COMPUTER-AIDED DIAGNOSIS OF OCULAR HEALTH BASED ON HYBRID FEATURE SELECTION AND CLASSIFICATION

Abstract

Glaucoma and diabetic retinopathy (DR) are the ocular disorder that causes irreversible loss of vision. At present, ocular diseases are graded manually, which is time-consuming, labor-intensive and the diagnosis can be subjective. The use of a computer-aided diagnosis (CAD) system will reduce the time consumed for analysis and will clarify the inter-observer reliability in image interpretation. The focus of this thesis is to develop a CAD system for the early detection of ocular diseases such as glaucoma and DR. Glaucoma is a slowly progressive disease that damages the structural appearance of the optic nerve head without any early symptoms. Characterization of glaucoma can be done by extracting discriminate features like blood vessel ratio (BVR), cup to disc ratio (CDR), disc damage likelihood scale (DDLS) and neuroretinal rim (NRR) area from the fundus image. DR is associated with diabetics that damage the blood vessels which may lead to vision problems. They can be characterized by detecting the blood vessels followed by the detection of exudates. The analysis of glaucoma and DR is important to prevent earlier vision loss. The main objective of this research is to predict the potential features from retinal image analysis for the assessment of ocular pathologies such as glaucoma and DR. The proposed CAD system would assist the ophthalmologist in diagnosing ocular diseases by proving a second opinion as human experts‟ decision. Four approaches investigated in this thesis work are summarized below:

1. Segmentation of ocular pathologies for the early detection of glaucoma and DR. iv
2. Spatial and transform domain feature fusion for the classification of ocular diseases.
3. Hybrid feature selection and classification of ocular diseases such as glaucoma and DR.
4. Improved feature selection and classifier fusion for the classification of ocular diseases.

The main contribution of the first proposed method is the reliable segmentation of optic disc, optic cup, blood vessel and exudates for the detection of glaucoma and DR. The blood vessels are detected using a morphological operation followed by two dimensional matched filter. The optic disc and optic cup segmentation are carried out by superpixel segmentation followed by the fuzzy c-means clustering (FCM) technique. Exudates can be segmented by a dynamic decision thresholding technique. The effectiveness of the proposed algorithm is compared with four state-of�the-art techniques such as Otsu‟s thresholding, maximum entropy thresholding, K-means clustering and FCM algorithm. The ocular pathologies are classified using support vector machine (SVM). The experimental results indicate the high performance of the proposed algorithm with accuracy, sensitivity and specificity of 90.67%, 76.36% and 95.29% on PSGIMSR dataset images. The result also reveals that the proposed method performs significantly well for publically available datasets with accuracy, sensitivity, and specificity of 86.67%, 73.68%, and 96.15% on HRF dataset; 84.15%, 75% and 87.67% on DRISHTI-GS dataset; 86.42%, 78.79% and 91.67% on STARE dataset; 82.92%, 100%, and 50% on DRIVE dataset for ocular pathologies based evaluation criteria. The second method attempts to fuse two features from different domains to improve the accuracy of the classifier. The two sets of features are extracted from the spatial and transform domains. The spatial domain v v features are obtained from the intensity parameter taken from intensity hue saturation (IHS) and transform domain features are obtained from the sub�band of the wavelet packet transform (WPT). Sixteen different features such as mean, variance, standard deviation, skewness, kurtosis, entropy, energy, contrast, correlation, homogeneity, area, perimeter, eccentricity, convex area, filled area and solidity are extracted from the intensity and transform domain parameter. The extracted features are fused

using the principal component analysis (PCA) technique. The fused features from the corresponding domains are fed as input to the SVM classifier for the classification of normal and abnormal diseases. The proposed algorithm is compared with different fusion techniques such as min, max, average, entropy and covariance rule. The proposed IHS and WPT fusion methodology are tested with different fundus image datasets and the results obtained are compared with wavelet transform, WPT and IHS technique. An accuracy of 91.77%, a specificity of 94.08% and sensitivity of 83.15% is obtained for the proposed method using PSGIMSR dataset. In this approach, the PCA technique is used for reducing the feature dimension. There is a possibility of information loss, due to which classification accuracy can be affected. To overcome this disadvantage in the next chapter, features are selected using the particle swarm optimization technique. The third technique deals with a hybrid algorithm used to detect glaucoma and DR. In the proposed algorithm, the features are extracted from three different categories namely transform domain feature (60 features), textural feature (810 features) and clinical features (5 features). The performance of the classifier can be increased by selecting the prominent features for the classification of ocular diseases. To select the relevant features, a particle swarm optimization vi vi technique was employed. The combination of these features is intended to give a promising increase in the performance of the classifier. The proposed algorithm yields an accuracy of 93.56%, a sensitivity of 85.85%, specificity of 95.72%, precision of 85%, F1 score of 0.8542, kappa of 81.29%, Matthews correlation coefficient of 0.0112, Informedness of 0.8158 and classification error of 0.0644 for PSGIMSR dataset. The proposed method performs significantly well for publically available datasets with accuracy, sensitivity, and specificity of 90.69%, 85.71% and 93.10% on HRF dataset; 91.08%, 83.87% and 94.28% on DRISHTI-GS dataset; 90.12%, 82.35% and 95.74% on DRIVE dataset; 90.47%, 94.28% and 71.42% on STARE dataset. Finally, the fourth method aims at the detection of ocular diseases using binary antlion optimization (BALO) based classifier fusion (CF) technique. The features are extracted from multiple domains namely clinical, textural and transform domain features. The clinical features include CDR, BVR, DDLS, NRR and exudates area. The transform domain features are extracted from third level directional sensitive wavelet packet transform. Histogram of oriented gradient, local binary pattern and Haralick features are the textural features extracted from the fundus image. From a total of 875 features, the relevant features are selected using BALO-CF technique. The decisions from three different classifiers such as SVM, artificial neural network (ANN) and random forest (RF) classifier are fused using classifier fusion strategy. Moreover, the proposed BALO-CF algorithm is compared with three classifiers and five state-of-the-art optimization techniques such as particle swarm optimization, genetic algorithm, ant colony optimization, artificial bee colony optimization and firefly algorithm. The proposed algorithm yields an accuracy of 97.11% on PSGIMSR dataset; 95.56% on HRF dataset; 96.03% on DRISHTI-GS dataset; 96.29% on DRIVE dataset and 96.56% on STARE dataset