EE 5650: Object and Pattern Recognition

Course Syllabus for Fall 2017

Abstract

This course will introduce the student to both fundamental and advanced aspects of object and pattern recognition, using specific applications to demonstrate these principles. The use of modern engineering tools such as MATLAB® is emphasized.

Contents

1 Instructor 2
2 Course Goals and Objectives 2
3 Course Prerequisites 2
4 Course Grading 3
4.1 Breakdown of Graded Events .......................... 3
4.2 Grading Scale ........................................ 3
4.3 Turn-In Policy ........................................ 3
4.4 Computer Project Grading Rubric .................... 5
5 Course Materials and Resources 6
5.1 Textbook .............................................. 6
5.2 Web Sites ............................................ 6
5.3 Software and Other Resources ........................ 6
6 Miscellaneous Course Policies 6
6.1 Collaboration Policy ................................... 6
6.2 Academic Honesty .................................... 6
6.3 Disability Statement .................................. 7
7 Course Overview 7
8 Course Topic Outline 8
References 9
1 Instructor

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2 Course Goals and Objectives

Goal: The goal of this course is for the students to understand the fundamentals of the field known as pattern classification (also called pattern recognition, object recognition, and similar names).

Objectives: Students will be able to:

- Understand the nature and inherent difficulties of the pattern classification problem.
- Understand the basics of how to manipulate data and select feature sets of that data to achieve a desired pattern classification result.
- Understand concepts such as trade-offs and appropriateness of classification techniques (e.g., Bayesian, maximum-likelihood, principal components, nonparametric, linear discriminant, multi-layer neural networks, etc.).
- Understand that more advanced techniques are also available such as algorithm-independent machine learning, unsupervised learning, and clustering.
- Demonstrate the insight and judgment needed to choose an appropriate pattern classification technique to achieve a desired result.
- Demonstrate the programming skills to correctly implement the chosen pattern classification algorithm in MATLAB®, along with the ability to properly interpret the program results.
- Demonstrate the ability to communicate technical topics clearly, concisely, and with proper grammar.

3 Course Prerequisites

The student must have satisfactorily completed EE 4220 or the equivalent course at another university. If you are in this course without the appropriate prerequisites, you will be administratively dropped. This may happen immediately, but it can occur at any time during the semester if you are found to not have the prerequisites. This is a College-wide policy regarding prerequisites.

The student is expected to be reasonably comfortable with certain foundational topics such as linear algebra, probability and statistics, computational complexity, and programming in MATLAB. If the student feels “rusty” in any of these areas, it would be helpful
to review such material on your own *early* in the semester. Note that your text has an excellent appendix which reviews most of these topics.

4 Course Grading

4.1 Breakdown of Graded Events

Graded material is given the following weights. Note: The Final Exam is scheduled by the Registrar from 10:15 AM to 12:15 PM on Wednesday, December 13, 2017. The decision of whether to have a Final Exam or a Final Report will be made during the semester, with input from the students in the course.

<table>
<thead>
<tr>
<th>Weight</th>
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<tbody>
<tr>
<td>Exam 1</td>
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<tr>
<td>Exam 2</td>
</tr>
<tr>
<td>Final Exam or Report</td>
</tr>
<tr>
<td>Quizzes</td>
</tr>
<tr>
<td>Computer Projects</td>
</tr>
<tr>
<td>Homework/In-class exercises</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

Unless arranged for *ahead of time* by the student with the instructor, it is not possible to make up a missed exam or quiz without an Authorized Absence (available from the Dean of Students Office). This policy, in accordance with University Regulation 6-713, is strictly observed.

4.2 Grading Scale

The course will be graded on the following scale, where the student’s overall average in the course, as a percentage, is represented by $x$.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Average (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$90 \leq x \leq 100$</td>
</tr>
<tr>
<td>B</td>
<td>$80 \leq x &lt; 90$</td>
</tr>
<tr>
<td>C</td>
<td>$70 \leq x &lt; 80$</td>
</tr>
<tr>
<td>D</td>
<td>$60 \leq x &lt; 70$</td>
</tr>
<tr>
<td>F</td>
<td>$0 \leq x &lt; 60$</td>
</tr>
</tbody>
</table>

4.3 Turn-In Policy

All homework assignments and computer project assignments are due NLT 1600L (that’s 4:00 PM local time) on their respective due dates. Note that a homework assignment may include one or more computer exercises, which do *not* require a project-style write-up. A computer project is an assignment that *does* require a write-up (see below). The
number of homework assignments compared to computer projects (and the associated write-ups) will be determined as the course progresses. Note that the distinction between a regular homework problem and a computer exercise is blurry; many (if not most) homework problems are more easily solved with numerical analysis software such as MATLAB.

