CSE 487 Advanced Systems and Synthetic Biology

Credits
3.0

Lead Instructor
Georg Seelig

Textbook
U. Alon, Control Systems Engineering, An Introduction to Systems Biology: Design Principles of Biological Circuits, Chapman and Hall, 2006.

Course Description
This course assumes a basic understanding of synthetic and systems biology. It introduces a variety of advanced and more in-depth topics on cellular networks, including their operation and engineering. The course is intended for engineering and computer science students. Topics include advanced mathematical modeling of cellular networks; computational standards in systems and synthetic biology; computer algorithms for computational analysis; metabolic flux analysis, control and engineering; protein signaling pathways, analysis, control and engineering.

Prerequisites
either BIOEN 401, BIOEN 423,E E 423, or CSE 486

CE Major Status
Selected Elective

Course Objectives
At the end of this course students will be able to:

- Understand the different modeling approaches used to represent cellular networks (Structural, Continuous and Stochastic Approaches)
- Understand the differences between the fundamental cellular subsystems, metabolic, protein and genetic and how this influences potential engineering approaches.
- Develop an appreciation for the need for standards and ontologies in model exchange and part representation.
- Understand, implement and use a variety of computational approaching including FBA, MFA, Bifurcation and evolutionary methods.

- Understand the basic principles of metabolic control including small signal analysis and elementary mode analysis.
- Learn how to carry out a robustness analysis of a metabolic pathway and propose strategies for engineering pathways.
- Understand the control of protein networks, highlighting differences and similarities with genetic and metabolic systems.
- Use computational analysis to study the dynamic properties of protein networks and the design of robust systems.

ABET Outcomes

(a) An ability to apply knowledge of mathematics, science, and engineering. Lectures and homework deal with the application of differential equations, linear algebra and Laplace transforms to control systems.

(c) An ability to communicate effectively.

Course Topics

1. The importance of network structure in cellular networks
2. Review of continuous and stochastic models of cellular networks
3. The interplay between structure and dynamics
4. Bifurcation analysis and evolutionary design approaches in synthetic biology.
5. Standards and ontologies (SBML, CellML, PoBoL, CAD in synthetic biology)
6. Control systems in metabolism
7. Control systems in protein networks
8. Robustness and small signal analysis of cellular pathways
9. Advanced structural analysis including elementary modes, FBA and MFA
10. Metabolic engineering strategies
11. Protein networks, control and dynamical analysis
12. Protein network engineering