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Title: GLAUCOMA DIAGNOSIS IN A DIGITAL RETINAL IMAGE USING MULTI CLINICAL FEATURES EXTRACTED AND FUSED BY DEEP CONVOLUTIONAL NEURAL NETWORKS

Abstract:

The advancement in computerized medical imaging has pushed the boundaries of many researchers to develop automated algorithms for disease diagnosis without human intervention. Glaucoma diagnosis among various eye diseases has remained a major challenge in the medical field. The lack of trained specialists and large patient to ophthalmologist ratio, have motivated us to develop cost-effective computer-based diagnostic systems that can assist medical experts in early diagnosis and aid in reducing their time and effort on healthy scenarios. In the glaucoma prediction procedure, ophthalmologists analyze the retinal image for various eye pathologies such as increased cup-to-disc ratio (CDR), neuro-retinal rim (NRR) loss, peripapillary atrophy (PPA), retinal nerve fiber layer (RNFL) loss, disc asymmetry, etc. Through this thesis, we exploit many clinical indicators along with the recent deep convolutional neural networks for better feature learning.

Regarding the methodology, the first contribution proposes an automatic detection and segmentation of one of the major retinal landmarks i.e., optic disc. Using the location and intensity profile of the optic disc, a DI map is predicted using a U-net architecture and OD is located with the LoG operator. Following this, a Generative adversarial network is proposed to segment the disc boundary. A well-defined study is performed among retinal datasets to validate the model performance. The second contribution of this thesis is to use a multi-encoder U-net framework for optic cup segmentation which significantly outperforms the state-of-the-art. The third contribution detects the two major clinical indicators i.e., PPA and RNFL, of glaucoma using two breakthrough techniques (Transfer and Active Learning) of deep learning. We formulate a novel PPA detection algorithm using a fusion of statistical features and high-level features from a pre-trained deep CNN. Further, we propose an Active transfer learning framework for patch-level classification of RNFL loss. We show encouraging results in comparison to state of art and are able to handle well low dataset scenarios. The fourth contribution of the thesis proposes an automatic glaucoma detection algorithm using ensemble learning of various clinical signs (PPA, RNFL), an SVM-based prediction model using cup and disc extracted features like CDR, ISNT ratio, and finally deep pre-trained CNN-based prediction model. We perform a robust set of experiments to validate the algorithm under all pathological conditions.

This thesis presents localization, segmentation, and classification techniques for medical images and can be applied to other applications. The proposed algorithms have been validated on public standard datasets, such as Drishti-GS, Origa, Refugee, and a private community camp-based challenging dataset collected from the All India Institute of Medical Sciences (AIIMS), Delhi. In conclusion, we have shown encouraging results for disease identification. Ensemble learning with clinically significant features and a deep CNN is a novel approach for glaucoma.