ABSTRACT

In the field of biomedical engineering, the identification of physiological changes inside the human body is a challenging task. At present, identifying these abnormalities is graded manually which is very difficult, time-consuming, and tedious as it includes several complicated procedures. Hence, the use of Computer-Aided Diagnosis (CAD) gained more attention due to the necessity of a diseases detection system at an early stage. The primary focus of this research is to develop a CAD system for early detection and to aid the screening and management of glaucoma.

Glaucoma is another leading cause of blindness worldwide and ranks third in India, which affects the peripheral vision. Since, the damage caused is irreversible and early detection of glaucoma is significant for preventing eye disease from getting severe, mass screening would be the only option for early detection among the immense population for predicting the severity of glaucoma. Fundus camera is the cheapest imaging analysis modality which suits the monetary demands of the population. The characterization of glaucoma can be done by extracting structural features from the segmented optic disc and optic cup.

The main objective of this research is to predict the potentiality of the image analysis model for early detection and diagnosis of glaucoma for assessing ocular pathologies. The proposed CAD system would assist the ophthalmologist in diagnosing ocular diseases by proving a second opinion as human expert’s decision. The three approaches investigated in this research work are summarized below:

1. Ensemble-based deep learning model for the early detection and diagnosis of glaucoma.
2. Modified Kernel-based Fuzzy C-Means (MKFCM) segmentation framework for the detection of ocular disease.
3. A two-stage segmentation and classification model for the detection and diagnosis of glaucoma based on a deep learning framework.

The first module of the proposed method is the ensemble-based deep learning approach for the detection of glaucoma. For the classification of glaucoma, three pre-trained convolutional neural networks such as Residual Network (ResNet), GoogLeNet, and the Visual geometry group network (VGGNet). Four different datasets such as PSG Institute of Medical Sciences and Research (PSGIMSR), High-Resolution Fundus (HRF), DRISHTI-GS, and Optic Nerve Segmentation Database (DRIONS-DB) are used to evaluate the performance of the proposed algorithm. The proposed ensemble architecture yields an accuracy of 91.11%, sensitivity of 86.55% and specificity of 95.20% for PSGIMSR dataset. Similarly, an accuracy of 95.63%, 98.67%, 95.64%, and 88.96% are obtained using DRIONS-DB, HRF, DRISHTI-GS, and combined dataset.

The second method attempts in the segmentation of optic disc and optic cup based on super pixel followed by MKFCM clustering algorithm. The effectiveness of the proposed algorithm is compared with Hough transform, cross-validated clustering (CV) model, and gradient vector flow (GVF) model. Finally, the retinal images are classified using visual geometry group (VGG16) architecture. The proposed algorithm yields an average F-score of 0.979, an average boundary distance of 10.016, and an average correlation of 0.949. An average F-score of 0.867, 0.930, 0.904, and 0.975 of Hough transform, active contour model, CV, and GVF are obtained respectively.

Finally, the third method aims at early detection and diagnosis of glaucoma using a deep learning framework. The proposed algorithm has a two-stage network performing both segmentation and classification. In the first stage, the semantic segmentation model is trained with the region of interest for the segmentation of the optic disc. In the second stage, deep features are extracted from the segmented optic disc based on squeeze net architecture to discriminate the fundus images into normal and abnormal.

Five publicly available datasets are acquired namely ACRIMA, RIGA, Drishti-GS1, RIM-ONEv1, and RIM-ONEv2 datasets to validate the proposed algorithm. The proposed architecture is compared with different pre-trained models such as AlexNet, GoogleNet, ResNet-50, InceptionV3, SqueezeNet, XceptionNet, MobileNet, ShuffleNet, InceptionResNet, DenseNet, and NasNet-Large models. The proposed architecture yields an accuracy of 99.86% and an area under the curve (AUC) of 0.9999 for ACRIMA dataset, 97.05% accuracy, and 0.9990 AUC for DRISHTI-GS dataset and an accuracy of 100% is obtained used RIM-ONE v1 dataset.

Glaucoma detection involves a clinical examination of fundus images to determine the size of the OD, thickness of the rim, and deformities in the eye. These abnormalities are detected by using the proposed model and it is trained and tested on benchmark datasets and compared with existing state-of-the-art models. This research work shows that a prospective automated solution for glaucoma detection in the pursuit of alleviating blindness that can be demonstrated by the training performances, OD segmentation, and glaucoma detection accuracies, and the Receiver operating characteristics (ROC) characteristics.