7B10 IMPLANTED DEVICES AND SYSTEMS [5 credits]

Lecturers: Professor Richard Reilly, School of Medicine, School of Engineering

Semester: 2

Module Organisation
The module runs for 12 weeks of the academic year and comprises three lectures per week. Total contact time is 33 hours.

Module Description
The objective of this module is to provide a quantitative background to implanted neural systems. It will consider subcomponents with a special emphasis placed on the neural electrode interface for recording and stimulation. Focus will also be placed on the neuromodulation effects of electrical stimulation and on the goals of real time, closed loop control of implanted systems.

Prerequisites: 7B9 Neural Engineering, 3Bio1 Anatomy and Physiology

Learning Outcomes
At the end of this module it is anticipated that students will have obtained:
1. Understanding of the concepts involved in implanted devices and systems.
2. Ability to perform quantitative analysis of data from implanted systems.
3. Ability to apply design methodologies for implanted systems.
4. Ability to design and implement signal processing algorithms for chronically implanted systems.
5. Explain the use of biomedical signal processing to aid clinical interpretation of data.
6. Ability to design and conduct experiments, as well as to measure, analyse and interpret data from implanted devices and systems in living systems.
7. Ability to identify, formulate and adapt engineering solutions to unmet biological needs.
8. Ability to model and analyze biological systems as engineering systems.
9. Knowledge of the commercial market and understanding of the regulatory hurdles in medical devices.
10. Ethical issues and considerations for implanted devices and systems.
11. Ability to function on multidisciplinary teams.

Module Content
Section 1 Fundamental of Recording:
- Principles of Recording neural activity
- Recording neural activity in freely moving animals
- Neural Spike trains and Analysis

Section 2 Computational and Mathematical Modelling of Neural Systems
- Biological and theoretical neural networks
- Information processing in complex systems
- Learning models; Reinforcement learning
- Self-organization in nervous system
- Synchronization of oscillators in memory formation

Section 3 Fundamental of Neuromodulation
- Principles of Electric Field Generation for Stimulation of CNS
- Mechanism of Action of Deep Brain Stimulation
- Computational Modelling of Deep Brain Stimulation

Section 4 Biomedical Engineering and Neuroscience Considerations
- Electrodes for the Neural Interface
- Implantable microelectrodes
- Implantable Neural Stimulators
- Nonlinear dynamical modelling
- Closed loop control

Section 5 Clinical Applications of Neuromodulation
- Neuromodulation for Movement Disorders
- Neuromodulation for Psychiatry
- Neuromodulation for Functional Restoration: Hearing
- Deep Brain Stimulation for Cognitive Modulation
- Regulatory Approval of Implantable Medical Devices

Module Notes
Provided via Blackboard

Teaching Strategies
The module is taught using a combination of lectures and group assignments.

Assessment Modes
Written Exam (50%), and group learning assignment (50%).

Recommended Texts
- Theroretical Neuroscience: Computational and Mathematical Modelling of Neural Systems. by Dayan P.
- Neuromodulation Vol1 and Vol2, by Elliot S. Krames (Editor), P. Hunter Peckham (Editor), Ali R. Rezai (Editor),
- Implantable Neural Prostheses 1: Devices and Applications. By Zhou D., Greenbaum E.