Impact of Images Quality Variety and Resizing Level on Eye Fundus Optic Disc Segmentation

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Introduction

Various eye diseases such as glaucoma, diabetic retinopathy and hypertension can be diagnosed using eye fundus images. In eye fundus images analysis, image segmentation is one of the main steps. At this stage, different objects in the image are distinguished and defined, and thus assigned to different object classes. Applying various deep learning algorithms, the image quality and resizing play an important role. We aim to evaluate an impact of eye fundus images' quality and resizing level on Optic Disc (OD) segmentation. The segmentation is realized applying U-Net Convolutional Neural Network.

Eye Fundus Images Data Sets

- The DRISHTI-GS dataset consists of 101 full retinal fundus images that have been collected and annotated (ground truth labels) by 4 professionals. These images are 2896x1944 pixels in size.
- The RIM-ONE r3 dataset contains 159 stereo eye fundus images cropped by optic disc area and annotations with a resolution of 2144x1424 pixels. The right part of the stereo image is disregarded.
- The dataset prepared by the experts of Kaunas Clinic consists of 96 full eye fundus images and annotations with a resolution of 1920x440 pixels.

Experiments and Results

The experiments of OD segmentation have been performed on full size images resized to resolution of 256x256 pixels and images cropped by OD region resized to resolutions of 256x256 pixels and 128x128 pixels, and applying several different scenarios:

- The U-Net has been trained on Drishti-GS training set and tested on testing set of DRISHTI-GS, RIM-ONE v.3 and Kaunas Clinics.
- The U-Net has been trained on RIM-ONE v.3 training set and tested on testing set of RIM-ONE v.3, DRISHTI-GS and Kaunas Clinics.
- The U-Net has been trained on Kaunas Clinics training set and tested on testing set of Kaunas Clinics, RIM-ONE v.3 and DRISHTI-GS .
- The U-Net has been trained on data set compiled from all these data sets and tested on testing set of RIM-ONE v.3, DRISHTI-GS and Kaunas Clinics.

Experiment No. 1.

Images of full size are resized to resolution of 256x256 pixels.

OTHER METHODS	Input Image Resolution	Drishti	RIM-ONE
Tabassum, M. et.al, CDED-Net [1]	500x560 for Drishti, 570x429 for RIM-ONE	0.9597	0.9582
Sevastopolsky, A., Modified U-Net [2]	256x256	-	0.95

		TESTING SET		
	Exp. No. 1.	Drishti 256x256	RIM-ONE 256x256	Kaunas Clinics 256x256
TRAINING SET	**Drishti**	0.9529	0.7696	0.8160
	RIM-ONE	0.8171	0.9728	0.6439
	Kaunas Clinics	0.8620	0.6292	0.9529
	Mixed	0.9648	0.9644	0.9535

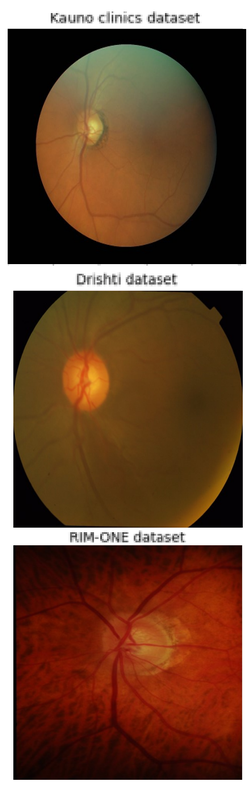
Experiment No. 2.

Images cropped by OD region are resized to resolutions of 256x256 pixels and 128x128 pixels.

