CISE 590 Special Topics in Intelligent Systems

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Course Description:
This course introduces the concepts and algorithms that are developed in the fields of soft computing. It looks at three computational methods which are finding growing interest at both industry and academia environments. These are: Fuzzy Logic, Artificial Neural Networks, and Genetic Algorithms.

- Fuzzy Sets and Fuzzy Logic are ways to represent and manipulate the types of uncertainty and vagueness that are usually present in human descriptions of the world. These tools can be used to build control systems that use the imprecise knowledge of human experts.
- Neural Networks, modeled after concepts from biological neural systems, use large numbers of simple interconnected computational units to perform tasks such as detecting patterns to noisy data and simulate massively parallel processing of interconnected elements.
- Genetic Algorithms are optimization techniques inspired by biological evolution to search for good solutions to complex problems. Each
- potential solution to the problem is assigned a quality, or ``fitness`` value. Probabilistic techniques are then used to find solutions with high ``fitness``.

These three problem-solving techniques are closely related, often being applied simultaneously to aspects of the same problem. The subject is provided with several examples and case studies to master the techniques and assess their relevance to solve real-world engineering problems.

Pre-requisite: Graduate standing

Learning Outcomes: On completion of this course, the students will:

- Acquire understanding and knowledge of soft computing models and algorithms and so they will be able to design program systems using these techniques to solve various real-world problems.
- Appreciate the importance of tolerance of imprecision and uncertainty for design of robust and low-cost intelligent systems.
- Apply these techniques in engineering case studies, including robotics, traffic light systems, and reservoir properties prediction and characterisation in petroleum engineering.

Textbook: *Soft Computing and Intelligent Systems Design, Theory, Tools and Applications,* F. Karray, C. De Silva, Prentice Hall, 2004.

References:

1) - Fuzzy Model Identification for Control, Janos Abonyi, Birkhauser, 2003
2) - Neural Networks Design, M. T. Hagan, H. B. Demuth, M. Beale, PWS Publishing, 2002
3) - Genetic Algorithms in Engineering Systems, Edited by A.M.S. Zalzala and P.J. Fleming, 2003

Web Resources

http://www.mathworks.com/products/matlab/: Matlab Technical Language with its Toolboxes: Fuzzy Logic, Neural Networks, and Genetic Algorithms.

http://www.cs.berkely.edu/~zadeh/: Home Page of Professor L. A. Zadeh, the founder of Fuzzy Sets and Fuzzy Logic. It is also the Home Page of BISC (Berkley Initiative for Soft Computing), A world-leading center for basic and applied research in soft computing.

http://www.nafips.ece.ualberta.ca/: North American Fuzzy Information Processing Society. Established in 1981, its purpose is to help and encourage the development of fuzzy sets and related technologies.

Grading (Tentative)

- HWs 10%
- Midterm Exam 20%
- Project 40%
- Final 30%

University policy regarding attendance will be followed, 1% will be deducted per absence.

Projects:

Students are urged to start working on the project early in the semester.
They can suggest their own projects, upon the instructor approval.
The project will be presented at the end of the semester as a conference paper.
Available projects are:

1. Fuzzy parking of car-like mobile robots
2. A Hybrid computational intelligence to face recognition problem
3. PVT proprieties prediction in reservoir engineering with neuro-fuzzy systems
4.

Course timetable

The course will run for a total of 15 weeks. The last week will be reserved for a review. Matlab software and its toolboxes will be used to do Homework and projects.

Week #	Topic	Assignment
1	Introduction, Why fuzzy logic? Why soft computing? Some examples and cases in industry	
2	Crisp vs. fuzzy sets, Operations on fuzzy sets. Set identities and laws, Relations between sets, Composition, Intersection and union of relations.	Project Selection
3	Fuzzy numbers and the extension principle. Fuzzy relations. Fuzzy rules and inference relations, Defuzzification. The complete fuzzy inference system, Multi-part rules, Generalized Modus-Ponens	
4	Advanced issues in fuzzy logic, Fuzzy control, Application to learning and identification.	HW 1
5	Neural networks, Basic concepts of mimicking nature for problem solving: Single-layer and multi-layer feedforward and feedback neural network topologies.	
6	Supervised vs. unsupervised learning; Radial basis function neural networks, Associative learning, Competitive learning, Support vector machines,	
7	Variations on back-propagation, Other topologies of neural networks	HW 2
8	Introduction to Neuro-Fuzzy systems, ANFIS	
9	Advanced architectures, CANFIS, DENFIS	HW 3
10	Genetic algorithms; Why genetic algorithms work? Probabilistic search techniques, Particle swarm optimization, Comparison of optimization techniques	
11	Evaluation; Population; Parent selection, Fitness; Genetic operators, Mutation; Crossover; Inversion operator; Performance enhancement, Elitism, Interpolating operator	HW 4
12	Application to non linear identification, Application to redundant robots control	
13	Hybrid genetic-fuzzy systems, introduction and case study of a GFS, GANFIS	HW 5
14	Project presentation and report	
15	Revision	

Dr. Amar Khoukhi September 2010