

Applied Optoelectronics in Medicine

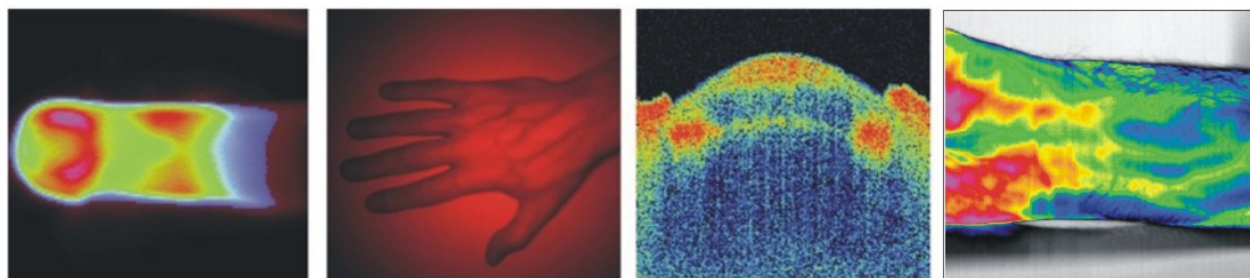
Aplikovaná optoelektronika v lékařství

Handout Scriptum

to the interdisciplinary lecture at the CTU Prague,
Faculty of Biomedical Engineering and Faculty of Electrical Engineering

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Topics and content

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Literature, recommended for further study	VII
Introduction, HF technology & OE applications in BME	1
Challenges, targets and applications of optoelectronics in focus of medical diagnostics. Noninvasive biosignal acquiring. Historical evolution and state of the art optoelectronic sensor examples.	
Light and life – ecological and biophysical aspects	25
The earth in radiation field of the sun. Biosphere windows to the space. Earth’s energetic drive. Basic radiation laws. Optical radiation & human skin.	
Metrological aspects in optoelectronics, light perception	47
Definitions of metrology, optoelectronics and photonics. Spectral radiation parameters, radiometry, photometry. Physiological optics, human eye as a high sensitivity “photo detector array”, spectral sensitivity. Predecessor models of the human eye in the animal kingdom.	
Spectral reflection, transmission and scattering behavior of biotissue	71
Regular and diffuse reflection / transmission. Spectral optical devices. Integrating sphere sensor (“Ulbricht Kugel”) theory. Experimental setup for spectral skin reflectance detection. Basics of colorimetry & tissue color analysis.	
Tissue optics, describing light distribution in tissue, optical skin model	93
Fundamentals and basic definitions. Approaches for describing the photon penetration in tissue. Radiative transfer theory (RTT). Kubelka-Munk theory, Monte-Carlo method. Optical model of the skin	
Biophysics of the human blood circulation, modelling	
Haemodynamics	113
Human haemodynamics – a sophisticated transportation system, evolution steps, blood pressure terms, studies of peripheral haemodynamics using ultrasound. Simulation of the human blood dynamics using electrical-haemodynamical analogon and theory of electric lines.	
Optoelectronic sensor concepts for functional vascular diagnostics – part I	135
Photoplethysmography (PPG) – basic facts and examination tests. Monitoring of peripheral venous blood volume changes. Venous muscle pump test. Venous occlusion test.	
8. Optoelectronic sensor concepts for functional vascular diagnostics – part II	157
Non-invasive monitoring of distal blood pressure. Photoplethysmographic registration of peripheral arterial blood volume pulse. Multi wavelength plethysmography, arterial pulse oximetry. Rhythmical phenomena in dermal blood perfusion.	
Optical imaging methods in medical diagnostics – part I	181
Basic requirements. Optical biopsy. NIR photography, NIR diaphanoscopy, NIR thermography imaging (IRTI). Laser Doppler perfusion imaging (LDPI).	
Optical imaging methods in medical diagnostics – part II	205
Photoplethysmography Imaging (PPGI) and optical coherence tomography (OCT) – basic facts, realisation strategies, approaches and applications.	

„It is not enough to know,
it must be applied;
it is not enough to want.
it must be done“

J. W. v. GOETHE (1749 – 1832)

Preface to the fourth, revised edition

The study of this scriptum shouldn't replace the active participation on the lecture. The main aim of this handout collection is to take notes easier during the teaching sessions and to be helpful for look up and repetition.

Application examples and brief presentations of research results from the Biomedical Optics areas taken by the RWTH Aachen University Chair for Medical Information Technology, Helmholtz-Institute for Biomedical Engineering should also help to make links between theory and applied diagnostic use.

The presented materials are only selected topics and can't be understood as a closed overview. For the deeper study some related sources are recommended in the literature list.

All constructive criticism is highly welcome and will be helpful for the next edition.

Vladimir Blazek

Aachen, in January 2016



Literature

a) Related titles, recommended for further study

- Blazek V: Optoelektronische Systemkonzepte für nichtinvasive Kreislaufdiagnostik. Opto Elektronik Magazin 1991; 7: 212-219
- Blazek, V., Schultz-Ehrenburg, U.: Quantitative Photoplethysmography. Basic facts and examination tests for evaluating peripheral vascular functions. VDI Verlag, Düsseldorf 1996, ISBN 3-18-319220-9
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- Cooper, J., Cass, T. (Eds.): Biosensors. 2nd ed., Oxford University Press, Oxford 2004, ISBN 0-19-963846-2
- Dössel, O.: Bildgebende Verfahren in der Medizin. Von der Technik zur medizinischen Anwendung. Springer, Berlin 2000, ISBN 3-540-660014-3
- Fraden, J.: Handbook of Modern Sensors. Physics, Designs, and Applications. 4rd ed., Springer, Berlin 2010, ISBN 978-1-4419-6466-3
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- Tuchin, V.V.: Tissue Optics: Light Scattering Methods and Instruments for Medical Diagnostics. 2nd Ed., SPIE Press, Bellingham 2007
- Spichiger-Keller, U.E.: Chemical Sensors and Biosensors for Medical and Biological Applications. Wiley VCH, Weinheim 1998, ISBN 3-527-28855-4
- Vo-Dinh, T. (Ed.): Biomedical Photonics Handbook. CRT Press, Boca Raton 2003, ISBN 0-8493-1160
- Wang, L.V., Wu, H.I.: Biomedical Optics, Principles and Imaging, Willey & Sons, Hoboken N. J. 2007
- Webster, J.G. (Ed.): Medical Instrumentation – Application and Design. 2nd ed., Wiley, New York 1995
- Welkowitz, W., Deutsch, S., Akay, M.: Biomedical Instruments – Theory and Design. Academia Press, New York 1997
- Wise, D.L. (Ed.): Bioinstrumentation and Biosensors. Dekker, New York 1991

b) Related web sites, recommended for further information

- Center for Bioelectronics, Biosensors and Biochip www.c3b.vcu.edu
- Biosensors and other medical and environmental probes www.ornl.gov/info
- Mendel's experiment animation www.mendel-museum.org
- Universe, expansion and the Big Bang theory www.space.com
- Cosmic microwave background radiation lambda.gsfc.nasa.gov
- How your heart works science.howstuffworks.com/heart.htm
- How vision works science.howstuffworks.com/eye.htm
- Ways of thinking about light
science.howstuffworks.com/light.htm