BE Areas of Study

Field 1: Biomedical Devices and Instrumentation (BDI)

Field Chairs: Dino Di Carlo and Jacob Schmidt

This field of emphasis is designed to train bioengineers interested in the applications and development of instrumentation used in medicine and biotechnology. Examples include the use of lasers in surgery and diagnostics, new micro electrical machines for surgery, sensors for detecting and monitoring of disease, microfluidic systems for cell-based diagnostics, new tool development for basic and applied life science research, and controlled drug delivery devices. The principles underlying each instrument and specific clinical or biological needs will be emphasized. Graduates of this program will be targeted principally for employment in academia, government research laboratories, and the biotechnology, medical devices, and biomedical industries.

Field 2: Molecular, Cellular, and Tissue Engineering (MCTE)

Field Chairs: Andrea Kasko and Daniel Kamei

This field of emphasis covers novel therapeutic development across all biological length scales from molecules to cells to tissues. At the molecular and cellular levels, this area of research encompasses the engineering of biomaterials, ligands, enzymes, protein-protein interactions, intracellular trafficking, biological signal transduction, genetic regulation, cellular metabolism, drug delivery vehicles, and cell-cell interactions, as well as the development of chemical/biological tools to achieve this. At the tissue level, this field encompasses two sub-fields which include biomaterials and tissue engineering. The properties of bone, muscles and tissues, the replacement of natural materials with artificial compatible and functional materials such as polymers, composites, ceramics and metals, and the complex interactions between implants and the body are studied at the tissue level. The emphasis of research is on the fundamental basis for diagnosis, disease treatment, and re-design of molecular, cellular, and tissue functions. In addition to quantitative experiments required to obtain spatial and temporal information, quantitative and integrative modeling approaches at the molecular, cellular, and tissue levels are also included within this field. Although some of the research will remain exclusively at one length scale, research that bridges any two or all three length scales are also an integral part of this field. Graduates of this program will be targeted principally for employment in academia, government research laboratories, and the biotechnology, pharmaceutical, and biomedical industries.

Field 3: Biomedical Imaging (BI)

Field Chairs: Liang Gao and Holden Wu

This field consists of the following two subfields: Biomedical Imaging Hardware Development (BIHD), Biomedical Signal and Image Processing (BSIP).

BI Subfield 1: Biomedical Imaging Hardware Development (BIHD)

The BIHD graduate programfield prepares the students for a career in developing imaging hardware for medical diagnosis and intervention applications. Students will learn the physical basis of biomedical imaging modalities, such as optical imaging, CT, and MRI. The students will also be trained with hands-on experiences to build state-of-the-art imaging devices and test their performance in real-world medical imaging scenarios. Through the structured curriculum and lab activities, the students will experience the excitement of cutting- edge hardware research, hone skills in analytical thinking and communications, and gain knowledge of imaging techniques that are used in the biomedical field.

BI Subfield 2: Biomedical Signal and Image Processing (BSIP)

The Biomedical Signal and Image Processing (BSIP) field prepares students for a career in the acquisition and analysis of biomedical signals; and enables students to apply quantitative methods applied to extract meaningful information for both clinical and research applications. The BSIP program is premised on the fact that a core set of mathematical and statistical methods are held in common across signal acquisition and imaging modalities and across data analyses regardless of their dimensionality. These include signal transduction, characterization and analysis of noise, transform analysis, feature extraction from time series or images, quantitative image processing and imaging physics. Students in the BSIP program have the opportunity to focus their work over a broad range of modalities including electrophysiology, optical imaging methods, MRI, CT, PET and other tomographic devices and/or on the extraction of image features such as organ morphometry or neurofunctional signals, and detailed anatomic/functional feature extraction. The career opportunities for BSIP trainees include medical instrumentation, engineering positions in medical imaging, and research in the application of advanced engineering skills to the study of anatomy and function.

Field 4: Biomedical Data Sciences (BDS)

Field Chairs: Aaron Meyer and Corey Arnold

The Biomedical Data Sciences (BDS) trains students to be experts in the use of computational, statistical, and machine learning tools for solving biomedical problems. BDS is intended for science and engineering students interested in how data science tools can operate alongside other areas of bioengineering to solve problems in areas including pattern recognition, prediction, control, measurement, and visualization. Students will be trained in the algorithmic and statistical fundamentals of the field. Directed interdisciplinary training will prepare students to be practitioners in the application of data science to analyze clinical imaging, molecular and cellular systems, medical devices, electronic health record data, and the many other areas of biomedicine that routinely generate data. In parallel to learning fundamentals, students will develop expertise in these application areas, providing them additional expertise in real-world problem solving. In total, this area fosters the development of students who go on to become data scientists with the unique ability to actively interface with practitioners in other areas of bioengineering and medicine.

Field 5: NeuroEngineering (NE)

Field Chair: Wentai Liu

The NeuroEngineering (NE) field is designed to enable students with a background in biological science to develop and execute projects that make use of state-of-the-art technology, including microelectromechanical systems (MEMS), signal processing, and photonics. Students with a background in engineering will develop and execute projects that address problems that have a neuroscientific base, including locomotion and pattern generation, central control of movement, and the processing of sensory information. Trainees will develop the capacity for the multidisciplinary teamwork, in intellectually and socially diverse settings, that will be necessary for new scientific insights and dramatic technological progress in the 21st century. NE students take a curriculum designed to encourage cross-fertilization of neuroscience and engineering. Our goal is for neuroscientists and engineers to speak each other's language and move comfortably among the intellectual domains of the two fields.