Special Issue on Research in Biomedical Engineering at the National University of Singapore: At the Forefront of Research in the 21st Century

The Bioengineering Division at the National University of Singapore (NUS) was formed in 2000–2001 by a core group of academics within the Faculty of Engineering. The original group of investigators provided impetus to the field, and the Division of Bioengineering has now matured into a full-fledged biomedical engineering department awarding undergraduate, master's, and doctoral degrees. More than 1400 scholarly articles have been published by the department faculty from 2002 to 2012.

As guest editor, I am pleased to provide 8 in-depth and scholarly review articles representing some of the key areas pursued by researchers in the Department of Biomedical Engineering at NUS. These articles, encompassing several major themes, examine the current status of research in fields that are being researched at our university. The following paragraphs provide a summary highlighting the significance of each article.

Superresolution microscopy is an ensemble of light microscopy techniques that extends imaging resolution beyond the diffraction limit of ~250 nm. To date, improvement in resolution of more than an order of magnitude has been reported, allowing direct visualization of the molecular-scale architecture in subcellular structures. In the review by Bertocchi et al.,[1] theoretical foundations and practical considerations of superresolution microscopy in 2- and 3-dimensional imaging are discussed, along with their recent applications to address biological questions.

Anterior cruciate ligament (ACL) injuries often are associated with maneuvers involving landing or a sudden change in direction. The review by Barraza et al.[2] presents some of the key findings of research on ACL injury mechanisms and strategies to protect the knee joint. Studies reported in the literature range from motion analyses and in vitro impact tests to knee finite element simulations and multibody dynamics musculoskeletal simulations, which collectively reveal the multifactorial nature of ACL injury mechanisms. Proposed strategies to protect the knee include knee bracing and strength training of important muscle groups. Reported results are still uncertain about the benefit of various methods developed to reduce the deleterious effects of ACL injury. Barraza et al. conclude that future biomechanics research on ACL injury needs to involve a multifactorial approach toward protecting the ACL from injury.

The interaction between nanoparticles and biomolecules gives rise to the interface between a nanoparticle and its biological environment. Intelligent design of such nano-bio interfaces is crucial to the functionality of nanoscale systems in biology. In their review, Kah et al.[3] discuss the most common nano-bio interfaces formed from molecules, including DNA, polymers, proteins, and antibodies, and discuss their applications in probing and modulating biological processes.

A robotic exoskeleton for rehabilitation is a fast-growing field of research because of the rapidly aging population in many countries. In their review article, Chen et al.[4] focus on treadmill-based, overground exoskeletons for rehabilitation, emphasizing on their mechanical design, actuation systems, and integrated control strategies. Chen et al. also discuss various limitations of current designs as well as technical challenges faced by biomedical engineers and provide a perspective for future development of more effective robot exoskeletons.

A review by Ren et al.[5] discusses the flexible robotic surgery and navigation technologies that are currently available and/or under research development, in particular those used for transoral robotic surgery. They examine the clinical background, classification of biomedical robotics applications, and surgical outcomes to illustrate the new paradigm of minimally invasive surgery. The state-of-

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the-art robotic and navigation systems for transoral procedures are reviewed by identifying their key properties and considerations for design. The future research trends of the robotic and navigation systems for transoral procedures in terms of emerging new material, actuation, and sensing technologies, also are discussed.

The group led by Chen et al.[6] compares several different optical microscopy methods for deep tissue imaging. The principle of focal modulation microscopy, a new addition to in vivo imaging modalities, is thoroughly examined. Chen et al. highlight the design issues and performance that can be achieved using these methods.

The inception of percutaneous aortic valve replacement began in 1992, and the first successful demonstration of such a novel technique of surgical replacement of a heart valve was performed in 2002. The review by Kumar et al.[7] presents a detailed analysis of the current state of art of percutaneous aortic valve replacement. A competitive landscape of various devices available in the market, along with their design considerations, biomaterial selection, and overall hemodynamic performance, also is presented.

Low et al.[8] review numerical simulation of red blood cells (RBCs), especially exploring issues related to 2-dimensional deformation and aggregation of RBCs in simple shear flow. They report that, in general, RBCs are simulated as a single biconcave capsule or as a doublet pair of biconcave capsules. The transition from swinging to tumbling motions of the RBC, as induced by reducing the shear rate or increasing the membrane bending stiffness, is discussed, as is the concept that the deformability difference between the the 2 RBCs in a doublet aggregate may induce their dissociation process.

In summary, the core research expertise available in the Biomedical Engineering department encompasses Bioimaging, Biomaterials, Biomechanics, Bionanotechnology, Biorobotics, Rehabilitation Engineering, Biosignal Processing, and Computational Bioengineering.

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