CS424-15 Computational Biology

23/24

Department
Computer Science
Level
Undergraduate Level 4
Module leader
Till Bretschneider
Credit value
15
Module duration
10 weeks
Assessment
Multiple
Study location
University of Warwick main campus, Coventry

Description

Introductory description

The module will cover topics on the acquisition of and analysis of large-scale data generated in biomedical sciences, particularly DNA/RNA sequences, live cell microscopy and multi-gigapixel pathology images. Students will be introduced to how these data are acquired, modern machine learning methods to process the data, and computational modelling approaches to help us better understand the complex phenomena underpinning biological processes. The module will be taught following an "algorithmic approach," demonstrating that addressing problems in computational biology requires a diverse range of theoretical concepts and algorithms, making it an exciting and rapidly evolving field for computer scientists.

Module aims

The module is designed to develop student research skills in the broad area of computational biology.

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.

- Molecular biology fundamentals;

- Sequence alignments;
- Phylogenetic Trees;
- Dimensionality reduction and clustering;
- Live cell microscopy fundamentals;
- Image based modelling of single cell dynamics;
- Introduction to tissue imaging and computational pathology;
- Whole-slide image (WSI) handling and processing;
- Recognising various kinds of cells in cancerous WSIs;
- Advanced research topics in computational biology;

Learning outcomes

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

- Have an understanding of how tissue slides are imaged with high throughput
- Have a basic grasp of fundamental molecular biology concepts as relevant to this module
- Understand some basic and commonly used algorithms in bioinformatics
- Know algorithms to compute sequence alignments and how these are applied in current research
- Understand basic problems in the processing and analysis of tissue images and some standard solutions to those
- Be able to apply image analysis and machine learning to real-world computational pathology problems
- Understand principles of fluorescence microscopy and image-based modelling of single cell dynamics

Indicative reading list

Zvelebil, M., and Baum, J.O., Understanding Bioinformatics. Garland Science, 2008;
Kremling, A., Systems Biology. CRC Press, 2014;
Pantanowitz, L., and Parwani, A., Digital Pathology. ASCP, 2017;
Alberts, B., et al., Essential cell biology: an introduction to the molecular biology of the cell (5/e). Garland, 2008.

Research element

Students need to develop and implement algorithms to address questions typically asked in current research projects. For example: Perform sequence analysis of homologous genes and construct phylogenetic trees, generate simulation data of gene regulatory networks and perform dimensionality reduction and clustering, develop models for cellular dynamics, analyze digital pathology images taken from real-world data.

Interdisciplinary

The module will cover a broad range of techniques used in biology, mathematics, and computer science.

Subject specific skills

By the end of the module, students will have acquired skills in:

- Implementing fundamental bioinformatics algorithms for computing alignments and phylogenetic trees
- Formulating and solving mathematical models of gene regulatory networks
- Applying methods of dimensionality reduction and clustering
- Formulating mathematical models of cellular dynamics
- Handling and processing of whole-slide images (WSI) data
- Recognising various kinds of cells in cancerous WSIs

Transferable skills

Technical - Technological competence and staying current with knowledge
Communication - Verbal, listening, writing, technical communication skills, using different medium for communicating
Critical Thinking - Problem-solving, analysis of possible solutions etc
Creativity - Ability to harnass creative ideas and turn them into tangible and strategic products/solutions

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Study

Study time

Type	Required
Lectures	20 sessions of 1 hour (13%)
Supervised practical classes	10 sessions of 1 hour (7%)
Private study	120 hours (80%)
Total	150 hours

Private study description

Background reading of research papers, working through additional examples and improving coding skills, revision.

Costs

No further costs have been identified for this module.

Assessment

You do not need to pass all assessment components to pass the module.

Students can register for this module without taking any assessment.

Assessment group C1

	Weighting	Study time
Assignment 1	16%	
Assignment 2	17%	
Assignment 3	17%	
In-person Examination	50%	
CS424 examination		

- Answerbook Pink (12 page)

Assessment group R1

	Weighting	Study time
In-person Examination - Resit	100%	
CS424 resit examination.		

- Answerbook Pink (12 page)

Feedback on assessment

Written comments on coursework

Past exam papers for CS424

Availability

Courses

This module is Optional for:

- Year 5 of UCSA-G504 MEng Computer Science (with intercalated year)
- UCSA-G503 Undergraduate Computer Science MEng
    - Year 4 of G503 Computer Science MEng
    - Year 4 of G503 Computer Science MEng
- Year 4 of USTA-G1G3 Undergraduate Mathematics and Statistics (BSc MMathStat)

- Year 5 of USTA-G1G4 Undergraduate Mathematics and Statistics (BSc MMathStat) (with Intercalated Year)

This module is Option list A for:

- Year 4 of USTA-G304 Undergraduate Data Science (MSci)

This module is Option list B for:

- Year 4 of UCSA-G4G3 Undergraduate Discrete Mathematics
- Year 5 of UCSA-G4G4 Undergraduate Discrete Mathematics (with Intercalated Year)