ES97J-15 Computational Synthetic & Systems Biology

21/22

Department
School of Engineering
Level
Taught Postgraduate Level
Module leader
Declan Bates
Credit value
15
Module duration
10 weeks
Assessment
100% coursework
Study location
University of Warwick main campus, Coventry

Description

Introductory description

Computational Synthetic & Systems Biology

Module aims

This module aims to introduce students to the new fields of Systems Biology and Synthetic Biology. In particular, it will focus on how computational and mathematical methods can be used for the modeling, analysis, and design of biological systems. The module aims to give students a hands-on computational experience through Matlab assignments. The module will aim to foster a highly multidisciplinary view of biology, and to describe the recent evolution of the field towards being an engineering science.

Outline syllabus

This is an indicative module outline only to give an indication of the sort of topics that may be covered. Actual sessions held may differ.

- Modeling biological circuits and systems

- Analysis of biological system models using linear systems theory
- Analysis of biological system models using nonlinear systems theory
- The role of feedback control in biological systems
- Robustness in biological systems
- Oscillations in biological systems
- Modeling physiological systems
- Engineering genetic circuits
- Modularity, retroactivity and insulation devices
- Design of synthetic circuits using chemical reaction networks

Learning outcomes

By the end of the module, students should be able to:

- Understand fundamental design principles of synthetic biological systems such as modularity, retroactivity, robustness and how modeling can be used in the design of synthetic biological circuits and systems
- Construct, simulate and analyse complex models of biological systems and understand the role of feedback in regulating biological phenomena
- Apply an array of computational packages and analysis methods on models and available datasets of diverse biological phenomena;
- Analyze and design synthetic biological systems by applying Matlab toolboxes and modeling techniques
- Work individually and in small, multi/interdisciplinary groups to tackle complex problems and communicate with scientists from experimental and/or theoretical backgrounds;
- Think creatively and beyond traditional discipline boundaries to combine experimental and theoretical concepts, literature and ideas from the field of Synthetic Biology.

Indicative reading list

1. Carlo Cosentino and Declan Bates. “Feedback Control in Systems Biology”, Taylor & Francis, 2011. ISBN 9781439816905
2. Domitilla Del Vecchio and Richard Murray. “Biomolecular Feedback Systems”, Princeton University Press, 2015. ISBN: 9780691161532
3. Aydin Tozeren and Stephen Byers. “New Biology for Engineers and Computer Scientists”, Pearson, 2004. ISBN: 9780130664631
4. Brian Hahn and Dan Valentine. “Essential MATLAB for Engineers and Scientists”, Elsevier, 2013 ISBN-9780123943989,
5. Nicholas F Britton. “Essential Mathematical Biology”, Springer, 2003. ISBN 978-1-4471-0049-2
6. James D Murray. “Mathematical Biology: An Introduction: Part 1”, Springer, 2002. ISBN 978-0387952239
7. Steven H Strogatz. “Nonlinear Dynamics and Chaos”, Perseus Books, 2000. 978-0738204536
8. Uri Alon. “An Introduction to Systems Biology: Design Principles of Biological Circuits”, Chapman & Hall, 2006. ISBN 9781584886426

9. James Keener and James Sneyd. “Mathematical Physiology”, Springer-Verlag, 1998. ISBN 978-0-387-75847-3
10. Edda Klipp et al. “Systems Biology: A Textbook”, Wiley VCH Blackwell, 2009. ISBN 978-3527318742

Interdisciplinary

Engineering - Biology

Subject specific skills

Advanced modelling and computational skills

Transferable skills

Team working, interdisciplinary working

Study

Study time

Type	Required
Lectures	12 sessions of 1 hour (8%)
Practical classes	3 sessions of 4 hours (8%)
Private study	126 hours (84%)
Total	150 hours

Private study description

The following is a suggestion of how 126 hours of private study could be used:
Directed reading on biological concepts prior to classes: 36
Research for individual assignment: 50
Preparation of individual assignment report: 25
Preparation of individual assignment presentation: 15

Costs

No further costs have been identified for this module.

Assessment

You must pass all assessment components to pass the module.

Assessment group A2

	Weighting	Study time
Individual assignment presentation	30%	
Individual Assignment Report	70%	
Individual Assignment Report (max 5200) words excluding figures		

Feedback on assessment

Hands-on Matlab laboratories will align student expectations with requirements for assessment, and provide preparation for undertaking their individual assignment. Assignments will be marked with detailed individual comments aligned with assessment criteria.

The assignment will consist of a report and an oral presentation. Both will be marked:

1. The report (70% of the module mark) will be marked considering its technical content (i.e., clarity, completeness, references etc.), originality and format (i.e., clear table of contents, consistent format of titles, references, tables and figures etc.). The report will be marked and returned to students with detailed comments.
2. The presentation (30% of the module mark) will be marked considering technical content, format, presentation skills and ability to answer questions.

Availability

Pre-requisites

System modelling and control (equivalent to ES3C8) knowledge is required. Suggested reading will be provided for the biology concepts, but no background module is specifically required for this.

Courses

This module is Optional for:

- Year 1 of TESA-H800 Postgraduate Taught Biomedical Engineering

This module is Option list A for:

- Year 4 of UESA-H163 MEng Biomedical Systems Engineering
- Year 4 of UESA-H114 MEng Engineering

This module is Option list B for:

- Year 4 of UESA-HH31 MEng Systems Engineering