JOURNAL PAPER: JOINT OPTIC DISC AND CUP SEGMENTATION BASED ON MULTI-LABEL DEEP NETWORK AND POLAR TRANSFORMATION

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http://hzfu.github.io/proj_glaucoma_fundus.html

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ABSTRACT

This paper was published in IEEE Transactions on Medical Imaging in 2018. Glaucoma is a chronic eye disease that leads to irreversible vision loss. We propose a deep learning architecture, named M-Net, which solves the optic disc (OD) and optic (OC) segmentation jointly in a one-stage multi-label system. The proposed M-Net mainly consists of multi-scale input layer, U-shape convolutional network, side-output layer, and multi-label loss function. For improving the segmentation performance further, we also introduce the polar transformation, which provides the representation of the original image in the polar coordinate system.

1. METHOD

Glaucoma is the second leading cause of blindness worldwide (only second to cataracts), as well as the foremost cause of irreversible blindness. Since vision loss from glaucoma cannot be reversed, early screening and detection methods are essential to preserve vision and life quality.

In our paper, we address OD and OC segmentation as a multi-label task and solve it using a novel end-to-end deep network. Fig. 1 illustrates the overall flowchart of our OD and OC segmentation method, named **M-Net** [1]. In our method, we firstly localize the disc center by using the existing automatic disc detection method, and then transfers the original fundus image into polar coordinate system based on the detected disc center, which introduces the advantages of spatial constraint, equivalent augmentation, and balancing cup proportion, and improves the segmentation performance.

Then the transferred image is fed into our M-Net, and generates the multi-label probability maps for OD and OC regions. Our M-Net is an end-to-end deep learning system, which contains a multi-scale U-shape convolutional network with the side-output layer to learn discriminative representations and produces segmentation probability map. We modify the U-shape convolutional network (U-Net) as the main body in our deep architecture. The multi-scale input has been demonstrated to improve the quality of segmentation effectively. The side-output layer acts as a classifier that produces

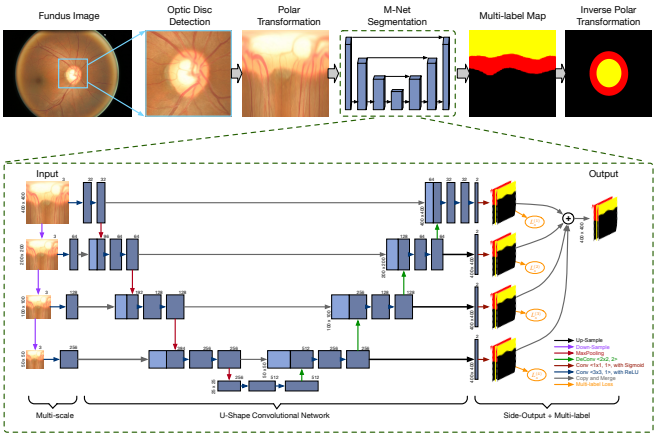

Fig. 1. Illustration of our Multi-label Deep Network.

a companion local output map for early layers. For joint OD and OC segmentation, a multi-label loss function based on Dice coefficient is proposed, which deals well with the multi-label and imbalance data of pixel-wise segmentation for fundus image. Finally, the inverse polar transformation recovers the segmentation map back to the Cartesian coordinate.

2. EXPERIMENT

Our M-Net is implemented with Python based on Keras with Tensorflow backend. We employ the ORIGA (650 images with 168 glaucomatous cases) and Singapore Chinese Eye Study (1676 images with 46 glaucoma cases) datasets to evaluate the performance. Our M-Net with PT achieves the AUC scores as ORIGA dataset ($AUC = 0.8508$) and SCES dataset ($AUC = 0.8997$), which are the best performances on these two datasets.

3. REFERENCES

[1] H. Fu, J. Cheng, Y. Xu, D. Wong, J. Liu, and X. Cao, "Joint Optic Disc and Cup Segmentation Based on Multi-label Deep Network and Polar Transformation," *IEEE TMI*, 2018.