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Retinal polarization-sensitive scanning in ophthalmic diagnostic technologies

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Abstract (600 word limits)

Retinal birefringence scanning (RBS) has recently been used to detect central fixation and proper eye alignment in ophthalmic diagnostics. It utilizes the property of the Henle fibers surrounding the human fovea to change the polarization state of light in a double-pass polarization-sensitive optical system. This principle has been employed in a series of vision screeners developed in our lab. They allow eye tracking and detection of central fixation using anatomical information directly from the fovea and without calibration, in contrast to other eye tracking methods that employ less accurate pupillary light reflex methods. In a binocular setting, RBS facilitates precise checking for eye alignment. These instruments have proven to be valuable in early detection of amblyopia and strabismus. Such systems are particularly useful when working with young children. The presentation focuses on a family of pediatric vision screeners and includes design optimization using a computer model of polarization-sensitive systems.

The usage can be expanded to add a fixation detection function to other ophthalmic technologies, such as laser-doppler flowmetry, fundus cameras, OCT devices, etc. As an example, a hybrid system integrating optical coherence tomography and retinal birefringence scanning is presented. It acquires and/or analyzes data only during moments of central fixation. This can significantly reduce the image processing time, and shorten the exam duration. Methods to attract the subject's attention are also discussed.

Special attention is paid to possible implementation of no-moving-part technologies, liquid crystal technologies, and clinical testing. Related topics will be discussed, such as automatic detection and correction of ocular defocus in vision screening, laser safety, decision making logic, fixation/attention attraction methods, and others.

The talk will be interesting to ophthalmologists, optometrists, medical students, biomedical engineers and physicists, as well as health care managers and general practitioners.

Biography (200 word limit)

Boris Gramatikov obtained his Dipl.-Ing. degree in Biomedical Engineering in Germany, and his Ph.D. in Bulgaria. He has completed a number of postdoctoral studies in Germany, Italy and the United States. He joined the faculty of the Biomedical Engineering Department of The Johns Hopkins University in 1996, and has been working in the Laboratory of Ophthalmic Instrumentation Development at The Wilmer Eye Institute since 2000. Areas of expertise include electronics, optoelectronics, computers, computer modelling, signal/image analysis, instrumentation design, bio photonics, ophthalmic and biomedical optics, polarization optics, all applied to the development of diagnostic methods and devices for ophthalmology and vision research.

Recent Publications (With Hyperlink):

1. Gramatikov, B.I. A Mueller matrix approach to flat gold mirror analysis and polarization balancing for use in retinal birefringence scanning systems. Optik – International Journal of Light and Electron Optics (Elsevier), Vol. 207, April 2020, 164474.
https://doi.org/10.1016/j.ijleo.2020.164474

https://www.sciencedirect.com/science/article/abs/pii/S0030402620303089

2. Gramatikov, B.I. Computer-aided fixation detection using retinal birefringence in multi-modal ophthalmic systems: Computer, electronics, algorithms. Computers in Biology and Medicine (Elsevier), Vol. 119, 2020, 103672.

https://doi.org/10.1016/j.compbiomed.2020.103672

https://www.sciencedirect.com/science/article/abs/pii/S0010482520300640

3. Gramatikov, B.I. A method of calculating compensators in polarization-sensitive optical systems. Optik – International Journal of Light and Electron Optics (Elsevier), Vol. 201, Jan 2020, 163474. Available online: 2019-09-30 , DOI: 10.1016/j.ijleo.2019.163474

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4. Gramatikov, B.I. Detecting central fixation by means of artificial neural networks in a pediatric vision screener using retinal birefringence scanning. BioMedical Engineering OnLine (Springer), 16: 52, Open Access, First online: 27 April 2017. DOI: 10.1186/s12938-017-0339-6.

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5. Gramatikov, B.I., Irsch K, Wu Y-K, Guyton, D.L. New Pediatric Vision Screener - Part II. Electronics, Software, Signal Processing and Validation. BioMedical Engineering OnLine (Springer); First online: 04 February 2016. Open Access.

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