ABSTRACT

The colour fundus images of human retina have been enhanced and utilized by the medical practitioner for the diagnosis of various eye-related diseases like proliferative and non-proliferative diabetic retinopathy, diabetic maculopathy and glaucoma. Due to the increase in population and scarceness of the ophthalmologist, screening more number of patients becomes a significant task. Moreover, the manual process is tedious, time consuming and impractical. For large data to be handled, there is a need for an automatic processing system that helps ophthalmologists. This great challenge opens up the possibility of developing algorithms with the recent technological advancements towards automation of screening fundus images. The image processing algorithms employed on fundus images play an important role in detection of pathologies, which improves the detection system in diverse angles. The computation-based detection system reduces human error and thus gives accurate result and is helpful for the ophthalmologist in the direction of the right treatment for patients.

The customary screening process of fundus images is essential to provide appropriate and timely treatment for patients to reduce the incidence of impaired vision and blindness. Many researchers are performing study and exploring to make the diagnosis system more effective by increasing the accuracy of the system. However, the methods developed and presently in use give results with less accuracy. Therefore, an effort is being made to develop an automatic method using computational algorithm to improve the accuracy. The two irreversible disorders related to human retina are Diabetic Retinopathy (DR) and Glaucoma. DR is the retinal disease which is caused due to excess sugar in human blood that lacks enough insulin and causes damages in the light sensitive tissues/tiny blood vessels in the retina. Glaucoma is the disease caused due to the prolonged increase in the fluid pressure, the optic disc, cup and nerve damages may take place. This research work mainly focuses on the detection of two most
important retinal diseases Diabetic Retinopathy (DR) and Glaucoma. The fundus images are collected with the publicly available datasets such as DRIVE, STARE, MESSIDOR, DIARETDB1, and HRF. In addition, real database has been obtained from Bejan Singh Eye Hospital, Nagercoil. The segmentation of anatomical and pathological retinal structures for DR detection has been proposed. The initial stage in developing automated computer-aided system is the detection of anatomical structures which are the optic disc and blood vessels.

In this work, the optic disc has been detected by means of region growing considering the intensity threshold feature along with orientation feature referred as Modified Region Growing (MRG) method. Those features are utilized in the selection of seed points, and segmentation of optic disc has been implemented on the STARE database. Next to the optic disc is the anatomy of feature of blood vessels that originate from the centre of OD and spread over the entire region of the retina. In abnormal eye, fluids and lipids are formed around the retinal blood vessels and thus lead to the formation of abnormal lesions such as exudate and hemorrhages. Hence detection of blood vessels becomes significant in DR diagnosis. The proposed method is applied on DRIVE and STARE database, extracts the feature based on the orientation analysis of gradient vector field, morphological, gray level and Gabor features from the green channel retinal image. The extracted features are then trained and classified by Adaptive Neuro Fuzzy Inference System (ANFIS). The pathological features to be identified for DR screening are the microaneurysm, exudate and hemorrhage. The early signs of DR are depicted as microaneurysms among other signs. In this work, microaneurysm is detected using morphological operations, where adaptive histogram equalization is carried out for image enhancement followed by morphological closing operation, and then filling the holes in vessels which results in binarized image. Then, extended minima transform is applied, and finally the vessels and exudate are removed to obtain the microaneurysm image. The proposed microaneurysm detection method is implemented on the DIARETDB1 database yield better accuracy results.
Hemorrhages are the clinical signs of retinal disease which is observed as dark patches to indicate bleeding from blood vessels. In this work, the Red-Green-Blue (RGB) image is pre-processed, to extract green channel image to which adaptive histogram equalisation is performed. Then, morphological opening operations with optimally adjusted structuring element are performed on the green channel image. The histogram equalised image is subtracted from the morphological opened image, and hemorrhage in fundus image has been detected using threshold pixel values. Exudate lesions are formed in retinal image due to the damage in retinal blood vessels. The hard and soft exudate are detected and segmented using mathematical morphological operations. The proposed algorithm for hard and soft exudate detection is applied over the retinal images of publicly available STARE datasets. The proposed method gives better accuracy in detecting the hard and soft exudate.

The classification of fundus images has been carried out by considering only the anatomical structures first and then with anatomical and pathological structures consecutively. The features such as mean, variance, entropy and area are extracted from segmented optic disc and from segmented blood vessels. In addition, the diameter and number of regions are also extracted from segmented blood vessels. The Neural Network (NN) classifier classifies the input image as normal or abnormal image using the sample features trained with NN classifier. The proposed work is implemented on STARE database and the performance results is analysed. The anatomical structures such as blood vessels and pathology symptoms like exudate and microaneurysms have been segmented and applied to DRIVE, DIARETDB1 and MESSIDOR databases. The features from the blood vessel, exudate and microaneurysm are given to the Support Vector Machine (SVM) classifier which classifies the input image as normal (not affected DR) or DR images based on the training done by giving the sample features. The estimation of the DR severity level in retinal images using computational intelligence techniques has been developed and implemented on publicly available STARE and real-time databases. The abnormal image from
former classification process has been used, and the pathological symptoms like exudate and hemorrhages, are taken for the classification of the DR severity level. Based on the features, area and intensity level of the hard exudate and hemorrhages, the abnormal images are classified using SVM classifier as mild, moderate, severe and proliferative.

The second prime disease in retinal imaging, glaucoma caused due to the increase in fluid pressure is analyzed based on the OD and OC in fundus images. In the proposed work, the OD and OC detections have been performed using mathematical morphology operations. The neural network has been trained and tested using the features such as Cup to Disc Ratio (CDR), blood vessels in Inferior Superior Nasal Temporal (ISNT) and vessel intensity extracted from the publicly available High Resolution Fundus (HRF) dataset to classify fundus image into normal and abnormal image. Moreover, analysis has been made considering wavelet decomposition method performed on the pre-processed image. The wavelet filter (daubechies) features like average, energy, standard deviation and variance are used to train the supervised classifier which classifies retinal images into normal or abnormal and achieve a high level of accuracy over the HRF database.

The severity of glaucoma is assessed based on Cup to Disc Ratio (CDR), and Neuro Retinal Rim (NRR) surface areas in retinal image. The features extracted from the neuro retinal rim area are the Enhanced Local Binary Pattern (ELBP), Gray Level Co-occurrence Matrix (GLCM) and optic band features from NRR. The features of both healthy and glaucomatous images have been trained and tested by means of SVM classifier to grade into mild, moderate and severe glaucoma over the HRF database. With the help of the image processing algorithms developed in this research, it is easier to predict diagnostic tools that play a key role in group screening and observing of pathologies such as diabetic retinopathy and glaucoma.