REVIEW

by

Prof. Uma Maheswari Rajagopalan, PhD, Shibaura Institute of Technology, Japan

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)"

The work done in the thesis, on deep learning model for vasculature characterization and classification is a time one and its contribution to the scientific field of optics and also biomedical field is significant. The thesis is constructed from 5 chapters with chapters one and two introductory and background on the basics of the main techniques, namely, Optical Coherence Tomography and its variations (OCT) and deep learning used in the thesis. Chapters 3 and 4 are basically the publications respectively, I, II and III, IV. Chapter 5 is the concluding chapter for the work. Now let me state my comments on the thesis below:

On Organization:

Chapter 2 gives a strong background on OCT technology and also the Deep learning models and so a very useful chapter for any novice and also one interested in extending the work. My only concern could be sometimes the paragraphs are very long and they could be better

organized and made into smaller ones, for example, in Chapter 2, '2.4.1 Advancements of Deep Learning in OCT', the paragraph 2 is long. Therefore, paying attention to paragraph writing could help the reader.

Chapters 3 and 4 often refer to the publications as Publication I, II etc. I would advise the author instead repeatedly mentioning the publication within the chapters, it is better to state clearly once at the beginning. There is no necessity for repeated mentioning. The organization of the thesis clearly states how the publications are distributed into the chapters. I found that the term 'publication' appears overall 54 times in the chapter. Therefore, it is better to avoid the redundancy of the word.

Now let me state some of the concerns regarding the thesis chapters:

1. To the reviewer, it is not clear how the classified varicose vein addressed in the thesis would have practical real-world implications? The work itself is done with ex-vivo sample and it is not done with any in vivo. At least the author should mention the limitations of the learning models with respect to real world implications. As she develop the work, the focus becomes real time computational issues.
2. The author talks about accuracy. It is not clear how the accuracy was defined in the physical sense. There is a definition provided in Eq.3.8. Other than that it appears many times, a total of 76 times. How accurate in comparison to what? It is better to clarify.
3. Because it is a work done with Ex vivo vein, main concerns are that the structures done would be static. On the other hand, in the real world, they would dynamic structures dynamically accommodating to external changes. Some suggestions on how far the present DL models proposed and investigated could be used for such real cases? Or is the case these models restricted to static vasculature evaluation.
4. The following statement appears in the publication II:
   'Practically in laboratory environments, such measurements are done using a vernier caliper whose accuracy is of the order of a few millimeters.'
   The reviewer beliefs vernier caliper scales can reach up to tens of micrometer levels. If differential scales are used, then it could reach even further.
5. One more point is that the veins used are fairly large. Are the veins you address for the study need to be large or is that the case to demonstrate you used larger vessels?
6. In the chapter 4, please add scales to the images. In the attached publications, I do see scales.

But not necessarily in the chapters.

7. In Fig.4.7, the vertical scale in linear or log?

On Publications:

Publication I:

The first one, Opto-Net focuses on the segmentation of veins in particular, Varicose veins. Opto-Net is based on the U-net architecture with modifications done to it for extracting wide range of separable features by employing the atrous and depth-wise convolutions. The result: The model proved to be "highly adequate in segmenting the varicose wall without deteriorating the segmentation quality".

One main concern here is the number of human samples used in the study. This could be the major limitation of the study when considering practical application of the study.

The second limitation is that it is an ex vivo study. Of course the model needs to be tested in in vivo conditions. I have no doubt that if the model could be used in in vivo applications for evaluation of veins, it would have significant implications in the biomedical field. I know that could be beyond the scope of the work but worth venturing in the future.

Publication II

It is an extension of Publication I. In this publicaiton, the author addresses the evaluation of vein shape and vein thickness by a model called TREE that uses Transfer-learning. The model's specialty is that it uses a single encoder and two decoders, one for shape and one for thickness. Therefore, it can predict the thickness of the veins. Again the main concern is the demonstration with a fewer samples and that too ex vivo. However, the strength of the proposal and it strength is validated.

Publication III

In this work, critical focus on the SS-OCT method is given especially in relation to the processing involved in the computations involved. The author has proposed refining method to reduce computation and also propose method to reduce speckle noise inadvertently produced in OCT due to the coherency involved and also multiple scattering from the sample. Therefore in a way, this work sets new direction for looking into the current approaches used in OCT itself.

Publication IV

This work also addresses the problems of computational complexity and speckle noise in the OCT and proposes a WAVE-UNET as a way to solve the problems. The model succeeded in generating good quality output with reduced time complexity through demonstration of a few objects such as the vein and strawberry surface.

Summary

In Summary, the doctoral student has started off with application of DL models to OCT and finally looking into the OCT basics itself and have some up with models that could reduce the computational complexity and considering the prevalence of OCT in Ophthalmology and other fields, I believe the works have significant implications.

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/ Prof. Uma Maheswari Rajagopalan, PhD /