The recommended format for a typical homework assignment is the standard engineering format (engineering paper; Given, Required, Solution, Answer). Plots from MATLAB may be turned in on normal printer paper, but should be clearly labeled with the student’s name, assignment and problem number, and so forth.

The format for computer project reports is given on the course website (in the Admin section). You must strictly follow this format to avoid needlessly losing points. A note on software implementation for the computer projects: the student is not allowed to use any program from any of the MATLAB Toolboxes, or any other pre-written MATLAB software. Many, many past students would agree that writing the code yourself is the best way to understand the pattern recognition and classification algorithms.

The required turn-in method for a computer project is electronic (as e-mail attachments) and should include both your report (in PDF format only) and any original MATLAB software you created for the project. Pay attention to any required naming conventions for your files that are listed in the project assignment instructions.

Late turn-ins will not be accepted unless an extraordinary situation exists. Unforeseen computer, e-mail, or printer problems do not constitute an extraordinary situation—so plan ahead! Computer projects and homework almost always take longer than you expect...

How will your computer projects be scored? See the rubric on the next page to find out...
# 4.4 Computer Project Grading Rubric

The following rubric will be used to score the regular computer projects. Students who read the rubric *before* starting the first project consistently score better than their peers who don’t bother to read the rubric. Note: a typical “pretty good” project turn-in will only score about 70% according to this rubric. It will take real effort to get into the “A” range on the projects.

<table>
<thead>
<tr>
<th>Score</th>
<th>10 - Excellent</th>
<th>7 - Average</th>
<th>4 - Minimal</th>
<th>0 - Unsatisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Results</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correctness</td>
<td>The project results are completely correct.</td>
<td>The project results are mostly correct.</td>
<td>The project results are incorrect in a few areas.</td>
<td>The project results are incorrect in multiple areas.</td>
</tr>
<tr>
<td>Completeness</td>
<td>All parts of the results are present and well presented.</td>
<td>All parts of the results are present but are not well presented (e.g., poor or missing figures or tables).</td>
<td>Minor parts of results are missing.</td>
<td>Major parts of results are missing.</td>
</tr>
<tr>
<td>Interpretation</td>
<td>Interpretation of results is excellent and provides an appropriate level of critical insight.</td>
<td>Interpretation of results is adequate and provides a moderate level of critical insight.</td>
<td>Interpretation of results is minimal or lacking critical insight.</td>
<td>Little or no interpretation of results.</td>
</tr>
<tr>
<td><strong>Method</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Algorism</td>
<td>Application of algorithms shows originality and thoughtful application, with no coding errors.</td>
<td>Application of algorithms is appropriate, with no coding errors.</td>
<td>Application of algorithms is basic, and may have minor coding errors.</td>
<td>Incorrect algorithms or errors in code.</td>
</tr>
<tr>
<td>Efficiency</td>
<td>Code shows sophisticated and/or original techniques to maximize efficiency.</td>
<td>Code shows a significant attempt to use efficient techniques.</td>
<td>Code shows a moderate attempt to use efficient techniques.</td>
<td>Code shows little or no attempt to use efficient techniques.</td>
</tr>
<tr>
<td>Clarity</td>
<td>Code includes very helpful comments and is logically organized.</td>
<td>Code is adequately commented and is logically organized.</td>
<td>Code is poorly commented and is disorganized.</td>
<td>Use of obfuscated, poorly designed code.</td>
</tr>
<tr>
<td><strong>Report</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content</td>
<td>The content is very well formulated, shows impressive insight or originality, and is very well organized.</td>
<td>The content is well formulated, somewhat insightful, and is well organized.</td>
<td>The content is only moderately insightful and not well organized.</td>
<td>The content is minimal, missing information, and/or is poorly organized.</td>
</tr>
<tr>
<td>Style</td>
<td>The paper is clear, concise, and consistent. It is easily understandable and a pleasure to read.</td>
<td>The paper is understandable but could be improved.</td>
<td>Multiple sections of the paper are difficult to read/understand.</td>
<td>The entire paper is difficult to read/understand.</td>
</tr>
<tr>
<td>Mechanics</td>
<td>The writing is near perfect with almost no grammar or spelling errors.</td>
<td>Minor grammar or spelling errors are present, but are not too distracting. Content is clear.</td>
<td>Some grammar or spelling errors are significant and detract from the meaning. Requires closer editing.</td>
<td>Pervasive grammar or spelling errors distort meaning and make reading difficult.</td>
</tr>
<tr>
<td>Formatting</td>
<td>Required formatting guidelines are correctly followed.</td>
<td>There are minor formatting errors present in the paper.</td>
<td>There are major formatting errors present in the paper.</td>
<td>Required formatting guidelines are not being followed.</td>
</tr>
</tbody>
</table>

