Biophotonics: Computational and Optical Advances in Multidimensional Biological Imaging

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Revolutionary advances in biological and biomedical imaging over the last twenty years have brought about the development of improved methods for non-invasively imaging dynamic biological processes. Of particular significance have been optical (photonic) techniques that have allowed for the visualization and manipulation of molecular and cellular structures within living tissue with minimal perturbation. The importance of these approaches has led to the development of a relatively new field, Biophotonics, the study of photon interaction with biological materials. A fertile area of Biophotonics research and development is in the area of optical instrumentation where collaborative efforts are needed to develop the next generation of optical instrumentation and computational approaches for visualizing and assaying key biological and biomedical phenomena. The efforts of the multidisciplinary UW-Madison Laboratory for Optical and Computational Instrumentation (LOCI), to develop optical and computational approaches for biological and biomedical studies will be presented. These efforts include signal-processing approaches for multidimensional image analysis, image informatics, and nonlinear optical and intrinsic fluorescence studies of biological tissue. These biological applications have mostly been in the fields of neuroscience and cell biology, where laser scanning microscopy techniques such as confocal microscopy have allowed unprecedented clarity in revealing key biological phenomena such as the dynamic behavior of cytoarchitecture. A key area of emphasis for these biophotonics-based methods has been in cancer research. Noninvasive nonlinear optical methods such as Multiphoton microscopy, second harmonic generation (SHG), and fluorescent lifetime microscopy (FLIM), hold great promise for investigations in human cell and animal models of cancer and new data from pancreatic, prostate and breast cancer research will be shown. The unrivaled ability of these techniques to obtain high-resolution multi-parametric images of intrinsic and extrinsic signals from deep within tissues can be exploited to understand cancer progression.