IE7860: Intelligent Engineering Systems - 4 Credits
(Computational Intelligence, Learning Systems, Machine Learning, Data Mining)
Course Syllabus
Fall 2012

Instructor: Ratna Babu Chinnam, Ph.D. (Ratna.Chinnam@wayne.edu)
Classroom: 2031 MEB (2nd Floor) – 4815 Fourth Street
Office: Room 2161, 4815 Fourth Street, IME Department, Tel: 577-4846
Office Hours: By Appointment
Web Sites¹: http://blackboard.wayne.edu

Description: Utilize computational intelligence methods such as neural networks, support vector machines, evolutionary computing, fuzzy logic, decision trees, Bayesian networks, and other nontraditional methods to solve computationally complex and hard machine learning and data mining problems. While the course will address generic problem domains such as clustering, function approximation, pattern recognition, process modeling, forecasting, signal processing, and optimization, effort will be made to relate the students to problems from the general domain of industrial and systems engineering. Course will be project centric with the end goal of developing significant solutions to complex problems.

Course Objectives:
- In-depth understanding for the strengths and weaknesses of different classes of neural networks.
- Good understanding for the recent progress made by the scientific and technical community in the broader field of computational intelligence (including support vector machines, evolutionary computing, fuzzy logic, decision trees, Bayesian networks, and other upcoming and promising nontraditional methods).
- Hands-on experience in the application of computational intelligence methods for addressing research problems from different fields of science and engineering through multiple projects.

Prerequisites: Familiarity with MATLAB or another programming language; Graduate standing and good mathematics background.

OR


Additional tutorials and journal papers will be distributed in the class as needed to complement the material from the textbooks in the areas of Neural Networks, Evolutionary Computing, Support Vector Machines, Data Mining, and others.

Software: Access to MATLAB computing environment along with Neural Network ToolBox, Fuzzy Logic ToolBox, Bioinformatics ToolBox (SVMs), BNT ToolBox (Bayesian Networks), Global Optimization ToolBox (Genetic Algorithms), and others.

¹ Blackboard website is protected by individual user login names and passwords. The username is the uniquely assigned WSU AccessID. To activate your WSU AccessID or change the password or set an alternate forwarding e-mail address, visit http://webmail.wayne.edu. Call the WSU Computing & Information Technology (C&IT) Help Desk at 313-577-4778 for any difficulties.
Access to [Stuttgart Neural Network Simulator](http://www.ini.uni-stuttgart.de/online) developed at University of Stuttgart (Germany) and maintained at University of Tübingen (or [JavaNNS](http://www.javanns.com)).

Access to C and C++ modules for implementation of various neural networks and machine learning methods on personal computers.

Access to a wealth of other open-source software (e.g., [WEKA](http://www.cs.waikato.ac.nz/ml/weka/)) available for implementing machine learning methods.

### Grading:

<table>
<thead>
<tr>
<th>Assignment</th>
<th>Weight</th>
<th>Points</th>
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<tbody>
<tr>
<td>Two Short Projects</td>
<td>50 x 2</td>
<td>100</td>
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<tr>
<td>Semester Project</td>
<td>125 x 1</td>
<td>125</td>
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<tr>
<td>Two Exams</td>
<td>100 x 2</td>
<td>200</td>
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<tr>
<td>Five Special Assignments</td>
<td>25 x 5</td>
<td>125</td>
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**Total**: 650 points

Individual projects, exams, and special assignments might be curved and changed with regard to importance (i.e., in points), at the discretion of the instructor. All exams will be open-book exams. Project reports and special assignment reports have to be typed, and when feasible, results have to be justified and thoroughly summarized (without appending lots of pages of output). Reports have to be submitted at the beginning of the class on the due date. Late reports will receive lower grades.

### Short Projects:

Students are encouraged to bring some datasets/problems of interest. If requested, instructor can provide datasets.

### Semester Project:

This is a team project with two to three students. Students are encouraged to pursue a small "research" topic and produce a proceedings paper for a reputable conference or a journal.

### Attendance Policy:

Students attending any given class are required to join the class within the first five minutes to minimize any class disruptions.

### Academic Integrity Policy:

Wayne State University is committed to the highest standards of academic integrity. You are expected to conduct yourself in accordance with these standards. To the extent that this course relies on project reports and independent research papers, be especially aware of proper attribution and citation standards to avoid even the appearance of plagiarism. Per the Student Code of Conduct, any violations of academic integrity will be handled via a combination of downgrading (up to and including failing the course) and prosecution via the Dean of Students and College of Engineering's Judicial Officer, which can result in permanent transcript notations or even expulsion from the University. Be sure you are familiar with the material on the following links:

- [http://www.doso.wayne.edu/student-conduct/Student_Code_Conduct.html](http://www.doso.wayne.edu/student-conduct/Student_Code_Conduct.html)
- [http://www.trc.wayne.edu/node/48](http://www.trc.wayne.edu/node/48)

### Educational Accessibility Services:

If you feel that you may need an accommodation based on the impact of a disability, please feel free to contact me privately to discuss your specific needs. Additionally, the Office of Educational Accessibility Services (EAS) coordinates reasonable accommodations for students with documented disabilities. The Office is located in 1600 David Adamany Undergraduate Library, phone: 313-577-1851 (Voice) / 577-3365 (TTD).

