Measurement device and method for measuring and generating a topographic map of the preretinal space

Urządzenie do pomiarów i sposób pomiarów i generowania mapy topograficznej przestrzeni przedsiatkówkowej (Pat.245133)

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ABSTRACT and APPLICATIONS:

The presented research was conducted as a part of the CAVRI (*Computer Analysis of VitreoRetinal Interface*) Project. This project is based on interdisciplinary cooperation between the scientists from Poznan University of Technology (PUT) with ophthalmology specialists from the Poznan University of Medical Sciences (PUMS).

This invention presents the results of studies concerning the automatic investigation of *Optical Coherence Tomography* (OCT) retina images. The disorders at the border of the human eye retina and vitreous (called *VitreoRetinal Interface* – VRI) can cause severe retinal damage and carry a high risk of vision loss. Their early detection and accurate assessment are beneficial for successful therapy.

Current approaches for evaluating the VRI pathologies are based only on descriptive methods (subjective analysis without quantitative measurement). The authors of this invention introduces innovative solutions for quantitative assessment of the preretinal space and VRI based on automatic OCT image analysis.

The invention describes the development of novel methods for segmentation and parameterization of VRI pathology, namely the *VitreoMacular Traction* (VMT). The proposed method uses fully convolutional neural networks. The tested architectures based on the encoder-decoder design are UNet, LFUNet, ReLayNet, AttUNet, and DRUNet.

The object of the invention is a device for measuring the preretinal space from OCT or OCTA images of the retina and a method for measuring the parameters of the preretinal space and a topographical map of this measurement in ophthalmology and other specialities examining the visual system for diagnosis, monitoring of disease progression and qualification for surgery (e.g. vitrectomy) and intraoperative assessment.

The proposed solutions were tested on a specially prepared database of OCT images prepared by inventors from PUMS. The authors from PUT prepared a custom software called *OCTAnnotate* to provide the ophthalmology experts with specialized tools to evaluate the *VitreoRetinal Interface*. The methods proposed were also implemented in this open-source software.

The obtained segmentations were the basis for automated parameterization of pathologic retina structure.

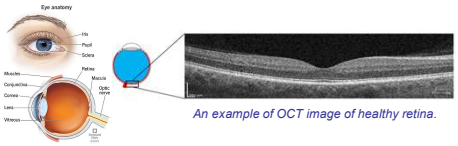
The devised parameters valuable for clinicians are the volume of the preretinal space, the area of attachment of the vitreous to the retina surface, the contour of the fovea, and the parameters of the fovea pit shape.

The developed techniques allowed for the generation of profiles of VMT disorder in the form of data or images understandable to clinicians.

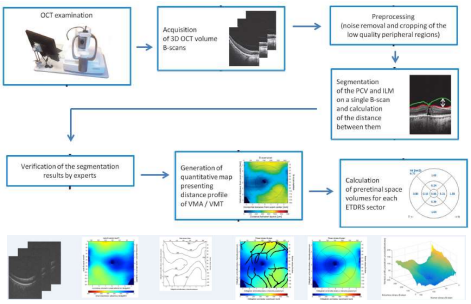
The results of experiments show that the designed algorithms provide valuable information for quantitative analysis of the VMT pathology stage and its progress in a long-term observation.

ADVANTAGES and FEATURES:

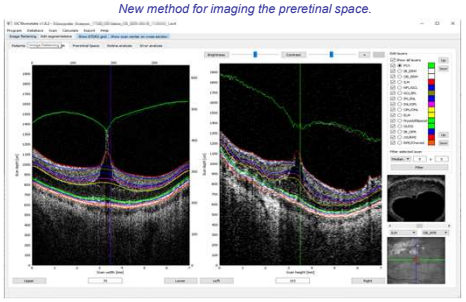
1. The proposed system based on fully convolutional neural networks allows for achieving preretinal space segmentation accuracy of up to 96%.
2. Knowledge of the parameters of the preretinal space obtained by the method according to the invention is important for the ophthalmic surgeon in order to make the right decisions on the choice of instrument manipulation techniques during vitrectomy.
3. The data obtained can also be used in the evaluation of the pharmacokinetics of drugs administered directly into the vitreous chamber, since there are differences in the distribution and concentration of the preparations inside the eye depending on the volume of the preretinal space.
4. The invention allows the generation of virtual three-dimensional maps of the preretinal space.
5. The differences between the invention and existing solutions make it possible to perform a fully or partially automated analysis process, so that clinical data relevant to diagnostic and therapeutic decision-making can be obtained.
6. The differences characterise the developed device, which can be operated by users without specialised training and without engineering expertise.
7. The invention defines a numerically efficient methodology that is suitable for application to a clinical recording device for image data sets.
8. Implementations according to the invention comprise a device and method for visualising and measuring the preretinal space, and for this purpose maps are generated containing a description of the parameters of the preretinal space.
9. Numerical data taking into account the thickness, volume and profile of the preretinal space can be demonstrated in the form of colour maps, hypsometric maps, vision sequences of these maps and in the form of m3D visualisations with the possibility of making arbitrary rotations and scaling of the map taking into account changes over time.

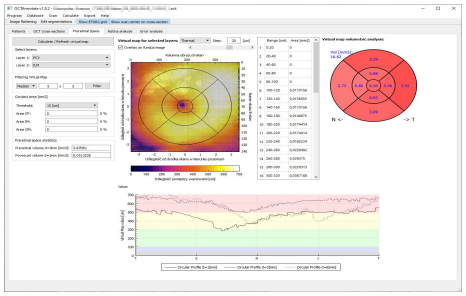


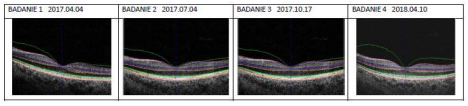
An example of OCT image of healthy retina.

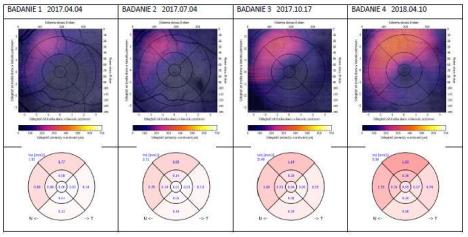


New method for imaging the preretinal space.









Comparison of the results of using the standard method with a single OCT scan and the patented method using colour maps and ETDRS maps, which allows changes in the upper and lower quadrants to be seen.

Polish patent granted at March 1, 2024, number: Pat.245133, more details: https://ewyszukiwarka.pue.uprp.gov.pl/search/pwp-details/P.434532

TECHNOLOGY READINESS LEVEL:

TRL8 - research and demonstration of the final version of the technology completed
TRL9 - development phase (applications of *Artificial Intelligence* to medical image analysis)

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