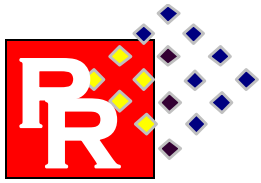
THEORY & APPLICATIONS / ADVANCED TOPICS IN PATTERN RECOGNITION (3)
ECE 455 / ECE 555
FALL 2007



Class Homepage: http://engineering.rowan.edu/~polikar/CLASSES/ECE555

Instructor:	Robi Polikar
Office& Phone:	136 Rowan, 256-5372 (voice-mail available)
Office Hours:	Open door policy – You are welcome in anytime when the door is open.
E-mail:	polikar@rowan.edu
Class Meeting:	Tuesdays & Thursdays 15:45 – 17:00 at Rowan 239
Required Text:	1. Pattern Recognition & Machine Learning, Bishop, Springer, 2006
	2. Introduction to Machine Learning, Alpaydin, MIT Press, 2004.
Reference Texts:	1. Learning from Data 2/e, V. Cherkassky, F. Mulier, Wiley, 2007.
	2. Combining Pattern Classifiers: Methods & Algorithms, L.I. Kuncheva, Wiley, 2004.
	3. Pattern Classification 2/e, Duda / Hart / Stoke, John Wiley & Sons, 2001.
	4. Pattern Recognition 2/e, Theodoridis / Koutroumbas, Academic Press, 2003.
	5. Statistical Pattern Recognition 2/e, Webb, Wiley, 2002.

ABOUT THIS CLASS & OBJECTIVES

Pattern recognition deals with automated classification, identification, and / or characterizations of unknown systems. Virtually unlimited number of applications benefits from pattern recognition techniques. Although it employs elegant and sophisticated mathematical and statistical analysis techniques, pattern recognition is nevertheless a very application driven field. Identification of pathological disorders from various biological indicators, hand written character recognition, finger print analysis, face recognition, iris scan based recognition, financial data predictions, or automated determination of whether one should get a credit card based on his/her past credit history are just a few of such applications that call for pattern recognition techniques.
This class has three main goals:

1. To equip you with basic mathematical and statistical techniques commonly used in pattern recognition. Achieving this objective will not only help you understand, compare and contrast various pattern recognition techniques that will be discussed in this class, but also provide you with an adequate background on probability theory, statistics, and optimization theory to tackle a wide spectrum of engineering problems.
2. To introduce you to a variety of pattern recognition algorithms, along with pointers on which algorithms work best under what conditions, so that you can make sound decisions on what approaches to take when faced with a real world problem. In order to best prepare you for such real world problems, we will routinely use such real-world problems in this class.
3. To provide a detailed overview of some advanced topics in pattern recognition in particular those that involve the ensemble of classifiers approach. This is a recent and rapidly growing development in pattern recognition and computational intelligence. Our coverage and your project work on this topic will provide you many of the skills you will need to be able to conduct independent research on a new topic area and in successfully completing your graduate degree.

There will be a set of objectives for each topic we discuss guiding you towards achieving the goals of this class. Described in considerable detail, they will tell you exactly what I think you should be able to do if you understand the concepts. My expectations of you will therefore be limited to these objectives. All student performance evaluation modalities that will be used in this course (homeworks, exams, projects) will be geared towards testing whether you have achieved these course objectives.

Upon successful completion of this class, you will be able to analyze a given pattern recognition problem, and determine which algorithm to use. You will also be able to modify existing algorithms to engineer new algorithms to solve a particular problem at hand. In the mean time, you will gain a working knowledge of one of the most recent developments in pattern recognition: using ensemble systems for automated decision making.

