Title: Smart Implantable Brain-Machine Interfaces Intended for Sensing and Subsequent Treatment

Speaker: Mohamad Sawan

Abstract

Emerging Brain-Machine Interfaces (BMIs) for diagnostic and recovery of neural vital functions are promising alternative to study neural activities underlying cognitive functions and pathologies. This tutorial covers the architecture of typical BMI intended for wireless neurorecording and neurostimulation. Massively parallel multichannel spike recording through large arrays of microelectrodes will be introduced. Then the main building blocks used to implement such typical devices will be described. In particular, bioamplifiers dedicated for very-low amplitude signal acquisition and for stimulation drivers of high-impedance loads. Attention will be paid to integrated biopotential neural bioamplifiers. Then, interference reduction, as well as low-power design optimization will be discussed. Biosensors intended to convert chemical signals to electrical ones could allow real-time measurement of pH, oxygen, nitric oxide concentrations, and Lab-on-chip technologies. Some other biosensors are being developed to allow helping to learn about the progression of diseases such as tumours. Also, the tutorial includes wireless power and data links to the implants. It encloses electromagnetic inductive links. Power sources and energy transfer based-on transcutaneous RF inductive powering. Power management and efficiency, data recovery, up- and downlink data transmissions, various modulation and demodulation circuitries. Tests and validation of devices : electrical, mechanical, package, heat, reliability will be summarized. Case studies will be covered and include research activities dedicated to vision recovery. First, we present the recording strategy used to understand the mechanism of vision, then the implant used to apply direct electrical microstimulation, to present the environment as phosphenes in the visual field of the blind, will be shown. As another case study, we will summarize latest activities on locating the seizure foci using multimodal fNIRS/EEG processing. Then, for refractory cases to surgery and medications, we will show the onset detecting seizure and techniques to stop it, using bioelectronic implant.

Biography

Prof. Mohamad Sawan received the Ph.D. degree in electrical engineering from Université de Sherbrooke, Sherbrooke, QC, Canada, in 1990. He joined Polytechnique Montréal in 1991, where he is currently a Professor of Microelectronics and Biomedical Engineering. Dr. Sawan was Deputy Editor-in Chief of the IEEE Transactions on Circuits and Systems-II: Express Briefs (2010-2013), Co-Founder and Associate Editor of the IEEE Transactions on Biomedical Circuits and Systems, Associate Editor of the IEEE Transactions on Biomedical Engineering, and the International Journal of Circuit Theory and Applications. He is founder of the International IEEE-NEWCAS Conference and of the Polystim Neurotechnologies Laboratory, and Co-Founder of the International IEEE-BioCAS Conference, and the International IEEE-ICECS. His scientific interests are the design and testing of analog and mixed-signal circuits and systems, signal processing, modeling, integration, and assembly. He holds the Canada Research Chair in Smart Medical Devices, and he is leading the Microsystems Strategic Alliance of Quebec (ReSMiQ). Dr. Sawan published more than 700 peer reviewed papers, two books, 10 book chapters, and 12 patents. He received several awards, among them the Barbara Turnbull 2003 Award for spinal cord research, the American University of Science and Technology Medal of Merit, and the ACFAS - Bombardier and Jacques-Rousseau Awards. Dr. Sawan is Fellow of the IEEE, Fellow of the Canadian Academy of Engineering, and Fellow of the Engineering Institutes of Canada. He is also “Officer” of the National Order of Quebec.