PREFACE

The human eye is one of the most important organs in the human body. It is very sensitive and exposed to a variety of diseases, so it should take a lot of care to protect it, and keep safe. Worldwide growth of the aged population and pollution, there is increasing the eye disease patients, however the ophthalmic services are comparatively decreasing, especially in rural areas and developing countries. According to survey of the World Health Organization (WHO) there are 37 million blind people and 124 million with low vision people presents in worldwide. The main causes of global blindness are age-related macular degeneration, diabetic retinopathy, glaucoma, and corneal scarring. Diagnosis of these diseases are 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. According to literature survey, the retinal blood vessel segmentation approaches are mainly classified into seven categories, namely, the intensity based pattern recognition techniques, mathematical morphology based, vessel tracking based, model based, parallel hardware based, multi-scale based techniques and matched filter based approach. In this thesis our concentration on matched filter based 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 template/kernel matching. So the kernel is designed in such a way that they matched better with the cross-sectional intensity profile of the retinal image. Therefore the objective of the proposed work in this thesis is to identify the suitable probability distribution function as a kernel to design a new matched filter approach that performs better retinal blood vessels segmentation. Furthermore, in this thesis two segmented retinal images are registered by using the feature based registration technique.

At the beginning, this thesis is focused on the problem of the matched filter based retinal blood vessel segmentation approaches which are simple and effective. However, matched filter based approach to detect both vessels and non-vessel edges. Hence, this also leads to non-vessels detection. To overcome the problem of detecting the non-vessel

edges, propose an extension of matched filter based on the second derivative of Gaussian. The proposed approach is effective for the segmentation of thin as well as thick retinal blood vessels. The 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, focus on the cross- sectional intensity profile of retinal image and justify that the cross-sectional intensity profile of retinal images are slightly skewed not in a Gaussian shape. To deal with these issues, a novel matched filter approach with the Gumbel probability distribution function as its kernel is introduced to improve the performance of retinal blood vessel segmentation. Before applying the proposed matched filter, the input retinal images are pre-processed. During pre-processing stage Principal Component Analysis (PCA) based gray scale conversion followed by Contrast Limited Adaptive Histogram Equalization (CLAHE) are applied 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 data sets confirm that the proposed approach achieved the best performance with respect to other prominent Gaussian distribution function and Cauchy pdf based matched filter approaches.

Finally, in this thesis presents a novel Binary Robust Invariant Scalable Key point (BRISK) feature-based segmented retinal image registration approach to detect the changes in vascular structure. 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 of retinal blood vessels with respect to their background, Gumbel PDF based matched filter approach to achieve the better segmented retinal image, and BRISK framework are used for feature points detection and match-

ing 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 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.

The overall thesis is organized into seven chapters as follows:-

Chapter 1 presents background to discuss about the human eye, retina, related diseases, the motivation behind the thesis work, and objectives of this thesis. Finally the concluding with an organization of this thesis.

Chapter 2 is organized in twofold literature review. The first folds presents a comprehensive literature review and comparative study of various classical as well as state-of-the art methods for retinal blood vessel segmentation, and second fold presents a comprehensive literature review of various classical as well as state-of-the art methods of intensity based and feature based retinal image registration.

Chapter 3 presents a novel extension of matched filter based retinal blood vessel segmentation approach, namely SDOG-MF. The SDOG-MF approach is based on second-order derivative of the Gaussian and local entropy thresholding. The proposed approach was able to identify thin retinal blood vessels as well as thick blood vessels. The proposed approach has been implemented on twenty retinal images taken from a test set of DRIVE database and twenty retinal images taken from STARE database. The segmented results of the DRIVE and STARE database is compared with hand-labeled ground truth images available in the respective database. The performance of the proposed approach is compared with some other existing standard methods for the same task available in the literature and it was found that the accuracy of proposed approach was good enough for retinal images taken from a test set of DRIVE database whereas the TPR and FPR was improved in case of retinal fundus images taken from STARE database.

Chapter 4 presents a novel matched filter approach with the Gumbel probability distribution function as its kernel. In the proposed approach, a customary Gaussian function

used by prominent researchers and Cauchy probability distribution function used by is replaced by Gumbel probability distribution function and achieve higher accuracy in retinal blood vessel segmentation. The reason to achieve the highest accuracy is due to better matching of gray scale cross-sectional profiles of retinal image and Gumbel pdf based kernel. The proposed matched filter with the Gumbel pdf as its kernel is compared with respect to the prominent Gaussian distribution function and Cauchy pdf based matched filter approaches and achieved the best performance. For the comparative analysis 20 retinal images have been selected from the test set of the DRIVE data set and STARE data set.

Chapter 5 presents a novel BRISK feature-based segmented retinal image registration approach because the BRISK framework is an efficient key point detector, descriptor and matching approach. The Gumbel pdf based matched filter approach is used for segmentation of source and target image because the Gumbel pdf based matched filter approach provided a better segmentation result with respected to other existing matched filter approach. The performance of the proposed registration approach was demonstrated by evaluating the normalized cross correlation measure for image pairs. On the basis of comparative analysis of the proposed approach with the SURF and Harris partial intensity invariant feature descriptor based segmented retinal image registration approach, it was found that the performance of proposed approach is better in both aspects, the performance as well as computation time.

Chapter 6 presents conclusions of the thesis and summarize the main findings of this thesis work. This chapter also proposes some future perspectives of thesis work.