Ph.D THESIS INFORMATION

Thesis title:	**ESTIMATING INFORMATION AND RECONSTRUCTING IMAGE OF LIGHT-ABSORBING STRUCTURES IN THREE-DIMENSIONAL SPACE FROM AN OBSERVED TWO-DIMENSIONAL IMAGE OBTAINED WHEN NEAR-INFRARED LIGHT TRANSMITTED THROUGH THE SCATTERING MEDIUM.**
Specialization:	**Engineering Physics**
Specialization code:	**9520401**
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The main contributions of the thesis

The thesis aims to use transillumination (diaphanography) with near-infrared (NIR) light with wavelengths between 700 nm and 1200 nm to capture the image of light-absorbing structures in the scattering medium. From the observed image, scattering suppression techniques and information estimation (depth, width) of the light-absorbing structure were developed using the depth-dependent point spread function (PSF) to reconstruct the cleared image of the light-absorbing structure in two- and three-dimensional space. The main contributions of the thesis are:

- An overview of issues and the state-of-the-art related to the topic, analysis and evaluation of imaging methods and image reconstruction of light-absorbing structures in biological tissues, applications for imaging blood vessels and light-absorbing structures inside the existing small animal's body.
- Propose methods and techniques related to scattering suppression method and improve the efficiency of scattering suppression method to reconstruct the cleared

light-absorbing structures image by proposing to use the Attention Res-Unet model with Attention Gate and Residual Block.

- Propose methods and techniques related to estimating information (depth and width) of the light-absorbing structure in order to reconstruct a three-dimensional image of the light-absorbing structure in biological tissue; by examining four CNN deep learning models, ResNet-50, VGG-16, VGG-19, and DenseNet-169, to select the DenseNet-169 model for high performance and more accurate proportions (65%) compared to the other 4 models with 1,600 images, at 40 different depths (from 0.5 to 20.0 mm), with a correlation index $R^2 = 0.9911$.
- Propose a new method to solve the problem of transmitted images with complex structures located at various depths. By using pixel-by-pixel scanning of deep learning matrices and blurry images to solve this problem, with enhanced image datasets (three datasets with 03 different structure sizes and corresponding depths of 0.1 to 100.0 mm used for training), the restored image error is 2.18% compared to reality.
- Proposes a method of using the depth matrix obtained from the CNN model to restore the cleared light-absorption structure by setting a binary threshold with a reproducibility error of 6.82% over the actual size. This method helps to reduce computational time and resources.

The achievements of the thesis aim to contribute a small part in the development of new diagnostic techniques. The thesis proposes feasible and effective solutions for the reduction of blurring and estimation of structural information as a basis for further research in the application of optical techniques used in biometric devices, biomedical applications such as vascular diagnostics, investigation of cysts in breast tissue at an early stage,... as well as other light-absorbing structures in biological tissue.

Advisors Ph.D. Student

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