ATTENDANCE POLICY & ESTIMATED AMOUNT OF WORK

Attendance is absolutely necessary for success in this class, and therefore it is required. Since this is a senior / graduate level class, I am going to take random attendances instead of regular ones, and will consider them in assigning final grades. Everyone gets one – and only one – unexcused absence. This should be used wisely, and only for extenuating circumstances, because, after that, all unexcused absences will work against you. For anticipated future events during which you will be absent, you can request to be excused –up to two times during the semester – if and only if such a request is made 24 hours in advance of the class meeting time. You may only sign the attendance sheet if you are present during the first 10 minutes of the class. Tardiness beyond 10 minutes is counted towards your excused absences. You are responsible for any missed material, and given the pace and level of this course, even a single missed lecture will be difficult to catch up. **So don't miss class!**

Note that pattern recognition is a fast-paced, mathematically and computationally intensive graduate level course. You will be learning a substantial amount of cutting edge material, and you will be writing simulation programs to test them. Expertise (not just familiarity) with Matlab or some other programming language is required. Because this is a graduate level course, you will also be expected to do a substantial amount of reading – not only from the text but also from scientific magazines and journals. Successful completion of this course will demand significant amount of time commitment from you, a good portion of which may be spent on reading. As a rule of thumb, **expect to spend three - four hours for each hour we spend in class, i.e. 9 – 12 hours a week** on top of class meetings. It is safe to assume that you will spend more time on this class than you did on DSP. Please budget your time accordingly.

Pattern Recognition is a challenging, yet intellectually very rewarding course! I therefore assume that you are in this class because you are truly interested in Pattern Recognition. You should not be in this course if you signed up for it for any other reason than enthusiastic and genuine interest in learning the contents of this course.

CLASS MECHANICS

This class will meet twice a week, for 75 minutes each, of actual meeting time every week. We will have regularly scheduled homework assignments, "Did you read the book? " quizzes – given during the first five minutes of the class, "Were you paying attention" quizzes given at the end of the class, one or two midterms (which will include take sections) and a final project. There will not be a final exam. The details for these are provided below.

TEAM POLICY FOR CLASS RELATED WORK

You are not only allowed, but in fact encouraged to work in teams (usually of no more than two) for most class related work, including homework assignments – except take home exams / quizzes. Whether you can use a team for the final project will depend on the complexity of the project. You are free to form / deform as many teams as you wish during the semester for all homework assignments. As long as all team members contribute equally and their names appear on the homework assignments, one can be submitted by each team. Team members may inform me – under the condition of anonymity – of other team members who are not equally cooperating or participating in team effort.

HOMEWORK ASSIGNMENTS

There will be regular homework / lab assignments, typically in the form implementing algorithms, that will challenge you, however, you will realize that you learn a lot from these assignments. As an added bonus, you will notice that your analytical thinking, problem solving will also improve significantly, not to mention your math skills. You will also find out – much to your pleasant surprise – that the skills you developed in DSP will be of great benefit in implementing algorithms and completing these homeworks. Assignments must be neatly and professionally prepared. All homework assignments will be due one week from the day they are assigned, unless indicated otherwise.

Late Policy: Late submissions will not be accepted.

READING ASSIGNMENTS, "DID YOU READ THE BOOK" AND "WERE YOU PAYING ATTENTION" QUIZZES

As in most graduate level courses, you will be asked to read certain portions of the course material on your own. Homework questions will, and exam questions may be drawn from such portions. In order to get you in habit of reading, there will be weekly reading assignments, from which there may be occasional quizzes. If and when given, the quizzes will last no more than 10 minutes, and will simply test whether you read the material. There may also be quizzes at the end of a lecture, purely on that lecture's topics. These questions will simply test whether you were paying reasonable attention to the lecture material. Neither type of quizzes will test your detailed comprehension, nor mathematical problem solving skills.

COURSE PROJECT

A final project to help you put all course-developed skills to work will be assigned. You may choose from one of the three options below:

Graduate Students: (Undergraduate students get 15% bonus for selecting this option)

Develop a new technique, either from scratch, or by suitably modifying an existing technique for a specific problem; test it on at least four standard benchmark databases available at the UCI Machine Learning Repository. (http://www.ics.uci.edu/~mlearn/MLSummary.html)

Undergraduate Students:

Identify a new pattern recognition algorithm not covered in class - that is relevant to class material – from a recent journal article (>2005). Implement the algorithm and evaluate it on at least 5 datasets from the UCI Repository and two real world datasets that are of general interest.

All students:

Suggest your own project topic. Must be pre-approved by the instructor.

