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, puneetm@umd.edu
Office Hours: Mon. 2:00 – 3:00 pm, AVW 4172, or by appointment

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. There will also be a semester project. 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:

1. *Fundamentals of Natural Computing*, Leandro Nunes de Castro, 2006.
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