



The Hebrew University of Jerusalem

Syllabus

Computational models in genetics and living systems - 67107

Last update 27-01-2021

HU Credits: 2

Degree/Cycle: 1st degree (Bachelor)

Responsible Department: Computer Sciences

Academic year: 0

Semester: 2nd Semester

Teaching Languages: Hebrew

Campus: E. Safra

Course/Module Coordinator: Dr. Tamar Friedlander

Coordinator Email: tamar.friedlander@mail.huji.ac.il

Coordinator Office Hours: Thursdays 15:00-16:00

Teaching Staff:

Dr. Tamar Friedlander,
Dr. Oren Forkosh

Course/Module description:

The course will survey various cases of optimization and computation in natural high-dimensional biological systems.

Course/Module aims:

Learn about optimization in natural biological systems.

Learning outcomes - On successful completion of this module, students should be able to:

The students will familiarize themselves with various examples for optimization and computation in natural biological systems, such as evolution in biological populations.

The students will apply the theory and be able to simulate evolution in a natural population.

Attendance requirements(%):

Attendance in the project presentation session is required.

Teaching arrangement and method of instruction: Lectures, home assignments

Course/Module Content:

1. What is the difference between natural and artificial systems and how they approach optimization problems?
1. 2. Stochastic vs. deterministic optimization: the role of population size.
2. 3. How does evolution solve optimization problems? Fitness and natural selection.
3. 4. Fitness landscapes: how evolution navigates in very-high dimensional space.
4. 5. Genetic algorithms.
5. 6. The role of population diversity in stochastic optimization.
7. Complex systems. How simple and local rules of interaction allow animals to solve complicated problems such as foraging for food, finding mates, or evading predators? Tools: Reynold's Boids (artificial life, computer graphics), Game of life, Nonlinear dynamics and Chaos,

Graph theory

8. *Constrained optimizations. Ways in which evolution effects animal behavior or what can we*

learn from economics about natural selection: from rock-paper-scissors games to pareto

optimality. Tools: Stochastic processes, Game theory

9.. *Being different. Personality. The advantages (and disadvantages) of being different, about group*

synergy, cooperation, and competition. Tools: Dimensionality reduction

10. *Animal communication. How to transfer information and make sure it reaches the 'right' ears?*

Tools: Bayesian networks

11. *Social interactions. Top-down approaches to looking at behavior: from the group to the*

individual. Tools: Information theory, Maximum Entropy models

12. *Methods. Using machine-learning tools to understand animals: from virtual reality*

environments for animals to tracking the movement of the mouse's tail. Tools: Deep learning

13. *Emotions. What are emotions? Why do we have them? and when is it bad to feel? Tools: Dynamical systems*

Required Reading:

none

Additional Reading Material:

"Collective Animal Behavior" by David J. T. Sumpter

Course/Module evaluation:

End of year written/oral examination 0 %

Presentation 10 %

Participation in Tutorials 0 %

Project work 50 %

Assignments 40 %

Reports 0 %

Research project 0 %

Quizzes 0 %

Other 0 %

Additional information: