

## Editorial

# Biomedical Engineering Imaging

The role of biomedical engineering in medical and pharmaceutical research has grown substantially in the last decade. In particular, traditional and novel engineering imaging techniques, both experimental and computational, are allowing the capture of form and function of biomedical processes to a resolution and in other ways not previously possible.

In this Special Volume, a selection of the many ways that engineering is contributing to improved imaging that is progressing biomedical and pharmaceutical biotechnology is presented. As a result of the complexity and scales of space and time involved, there are various engineering imaging approaches that can be employed, each with its own strengths and weaknesses. The review articles herein include a blend of experimental and computational approaches, new and traditional techniques, different modes and parts of the frequency spectrum, and expensive and economical techniques. Furthermore, often the functionality and dynamics of the biological system rather than just a static structure are important. Therefore, increasingly, the acquiring of understanding of the systems and the development of downstream biotechnology require higher resolution not only in spatial dimensions but simultaneously in time.

For the general reader, the article by Azhari gives a valuable introduction to the physics, methods and application of imaging in general, and specifically of ultrasound. A non-invasive method, ultrasound can provide views of rapid anatomical changes and, when combined with Doppler techniques, can also provide real time quantitative flow information. Recently, the ultrasound technique has found uses in drug delivery, gene therapy and molecular imaging.

Bednar and Ntziachristos describe how acoustics are combined with optics in the form of multi-spectral opto-acoustic tomography to provide high resolution optical imaging and the simultaneous resolution of multiple tissue molecules and opto-acoustic agents. This method has the potential to be further developed and has important implications for drug discovery applications.

Functional imaging is needed to track the spatial distribution and temporal changes *in vivo* of administered radiopharmaceuticals. The development of various aspects of software used in functional imaging is described by Wen *et al.* This increased ability to trace biochemical and physiologic processes will lead to improved drug development and advances in personalized medicine.

The application of powerful engineering techniques such as Particle Image Velocimetry through plane laser illumination or more recently via X-ray imaging is revealing the important effects of biomechanical forces on biological processes. Jamison *et al.* describe specific examples such as platelet activation and liquid evacuation from neonates. The prospect is open for pharmacological treatments for physically mediated effects and new diagnostic techniques for a variety of diseases including diabetes.

Increasingly, with improved algorithms and computing power, computational prediction is being fused with experimental observations to provide detailed information on biofluid dynamics. Oshima *et al.* describe an integrated numerical simulation system with geometry input from medical imaging to develop a targeted drug delivery system for cerebrovascular disorders. By including the effects from the entire circulatory system through appropriate boundary conditions, the analysis region can be part of the circulatory system containing, for example, an aneurysm.

Increasingly, techniques of imaging require expensive equipment. The paper by Leweke demonstrates however that simpler traditional methods, such as dye visualization, together with Laser-Induced Fluorescence and appropriate scale models, can provide profound insight into biofluid issues. The article describes important insights into the fluid dynamics in blood vessels near stenoses, particle or cell motion along vessel walls, and the mixing in bioreactors required to produce quality biopharmaceuticals.

In general, it is hoped that this issue provides an important glimpse into the potential of engineering techniques to contribute significantly to the imaging and understanding of biological processes and the development of technologies in the area of biopharmaceuticals.

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