ELG7177 - Topics in Communications I: Neural Networks and Fuzzy Systems

Winter 2009 (Jan. 6 - April 9): Tuesday, 11:30-13:00, CBY B202
Thursday, 11:30-13:00, CBY E015

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Marking system: Assignments …. 10%
Project report ... 50%
Final exam. ….. 40%

Calendar Description:
Soft computing. Fuzzy set theory: rules, reasoning and inference systems. Regression and optimization; derivative-based optimization, simulated annealing, downhill simplex search. Neural Networks: adaptive networks; bi-directional associative memories; supervised and unsupervised learning; learning from enforcement. Applications: neuro-fuzzy modelling and control, pattern recognition.

Course outline:

1. **Introduction to soft computing.**
   Soft computing, encompassing both *neural networks* (NN) and *fuzzy logic* (FL), represents a synergetic approach to the development of computationally intelligent systems for solving complex real-world problems. NN techniques provide the ability to recognize patterns, learn and adapt to changing environments. Fuzzy systems emulate the human mind ability to reason in uncertain environments.
2. **Fuzzy cognitive maps.**
3. **Fuzzy logic systems**.
   Fuzzy set theory. Fuzzification. Fuzzyrules. Defuzzification. Fuzzy reasoning. Fuzzy inference. Fuzzy logic control (FLC).
4. **Applications of FLC**
   Backing-up a car. Backing up of a tractor & trailer. **….**
5. **Regression and optimization**.
   Least-square estimators. Derivative-based optimization: descent methods, steepest descent method, etc. Derivative-free optimization: genetic algorithms, simulated annealing, random search, downhill simplex search.
6. **Neural networks**
   Bidirectional associative memories. Adaptive networks and backpropagation. Supervised learning: perceptrons, backpropagation multilayer perceptrons, radial basis function NN. Learning from reinforcement. Unsupervised learning: competitive learning, Kohonen self-organizing NNs, Hebbian learning, Hopfield networks. Hardware NN architectures.
7. **Applications of NN**
   NN modeling of 3D objects. Pattern recognition. Inverse kinematics in robotics. **….**

References:

- B. Kosko, Neural Networks and Fuzzy Systems: A Dynamical Systems Approach to Machine Intelligence, Prentice Hall, 1992.
- J.-S.R. Jang, C.-T. Sun, and E. Mizutani, Neuro-Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence, Prentice Hall, 1997
- K.M. Passino and S. Yurkowich, Fuzzy Control, Addison-Wesley, 1998
- W. Pedrycz, F. Gomide, Fuzzy Systems Engineering: Toward Human-Centric Computing, John Wiley, Hoboken, NJ, 2007

Note:

- The orientation of the course is toward practice-useful methodologies. The course will involve lectures and paper design projects.

Links:

- IEEE Computational Intelligence Society: Multimedia Tutorials Center => http://ewh.ieee.org/cmte/cis/mtsc/ieeecis/index.htm
- Foundations and Applications of Granular Computing by Witold Pedrycz => http://ewh.ieee.org/cmte/cis/mtsc/ieeecis/Wltold_Pedrycz.pdf
- An Overview of Neural Networks by Ben Best => http://www.benbest.com/computer/nn.html#intro
- Neural Networks at your Fingertips => http://www.neural-networks-at-your-fingertips.com/
- Fuzzy Systems for Control Applications (slides E.M. Petriu) => http://www.site.uottawa.ca/%7Epetriu/Fuzzy-tutor.PDF
- Neural Networks: Basics (slides E.M. Petriu) => http://www.site.uottawa.ca/~petriu/NN_basics-tutorial-2004.pdf
- Biology Inspired Approximate Data Representation for Signal Processing, Soft Computing and Control Applications (slides E.M. Petriu) => http://www.site.uottawa.ca/~petriu/wisp2007-BiologyInspiredAproxDataRepr-30Sep2007.pdf
- Neural Networks: Modeling Applications (slides E.M. Petriu) => http://www.site.uottawa.ca/~petriu/NN_modeling-tutorial-2004.pdf
- NN Modelling of the Geometric and Elastic Properties of 3D Objects from Experimental Measurement Data (slides E.M. Petriu) => http://www.site.uottawa.ca/~petriu/CAMPS%202006-NN_Model_Geom_Elast-d.pdf