CMSC 828Q: Nature-Inspired Computing – Fall 2019

**Time and Place:** Tuesdays and Thursdays, 12:30 – 1:45 pm, CSI 1122

**Instructor:** James Reggia, Iribe 4124, 301-405-2686, reggia@cs.umd.edu
Office Hours: Th. 1:45 – 2:45 pm, or by appointment

**Half-Time TA:** Puneet Mathur, pmathur3k6@gmail.com, office hours pending.

**Class web page:** http://www.cs.umd.edu/class/fall2019/cmsc828Q
Gives exam dates, homework assignments and their due dates, lecture slides, reading assignments, and links to other useful information.

**Prerequisites:** graduate status in computer science, math, engineering, or permission of the instructor.

**Objective:** The primary objective of this course is to examine nature-inspired computational methods in evolutionary computing, artificial life, neural computation, physical materials, and related areas, with an emphasis on understanding the basic computational principles involved.

**First exam:** Thursday, October 10, regular classroom

**Second exam:** Thursday, December 5, regular classroom

**Content:**

*Conceptual Framework*
- Definitions, terminology, introduction to different paradigms, core concepts such as self-organization and emergence, history, overview

*Evolutionary Computation*
- Genetic Algorithms: biology, method, variants, schema theorem, applications
- Genetic Programming: evolving computer programs, tree/linear/graph based genomes
- Evolution Strategies: method, variations, optimization
- Applications: evolving rule-based systems, neural networks, multi-agents systems, etc.
- Issues: preferred operators, co-evolution, speciation, creative evolutionary systems, network representations and genetic operations, cellular coding, spatially-distributed populations

*Artificial Life*
- Dynamical Systems: fixed points, limit cycles, chaotic attractors, etc.
- Cellular Automata: basics, life-like properties, environments, self-replicating machines, adaptation, applications
- Multi-Agent Artificial Life Worlds: flocking, swarm intelligence, particle swarm optimization, ant colony optimization
- Developmental Systems: L-systems, morphogenesis, self-assembly, pattern formation

*Neural Computation*
- Feedforward Networks: gradient descent learning, error backpropagation, deep learning
- Recurrent Networks: neurocontrollers, coupled oscillators, rhythmic behavior, attractor networks, self-organizing maps, radial basis function networks, echo state networks, BPTT and LSTM
- Topics: neurocognitive systems, reverse engineering the brain, GANs

*Immunological Computation:* principles, artificial immune systems, applications

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Natural Computational Materials
   Nanotechnology: bio-robotics, DNA/molecular computing, optical computing, etc.
   Quantum Computing: qubits, quantum gates, quantum algorithms, etc.

Additional Topics (as time permits)
   reinforcement learning in multi-agent systems, imitation learning, biologically-inspired
   robotics, multi-SOM systems, artificial consciousness, models of language and language
   acquisition, binding problem, simulated annealing, biologically-plausible supervised learning,
   machine creativity, etc.

Workload and Grading: There will be regular reading and homework assignments. Some
   assignments will include conducting online experiments. Homework assignments are always to
   be treated as independent work. Grading will be based on homework assignments, worksheets,
   and class participation (collectively 10%), a semester project (20%), and two exams (35% each)
   given during the semester.

Textbooks:
   2. Additional readings from several sources (pdf’s will be provided).

Disabilities: Any student eligible for and requesting reasonable academic accommodations due
to a disability needs to provide the instructor with a letter of accommodation from the Office of
Disability Support Services (DSS) within the first two weeks of the semester.

Class Absence Policy: The campus has an established policy governing class absences. This
   policy requires instructors to provide the following information. For this class, the “major
   scheduled grading events” are the exams and the semester project. A maximum of one self-
   signed medical excuse for other grading events will be accepted.

Academic Integrity: All homework assignments are to be done individually and independently;
   all submitted work must be your own. All students are expected to be familiar with and to uphold
the Code of Academic Integrity administered by the Student Honor Council at UMCP (please see
http://www.shc.umd.edu). Further details of CMSC Dept. Academic Integrity policies are at
http://www.cs.umd.edu//class/resources/academicIntegrity.html