WAYNE STATE UNIVERSITY
COLLEGE OF ENGINEERING

IE7860: Intelligent Analytics - 3 Credits
(Computational Intelligence, Learning Systems, Big Data)
Course Syllabus – Winter 2018

Instructor: Ratna Babu Chinnam, Ph.D.
Professor, Industrial & Systems Engineering Department
Ratna.Chinnam@wayne.edu | Tel: 313.577.4846

Classroom: ISE Conference Room

Office: Room 2161, 4815 Fourth Street (MEB), Wayne State University, Detroit, MI 48202

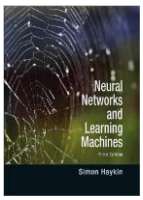
Office Hours: By Appointment

Web Sites[1]: http://blackboard.wayne.edu

Description: Computational intelligence methods to solve complex analytics problems and develop effective decision support systems. While the course will address generic topics such as dimensionality reduction, feature selection, clustering, function approximation, pattern recognition, process modeling, forecasting, and optimization, the focus will be on developing advanced analytics solutions. Particular attention will be given to big data problems and thinking. Course will be project centric with the end goal of developing significant solutions to complex problems.

Course Learning Outcomes:
- At the end of the course, the successful student will be able to develop in-depth understanding for the strengths and weaknesses of different classes of neural networks.
- At the end of the course, the successful student will be able to develop good understanding for the recent progress made by the scientific and technical community in the broader field of computational intelligence (including support vector machines, decision trees, Bayesian networks, deep structure learning, and other upcoming and promising nontraditional methods).
- At the end of the course, the successful student will have acquired hands-on experience in the application of computational intelligence methods for developing analytics solutions and decision support systems for significant problems in practice.

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



Textbook: Simon Haykin, *Neural Networks and Learning Machines*, Third Edition, Prentice Hall, NJ: Upper Saddle River, 2009 (ISBN: 0131471392). [Amazon]

References:
Vapnik, V., *The Nature of Statistical Learning Theory*, Second Edition, Springer, NY: New York, 1999 (ISBN: 0387987800).
Mitchell, T., *Machine Learning*, McGraw-Hill, 1997 (ISBN: 0070428077).
Russell, S., Norvig, P., *Artificial Intelligence: A Modern Approach*, Third Edition, Prentice Hall, NJ: Upper Saddle River, 2009 (ISBN: 0136042597).
Bishop, C. *Pattern Recognition and Machine Learning*. Springer, NY: New York, 2007 (ISBN: 0387310738).

Additional tutorials and journal papers will be distributed in the class as needed to complement the material from the textbooks in the areas of Deep Learning, Decision Trees, Random Forests, Data Mining, and others.

Software: Access to MATLAB computing environment along with Neural Network ToolBox, Statistics & Machine Learning ToolBox (SVMs), 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 https://computing.wayne.edu/accessid. Call the WSU Computing & Information Technology (C&IT) Help Desk at 313-577-4778 for any difficulties.

Other open-source software (e.g., R, WEKA, Deep Learning Toolbox) available for implementing machine learning methods.

Grading:

Semester Project	@ 125 x 1	125 pts
Two Exams	@ 100 x 2	200 pts
Eight Assignments	@ 25 x 8	200 pts
	Total	520 pts

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 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.

Assignments: 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.

Religious Holidays: Because of the extraordinary variety of religious affiliations of the University student body and staff, the Academic Calendar makes no provisions for religious holidays. However, it is University policy to respect the faith and religious obligations of the individual. Students with classes or examinations that conflict with their religious observances are expected to notify their instructors well in advance so that mutually agreeable alternatives may be worked out.

Student Services:

- *The Academic Success Center* (1600 Undergraduate Library) assists students with content in select courses and in strengthening study skills. Visit http://success.wayne.edu for schedules and information on study skills workshops, tutoring and supplemental instruction (primarily in 1000 and 2000 level courses).
- *The Writing Center* is located on the 2nd floor of the Undergraduate Library and provides individual tutoring consultations free of charge. Visit http://clasweb.clas.wayne.edu/writing to obtain information on tutors, appointments, and the type of help they can provide.

