REVIEW

by

Assoc. Prof. Hsiang-Chieh Lee, PhD, National Taiwan University, Taiwan
Member of the scientific jury appointed by Order No. RD-15749/08.10.2025 of the Director of IOMT-BAS

Regarding the dissertation for awarding the educational and scientific degree "Doctor of Philosophy" in higher education area 4. Natural Sciences, Mathematics and Computing, professional field 4.1. Physical sciences, doctoral program "Physics of wave processes"

PhD candidate: Maryam Viqar, Institute of Optical Materials and Technologies "Acad. J. Malinovski", Bulgarian Academy of Sciences
Supervisors: Assoc. Prof. Violeta Madjarova, PhD, and Prof. Elena Stoykova, DSc, Erdem Sahin, Ph.D. (Tampere University, Finland) and Prof. Atanas Gotchev, Ph.D. (Tampere University, Finland)

Dissertation title: „Deep Learning Models for Vascular Image Reconstruction and Analysis in Swept-Source Optical Coherence Tomography (SS-OCT)"

This doctoral thesis investigates integrating Deep Learning (DL) with Swept-Source Optical Coherence Tomography (SS-OCT) to improve vascular analysis and image reconstruction. Focusing on varicose veins, the research develops "Opto-UNet," an optimized network for precise layer segmentation. Additionally, a transfer learning model named "TREE" is introduced to simultaneously predict segmentation maps and estimate vein wall thickness utilizing a novel Sensitive Pattern Detector (SPD) module.

To address processing bottlenecks, this thesis proposes "WAVE-UNET," which reconstructs high-quality images directly from raw wavelength-domain data, bypassing the computationally intensive k-linearization step. Furthermore, a dual-domain framework using Spatial (SD-CNN) and Fourier Domain (FD-CNN) networks is implemented to restore morphological details and suppress speckle noise. Results demonstrate superior accuracy and reduced computational time compared to standard pipelines.

Overall, this research pioneers the use of optimized Deep Learning architectures to automate the precise segmentation and physical characterization of varicose veins, enhancing the diagnostic utility of Swept-Source OCT by overcoming traditional image reconstruction limitations. Furthermore, by enabling accurate, non-invasive estimation of vein wall thickness and morphology, this thesis provides essential computational tools for future investigations into the biomechanics of venous diseases and the development of superior vascular grafts.

To further improve this thesis work, the author might consider expanding the clinical datasets. For example, the segmentation and thickness estimation models were developed using a dataset derived from only four patients. To ensure the TREE model is robust enough for general clinical use, future work should incorporate a significantly larger dataset. Second, while this thesis demonstrates that the proposed DL models have lower inference times compared to standard processing, further optimization with specific hardware computing devices—such as edge devices—could enable true real-time processing directly within portable clinical OCT probes. Lastly, the ground truth for training the reconstruction networks relied on averaging seven consecutive B-scans. Future studies could benchmark the proposed frameworks against more advanced, state-of-the-art speckle-reduction algorithms.

Summary:
As described above, I recommend the permission to publish this thesis.

02.12.2025 /Prof. Hsiang-Chieh Lee/