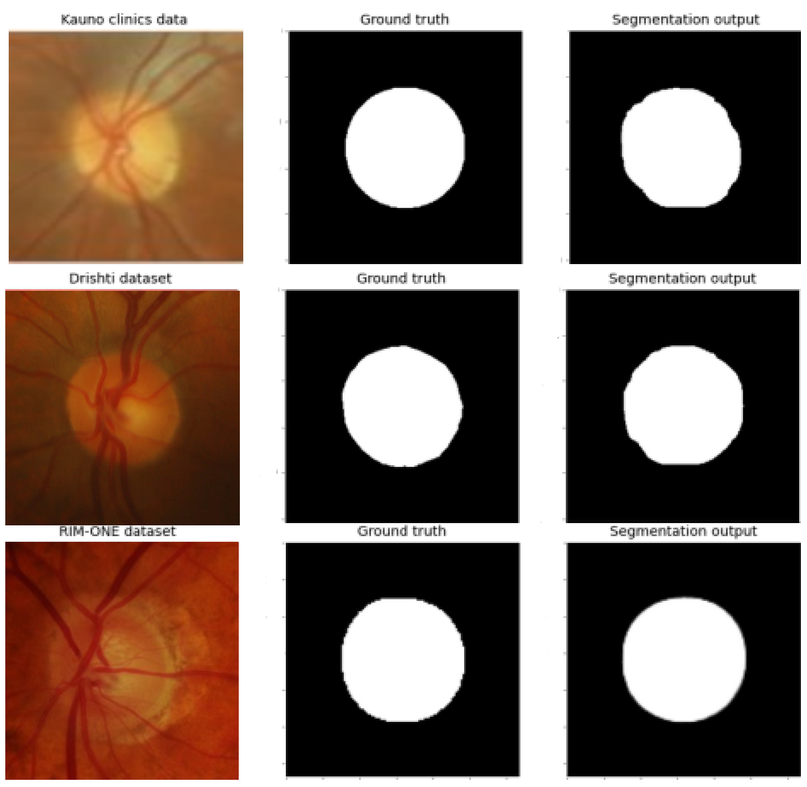
OTHER METHODS	Input Image Resolution	Drishti	RIM-ONE
Yuan, X. et.al, W-Net [3]	480x480	0.9710	0.9747
Liu et.al., DDSC-Net [4]	240x240	0.9780	-

		TESTING SET					
		Drishti		RIM-ONE		Kaunas Clinics	
	Exp. No. 2.	256x256	128x128	256x256	128x128	256x256	128x128
TRAINING SET	**Drishti**	0.9747	0.9632	0.9686	0.9591	0.9660	0.9504
	RIM-ONE	0.9782	0.9662	0.9844	0.9704	0.9700	0.9680
	Kaunas Clinics	0.9760	0.9680	0.9667	0.9557	0.9766	0.9662
	Mixed	0.9826	0.9700	0.9831	0.9710	0.9807	0.9697

Full size images



Visual of the best results



Conclusion

The results of experiments indicate that OD segmentation results are quite low when testing on the datasets of full size images that the network has not been trained on. Meanwhile, combining images of different datasets into one dataset and training the network on this combined dataset, the OD segmentation results achieve a sufficient accuracy in terms of Dice coefficient. Here, the highest score of 0.9648 achieved on the DRISHTI-GS dataset. Training the network on images cropped by OD region, the OD segmentation results achieve a sufficient accuracy in terms of Dice coefficient when testing on the datasets of cropped images that the network has not been trained on. However, the highest OD segmentation accuracy achieved on RIM-ONE test dataset when the network has been trained on dataset compiled from images of all three datasets. Here, the higher score of Dice coefficient achieved performing on cropped images resized to resolution of 256x256 pixels (Dice 0.9831) than on cropped images resized to resolution of 128x128 pixels (Dice 0.9710).

References

[1] Tabassum, M., M. Khan, T., Arslan, M., S. Naqvi, S., Ahmed, M., Madni, H. A., Mirza, J. *CDED-Net: Joint Segmentation of Optic Disc and Optic Cup for Glaucoma Screening.* IEEE, 2017. [2] Sevastopolsky, A. *Optic Disc and Cup Segmentation Methods for Glaucoma Detection with Modification of U-Net Convolutional Neural Network.* [Online]. Available: https://doi.org/10.1134/S1054661817030269, 2017. [3] Yuan, X., Zhou, L., Yu, S., Wang, X., Zheng, X. *A multi-scale convolutional neural network with context for joint segmentation of optic disc and cup.* ELSEVIER, 2021. [4] Liu, B., Pan, D., Song, H. *Joint Optic Disc and Cup Segmentation Based on Densely Connected Depthwise Separable Convolution Deep Network.* BMC Medical Imaging , 2021.