Biomedical Imaging

The pioneering work of determining the underlying biological mechanisms of disease and the life-saving work of diagnosing and treating medical problems rely on increasingly sophisticated imaging techniques developed by engineers. At Cornell, extensive collaborations among engineers, physical scientists, life scientists, and clinicians provide superb opportunities to create and improve these tools.

BME faculty members focus on time-resolved and spectrally-resolved measurement and visualization of biological structures across scales, with spatial scales ranging from cells to whole organisms, temporal scales ranging from milliseconds to years, and spectral scales ranging from megahertz radiofrequency waves to exahertz x-rays. A wide range of imaging modalities and methods for achieving contrast are developed and used, including optical imaging, MRI, and CT. Cornell is known for pioneering development and application of nonlinear optical imaging techniques for in vivo imaging. In addition to new imaging hardware and techniques, Cornell researchers are inventing new image analysis methods and novel contrast agents for clinical and research use. BME faculty apply these imaging tools to a diverse set of human health related problems including neurodegenerative disease, cancer, and congenital heart disease. Biomedical imaging is also tightly interconnected with other areas of BME, providing in vitro and in vivo tools to evaluate biomaterials, validate system biology models, monitor drug delivery, and map biomechanical properties.

Some specific faculty projects

Prof. Warren Zipfel’s lab focuses on the development of two-photon excited fluorescence microscopy, the imaging technique invented in Prof. Watt Webb’s lab at Cornell and now the tool of choice for cell-resolved, in vivo optical imaging. They apply this imaging technique to a variety of research problems, focusing on direct visualization of the initiation and growth of tumors in animal models of cancer.

In Prof. Chris Schaffer’s lab, light is used not only to visualize biological systems, but also for targeted ablation and manipulation. For example, using extremely short laser pulses, Schaffer’s lab causes localized injuries to individual blood vessels in the brains of rodents, triggering a small stroke. These targeted microstrokes allow the lab to study the role of microvascular lesions in neurodegenerative diseases, such as Alzheimer’s disease.

Prof. Yi Wang holds a joint appointment with Radiology at Weill Cornell Medical College and is the technical director of the new MRI imaging center in Ithaca which is equipped with a new state-of-the-art GE 3 Tesla imager. His research interest is to develop and improve MRI methods using mathematics, physics, electronic engineering, biological, and computer science tools to help physicians better diagnose diseases. His research activities include fast organ functional imaging, suppressing motion artifacts in MRI of the heart, and developing tools to quantitatively map magnetically susceptible bio mark- ers such as iron overload in neurodegenerative diseases and contrast agents in molecular MRI.
In Prof. Jonathan Butcher's lab, multiple different imaging modalities are applied to the study of cardiac development, the dynamics of heart valve operation, as well as models of congenital and acquired cardiac disease. His lab uses multiphoton microscopy, high frequency ultrasound and micro-CT to investigate the structure and dynamics of living hearts in normal and disease states.

Prof. Peter Doerschuk's group develops novel, quantitative image analysis algorithms that are used for a diverse set of imaging problems, including determining virus structure from electron microscope images and inferring the state of the brain's neurovascular system from optical images.

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Representative publications

