ECE 657
(Spring Term 2020)

COMPUTATIONAL INTELLIGENCE/ INTELLIGENT SYSTEMS DESIGN

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INSTRUCTOR

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COURSE OUTLINE:

Conventional approaches for dealing with complex systems are usually applied under the assumption of a good understanding of the system's behavior/functionalities and its operating environment. These techniques fail, however, to provide satisfactory results when applied to many real-world systems, for which analytical and/or experimental models may not be available. These systems may also operate under unpredictable and possibly noisy/uncertain environments. Recent developments in the area of intelligent systems, operational artificial intelligence and machine learning have provided powerful tools for accurately predicting behavior of complex systems/processes. The course outlines fundamentals of soft computing-based design approaches using tools such as machine learning, connectionist modeling, classification, clustering, deep learning, approximate reasoning, and evolutionary algorithms. Fundamentals and advances in the field are presented. Their implementations and applications in various real-world systems are discussed. These tools could be used in virtually all fields of engineering including big data analytics, information retrieval, smart grid control, driverless cars, intelligent transportation, intelligent mechatronics, optimization, communication, robotics and manufacturing, to name a few. The course involves tutorials on Python implementation of the major algorithms taught in class as applied to examples of real-world systems

COURSE PRE-REQUISITE

ECE 650 or equivalent is strongly recommended. If the student has taken an equivalent or a very related course (to ECE650) from the university of Waterloo other institutions, they need to contact the instructor to give them an override permission.

LECTURE TIME

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TEXTBOOKS

Material taught in this course are mainly provided from the following textbooks:

1. F. Karray and C. de Silva, *Soft Computing and Intelligent Systems Design*, Addison Wesley Publishing, Pearson Education, August 2004
2. S. Marsland, Machine Learning, CRC Press, 2015
3. Computational Intelligence: A Methodical Introduction, R. Kruse, C. Borgelt, C. Braune, 2nd Edition, Springer, 2016
4. Other online material tackling recent topics in the field of computational intelligence will be posted regularly on the course Learn page

OTHER RELATED TEXTS

1. M. Negnevitsky, *Artificial Intelligence, A Guide to Intelligent Systems*, Pearson Publishing, 2006
2. C. T. Lin and C.S. Lee, *Neural Fuzzy Systems*, Prentice Hall Publishing, 1995
3. J. Jang, C. Sun, and E. Mizutani, *NeuroFuzzy and Soft Computing*, Prentice Hall Publishing, 1997

COURSE SCOPE
The course is useful for graduate students in virtually all areas of engineering, particularly for those dealing with complex systems or processes. We make use of advanced computational tools of machine learning, approximate reasoning and evolutionary computing. A background in two or more of the following areas should be useful: fuzzy logic, artificial neural networks, machine learning, AI, system's optimization, nonlinear mapping, calculus of variation, differential calculus, statistical analysis, advanced algebra, game theory.

COURSE MATERIAL AND ONLINE RESOURCES
All course material, including slides, notes, assignments, exams are posted on the course page on Learn. Exams and reports are uploaded on the course web page on Learn

TENTATIVE COURSE OUTLINE
The main sections of this course are given as follows:

1. Introduction (one week)
2. Machine Learning and Major Classes of Artificial Neural Networks (two weeks)
3. Advanced concepts on Classifiers, Support Vector Machines, Nonlinear Regressions and Deep Learning and their Applications in Real World Systems (three weeks)
4. Approximate Reasoning, Fuzzy Inferencing and Intelligent Systems (Three weeks)
5. Evolutionary Computing and Hybrid Systems (two weeks)

COURSE REQUIREMENT:
1) Assignments (40%):
Assignments will be provided on a biweekly to tri-weekly basis. Students will have to work independently on the assignments.
2) Quizzes (10%): By the end of every lecture, a 15 minutes quiz will be made available for the students. A total of 10 quizzes can be accessed through the system.

3) Midterm Exam (20%) (Online on Learn)

4) Research paper (30%):
A group-based journal paper is expected in which the students research a problem of their own choice. The students can utilize what they have learned in the course as well as any extra subjects not covered in the course in their work. Groups need to submit a proposal by a due date later specified.

LIBRARY MATERIAL
A large set of relevant of journals and texts related to the subject are available in the library or online, including:
IEEE Transactions on Fuzzy Systems
IEEE Transactions on Neural Networks and Learning Systems
IEEE Transactions on Evolutionary Computation
IEEE Transactions on Cybernetics
Fuzzy Sets and Systems