**Total:** 0.00 out of a possible 100 points maximum

Qualitative points (max of 10)

0.00 Final score
5 Course Materials and Resources

5.1 Textbook
The primary textbook used for this course, by R. O. Duda, P. E. Hart, and D. G. Stork, is listed as [1] in the reference section of this syllabus. You will use the book extensively in this course. For some topics, handouts may also be used.

5.2 Web Sites
We will make use of the course web site hosted under the WyoCourses system. It is a secure web host for UW students, and you will need to log in with your normal UW student account details. We will mainly use just the “Files” area of the website. A copy of this syllabus, lecture slides, assignments, and other supplemental material will be posted to this web site. You are responsible for checking it regularly. Files will be organized using easy-to-understand subdirectory and file names.

5.3 Software and Other Resources
Each student must become familiar with the following software:

- MATLAB, version 7 (or higher), The MathWorks, Inc.

This software is available in the ESIG Labs (EN 1034, 1039 and 1041) and in the ECE Department Computer Lab (EN 5038). Note that there are significant price reductions on MATLAB and its Toolboxes for student purchasers if you wish to work at home.

6 Miscellaneous Course Policies

6.1 Collaboration Policy
For homework and computer projects, you may work with other students currently enrolled in the course. You must, however, document any help you receive; e.g., as comments directly in the source code of your program, in the References section of your project report, or on your homework turn-in. No comments mean you are submitting the item as totally your own work; my assumption will always be that you are an honorable person unless you cause me to believe otherwise. Simply copying another person’s assignment is not allowed—the actual item you turn in must ultimately be your own work. You may be called upon to explain to me in person and in detail how certain answers were derived or how your software works. Quizzes and exams must always be the student’s own work.

6.2 Academic Honesty
“The University of Wyoming is built upon a strong foundation of integrity, respect and trust. All members of the University community have a responsibility to be honest and have the right to expect honesty from others. Any form of academic dishonesty is unacceptable
to our community and will not be tolerated.” [excerpted from the UW General Bulletin]
All persons should report suspected violations of standards of academic honesty to the
instructor, department head, or dean. See UW Regulation 6-802, “Procedures and Author-
ized University Actions in Cases of Student Academic Dishonesty.” You can read this and
all other University regulations at: http://www.uwyo.edu/generalcounsel/index.html

6.3 Disability Statement

If you have a physical, learning, sensory, or psychological disability and require accommo-
dations, please let the instructor know as soon as possible. You must register with, and
provide documentation of your disability to, Disability Support Services (DSS) located in
room 109 of Knight Hall. You may also contact DSS at (307) 766-3073 or udss@uwyo.edu.
Visit their website for more information: www.uwyo.edu/udss.

7 Course Overview

Welcome to Object and Pattern Recognition! This course will prepare you to deal com-
petently with various pattern (or object) recognition challenges that may confront you in
the future. This subject crops up in many engineering situations. For example, charac-
ter recognition for document scanners, product inspection of automated assembly lines,
biometric identification (based on voice, face, retina, fingerprints, etc.) for security check-
points, and automatic target recognition for missile guidance systems are a few of the
obvious applications of pattern recognition.

