EE 614 Artificial Neural Systems
Spring 2015, Tue+Thu 2:30-3:45pm
Also satisfying ECE 696 Advanced Level Communications Requirement

Instructor: Jacek Zurada, Professor, jacek.zurada@louisville.edu, ph 852-6314, fx 852-3940, Lutz 405

Online Catalog Description:

ECE 614 Artificial Neural Systems. Credit 3. Prerequisite: Graduate/Professional Standing. Foundations of learning machines and neural processing algorithms: supervised and unsupervised learning of feed-forward and recurrent neural networks, perceptron layers, associative memories, feature maps. Applications in the areas of classification, control, and signal processing. Implementation issues.

Prerequisites (by Topic):

Introduction to linear and nonlinear systems, stability, solid geometry, matrix calculus, introduction to optimization, and electronic microsystems.

References:

Jacek M. Zurada, *Introduction to Artificial Neural Systems*, PWS, 1992 (a free PDF)
Jose Principe et al., *Neural and Adaptive Systems: Fundamentals through Simulations*, Wiley 2000
Dana H. Ballard, *An Introduction to Natural Computation*, MIT Press 1997
Handouts and references to on-line resources, also selected papers

Objectives:

Course designed to provide students with foundations of learning machines and neural processing algorithms, as well as with neural networks development, and neurocomputing simulation techniques. It includes a design project (see Laboratory Projects). Such projects are completed using neural networks student-written software, or existing development tools (see Computer Usage). Oral presentations and project reports are required to enhance students' communications skills.

Course Learning Outcomes: Students who complete this course will be able to:

1. Calculate mappings by multilayer perceptron networks (MLP)
2. Train and test an MLP to classify patterns, including noisy training sets
3. Design an MLP that performs prediction, regression or classification tasks using professional package (such as the NN Toolbox in MATLAB) or student-written software
4. Prepare training data in terms of normalization and scaling
5. Perform clustering of data with unsupervised training methods such as Winner-Takes-All (WTA)
6. Compress multidimensional data through classical Principal Component Learning (PCA)
7. Compress multidimensional data through Hebbian or Sanger learning
8. Visualize complex data on topographical maps and understand the maps
9. Design stable states and analyze the states' convergence to a fixed point for fully coupled associative memory or Hopfield networks in asynchronous mode
10. Program and test at least one NN software simulator
11. Identify, formulate and solve an open problem that can be solved with NNs
12. Respond to needs of life-long learning and browse through learning resources on SVM classifiers, or NMF feature extractors, or an Extreme Learning Machine, or Deep Learning concepts

Topics Covered by Class Schedule (2 sessions/week, 75 min-s each):

1. Introduction and examples of applications
2. Fundamental models of artificial neural systems, learning rules, taxonomy of neural networks
3. Single-layer perceptron classifiers and approximators
4. Multilayer feedforward networks: Error back propagation (EBP) training and its modifications
5. Single-layer fully coupled networks with continuous and discrete time
6. Associative memories for pattern retrieval
7. Matching and especially self-organizing networks: unsupervised learning techniques (including Hebbian learning, principal component analysis), feature maps
8. Applications of neural algorithms in pattern recognition, signal processing, control, robotics, semantic studies and other areas
9. SVM classifiers, or NMF feature extractors, or an Extreme Learning Machine, Deep Learning concepts (if time permits)
10. Radial basis functions (if time permits)
11. Neural networks implementation: hardware and software (if time permits)

('if time permits' depends on the class size and other factors that occur during the semester)

Topics Covered by Laboratory Schedule: none

Computer Usage:

Using a neural network simulators such as MATLAB, SNNS or other. Modeling of training and recall processes with neural algorithms. Development or adaptation of existing neurocomputing tools for classification, regression and clustering, and coding of algorithms in high-level language. Examples of computer-based projects include: design of trainable classifiers, including design, simulation and performance evaluation of multilayer pattern classifiers trained with EBP algorithms; data clustering using NMF; mapping of multidimensional data into perceptual spaces, compression of multidimensional data vectors; design of associative memories for noise removal; training of autoencoders-based deep learning networks

Evaluation:

Three quizzes (17% each)
One project and seminar in a group of two, each must speak, joint report (13%)
One final or take-home final exam (20%)
Homework assigned about bi-weekly (16%)
Students who have taken ECE613 class will be assigned additional reading and reporting assignment beyond the outlined topics

Grading:

A - All requirements are met or exceeded on each assignment.
B - Substantially meets all requirements on each assignment, with only minor deficiencies in one or two assignments.
C - Satisfies requirements of the majority of the assignments, with major deficiencies in remaining assignments.
D - Major deficiencies in all assignments.
F - None of the requirements are addressed.

Contribution of Course to Meeting the Professional Component:

Engineering Science: 1 credits or 33%
Engineering Design: 2 credits or 67%

Relation of Course to Program Outcomes:

This course strongly supports the attainment of Program Outcomes 1-3, 5, 9 and 11 in terms of technical competencies, and outcomes 7a, 7b in terms of communications skills.
This course is also satisfying Advanced Level Communications Requirements for students enrolled in the EE MEng program. To satisfy these ABET Advanced Level Criteria, students taking this course will also co-register for ECE 696 Oral Presentation (0 credit) (unless they already earned such credit earlier), and will present the results of their work before a faculty committee. These presentations will become a record for the accreditation purposes.

All Individual student project/seminar work will also be assessed via individual presentations, and tabulation of individual contributions within the team Project Report.

Academic and Professional Integrity:

I expect you to act professionally and ethically, in accordance with the **Code of Student Rights and Responsibilities** (*UofL Undergraduate Catalog*, 2008-2009, at http://louisville.edu/undergraduatecatalog/currentcat/generalinfo/academic-policies-and-procedures.html (see especially, **Section 5. Academic Dishonesty and Section 6. Discipline Procedures for Academic Dishonesty**), and relevant sections of the **Codes of Ethics** of the relevant professional societies: the *Association for Computing Machinery* (ACM), the *Institute of Electrical and Electronics Engineers* (IEEE) and the *National Society of Professional Engineers* (NSPE). Cheating of any form, including the use of homeworks from prior semesters and plagiarism (defined in the Code of Student Rights and Responsibilities, Section 5.E. as "*Representing the words or ideas of someone else as one's own in any academic exercise, ...* [examples follow in the Catalog, p. 16]," can result in disciplinary action, including an F in the course and suspension/expulsion from the School and University. I will deal with cases involving cheating in accordance with the Speed School Academic Integrity policy..

Disabilities:

The University of Louisville is committed to providing access to programs and services for qualified students with disabilities. Students with disabilities, who need reasonable accommodation to complete assignments successfully and otherwise satisfy course criteria, are encouraged to meet with the instructor during the first week of the semester to identify and plan specific accommodations. Students are asked to supply a letter from the Disability Resource Center, certifying their eligibility, and other documentation, as needed, which will assist in planning of modifications. Students may also contact the Disability Resource Center for information, verification of eligibility and auxiliary aid.

Prepared by: Zurada Date: Jan 2011, Jan 2013, Jan 2015