CSE 486 Introduction to Synthetic Biology

Credits
3.0 (3 hrs lecture)

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

Course Description
Mathematical modeling of transcription, translation, regulation and metabolism in cell; computer aided design methods for synthetic biology; implementation of information processing, Boolean logic and feedback control laws with genetic regulatory networks; modularity, impedance matching and isolation in biochemical circuits; parameter estimation methods.

Prerequisites
either MATH 136 or MATH 307, AMATH 351, or CSE 321 and MATH 308 or AMATH 352.

CE Major Status
Selected Elective

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

1. Understand the challenges and applications of synthetic biology.
2. Understand the basic cellular processes including transcription, translation, regulation, metabolism, and information processing.
3. Build mathematical models of biochemical systems inside cells using Boolean logic, finite state machines, ordinary differential equations and/or stochastic processes.
4. Understand biochemical processes in terms of stability, robustness, parameter sensitivity, modularity, and evolvability.
5. Estimate model parameters from data.
6. Use Matlab or similar software to model, design and simulate systems.

7. Use molecular sensors, regulatory elements, reporters, enzymes, etc. in new designs and predict their behavior mathematically.
8. Understand the risks and ethical considerations of synthetic biology.

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 design a system, component or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability. Students are required to apply the skills acquired in this course to design control systems to meet specific performance requirements.

(e) An ability to identify, formulate and solve engineering problems. Some of the homework assignments require students to evaluate different design approaches to reach an acceptable design.

Course Topics

1. The applications of synthetic biology
2. The risks, ethics and challenges of synthetic biology
3. Transcription, translation and regulation
4. Metabolism
5. Review of mathematical modeling
6. Mass action and enzyme kinetics
7. Stochastic chemical kinetics
8. Modeling software
9. In vitro synthetic biology
10. Composition, modularity and sensitivity
11. Robustness and sensitivity in biochemical systems
12. Parameter estimation and system identification
13. Review of recent literature in synthetic biology