BME 695 Frontiers in Biophotonics (Fall 2019)

Time:

Location: Jischke Hall of Biomedical Eng (TBA)

Instructor:

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Description:

This course is a graduate student course (not advanced). The goal is to expose the students to modern biophotonic technology. As the name of the course suggests, it will emphasize the basics in photonics and their applications in biological systems. In this semester, the biological system we will focus on is the brain. The optical techniques are clustered in different research areas associated with the brain, from local neuron and neuronal structure, to more global brain perfusion and function. We will also discuss the optical methods applied in brain stimulations and photo-dynamic therapy. Cutting edge technology will be covered in the course, such as Optogenetics, CLARITY, etc.

Objectives:

Upon completion of the course each student will be able to:

- develop basic understanding about photonics and light-matter interactions.
- develop broad understanding of the current field of brain research and its needs.
- explain the physics behind each optical technology and its unique application in brain science.
- understand the interdisciplinary research and its impact on modern biophotonics.

Topics (tentative):

Fundamentals of Photonics:
Class 1: Introduction to Photonics (Coherence, Interference and Diffraction)
Class 2: Laser and LED

Class 3: Photon Detector
Class 4: Fiber Optics
Basics of Light-matter Interactions:
Class 5: Absorption, Dispersion and Scattering
Class 6: Fluorescence and Nonlinear Optics
Brain:
Class 7: Brain
Class 8: Brain and Optics
Neuron and Neuronal Activities:
Class 9: Multiphoton Microscopy
Class 10: Raman and Infrared Spectroscopy of Vibrational Modes (1)
Class 11: Raman and Infrared Spectroscopy of Vibrational Modes (2)
Class 12: CARS Microscopy
Class 13: Light Sheet Microscopy and CLARITY
Class 14: Optical Coherence Tomography (1)
Class 15: Optical Coherence Tomography (2)
Brain Perfusion and Function:
Class 16: Diffuse Optical Imaging (1)
Class 17: Diffuse Optical Imaging (2)
Class 18: *Midterm Project*
Class 19: Instrumentation and Experimental Methods for Diffuse Optical Imaging
Class 20: Application of Diffuse Optical Imaging
Class 21: Functional Near Infrared Spectroscopy
Class 22: Multimodal Functional Imaging
Class 23: Laser Doppler Flowmeter and Laser Speckle Imaging
Class 24: Optoacoustic Imaging
Brain Modulation:
Class 25: Acoustic Modulation
Class 26: Optogenetics
Brain Diseases and Injuries:
Class 27: Brain Diseases and Injuries
Class 28: Photothermal Therapy and Photo Dynamic Therapy
Final Presentation:
Class 29: Student Presentation
Class 30: Student Presentation
Class 31: Student Presentation
Class 32: Student Presentation

Prerequisites:

Basic knowledge of physics, biology, physiology and data processing.

Attendance:

In-class attendance is mandatory

Textbook:

Textbook is not required. Hand-out and reading materials will be posted online before the class.

Project:

The students are required to give an oral presentation (30min) and write a "mini" NIH proposal based on the papers selected from the most recent publications of biophotonics. Each paper will be selected to have the maximum overlap with the student's current research interests. The paper will be given to the students 2 months before the final presentation. The final proposals and presentations will be evaluated by the instructor for 1) clarity; 2) logical progression; 3) broad understanding of the scientific background; 4) significance of the research; 5) Q&A session after the presentation; 5) presentation skills.

Grading:

Attendance (20%)
Presentation (40%)
Midterm/Final project (40%)

Ethics:

Dishonesty in connection with any University activity are not tolerated? Cheating, plagiarism, or knowingly furnishing false information to the University are examples of dishonesty. The commitment of the acts of cheating, lying, stealing, and deceit in any of their diverse forms (such as the use of ghost-written papers, the use of substitutes for taking examinations, the use of illegal cribs, plagiarism, and copying during examinations) is dishonest and must not be tolerated. Moreover, knowingly to aid and abet, directly or indirectly, other parties in committing dishonest acts is in itself dishonest. (University Senate Document 72-18, December 15, 1972)