Deep Learning based segmentation of retinal fluids using optical coherence tomography (OCT) data

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PURPOSE

- OCT, a non-invasive imaging modality, plays a central role in ophthalmology, visualizing the main signs of an age-related macular degeneration causing blindness.
- Efficient and precise segmentation of various abnormalities seen in OCT imaging can generate significant benefits by helping to detect and analyze the progression of the disease, thus advising and supporting effective treatment.
- For this purpose, we propose a new deep learning-based segmentation pipeline for retinal fluids in OCT.

RESULTS

- Using a custom CNN-variant (SeResNet50) and freezing different blocks of the network allowed a segmentation result even with minimal data.
- According to this efficient interplay of transfer learning techniques across ImageNet and the OCT data, an **overall Dice coefficient of 66.3** and **MeanIoU of 69.6 percentage points** could be achieved by training all fluid categories simultaneously.

CONCLUSIONS

- This work constitutes that an individual adaption of the network and the **integration of domain-specific knowledge of other modalities** through special transfer learning techniques enables semantic features to be learned even with minimal and complex datasets.
- This resulted in an **overall segmentation improvement of 15.3%** measured by the Dice coefficient, compared to a standard segmentation implementation (nnUNet).

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METHODS

- The underlaying data is formed by an OCT B-scan dataset containing 1540 images and masks, split in 1291 training and 249 validation cases, annotated for three different retinal fluids: intraretinal fluid (IRF), subretinal fluid (SRF) and pigmented epithelial detachment (PED), captured by a CIRRUS™ HD-OCT 4000 (ZEISS, Dublin, CA).
- The performance of the model is also evaluated using the RETOUCH dataset, containing 70 SD-OCT volumes from three different OCT vendors.
- The proposed segmentation model is built with a custom encoder network and appropriately designed CNN network with common structure for the decoder. The encoder is based on a squeeze-and-excitation architecture (SeResNet50), which in addition to traditional residual networks, incorporates SE-Blocks, helping to capture spatial correlations between features, by calculating channel weights of the corresponding feature layers. Another major technique to improve the model performance is transfer learning. Different transfer learning strategies including partial freezing variants, utilizing trained weights from ImageNet are performed. Additionally, the freezing operations are implemented according to the specific training status of the network. An overview of all applied techniques is presented in Figure 1.
- According to the performance evaluation, nnUNet serves as a comparison here, as it is a segmentation framework automatically adopting its parameters based on the underlying dataset and achieves very good results on very different varying datasets.
- The whole implementation is done using "Tensorflow-Keras," and the model is optimized using Tversky loss. For the quantitative evaluation, the Dice coefficient and MeanIoU serve as useful segmentation performance metrics.

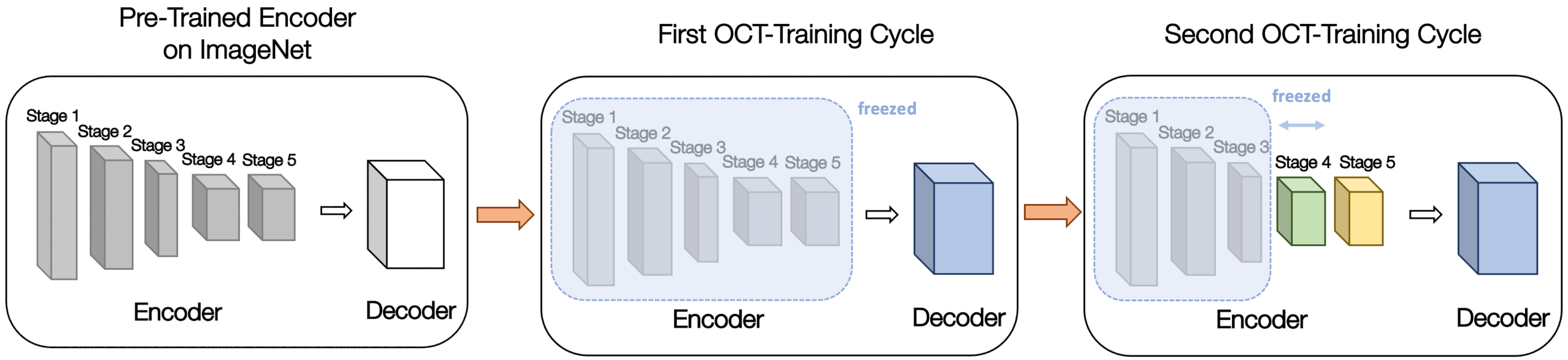

Figure 1: Transfer Learning Pipeline