Fine-tuning Convolutional Neural Networks: a comprehensive guide and benchmark analysis for Glaucoma Screening

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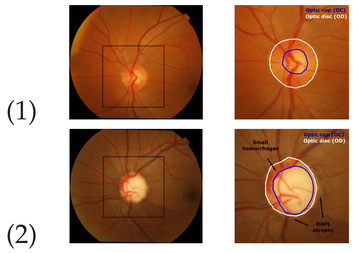
Context and Objectives

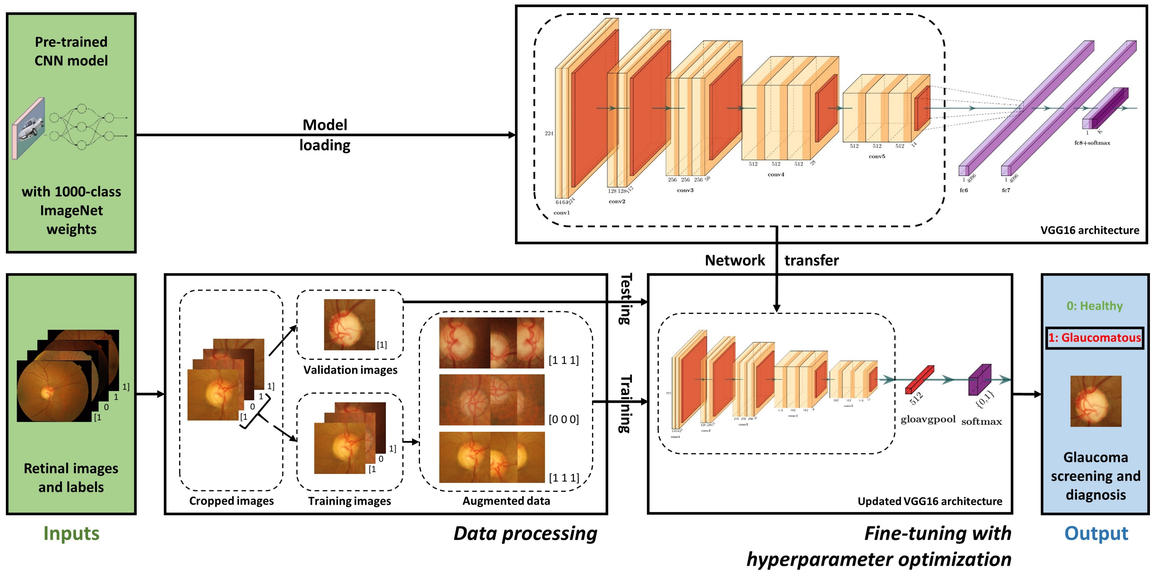
Glaucoma is a neurodegenerative eye disease, causing gradual vision loss and ending up to complete blindness. Dispensing and ensuring early screening of the pathology remains essential, to inhibit the development of the spreading disease and avoid irreversible vision damages. The assessment of the structural changes within the optic nerve (ONH) remains the most reliable way to screen the disease at the earlier stage.

In this work, we exploited powerful deep learning (DL) algorithms for early screening and diagnosis of glaucoma from retinal fundus images. Hence, developed computer-aided diagnosis (CAD) systems has a great potential for assisting clinicians and health professionals.



Healthy (1) and glaucomatous (2) retinal images, with a focus on ONH region.

Methods



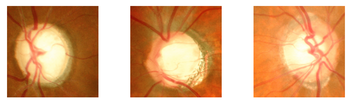
- We exploited five well-known Convolutional Neural Networks (CNNs): VGG16, ResNet50, Inception-v3, DenseNet121 and MobileNet
- We adopted fine-tuning technique, aiming at exploiting ImageNet-trained DL models and transferring them to the task of glaucoma screening
- We used KIM-EYE dataset to train/test our models, with standard data processing (image cropping, data augmentation, train/test split)
- We proposed a two-stage training strategy with both warm-up and fine-tuning phases, associated with adaptative hyperparameter optimization for reliable convergence of the networks.

Results

Healthy (H) images

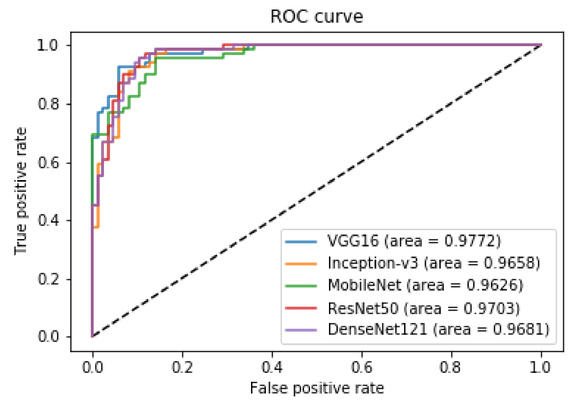
Prediction score 0.9312 0.9888 0.9765

Glaucomatous (G) images



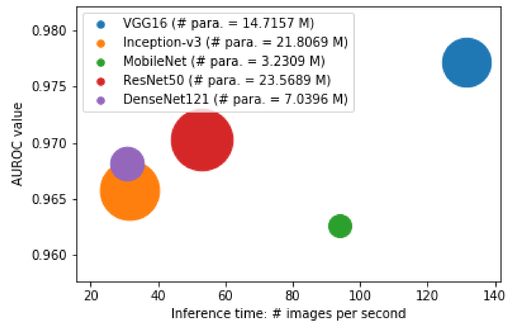
Prediction score 0.9963 0.98741 0.9722

Qualitative results with retinal images and the prediction score on the ground-truth class.



ROC curve of the fine-tuned DL models.

Benchmark Analysis



Model	Model comp. (M)	Memory size (Mb)	AUROC density	Inference time (ms)
VGG16	14.72	118	0.0664	**7.60**
ResNet50	23.57	189	0.0412	18.86
Inception-v3	21.81	175	0.0443	31.88
DenseNet121	**7.04**	57.3	0.1375	32.58
MobileNet	**3.23**	**26**	**0.2979**	**10.64**

Results of benchmark analysis on the performance indices: model complexity, memory size, AUROC density and inference time.

Conclusions

We proposed a novel approach for fine-tuning CNNs for glaucoma screening and diagnosis. Outstanding accuracy rate in glaucoma assessment has been reached on evaluation images.

Moreover, a benchmark analysis of the implemented models was conducted. This study aims at giving researchers standards on developing DL models for further applications and deployments.

References

[1] A. Mvoulana et al., Novel approach for early glaucoma screening and diagnosis using in-depth clinical analysis of the optic nerve head from retinal images. Under-reviewing for *Ophthalmology, 2020*

[2] A. Mvoulana et al., Fine-tuning Convolutional Neural Networks: a comprehensive guide and benchmark analysis for Glaucoma Screening. Accepted for *ICPR 2021, Milan (Italy)*