MSc course program on biomedical optics

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ABSTRACT

A new Msc study course programme on Biomedical Optics has been developed and adapted. The programme consists of three main parts:

- Fundamentals of tissue optics,
- Optical sensing for diagnostics and monitoring,

The full programme and some comments on it are presented.

Keywords: biomedical optics education.

1. INTRODUCTION

Biomedical Optics has become a significant research and clinical application area attracting wide public attention during the recent decade. Large and well-attended annual symposia and conferences on Biomedical Optics are organized in Europe (EUROPTO BIOS-Europe series), USA (SPIE BIOS-series in San Jose, CA), and elsewhere. Results of research and development are regularly published at “Journal of Biomedical Optics”, “Biophotonics International” and other specialized journals. Many physicists are involved in this promising interdisciplinary area now, as well as doctors and other specialists with bio-medical background. The additionally needed knowledge and skills most of them had acquired by self-education and self-training. Only few topics of Biomedical Optics are included in traditionally well-established study programmes like Medical Physics or Bioengineering. In fact, regular study courses on Biomedical Optics at BSc and MSc levels are hardly available both in Europe and USA - mainly due to lack of textbooks, teaching methodology and internationally recognized study programmes.

The Physics Department at Faculty of Physics and Mathematics, University of Latvia, has announced a new two-year “pilot” MSc curriculum on Biomedical Optics in 1995. The basic courses included are Biomedical Optics, Lasers and Other Light Sources, Optical Medical Instruments, Medical Lightguides, Anatomy and Physiology, Optical Methods of Patient Treatment, etc.

The newly developed MSc course programme on Biomedical Optics (128 lecture hours) is presented below. Any comments and suggestions on it would be highly appreciated.

2. THE PROGRAMME

A. Fundamentals of tissue optics.

1. Propagation of optical radiation in tissues.

1.1. Optical wavelength range: ultraviolet, visible and infrared spectral regions and their limits; specific “A”, “B” and “C” bands of UV and IR. Main processes of the light-matter interaction: absorption, scattering, reflection, refraction, luminescence, interference, polarization; their physical models and mechanisms. Energetic structure of matter in gaseous, liquid and solid state, character of corresponding absorption and emission spectra.

1.2. Specific features of living tissues from the point of optics. Relations of scattering and absorption in tissues; the “therapeutic window”.

1.4. Experimental studies of light propagation in tissues; tissue phantoms in experiments. Basic principles of optical tomography.

2. Skin optics.
   2.1. Structure of human skin. Thicknesses and optical properties of appropriate skin layers. The Kubelka-Munk model. Experimental data on skin absorbance and remittance in different spectral regions. Skin pigments (melanin, bilirubin, carotene, haemoglobin) and their spectra.
   2.2. Influence of UV radiation to human skin. Human erytherma action spectra. Melanogenesis (tanning) and its mechanism. Classification of human skin types according to sunburn. Sunscreens; sun protection factor (SPF) values and subsequent effects.

   2.1 Composition of blood. Spectral properties of erythrocytes, thrombocytes and blood plasma.
   2.2. Differences between oxygenated and unoxygenated haemoglobin absorption spectra. Principles of optical pulse oximetry.
   2.3. Routine “in vitro” blood spectral analysis in laboratories: basic requirements and equipment.

4. Optics of the hard tissues.
   4.1. Structure of human bones, nails and teeth; their spectral characteristics.

5. Eye optics.

**B. Optical sensing for diagnostics and monitoring.**

2. Photoplethysmography; its use for heartbeat rate, blood supply and arterial blood pressure sensing.

**C. Laser-tissue interactions and laser treatment.**

1. Basic designs of medical lasers and radiation delivery devices.


4. Low-power laser therapy and biostimulation: techniques and possible mechanisms. Laser acupuncture and wound healing.


3. INFORMATION SOURCES AND THE TWO-YEAR TEACHING EXPERIENCE

A broad spectrum of information sources was used to prepare this programme. The books referred below (in chronological order) are very informative and useful, as well as a number of review papers from journals and proceedings which are not reflected here. One must note that Biomedical Optics is a very dynamic and rapidly developing field, therefore all recent proceedings of the SPIE and EUROPTO BIOS-conferences can be recommended to be always on the “cutting edge”.

A lot of information for this programme was collected during author’s 6 month stay at King’s College London in 1995, especially by attending the Oxford Summer School Optics in Medicine; also the 6 week TEMPUS-PHARE project to develop this programme at London and Linkoping universities in 1996 was very useful. A number of books and papers on specific items were found in libraries and by search in the MEDLINE database, some information on the topic is available at Internet, as well.

Two MSc student groups (8 and 9 persons) were educated following this programme in academic years 1995/1996 and 1996/1997. The students were with various backgrounds - physics, engineering, biology and medicine. Generally all of them have acquired the main items of the course without significant difficulties, only few students with medical background had some problems with physical description of the biooptical phenomena in tissues. The 2nd year students worked out their MSc thesis this spring; for illustration, there are some titles of the MSc thesis:
- Application of Tissue Fluorecence for Cancer Diagnostics,
- Phototherapy of Infant Hyperbilirubinemia,
- Image Analysis in Medical Diagnostics,
- Dosimetry Problems of Intravascular Laser Irradiation,
- Methods of Underskin Optical Monitoring.

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5. REFERENCES