of local image regions in terms of radial and tangential characteristics to find a closed contour with an accurate tracing of OD boundary with no loss of data. Several experiments were conducted for real time images, four databases and the performance of DW were compared with MLVM, HT and GVF snake in terms of accuracy. It is observed that the OD
boundary detected showed consistent results with the ground truth when tested against small, medium and large size disc. The algorithm detected the disc even when there are fuzzy boundaries, inconsistent image contrast, discontinuities along the boundaries where blood vessels cross or missing edge features. The case in which OD was not detected correctly is due to the pathologies near the border of OD candidates and when the image was captured with the fovea as centre and OD to the other side.

A novel approach employing color clustering in L*a*b* color space is used to segment the cup information from the images. Optic cup segmented using CMM technique achieved a high F score and the cup boundary was detected well in all the quadrants except in those regions where there are a strong blood vessel convergence. Due to the incorporation of disc size and rim width, stages of disc damage were identified by the quantification of neuroretinal rim. Extraction of textural features reflects the physiological changes in fundus images due to the increase in cup size. Evaluation and selection of prominent features from the structural, textural features and classification using ANFIS has led to an enhanced specificity and sensitivity of glaucomatous image classification. Results produced by ANFIS are highly encouraging and a comparative analysis performed between ANFIS and neural network suggests that the glaucoma assessment using ANFIS outperforms the stand alone neural network in terms of training performances and classification accuracies. Although classification capability of single individual parameter is better, discriminating power is still increased with the combination of textural and optic nerve head parameters using ANFIS. Glaucoma detected using structural and textural features provides higher accuracy than the approaches related to profile calculation and texture, higher order spectral features reported in the literature.
Early stage of DR is also assessed in this work by extracting anatomical and textural features. Color information used in the preprocessing stage helps to identify the exudates pixels clearly. Features derived from the blood vessel and candidate exudates show discriminatory performance in the classification of images. Pixel based and image based approaches criteria were used to evaluate the accuracy of the system. With the color histogram technique used for pixel approach, the two bright lesions namely hard exudates and soft exudates were detected. There are a very few false positives and even the faint exudates present closer to the disc are detected in this approach. Further the faint blood vessels were also not recognized as exudates. Color Histogram technique allows higher segmentation accuracy than the other methods. The complete analysis of the system can be done in 20 seconds without any user involvement. In the image based approach, anatomical and textural features extracted from the segmented images does not misclassify any of the abnormal images and outperforms the accuracy of using only color features. Features extracted do not show overlapping of classes and the combination of anatomical and textural features are successful in detecting the abnormalities with a high sensitivity and specificity. Stages of DR are identified using the distance between macula and the detected exudates.

All the functionalities are integrated through a GUI, which can assist the medical professional to perform measurements in a perfect fashion and apply targeted measurements according to medical protocols. The technique is of clinical significance with a higher accuracy and eliminates subjective variability encountered in currently used clinical practice. Analysis of retinal images to detect the early stage of the disease can be done without any user involvement by using the developed application. Automated diagnosis using digital image analysis offers huge potential benefits to examine a large number of images with time and cost savings, offers more
objective measurements than current observer driven techniques and reduces the workload required from manual trained graders.

7.2 FUTURE WORK

Future research in glaucoma could be focus on detecting patients with the tilted discs by using different texture descriptors or by finding new texture descriptors that automatically adapts to the variability of the texture. In the detection of DR, there are a few cases such as image lighting artifacts where the proposed automatic approach achieves a relatively lower segmentation performance. In some cases, the image lighting artifacts may affect the segmentation performance which could be considered as a future problem to be solved. In few images exudates appear close to the optic disc, leading to form a single region enclosing both a true lesion and optic disc. So, DR lesions and high intensity areas such as OD may not be separated from each other and affect the segmentation results. Therefore suitable steps are to be developed to overcome this problem.

The fundus image analysis system developed in this thesis can be implemented on an embedded processor mounted on the fundus camera itself. This will directly indicate the severity of the disease in real time so the patients affected by glaucoma and diabetic retinopathy can be immediately directed to the nearby health center. The fundus camera with an inbuilt processor does not require the assistance of trained technician near the screening site. Even though the target of the detection system presented in this thesis is to detect ocular disease like glaucoma and diabetic retinopathy, the system can also be extended to detect other diseases that affect the retina like hypertensive retinopathy, age-related macular degeneration and macular edema.
The screening system developed to detect automated detection of glaucomatous changes in the eye fundus could even be deployed in public places to reach many people. This would not only reduce health care costs of treating glaucoma but would also prevent affected patients from vision loss and control disease progression. As DR is a progressive disease, abnormalities can appear and disappear on the retina. Since patients are supposed to have a regular dilated retinal examination, the images of previous visits will usually be available. By analyzing the progressive changes in the retina over time, subtle abnormalities could be detected. In practice, this would mean registering the older data with the images most recently acquired and analyzing the differences between the images. Temporal change detection is a technique which could be interesting for automatic screening in the long term. The fundus image analysis system can be extended by developing algorithms for retinal image registration and retinal change detection which in turn assists the ophthalmologist to study the post medication improvements. Further, a system can also be devised to integrate automated fundus image analysis in the telescreening framework to address well-known challenges in large-scale disease screening.