Furthermore, a paper submission (possibly after semester ends) to a conference is required for all graduate students to get an A from this course. Many pattern recognition related conferences have deadlines after the semester ends. Therefore, a letter of intent to submit, and a draft version of the paper – in the appropriate conference required format - that shows justifiable progress on the final project that would warrant a reasonable chance of acceptance will be sufficient for this purpose. Acceptance of your paper to the conference is not a condition for the "A," just the submission. If your paper is accepted, financial assistance will be available to cover – at least a part of – the travel and attendance costs, provided by the instructor and/or the department. Here are some conferences that are either directly on pattern recognition or accept a large number related application papers that have already published their submission deadlines:

Int. Conf. on Acoustic Speech and Signal Proc. – Las Vegas, NV, http://www.icassp2008.org/, Oct 5
International Conf. on Pattern Recognition – Tampa, FL, http://www.icpr2008.org/ April 8
World Congress on Computational Intelligence – Hong Kong, PRC http://www.wcci2008.org/ Dec 1
Int. Conf. on Computer Vision and Pattern Rec. – Anchorage, AK, http://vision.eecs.ucf.edu, Nov. 26
Int. Conf. on Fusion – Fusion 2006 – Florence, Italy, http://www.fusion2008.org, Feb 15
Int. Conf. on Circuits and Systems, Seattle, WA, http://www.iscas2008.org/, Oct 5.

Note that without a paper submission, the best attainable graduate grade is an B+.

CLASS ETHICS:

- No eating /drinking in class (except bottled water). Absolutely no dinner! Please time yourself accordingly.
- No cell phones in class (if you need to have a cell phone in class due to extenuating circumstances, please let me know ahead of time). A cell phone ringing during class will result in a difficult-to-repair damage to "professionalism" part to its owner's grade (see below). Furthermore, I reserve the right to answer any cell phone going off in the class.

- No web surfing, instant messaging and / or other unrelated use of computers, when we use computers in class / labs.
- In-class discussions are welcome, and in fact encouraged, within the limits of mutual respect and courtesy.
- You are responsible for checking the class web page often for announcements, homework / exam solutions.
- You are encouraged to work with other students for all exercises, except exams and quizzes.
- Although I do not anticipate, and certainly hope that will never be an issue, it is my responsibility to remind you that academic dishonesty will not be tolerated, and will be dealt with according to university rules and regulations.

PREREQUISITES

- Basic knowledge of probability, statistics and random variables
- Calculus III or Math for Engineering Analysis,
- Signals and systems / digital signal processing
- Expertise of MATLAB or C/C++
- Enthusiasm, genuine interest, and willingness to put forward extra effort
- Time, patience, perseverance

RECOMMENDED CO-REQUISITE

- Engineering Optimization class taught by Dr. Chandurapatla is an immensely relevant course that is offered at a most fortunate and timely semester. I highly recommend all students to take this course concurrently with Pattern Recognition. Engineering Optimization is offered on Tuesday evenings (once a week) at 5:30 PM.

GRADING SCALE

Since this is an upper level class, your grade will depend more on the homework assignments and the final project, rather than exams. An absolute grading scheme will be used to assess your final grade:

Midterm Exam:	20%
Homework:	25%
Project[1]:	35%
Quizzes:	10%
Professionalism:	10%

100-95:	A,	95-90:	A-		
89-87:	B+,	86-83:	B,	82-80:	B-
79-77:	C+,	76-73:	C,	72-70:	C-
69-67:	D+,	66-63:	D,	62-60:	D-
59-0:	F				

Professionalism includes good academic citizenship, professional conduct, and active class participation.

DISABILITY

If you have a documented physical and/or learning disability, please feel free to inform me or the Center for Academic Success – CAS (director, Ms. Melissa Cox – cox@rowan.edu, or 256-4260) regarding what kind of accommodation you need to help you succeed in this class. While you are not required to disclose your disability to me, you must provide appropriate documentation to the CAS to receive official university assistance. All such requests will be held confidential to the extend possible.

[1] 10% of project component will come from preparing an appropriately formatted and edited, near final version of the draft conference manuscript that is ready for submission.

