Engineering Tripos Part IIA, 3G3: Introduction to Neuroscience, 2019-20

Module Leader

Dr G Hennequin [1]

Lecturers

Dr G Hennequin, Dr M Lengyel, Dr T O'Leary

Lab Leader

Dr G Hennequin [1]

Timing and Structure

Lent term. 16 lectures.

Aims

The aims of the course are to:

- Introduce students to how the brain processes sensory information, controls our actions, learns through experience and lays down memories.
- Elucidate the computational and engineering principles of brain function.

Objectives

As specific objectives, by the end of the course students should be able to:

- Have a basic grasp of neuroscience that can act as foundation for further study.
- Understand the basic principles of sensory processing, decision making, learning and memory and how engineering concepts can be applied to them.

Content

Perception and action (6L) (Dr G Hennequin)

- Neurons and synapses
- Perception as Bayesian inference
- Decision making

Dynamics of single neurons (2L) (Dr T O'Leary)

- Introduction to basic cell physiology and ion channels
- How do neurons communicate? The action potential and the Hodgkin-Huxley model

Learning and memory (8L) (Dr M Lengyel)

- The cellular basis of learning and memory

- Animal learning
- Memory

Coursework

Simulation of different types of neural coding of natural images. Laboratory report and/or Full Technical Report.

Efficient coding in visual cortex

Learning objectives:

- To apply basic techniques from linear algebra, optimization and statistics to understand how the primary visual cortex might efficiently encode natural scenes
- To learn (or consolidate) how to implement simple algorithms in Matlab
- To consolidate critical analysis and report-writing skills

Practical information:

- Sessions will take place in the DPO.
- This activity involves preliminary homework (estimated 30 min duration), consisting of mathematical derivations (including some basic vector calculus) to be performed before coming to the lab.

Full Technical Report:

Students will have the option to submit a Full Technical Report. This will take the form of a unifying review of 3 papers addressing efficient coding of sensory information in the brain.

Booklists

Please see the Booklist for Part IIA Courses [2] for references to this module.

Examination Guidelines

Please refer to Form & conduct of the examinations [3].

UK-SPEC

This syllabus contributes to the following areas of the UK-SPEC [4] standard:

Toggle display of UK-SPEC areas.

GT1

Develop transferable skills that will be of value in a wide range of situations. These are exemplified by the Qualifications and Curriculum Authority Higher Level Key Skills and include problem solving, communication, and working with others, as well as the effective use of general IT facilities and information retrieval skills. They also include planning self-learning and improving performance, as the foundation for lifelong learning/CPD.

IA1

Apply appropriate quantitative science and engineering tools to the analysis of problems.

KU1

Demonstrate knowledge and understanding of essential facts, concepts, theories and principles of their engineering discipline, and its underpinning science and mathematics.

KU2

Have an appreciation of the wider multidisciplinary engineering context and its underlying principles.

E3

Ability to apply mathematical and computer based models for solving problems in engineering, and the ability to assess the limitations of particular cases.

P3

Understanding of contexts in which engineering knowledge can be applied (e.g. operations and management, technology, development, etc).

US1

A comprehensive understanding of the scientific principles of own specialisation and related disciplines.

US2

A comprehensive knowledge and understanding of mathematical and computer models relevant to the engineering discipline, and an appreciation of their limitations.

US3

An understanding of concepts from a range of areas including some outside engineering, and the ability to apply them effectively in engineering projects.

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Links
[1] mailto:gjeh2@cam.ac.uk
[2] https://www.vle.cam.ac.uk/mod/book/view.php?id=364091&chapterid=49011
[3] https://teaching.eng.cam.ac.uk/content/form-conduct-examinations
[4] https://teaching.eng.cam.ac.uk/content/uk-spec