ABSTRACT

Digital color fundus imaging a popular imaging modality, is used for the diagnosis of retinal diseases to assess two sight threatening diseases namely glaucoma and Diabetic Retinopathy (DR). In glaucoma diagnosis, commonly used quantitative classification of the optic nerve known as Cup to Disc Ratio (CDR) does not account for the focal narrowing of the neuroretinal rim and disc size. As glaucoma progresses, optic cup grows larger and leads to changes in the respective fundus images. A fundus image analysis system is therefore developed to detect glaucoma in two phases by considering a structural feature with the incorporation of rim width, disc size and distribution of textural features to reflect the physiological changes in the fundus images. First phase involves the segmentation of optic disc, optic cup, extraction of structural features and quantification of neuroretinal rim. Textural features are combined with the structural features and classified using Adaptive Neuro Fuzzy Inference System (ANFIS) in the second phase.

The methods described in the literature often fail to segment the optic disc boundary accurately due to fuzzy boundaries, blood vessel interruption, inconsistent image contrast or missing edge features. To incorporate the above information in tracing the disc boundary, a Differential Windowing (DW) technique in the polar coordinate domain is proposed. In the DW technique, representation of the images in polar coordinate facilitates the description of local image regions in terms of their
radial and tangential characteristics to find a closed contour in the region of interest. Left or right eye identified using the blood vessel convergence was detected with 100% accuracy. Accuracy of the DW technique achieved an average success rate of 98.5% for 340 images. Unlike most of the previous methods discussed in the literature for optic cup detection, a novel approach using Color Mathematical Morphology (CMM) employing color clustering based on pallor in fundus images is proposed to differentiate the optic cup from the disc boundary. To incorporate the evaluation of disc size and rim width in clinical grading of the disc, a structural feature namely Rim to Disc Ratio (RDR) was evaluated and quantified to identify the rim loss in Inferior Superior Nasal and Temporal (ISNT) quadrant.

To manifest the physiological changes in the fundus images due to glaucoma progression, the first order features using histogram viz. mean, standard deviation, skewness, kurtosis, entropy and second order textural features namely contrast, homogeneity, energy, correlation and entropy using Gray Level Cooccurrence Matrix (GLCM) are extracted. Six prominent features were selected using sequential forward floating selection algorithm and fed as input to ANFIS. The method was evaluated on 280 images with a tenfold cross validation of data. ANFIS classified normal subjects with a specificity of 97.6% and glaucoma subjects with a sensitivity of 99.3%. Results prove that texture descriptors based on second order statistical features outperform histogram based descriptors in particular when they are combined with the structural feature and reduce misclassification of images.
Glaucoma patients affected by diabetes are prone to severe vision loss. Existing segmentation methods to detect DR need user involvement with large computational efforts and are applicable to detect only hard exudates. To address these issues, an integrated method is proposed for the early detection of DR by considering anatomical and textural features since the disease is not detected in few images until severe vision loss occur. Before starting the search of the abnormal lesions from an acquired fundus image, the images are preprocessed using color space conversion and fundus region detection. With the help of the fundus mask, an exudates detection algorithm can process only the pixels of the fundus and omit the background pixels. Once the optic disc is localized from the color fundus image, it is masked and the exudates are detected based on Color Histogram (CH) thresholding. Pixel based CH technique when evaluated on 200 real time images provided an average sensitivity of 99.11 %, specificity of 98.32 % and 99.1 % accuracy.

For an image based approach, anatomical and textural features were extracted from the segmented images and provided as input to ANFIS to classify the images. Accuracy of ANFIS for 250 test images is 99.2 % with 100 % sensitivity and 98.3 % specificity. Combination of color and textural features are effective in detecting the abnormalities with a high sensitivity and specificity. Segmentation algorithms used for the detection of optic disc, optic cup can be used in applications like glaucoma assessment, DR, hypertensive retinopathy and macular edema. The proposed system can be integrated with the existing ophthalmologic tests and can be used as a diagnosis system in local health camps for effective large scale screening.