But the field is far more pervasive than that. Any time a particular pattern in any
kind of signal or image needs to be detected, recognized, and then some action or decision
taken, the basics of pattern classification are being applied. For example, suppose you’re
out for a drive. The anti-lock brakes on your car or truck are dependent on the embedded
microcontroller detecting the pattern of the signals provided by the wheel rotation sensors
and frame accelerometers that together are classified as “skid is imminent,” and then taking
the action of adjusting the braking to the appropriate wheels to avoid the skid before it
occurs. As you drive along, pressure sensors embedded in some roads provide signals to
the associated traffic lights that classify patterns of traffic flow and adjust the timing and
duration of red lights, turn arrows, etc. If you take a moment, you can probably come up
with many more situations in everyday life where pattern classification is being applied.
Thus, while the field often goes by different names, the topics covered by this course are
broadly applicable to many subfields of engineering.

But despite its wide application, the field is still in its infancy. Pattern recognition
is a very difficult problem that has resisted a general, robust solution over the several
decades it has been studied. For example, a human child of around three years old can
recognize numbers and letters despite almost any variation of color, background, lighting,
size, or rotation. The most powerful computers in the world still cannot match this feat!
So there is plenty more work for researchers to contribute to this field. Keep in mind
that an understanding of pattern recognition that will be useful to engineers requires a
quantitative, mathematical approach—so be prepared for that. However, the emphasis in
this course is on fundamental principles and practical applications, rather than esoteric theory or arcane derivations.

Just like with anything worthwhile in life, if you aren’t willing to put in the time, you won’t ever get good at it. Be prepared to devote considerable time to this class. I promise to be sensitive to the time requirements of every assignment I give you, but you have to put forth the effort. As Robert E. Heinlein was known to say, “TANSTAFL.”

Some recommendations for success in this class which you might want to consider...

Don’t miss class. New material is covered each lecture. If you miss class, you are responsible for covering the missed material on your own. Repeat lectures will not be given during office hours.

Read in advance. Based upon the topics we’re covering or are about to cover, use the table of contents and/or index of your text (and any supplementary references you use) to read about these topics in advance.

Start computer projects/homework early. Give yourself some time to consider the problem and determine whether or not you need instructor assistance. Last-minute questions are a bad idea.

Do your best on the computer projects and homework. Together they comprise 40% of your grade!

Ask questions. This includes during class, during discussions, and during office hours. I don’t like a silent class—feel free to ask questions or make reasonable comments at will (but no distracting side conversations).

Don’t arrive late for class. If you know you’ll be delayed (or absent) for some reason, just let me know ahead of time in person or via e-mail. It’s the courteous and adult thing to do.

Let’s have fun in this class! I like lively, attentive, alert students with an active sense of humor. It’s more fun that way for all of us...

8 Course Topic Outline

Basically, we’ll cover Chapters 1–6 in detail, and if time permits we may discuss parts of Chapters 8–10. The speed and depth of coverage will depend to some degree upon the students, but remember: this is a graduate-level class. That means a much greater amount of independent reading and work outside of class is expected of you than for an undergraduate class.

- Introduction to Pattern Classification (Chap. 1)
- Bayesian Decision Theory (Chap. 2)
- Maximum Likelihood and Bayesian Parameter Estimation (Chap. 3)
• Nonparametric Pattern Classification Techniques (Chap. 4)
• Pattern Classification using Linear Discriminant Functions (Chap. 5)
• Pattern Classification using Neural Networks (Chap. 6)
• Further discussions

There are thousands of references on this subject. A short sampling is listed next.

References


...one more page to the end...
Finally . . .

Congratulations on reading this far! Lesser mortals gave up several pages earlier. As a reward, perhaps these quotes will inspire you in a positive manner . . .

*Any fool can know. The point is to understand.*
— Albert Einstein

*It is difficult to say what is impossible, for the dream of yesterday is the hope of today and the reality of tomorrow.*
— Robert H. Goddard

*They never said it would be easy, but they never said it’d be this hard. They never said it would be easy, but I never thought we’d come this far.*
— Sheryl Crow

*To study, and when the occasion arises to put what one has learned into practice—is that not deeply satisfying?*
— Confucius

*That which does not kill us makes us stronger.*
— Friedrich Nietzsche