Semi-Supervised Learning for OCT Image Segmentation

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Introduction

Optical coherence tomography (OCT) images can be used to assess the amount of retinal fluids as symptoms of major vision-threatening diseases. The application of Convolutional Neural Networks (CNNs) for automatic fluid segmentation has been utilized in the past. However, CNN performance heavily relies on the quantity of annotated training data, often limited in case of expert-annotated OCT images. To address this issue, this study investigates semi-supervised learning (SSL) methods to enhance segmentation in scenarios with sparse annotations. In particular, we employ contrastive learning (CL). This method leverages the abundant pool of non-annotated OCT images by utilizing intra-volume and inter-volume dependencies and differences, encouraging the network to extract semantic information from unlabeled data.

Materials and Methods

We utilize a encoder, decoder UNet architecture and use the OCT dataset from the RETOUCH challenge. The core of the methodology involves simultaneously learning from labeled and unlabeled images in a CL framework. Our method aims to extract informative features by comparing pairs of unlabeled data within a network's feature subspace. This comparison involves extracting representations of input images after a specific number of network layers and assessing their similarity through a contrastive loss function.

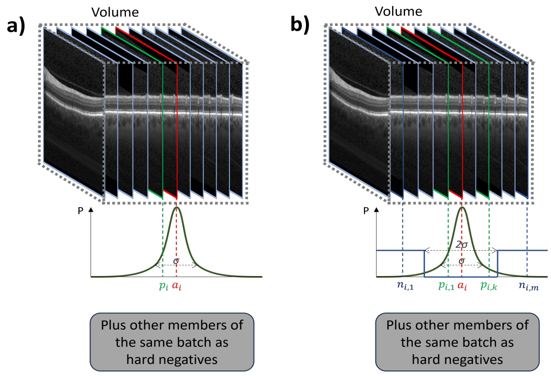

Fig. 1 Pair generation strategies for global CL. a) Strategy proposed by [1]. b) our strategy, involving multiple pairs of similar and dissimilar images.

In particular, global representations [1] are extracted at the end of the encoder and local representations [2] at different stages of the decoder. The generation of suitable pairs of similar and dissimilar images is key for successful CL. For global CL, we select multiple "positive" and "negative" images from a volume to form similar and dissimilar pairs with a distinct anchor image of the same volume. For local CL, instead of selecting whole images to form pairs, we restrict the selection to distinct local regions, i.e., patches of images. (fig.2).

Results

Compared to the supervised baseline, we manage to increase the performance of the segmentation model in terms of Dice score from 43.6% up to 59.3% for the global CL method and up to 56% for the local CL method while also outperforming the method for global CL proposed by [1].

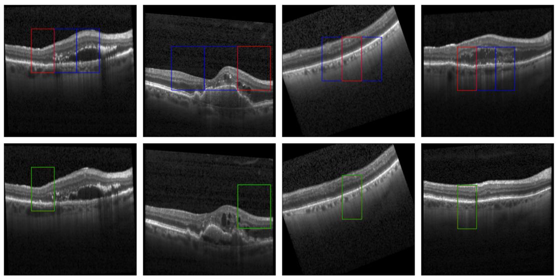

Fig. 2 Patches of similar regions (red-green) and dissimilar regions (red-blue)

Discussion

The results indicate the great potential of CL in situations where annotations are sparse. Our results could certainly be improved upon by further investigation of different pair generation strategies and optimization of hyperparameters. We believe that the proposed methods offer a versatile toolbox for enhancing OCT image segmentation and are applicable, with minor adjustments, across various other domains and modalities, especially in clinically relevant low-annotation settings.

References

[1] A. Gomariz et al., Unsupervised domain adaptation with contrastive learning for oct segmentation, International Conference on Medical Image Computing and Computer-Assisted Intervention, 351–361, 2022.
[2] K. Chaitanya et al., Contrastive learning of global and local features for medical image segmentation with limited annotations. Advances in neural information processing systems, 33:12546–12558, 2020.