Chapter 6

Conclusions and scope for future work

The conclusions of work of this thesis and suggestions for future research are presented in this chapter.

6.1 Conclusions

The human eye is one of the most important and sensitive organ of the human body. It is exposed to a variety of diseases such as age-related macular degeneration, diabetic retinopathy, glaucoma, and corneal scarring, which are the main cause of blindness, so it should take a lot of care to protect it. Diagnosis of these diseases is possible by examining the retinal blood vessel structure. Therefore an accurate retinal blood vessel segmentation is a prominent task in computer aided diagnosis of retinal pathology. In this thesis, the concentration was on matched filter based retinal blood vessel segmentation because it provides the best retinal vessel structure with respect to other segmentation approaches.

The matched filter approach, for retinal blood vessel segmentation is based on pre-defined template/kernel matching. The kernel is designed in such a way that they match better with the cross-sectional intensity profile of the retinal image. The matched filter based retinal blood vessel segmentation approaches are simple and effective, but it detects both vessels and non-vessel edges. Hence, this may lead to non-vessels detection also which is undesired. To overcome the problem of detecting the non-vessel edges, an extension of matched filter based on the second-order derivative of Gaussian (SDOG) was

proposed. The proposed approach is effective for the segmentation of thin as well as thick retinal blood vessels. On the basis of experimental results obtained for both DRIVE and STARE databases confirms that the proposed approach achieved the higher True Positive rate (TPR), False Positive Rate (FPR), and accuracy as compared with other available retinal blood vessel segmentation approaches in literature. The proposed approach is also performing better for the segmentation of pathological retinal images.

Secondly, in this thesis we focused on the cross-sectional intensity profile of retinal image and justified that the cross-sectional intensity profile of retinal images do not exactly match with the Gaussian shape as reported in literature. After that, on the basis of experimental analysis we proved that the cross-sectional intensity profile of retinal images was slightly skewed. To deal with these issues, a novel Gumbel probability distribution function based matched filter approach was introduced to improve the performance of retinal blood vessel segmentation. The contrast difference between the retinal blood vessel and their background is low. Therefore the input retinal images were pre-processed by using Principal Component Analysis (PCA) based gray scale conversion followed by Contrast Limited Adaptive Histogram Equalization (CLAHE) for better enhancement of the retinal image. The post-processing step after applying the proposed matched filter include the entropy based optimal thresholding and length filtering to obtain the segmented image. Furthermore exhaustive experiments have been conducted for selecting the appropriate value of parameters to design a new matched filter. The experimental results obtained from both the DRIVE and STARE database confirmed that the proposed approach achieved the best performance with respect to other prominent Gaussian distribution function and Cauchy pdf based matched filter approaches.

Furthermore, in this thesis a novel Binary Robust Invariant Scalable Key point (BRISK) feature-based segmented retinal image registration approach to detect the changes in vascular structure was proposed. The BRISK framework is an efficient key point detector, descriptor and matching approach. The proposed approach contains three steps, namely, pre-processing to enhance the contrast difference between the retinal blood vessels and their background by using PCA based gray scale conversion followed by CLAHE, Gum-

bel PDF based matched filter approach to achieve the better segmented retinal image, and BRISK framework which is used for feature points detection and matching between the pairs of segmented source and target retinal images for the registration. The effectiveness of the proposed approach is demonstrated by evaluating the normalized cross correlation similarity measure of registered image pairs. On the basis of experimental analysis, it has been observed that the performance of the proposed approach is better with respect to SURF and Harris partial intensity invariant feature descriptor based segmented retinal image registration in both aspect, registration performance as well as computation time. Finally we conclude the thesis work in few words as follows:

- Two novel and efficient matched filter approach using a second-order derivative of Gaussian and Gumbel pdf as a kernel has been proposed in this thesis.

- The performance of both proposed approaches are good enough with respect to various retinal image segmentation approaches which exists in the literature.

- Both proposed approaches are compared with each others and found that the Gumbel pdf based matched filter approach is much better with respect to the second derivative of Gaussian based matched filter approach.

- Reason behind that the TPR and FPR of Gumbel pdf based matched filter approach is much better is that means Gumbel pdf based matched filter approach is able to detect the vessels as a vessel and non-vessels as a non-vessel.

- In this thesis, a fast and efficient segmented retinal image registration approach based on Gumbel pdf based segmentation and BRISK feature is proposed to detect the changes in vascular structure.

- The proposed registration approach is fast with respected to execution time and efficient because the proposed approach is able to register the poor quality retinal images together with good quality retinal image.

6.2 Scope for future work

The research work presented in this thesis can help further into different directions. The scope for future works are as follows:

- It may be possible to improve the performance of retinal image segmentation by using some other segmentation techniques.
- Proposed segmented retinal image registration approach is useful for detecting the changes in retinal blood vessels structure and may help to identify the growth of retinal diseases.
- An automatic diagnosis system can be designed by using the proposed segmentation and registration approaches in coming future.
- Some more work may be carried out to design some new optimization criteria for feature point detection and registration