Multi-Modality Semi-Supervised Learning for Ophthalmic Biomarkers Detection

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A. Introduction

Optical Coherence Tomography (OCT) provides detailed retina images crucial for diagnosing ocular diseases such as age-related macular degeneration, diabetic retinopathy, and glaucoma [1]. Biomarkers from these images have been used as indicators for disease onset or progression.

Deep learning has potential in biomarker diagnosis, but challenges in generalization and personalization persist. Most existing OCT datasets lack comprehensive biomarker labels and have insufficient images per biomarker, affecting model generalization. While inter-visit variations in OCT scans for individual patients might be minimal, inter-patient variations for the same disease can be significant. Our contributions address these challenges as follows.

1) We used the OLIVES dataset to train a deep learning model for detecting six biomarkers simultaneously.
2) We integrated patient-personalized 1D clinical labels with 3D OCT scans and optimized both models using a guided loss function.
3) We Applied semi-supervised learning techniques to refine the performance and attain an F1 score of 0.70 on our test dataset with 3,872 images across 40 patients.

B. Dataset and Methodology

The Ophthalmic Labels for Investigating Visual Eye Semantics (OLIVES) dataset, introduced in [2], boasts 1,268 near-IR fundus images, each paired with a minimum of 49 OCT scans, 16 biomarkers, 4 clinical labels, and a DR or DME diagnosis. Specifically, our study focuses on 6 biomarkers for the detection task, which include IRHRF, PAVF, FAVF, IRF, DRT, and VD. Additionally, clinical labels are harnessed to delve into the relationships between patients and OCT scans.

OLIVES served as the training dataset, and the selected testing set is named RECOVERY. The initial phase involved training VGG16 on the OLIVES dataset and generating the pseudo labels for the RECOVERY dataset. Subsequently, a semi-supervised learning approach was adopted. Both datasets were merged for training, while predictions were systematically produced for the RECOVERY dataset. This iterative process facilitated the refinement of the model's performance. A joint loss function proposed in [2] is used to jointly optimize OCT scans and Clinical labels. Lastly, we employed non-rigid deformations and image resizing for data augmentation and utilized simulated cosine annealing for learning rate adjustment.

C. Experimental Result

The training was conducted among multiple versions of VGGNet, ResNet, and EfficientNet to establish the baseline. VGG16 is selected with the highest accuracy at 0.63 and a relevant lower model size than VGG19.

Model	Accuracy	Parameters
ResNet101	0.62	44.5 million
ResNet50	0.61	25.6 million
VGG16	0.63	138 million
VGG19	0.63	143 million
InceptionV3	0.58	23.8 million
Efficient_B3	0.59	12 million
Efficient_B2	0.59	9 million
Efficient_B1	0.56	7.8 million

TABLE I
COMPARISON OF BASELINE MODEL

Table II depicts the results of our proposed method.

Biomarker	F1 Score	Precision	Recall	Support
IRHRF	0.74	0.85	0.66	1204
PAVF	0.70	0.68	0.73	1219
FAVF	0.88	0.81	0.97	2010
IRF	0.58	0.49	0.70	695
DRT\DME	0.53	0.65	0.44	143
VD	0.75	0.69	0.83	426
MACRO AVG	0.70	0.66	0.76	5697

TABLE II
PROPOSED METHOD ACCURACY

D. Conclusion

In our study, we have explored the possible potentials of the OLIVES dataset and applied deep learning techniques for biomarker detection. By integrating the clinical labels with OCT scans and employing semi-supervised learning, we have enhanced the model's generalization capabilities and mitigated the personalization challenges. The achieved F1 score is approximately 7 percent higher than the baseline result.

References

[1] Michael D Abràmoff, Mona K Garvin, and Milan Sonka. Retinal imaging and image analysis. *IEEE reviews in biomedical engineering*, 3:169–208, 2010.

[2] Mohit Prabhushankar, Kiran Kokilepersaud, Yash-yee Logan, Stephanie Trejo Corona, Ghassan AlRegib, and Charles Wykoff. Olives dataset: Ophthalmic labels for investigating visual eye semantics. *Advances in Neural Information Processing Systems*, 35:9201–9216, 2022.