TENTATIVE SCHEDULE

Week of		Material to be uncovered	Reading Assignment
Sept.	3	Introduction and motivation: What is in this course? Fundamentals of pattern recognition. Concepts, terminology, evaluation of algorithms	
	10	Bayes theory, normal density, discriminant analysis for normal density, error probability. The problem of density estimation.	
	17	Feature extraction and selection: Principal component analysis, Fisher discriminant analysis. Density estimation: Parzen windows, k nearest neighbor, Probabilistic neural networks	
	24	The perceptron model – multiplayer perceptron neural networks, gradient descent optimization	
Oct.	1	Kernel based approaches: Radial basis function neural networks, support vector machines	
	8	Other kernel based approaches, mixture of Gaussians, EM algorithm	
	15	**Midterm exam I (take home)** (Catch-up week if necessary) – Continue with kernel based approaches	
	22	Multiple Classifier Systems. Concept of diversity, ensemble creation algorithms I – Bagging, boosting and AdaBoost, Bias – variance dilemma	
	29	Ensemble creation algorithms II – Stacked generalization, Mixture of experts	
Nov.	5	Applications of ensemble systems I - Incremental learning (Learn++), confidence estimation, data fusion	
	12	Applications of ensemble systems II – Feature selection, missing feature, error correcting output codes, learning in nonstationary environments	
	19	**Midterm exam II (take home)** Unsupervised learning, clustering algorithms	
	26	Other advanced topics of interest	
Dec.	3	Other advanced topics of interest	
	10	Project presentations	
	17	Project presentations	

INSTRUCTOR EVALUATION, QUESTIONS, COMMENTS, SUGGESTIONS

Questions, constructive criticisms, comments, and suggestions are always welcome. Please feel free to share your opinions about all aspects of the class: content, math level, workload, instructor's communication skills (or lack thereof), etc. There will be a box outside of my office for anonymous comments. Feel free to use this box, if you wish to remain anonymous regarding your comments. Also, you may use the "I've got something to say" form, available at class homepage for your comments. A copy is attached to this syllabus. I will also give you a mid-semester evaluation form, so that you can have a formal opportunity to voice your concerns or appreciations (if any at all…).

Date: ___ / ___ / ***2007*** ***Course:*** *Adv. Topics in Pattern Rec.* ***I am*** _____ *(optional)*

I'VE GOT SOMETHING TO SAY!©

I am having difficulty in understanding the following concepts:

This week's class was informative / interesting / entertaining /_____ (circle all that apply) because:

This week's class was confusing / boring / too fast / too slow / _____ (circle all that apply) because:

It would have been much better / beneficial if you could…:

Please continue the following activities as I find them useful in_____

While you are at it, please provide your feedback on the following **on a scale of 1 – 5**,
1: Poor / Strong disagreement with the phrase, 5: Excellent / strongly agree with the phrase

1. The professor's ability to communicate in a clear and understandable manner: _____
2. The professor's responsiveness to student's needs, questions and ideas:_____
3. The professor treat students in a professional manner:_____
4. The professor is enthusiastic about the subject and genuinely believes in its importance:____
5. The professor's knowledge of the subject material is thorough:_____
6. The professor is well prepared for the classes:_____
7. The professor's ability to impart knowledge about the subject is:_____
8. The professor encourages questions and comments during the class session:_____
9. The professor's use of the class time is:_____
10. The professor actively involves students in the teaching / learning process:_____
11. The professor's availability outside of class hours is:_____
12. The professor satisfactorily answers students' questions in class and in the office:_____
13. Professor clarifies /repeats material that is difficult to understand:_____
14. Professor makes use of the latest technology to improve student's learning experience:_____
15. Lecture materials (e.g. slide) are helpful for the understanding of the subject material:_____
16. The professor is genuinely concerned that students take valuable experience from the class:_____
17. Considering everything, how would you rate this teacher: _____

What do you <u>not like about Dr. Polikar's teaching</u>, if any, and what would you suggest that he can do improve?

What do you <u>enjoy about Dr. Polikar's teaching</u>, if any, that he should continue in this and future classes?