Class Recordings: Students need prior written permission from the instructor before recording any portion of this class. If permission is granted, the audio and/or video recording is to be used only for the student's personal instructional use. Such recordings are not intended for a wider public audience, such as postings to the internet or sharing with others. Students registered with Student Disabilities Services (SDS) who wish to record class materials must present their specific accommodation to the instructor, who will subsequently comply with the request unless there is some specific reason why s/he cannot, such as discussion of confidential or protected information.

Academic Dishonesty – Plagiarism and Cheating: Academic misbehavior means any activity that tends to compromise the academic integrity of the institution or subvert the education process. All forms of academic misbehavior are prohibited at Wayne State University, as outlined in the Student Code of Conduct (http://www.doso.wayne.edu/student-conduct-services.html). Students who commit or assist in committing dishonest acts are subject to downgrading (to a failing grade for the test, paper, or other course-related activity in question, or for the entire course) and/or additional sanctions as described in the Student Code of Conduct.

- *Cheating*: Intentionally using or attempting to use, or intentionally providing or attempting to provide, unauthorized materials, information or assistance in any academic exercise. Examples include: (a) copying from another student's test paper; (b) allowing another student to copy from a test paper; (c) using unauthorized material such as a "cheat sheet" during an exam.
- *Fabrication*: Intentional and unauthorized falsification of any information or citation. Examples include: (a) citation of information not taken from the source indicated; (b) listing sources in a bibliography not used in a research paper.
- *Plagiarism*: To take and use another's words or ideas as one's own. Examples include: (a) failure to use appropriate referencing when using the words or ideas of other persons; (b) altering the language, paraphrasing, omitting, rearranging, or forming new combinations of words in an attempt to make the thoughts of another appear as your own.
- *Other* forms of academic misbehavior include, but are not limited to: (a) unauthorized use of resources, or any attempt to limit another student's access to educational resources, or any

attempt to alter equipment so as to lead to an incorrect answer for subsequent users; (b) enlisting the assistance of a substitute in the taking of examinations; (c) violating course rules as defined in the course syllabus or other written information provided to the student; (d) selling, buying or stealing all or part of an un-administered test or answers to the test; (e) changing or altering a grade on a test or other academic grade records.

Student Disability Services:

If you have a documented disability that requires accommodations, you will need to register with Student Disability Services for coordination of your academic accommodations. The Student Disability Services (SDS) office is located at 1600 David Adamany Undergraduate Library in the Student Academic Success Services department. SDS telephone number is 313-577-1851 or 313-577-3365 (TTD only). Once you have your accommodations in place, I will be glad to meet with you privately during my office hours or at another agreed upon time to discuss your needs. Student Disability Services' mission is to assist the university in creating an accessible community where students with disabilities have an equal opportunity to fully participate in their educational experience at Wayne State University. Please refer to the SDS website for further information about students with disabilities and the services we provide for faculty and students:
http://studentdisability.wayne.edu/
Students who are registered with Student Disability Services and who are eligible for alternate testing accommodations such as extended test time and/or a distraction-reduced environment should present the required test permit to the professor at least one week in advance of the exam. Federal law requires that a student registered with SDS is entitled to the reasonable accommodations specified in the student's accommodation letter, which might include allowing the student to take the final exam on a day different than the rest of the class.

Course Drops and Withdrawals:

In the first two weeks of the (full) term, students can drop this class and receive 100% tuition and course fee cancellation. After the end of the second week there is no tuition or fee cancellation. Students who wish to withdraw from the class can initiate a withdrawal request on Pipeline. You will receive a transcript notation of WP (passing), WF (failing), or WN (no graded work) at the time of withdrawal. No withdrawals can be initiated after the end of the tenth week. Students enrolled in the 10th week and beyond will receive a grade. Because withdrawing from courses may have negative academic and financial consequences, students considering course withdrawal should make sure they fully understand all the consequences before taking this step. More information on this can be found at: http://reg.wayne.edu/pdf-policies/students.pdf

Deferred Grade:

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.

