Department of Biomedical Engineering
Graduate Seminar

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Subject: Cracking Brain Complexity through Multiphoton Imaging

Abstract:

Two-photon microscopy has become the workhorse of tissue imaging in the life sciences, particularly in neuroscience, where it is used to perform high-resolution, structural and functional brain imaging and stimulation in various biological systems and models. However, two-photon microscopy has severe limitations for deep brain imaging due to absorption and scattering at greater depths, as well as photo damage and toxicity accompanying higher laser power at the brain surface. Therefore, imaging and stimulating neuronal populations in deep cortical and subcortical areas with two-photon microscopy is challenging. In this talk, I will discuss the design, implementation, and applications of two- and three-photon microscopy for performing high-resolution, damage-free, and deep tissue imaging for clinical and neuroscience applications. In the first part of my talk, I will describe the design and implementation of table-top and endoscopic multiphoton microscopes for the treatment of a clinical problem which is vocal fold scarring. In the second part of my talk, I will describe the design and optimization of a three-photon microscope for live, in vivo, damage-free imaging at a sub-cellular resolution in deep layers of the cortex in awake mice. Specifically, I will demonstrate the application of the microscope for imaging structural features and functional evoked calcium responses of neurons through the entire cerebral cortex down to the subplate of primary and higher visual areas in awake mice. In the last part of my talk, I will demonstrate the use of three-photon microscopy to perform high-resolution deep-tissue imaging in intact cerebral organoids specifically for assessing the key components of early neurogenesis such as cell migration in Rett syndrome. Collectively, these technologies will enable my lab to crack the brain complexity through the study of its structure and function in various biological systems and models such as behaving mice, cerebral organoids, and human brain in healthy and disease states.

Bio:

Dr. Murat Yildirim is currently a research scientist at the Picower Institute for Learning and Memory at the Massachusetts Institute of Technology. He holds a PhD degree from UT Austin and he received his B.Sc. and M.Sc. degrees from Middle East Technical University in Turkey, all in Mechanical Engineering. His current research interests are developing next generation multiphoton systems to study the structure and function of the brain with various biological systems and models spanning from cerebral organoids, to small animals, to humans through their

interaction with femtosecond laser pulses for the diagnosis, characterization, and treatment of specific brain disorders to positively impact human mental health. He recently received a Pathway to Independence Award (K99/R00) from NIBIB. He is a member of SPIE, OSA, and SfN.

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