Computational Bioengineering

Spring 2019

Course Description

Fundamental Computational Bioengineering (BIOE4803) / Computational Bioengineering and Biomedicine (BME6313) aims to provide students with the ability to use computational methods to understand and analyze biological data. Topics covered include high-throughput biomedical data analysis, modeling of signaling pathways, network analysis, image analysis, and multiscale modeling.

Overall Goal: This course will introduce students to advances in computational biology from an engineering perspective, and equip them with a suite of tools emerging from systems biology.

Specific Objective I: To be able to choose the most appropriate quantitative tools (e.g., modeling method, quantitative image-analysis) to assess a biological system of interest.

Specific Objective II: To gain the skills needed to interpret large, complex, multimodal data (images, protein expression levels, gene-gene, protein-DNA interaction data, etc.) and be knowledgeable of the ways to characterize their interrelationships and dynamics.

Specific Objective III: To gain familiarity with the methods, platforms, languages, and databases available in the quantitative systems biology field that have broad applications in bioengineering.

Meeting Time & Location

MW 2:30-3:45 pm, MH 3.03.18

Course Instructors

Dr. Amina Ann Qutub AET 1.330
aminaq@rice.edu Office Hours: Wednesday 12:45-1:45 pm, by appointment

Method of Instruction

This class will contain lectures, modeling challenges, a modeling project, and a final exam. Readings from peer-reviewed articles will complement material covered in class.

Modeling Challenges: Modeling challenges are due at the beginning of class and count towards class participation. Students are encouraged to work in groups on assignments,

however each student must complete the material and handle in / present independent copies of their assignment.

Modeling Project: Reports and code are due at the beginning of class, as indicated on the schedule. A final report and presentation is due on the project **May 1**.

Final Exam: The final is a comprehensive exam. It is scheduled for **May 9**, 3:15-5:45 pm.

Course Readings

Required course readings will be found on the course Dropbox or Website (qutublab.org/CompBio).

Recommended textbooks for more in-depth discussions of course material include:

Alon U. (2006) "An Introduction to Systems Biology: Design Principles of Biological Circuits," Chapman & Hall/CRC Press.

Relevancy: Describes the concept of biological biomotifs (common circuit architectures), and how they can offer insight into molecular signaling dynamics.

Gershenfeld N. (1999) "The Nature of Mathematical Modeling," Cambridge Univ. Press.

Relevancy: Describes multiple modeling methods, including cellular automaton and stochastic modeling.

Grading Criteria

Modeling Project	40%
Course Participation	20%
Final Exam	40%
Total	100%

NOTES: If you believe that a mistake has been made in grading, you have ONE WEEK to request a regrade in writing. Peer evaluation on the modeling project (e.g., your contribution) will count towards your grade. Course participation includes completing inclass modeling challenges (ungraded and uploaded onto Dropbox), asking questions in class, contributing to in-class discussions and challenges and/or discussions with the instructor and TA outside of class.

Disabilities: If you have a documented disability that requires accommodation, please let the instructors know so that we can confidentially discuss your needs. You will also need to register with the Disability Support Services Office.

Introduction to Computational Bioengineering		
Date	**Topic**	**HW & Notes**
1/14	Course Overview	
1/16	Introduction to Computational Biology & Course Survey	
1/21, 1/28, 1/30	Introduction to Machine Learning for Biomedical Data	Modeling Challenge I due (1/28)
1/23	Matlab / Programming Tutorials I: Basic Coding	Optional but strongly encouraged
2/4, 2/6	Handling High-Dimensional Biomedical Data; Dimensional Reduction Methods	Modeling Challenge II due (2/4)
2/11, 2/13	Classification & Prediction Problems	
2/18, 2/20	Decision Trees	Modeling Challenge III (2/20) due
2/25	In-Class Project Work I (Required Attendance)	Divide team assignments & decide on milestones
2/27, 3/4	Introduction to Artificial Intelligence in Bioengineering	
3/6	Molecular Signaling Models: Protein-Protein Interactions, Motifs	
3/11-3/16	***No Class, Spring Break***	

3/18, 3/20	Molecular Signaling Models: Gene Signaling, Epigenetic Reprogramming	
3/14, 3/16	***No Class, Spring Break***	
3/25	In-Class Project Work II (Reports due at midnight)	**Preliminary Reports due for Project**
3/27	Project Mid-Term Presentations	
4/1, 4/3	Cell & Tissue Phenotyping Methods: Multiplexed Imaging & Image Analysis	Modeling Challenge IV (2/20) due
4/8, 4/10	Cell-Based Modeling	
4/15, 4/17	Matlab / Programming Tutorials II & III: Image Analysis	Optional but strongly encouraged
4/22	Multiscale Modeling	
4/24	Real-Time Modeling in Daily Life & in the Clinic	
4/29	Review, Q & A for Exam	
5/1	Final Project Presentations	**Modeling Project DUE**
5/4	Last Day of Classes	
5/9	Final Exam	