Abstract

Diabetes mellitus is caused due to the increased glucose level in the blood, affecting vital organs if not treated at the early stage. Human eyes are one such organ affected by diabetes causing diabetic retinopathy (DR), diabetic maculopathy (DM) and glaucoma. DR is basically a micro complication of microvasculature of retina, wherein the tiny blood vessels gets damaged due to increased blood sugar. The visible symptoms begin to manifest on the retina in the form of micro aneurysms (MA) which appear like small red dots. If the glucose level in the blood is not controlled then the fragile capillaries may rupture and causing hemorrhages, hard exudates, cotton wool spots etc. As DR advances it may affect the functioning of the macula resulting in diabetic maculopathy (DM) which may cause significant visual loss among DR patients. DM is characterized by the appearance of hard exudates in macular region and increase in the retinal thickness. When the fluid rich in fat and cholesterol leaks out of the damaged vessels of the retina to the macula, it affects the macular functionality. Again early detection and corrective treatment is the key to prevent loss of vision amongst DM patients. Glaucoma is next to DR in terms of people losing their vision worldwide. It adversely affects the functioning of the optic nerve and thereby causing damage due to the increase in the intraocular pressure (IOP) leading to the visual field loss. Recent studies indicate that there is a relation between prevalent diabetes and incident of glaucoma in diabetic patients. Although there is no cure for glaucoma presently, timely, comprehensive medication and treatment can prevent loss of vision. Symptoms of glaucoma are not always obvious; hence patients seek treatment only when the condition has progressed significantly. Early detection and remedial treatment will decrease the chances of vision loss in glaucoma subjects.
In cities usually people are aware of the complications of such diseases and therefore resort to regular screening of their eyes. However in rural areas where there is scarcity of healthcare facilities, mass screening of patients during scheduled camps can help in identifying prevalent eye disorders. Computer Aided Diagnosis (CAD) can play a prominent role in mass screening of DR, DM and glaucoma. CAD techniques can help to diagnose the patients affected by DR, DM and glaucoma even without the presence of an ophthalmologist. In this thesis, we propose such a CAD technique to identify eye diseases such as DR, DM and glaucoma using digital fundus images.

In the decision support system for automated detection of DR, we have classified the fundus images into normal and DR. We have used Discrete Wavelet Transform (DWT) and Support Vector Machine (SVM) classifier for automated detection of normal and DR classes. The wavelet based decomposition is performed up to the second level and eight energy features were extracted. Two energy features from the approximation coefficients of two levels, and six energy values from the details in three orientations (horizontal, vertical, and diagonal) are evaluated. These features are fed to the SVM classifier with various kernel functions (linear, radial basis function, polynomial of order 2 and 3) to evaluate the highest classification accuracy. We have obtained the highest average classification accuracy, sensitivity and specificity of more than 99% with SVM classifier (polynomial kernel of order 3) using three DWT features. We have also proposed an integrated index called Diabetic Retinopathy Risk Index (DRRI) using clinically significant wavelet energy features to identify normal and DR classes using just one number. We feel that, this (DRRI) can be used as an adjunct tool by the doctors during the eye screening to cross check their diagnosis. We have also classified fundus images into normal/Non
proliferative diabetic retinopathy (NPDR)/ Proliferative diabetic retinopathy (PDR) using higher order spectra (HOS) cumulants and Naïve Bayesian classifier with an accuracy of 90.74%.

In the automated classification of DM, we have classified the retinal fundus images into normal, non-clinically significant macular edema (NCSME) and clinically significant macular edema (CSME)suspect classes using texture parameters. Texture features are extracted based on the first order statistics, GLCM (Gray Level Co-occurrence Matrix) and run length matrix. The statistically significant features are then fed to two classifiers namely support vector machine (SVM) and Fuzzy-Sugeno (FS) classifier to choose the best classifier for automated diagnosis. The proposed technique is validated using 300 images, 100 images of each normal, NCSME and CSME. We have obtained the best results using FS classifier with an average accuracy of 86.67%, average sensitivity of 100%, and average specificity of 100% using ten-fold cross validation. The proposed automated system can aid clinicians as an adjunct tool in the process of diagnosing diabetic maculopathy during the mass screening of DR subjects and to detect the early stages of DM.

In the computer aided diagnosis of glaucoma we have used 510 fundus images to classify in to normal and glaucoma classes. Various features namely mean, variance, skewness, kurtosis, energy, and Shannon, Rényi, and Kapoor entropies are extracted from the Gabor transform coefficients. These extracted features are subjected to Principal Component Analysis (PCA) in order to reduce the dimensionality of the features. Subsequently these features are ranked using various ranking methods namely: Bhattacharyya space algorithm, t-test, Wilcoxon test, Receiver Operating Curve (ROC), and entropy. In this work, t-test ranking method has yielded the highest performance with an average accuracy of 93.10%, sensitivity of 89.75% and specificity of 96.20% using 23 features with Support Vector Machine (SVM) classifier. We have also
proposed a Glaucoma Risk Index (GRI) developed using principal components to classify the two classes using just one number. We have further classified the fundus images into normal/mild/moderate-severe using HOS cumulants and Naïve Bayesian classifier with an accuracy of 92.65%. This proposed system can help in the mass screening of glaucoma.