Bioelectronics

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Micro- and nano-technologies with unique interfacing functionalities and advantages by miniaturization and low power consumption enable novel applications in medicine and biology studies. Interfaces between biological systems and electronics provide quantitative measurement and documentation of behaviors, physiological functions and cognitive operation; direct control or modification of cells, tissues, or organs; and closed loops between biological objects and computers. With advances in wireless electronics, implantable devices and systems make the interfacing possible for freely behaving animals or patients without constrains, discomfort or limits in mobility. This increases the study or diagnosis accuracy in realistic environments as well as permits remote synthesis of cellular functions or delivery of therapeutic treatment. Furthermore, wireless communication enables networks for ubiquitous access to biological information at various system levels such in a population of interest, in a certain setting of laboratory or hospitals, and within individual's body. The deterministic and statistical understanding of complex bio-systems through integration of electronics and sensors will help to establish frameworks for design, analysis, modeling, computation, synthesis and implementation of synthetic biology and possibly new medicines to improve human welfare and assist better living.

Our research focuses on development of micro devices and systems for clinical and biological applications. The systems are based on technology platforms such as wireless energy transfer for batteryless implants, miniature electrochemical sensors, nanoparticle modified surfaces, microelectromechanical system devices and digital wireless communication. With close collaboration with clinicians and biologists, the applications include a wireless closed-loop chronic pain management system, a wireless intraoperative neurophysiological monitoring system for children's spinal surgery, wireless gastric electric activity of stomach mapping for gastroparesis studies, electrocorticography (ECoG) and neuronal signal recording systems for studies of neuro-disorders, batteryless and wireless gastroesophageal reflux disease symptom sensors, endoscopically-implantable wireless gastro-stimulators, wireless bladder volume monitoring implants for urinary incontinence management, microfluidic assays for prostate cancer metastasis risk assessment, and wireless wound/tissue condition monitoring sensors. Although these research projects directly target relevant clinical applications in translational medicine, the systems are appropriate for experimental implementation in scientific studies such as for behavior psychology, social neurobiology or cell biology. In general, our research aims to the miniaturization of integrated wireless devices embedded with multifunctional physiological and electrochemical sensors, and the implementation of such devices in complex, adaptive bionetworks.