BIO-INSPIRED COMPUTING
ASU CSE 598
Spring Term, 2019
Mon, Wed 3:05 - 4:20 pm CAVC3 59

Professor: Stephanie Forrest

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Office Hours: Mon. 2-3 (BYENG 394), Thu. 10:30-11:30 (Biodesign B120A) , or by appointment

Textbook: Selected Readings and optional textbooks:
M. Mitchell *An Introduction to Genetic Algorithms* MIT Press 1998.
L. Sompayrac *How the Immune System Works* (Blackwell Publishing, multiple editions, I like the 2nd edition the best)
D. Gordon *Ant Encounters* (Princeton, 2010)

Course Description

A graduate introduction to bio-inspired computing, discussing computational methods that are derived from biological processes and models. No prior knowledge of biology is expected. Basic knowledge of computer science and intellectual maturity are expected.

The course will cover computational algorithms, models, and applications that are inspired from five areas of biology: evolution, immunology, social insects, metabolic scaling, and epidemiology. Each topic will take about 3 weeks and will introduce the relevant biological concepts, cover important applications of the concepts in computing, discuss relevant mathematical models and analyses, and read one or two current research papers that are relevant to the topic.

There will be some assigned programming projects, and significant amounts of reading and discussion, which will require knowledge of computer science and intellectual maturity. Biological concepts will be presented in lecture accompanied by introductory readings. In addition to lectures, we will read one to two papers per week, and there may be some small writing assignments. Depending on class size, there may be a midterm and final.

I. Course Introduction (1 week) Why is biology is relevant to computer science? The role of abstraction and modeling. Evaluation metrics. Overview of topics and expectations.

II. Evolution

1. Biological Underpinnings (1-2 lectures)
2. Applications in computing and engineering (1-2 lectures /discussion)
   (a) Evolutionary computation and genetic programming
3. Mathematical Models (2 lectures / discussion)

   (a) Search spaces and biased sampling
   (b) Multiplicative weights update algorithm for recombination (Papadimitriou)
   (c) What is learnable by selection and mutation? (L. Valiant)
4. Current research (1-2 discussions)
   (a) Novelty Search
   (b) Automatically evolving neural network architectures
   (c) Repairing and improving software

III. Immunology

1. Biological Underpinnings (1-2 lectures)
2. Applications in computing and engineering (1-3 lectures /discussion)
   (a) Computer Security
3. Mathematical Models (1 lectures / discussion)
   (a) Probabilistic models
   (b) Differential equation models
4. Current research (1-2 discussions)

IV. Social Insects

1. Biological underpinnings (1-2 lectures)
2. Applications to computing and engineering (1-2 lectures)
   (a) Ant Colony Optimization (ACO) algorithms
   (b) Mult-agent systems
3. Computational models and theory (1-2 reading/discussion)
4. Current research (1-2 reading/discussion)

IV. Metabolic Scaling

1. Biological underpinnings (1-2 lectures)
2. Applications to computing and engineering (1-2 lectures)
   (a) Predicting power consumption on chips
   (b) Internet topology
3. Computational models and theory (1-2 reading/discussion)
4. Current research (1-2 reading/discussion)

V. Epidemiology and Ecology

1. Biological underpinnings (1-2 lectures)
2. Applications to computing and engineering (1-2 lectures)
    (a) Network topology and susceptibility to attack
    (b) Red Queen dynamics and arms races in cybersecurity
    (c) Epidemic spreading
3. Computational models and theory (1-2 reading/discussion)
    (a) Predator/prey models
    (b) SIR and SIS
4. Current research (1-2 reading/discussion)
    (a) TBD