### Dropping / Withdrawing Policy:

Students must drop classes via the Web by logging into Pipeline ([http://pipeline.wayne.edu](http://pipeline.wayne.edu)). If a student has a hold and needs help dropping a class then they should send an e-mail request from their WSU e-mail account to [registration@wayne.edu](mailto:registration@wayne.edu) with the appropriate course information. Students may drop a class (for fifteen week classes) through the end of the fourth week of class. Classes that are dropped do not appear on the transcript. Beginning the fifth week of class students are no longer allowed to drop but must withdraw from classes via Pipeline. It is the student’s responsibility to request the withdrawal. The withdrawal period for full-term classes ends at the end of the tenth week of the term. See the Academic Calendar for specific information on when the withdrawal period ends:

- [http://reg.wayne.edu/students/calendar.php](http://reg.wayne.edu/students/calendar.php)

### Deferred Grades Policy:

A grade of 'I' can only be assigned if all of the following criteria are met:

1. the student is NOT currently failing the class and,
2. there is NOT a substantial quantity of work yet to be completed,
3. there is no extra work required of the instructor beyond the normal duties of grading the paper/exam,
4. there is no need for the student to attend the class in subsequent terms.

The final decision to assign an incomplete grade rests with the instructor. An 'I' grade MUST be made up within one year of assignment of the grade.

### No Classes:

Oct. 16 (INFORMS Conference); Nov 22-Nov 24 (Thanksgiving Recess).
### Tentative Course Schedule:

<table>
<thead>
<tr>
<th>No. of Classes</th>
<th>Topic</th>
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<tbody>
<tr>
<td><strong>Artificial Neural Networks</strong> (Primary Source: Haykin 2009)</td>
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</table>
| 1.5 Classes | Course Introduction + Introduction  
Fundamental Characteristics of ANNs, Neuron Models, Role of Feedback  
Network Architectures, Knowledge Representation |
| 2 Classes | Learning Processes  
Error Correction Learning, Memory-Based Learning, Hebbian Learning, Competitive Learning  
Boltzmann Learning, Credit-Assignment, Learning With/Without A Teacher, Learning Tasks  
Statistical Nature of the Learning Process |
| 1 Class | Single-Layer Perceptrons  
Adaptive Filtering Problem, Unconstrained Optimization Techniques  
Perceptron and Error Correction Learning  
**Perceptron Special Assignment – Due: Before Starting RBF Material** |
| 3 Classes | Multilayer Perceptrons  
MLP Networks/ Notation and Back-Propagation Algorithm – One and a Half Class  
Performance Acceleration Heuristics, Computer Experiment  
Generalization, Cross-Validation, Network Pruning, Accelerated Convergence, Limitations of Back-Propagation Algorithm  
**MLP, RBF, SVM Networks Short Project – Due: Before Interim Exam** |
| 2 Classes | Radial Basis Function Networks  
Cover’s Theorem, Interpolation Problem, Ill-Posed HyperSurface Reconstruction Problem, Regularization Theory  
Regularization Networks, Generalized Radial-Basis Function Networks  
Properties of RBF Networks, Comparison to MLP Networks, Learning Strategies, Computer Experiment  
Validity Index Neural Networks |
| 2 Classes | Support Vector Machines  
Optimal Hyperplane for Linearly Separable Patterns  
Optimal Hyperplane for Nonseparable Patterns  
SVMs for Pattern Recognition  
SVMs for Nonlinear Regression |
| 3 Classes | Reinforcement Learning (Neurodynamic Programming)  
RL Model: Exploitation vs. Exploration  
Delayed Reward: Finding a Policy Given an MDP Model  
Learning an Optimal Policy: Model-free Methods  
Generalization: Over Inputs and Actions  
RL in Partially Observable Environments  
**RL Special Assignment – Due: Before Starting SOM Material** |
| 1 Class | Interim Exam |
| 1.5 Classes | Self-Organizing Maps  
SOMs, Training Algorithm  
Properties, Conscience, Computer Experiment  
**SOM Special Assignment – Due: Before Starting Recurrent Network Material** |
| 2 Classes | Temporal Processing using Feedforward Networks  
Network Architectures, Focused Time Lagged Feedforward Networks and Computer Experiment  
Distributed Time-Lagged Feedforward Network, Temporal Back-Propagation Algorithm  
**Distributed TLFN and Recurrent MLP Special Assignment – Due: Before Starting Fuzzy Inference** |
| 2 Classes | Dynamically Driven Recurrent Networks  
Recurrent Network Architectures and Related Issues  
Real-Time Recurrent Learning, Computer Experiment |
| **Fuzzy Logic and Computing** (Primary Source: Jang, Sun, and Muzutani 1997) | |
| 1 Class | Fuzzy Sets  
Basic Definitions, Set-theoretic Operations, MF Formulation and Parameterization |
| 1 Class | Fuzzy Rules and Fuzzy Reasoning  
Extension Principle and Fuzzy Relations, Fuzzy If-Then Rules, Fuzzy Reasoning |
| 1 Class | Fuzzy Inference Systems  
Mamdani Fuzzy Models, Sugeno Fuzzy Models, Tsukamoto Fuzzy Models  
Other Considerations |
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<tr>
<th><strong>Fuzzy Logic Short Project – Due: Before Starting Bayesian Networks Material</strong></th>
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<td><strong>Evolutionary Computing Methods and Algorithms</strong> <em>(Primary Source: Mitchell 1997)</em></td>
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<td><strong>Decision Trees</strong> <em>(Primary Source: Mitchell 1997)</em></td>
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<td><strong>Bayesian Networks</strong> <em>(Primary Source: Tutorials)</em></td>
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