Tentative Course Schedule:

No. of Classes	Topic
Artificial Neural Networks (Primary Source: Haykin 2009)	
1.5 Classes	Syllabus + Introduction *Fundamental Characteristics of ANNs, Neuron Models, Role of Feedback* *Network Architectures, Knowledge Representation*
1 Class	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	Perceptron, Bayes, & Naïve Bayes Classifiers *Perceptron* *Bayes Classifier* *Naïve Bayes Classifier*
1 Class	Unconstrained Nonlinear Optimization Techniques: Overview *Steepest Descent – First-Order Method* *Newton's Method – Second-Order Method* *Quasi-Newton Methods & Conjugate Gradient Methods (Avoid use of Hessian)* *Gauss-Newton Methods: Only appropriate for least-squares problems (Leavenberg-Marquardt & Others)*
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* *Matlab Examples* ***MLP Assignment – Due: One week***
1 Class	Model Assessment *Regression vs Classifiers (Confusion Table, ROC Curve)*
2 Classes	Feature Extraction, Selection, and Missing Data Imputation *PCA, Kernel PCA* *Linear Discriminant Analysis* *Sequential & Random Feature Selection (Filters vs. Wrappers)* *Missing Data Imputation* ***Feature Selection & Imputation Assignment – Due: One week***
2 Classes	Radial Basis Function Networks - TENATIVE *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* ***RBF Assignment – Due: One week***
2 Classes	Support Vector Machines *Optimal Hyperplane for Linearly Separable Patterns* *Optimal Hyperplane for Nonseparable Patterns* *SVMs for Pattern Recognition* *SVMs for Nonlinear Regression* ***SVM Assignment – Due: One week***
1 Class	**Interim Exam**
2 Classes	Temporal Processing & Dynamically Driven Recurrent Networks *Network Architectures, Focused Time Lagged Feedforward Networks and Computer Experiment* *Distributed Time-Lagged Feedforward Network, Temporal Back-Propagation Algorithm* *Recurrent Network Architectures and Related Issues* *Real-Time Recurrent Learning, Computer Experiment* ***Distributed TLFN and Recurrent MLP Assignment – Due: One week***
2 Classes	Deep (Structure) Learning (Primary Source: Articles)

	Hinton, Geoffrey E., and Ruslan R. Salakhutdinov. "Reducing the dimensionality of data with neural networks." Science 313.5786 (2006): 504-507. LINK *LeCun, Yann, Yoshua Bengio, and Geoffrey Hinton. "Deep learning." Nature 521.7553 (2015): 436-444. LINK (Paper) | (Presentation)* *Deep Learning Toolbox – Matlab LINK* ***Deep Learning Assignment – Due: One week***
Decision Trees & Ensembles	
3 Classes	Decision Trees (Primary Source: Mitchell 1997) *Representation, Appropriate Problems* *Learning Algorithm, Hypothesis Space Search in Decision Tree Learning* Ensembles: Boosting, Bagging, Random Forests ***Decision Tree & Ensembles Assignment – Due: One week***
1 Class	**Final Exam**

Typical Analytics Project Life Cycle:

- **Problem Formulation for Business**
  - Identifying a clear business need aligned with the use of data and analytics for decision making
  - Define the overall business objective
  - Determine the major factors/issues at play
  - Define the problem scope
  - Determine key decisions and business drivers
- **Mapping Problem to Technical Solution Methodologies**
  - Understand the major analytics solution methodologies and their strengths and limitations
  - Develop a solution framework for the business problem
  - Ensure effectiveness and feasibility of the solution framework (consultation with business customer is key)
- **Data Capture, Cleansing, & Exploration**
  - Leverage both structured and unstructured data sources
  - Determine the overall quality of available data and means for addressing gaps
  - Organize and cleanse the data
  - Explore the data and identify critical model features (feature engineering)
- **Modeling & Analysis**
  - Develop the proposed solution framework
- **Validation**
  - Understand basic validation techniques
  - Present preliminary results to business customer
  - Refine the models to address any short comings
- **Implementation**
  - Develop an implementation plan
  - Communicate effectively
  - Execute
- **Monitoring & Feedback**
- **Sustainment**