ISTA 421 (undergraduate) and INFO 521 (graduate)
Introduction to Machine Learning
Fall 2017

Course Description:
Machine learning describes the development of algorithms whose parameters can be adjusted (i.e., *learned*) based on data in order to recognize patterns and make decisions. This course will introduce the fundamentals of modern machine learning. We will describe how to implement several practical methods for pattern recognition (regression and classification), clustering, and dimensionality reduction, as well as methods for training and evaluating learned models.

Prerequisites:
Calculus I (derivatives) and II (integrals), linear algebra;
Programing experience (the primary language used in the course is python);
Introductory statistics or probability (ISTA 311 recommended; ISTA 116 or comparable is sufficient).

Units: 3

Course Location and Times:
Aero & Mech Engr, Room S324
Monday and Wednesday, 5:00 PM to 6:15 PM

Instructor Information:
Clayton T. Morrison, PhD
Associate Professor
School of Information
Office: Harvill 437A
Office Phone: 520-621-6609
Email: claytonm@email.arizona.edu
Office Hours: Contact by email to set up an appointment

Course Objectives:
The objective of this course is to introduce the core methods used in modern machine learning, and gain experience implementing these methods as algorithms in a programming language (python) and use and evaluated them on data.

Textbooks:

• Simon Rogers and Mark Girolami (2016). *A First Course in Machine Learning, Second Edition*. Chapman & Hall / CRC Press.
(First edition is available online for free through the UA Library. However, be aware that the second edition include three additional chapters that we will reference in this course.)

Some additional readings will be provide in class and through the D2L website.

We may also reference some material from the following, available for free online:
• Gareth James, Daniela Witten, Trevor Hastie and Robert Tibshirani (2013). *Introduction to Statistical Learning, with Applications in R*. Springer. Available online for free: http://www-bcf.usc.edu/~gareth/ISL/
• Trevor Hastie, Robert Tibshirani and Jerome Friedman (2009). *The Elements of Statistical Learning: Data Mining, Inference, and Prediction* (Second Edition). (online: http://www-stat.stanford.edu/~tibs/ElemStatLearn/download.html)

Other resources, recommended but not required for this course:
• Y. S. Abu-Mostafa, M. Magdon-Ismail and H.-T. Lin. (2012). *Learning from Data*. AMLBook. [Very good introductory book with more of a focus on learning theory.]
• David Barber (2012), *Bayesian Reasoning and Machine Learning*. [Available for free online: http://www.cs.ucl.ac.uk/staff/d.barber/brml/]
• Kevin P. Murphy (2012). *Machine Learning: A Probabilistic Perspective*. The MIT Press. [Very comprehensive, a good reference; but beware of numerous errors in the first four printings – read with the errata handy (available from Kevin's book site: http://www.cs.ubc.ca/~murphyk/MLbook/).]
• Christopher Bishop (2006). *Pattern Recognition and Machine Learning.* Springer. [More advanced, Bayesian perspective.]

Grade policies:

Grade categories and proportions:
Grading will be based on programming exercises and written assignments (Assignments), one in-class midterm (Midterm) and a final assignment (Final Assignment). **Points** will be assigned to each according to the amount of effort expected. Graduate students will receive additional and alternate problems, and therefore need to earn more points total for many of the assignments; this reflects the expected higher level of competency and preparation of graduate students.

The total points in each category are scaled to contribute to the final **cumulative grade percentage** value according to the following distribution (the same distribution scaling is used for both undergraduates or graduates):

Assignments: 75%
(Written Homework & Programming Exercises, assigned approximately every other week.)
Midterm: 10%
Final Assignment: 15%

Letter grades are then assigned according to the final cumulative grade percentage:

A: 90% ≤ cumulative grade
B: 80% ≤ cumulative grade < 90%
C: 70% ≤ cumulative grade < 80%
D: 60% ≤ cumulative grade < 70%

Late Work Policy:
Assignments are due as assigned.
No examinations may be taken after the examination date.
Assignments will generally be turned in as PDF documents and code to the appropriate course D2L drop box folder.
In case of emergencies affecting turning work in on time, you ***must*** contact the instructor *immediately*.

Classroom Behavior:
Please be considerate: Please disable your cellphone/pager ringer. If you get an urgent call, please quietly leave the lecture hall to conduct it. Screens are distracting! If you want to use a laptop or tablet for taking notes, please sit toward the side of the class in order to not disrupt other students.
Asking Questions: During class, feel free to interrupt with questions whenever they occur to you. The instructor may ask you to hold off on your question for a few moments.
Answering Questions: We frequently ask questions of the class during lectures to judge the level of understanding (and to break up the monotony). Some students really like answering questions, sometimes to the point of discouraging anyone else from answering. If you are an eager answerer, pace yourself; let someone else answer an easy one once in a while, and save the hard ones for yourself.

Planned Topics (subject to revision)

- Introduction
- The Linear Model
  - Linear Regression and Linear Least Mean Squares
  - Linear classification and the Perceptron
  - Extending the Linear Model
- Learning theory
  - Evaluation
  - Cross Validation
- Probabilistic methods
  - Review of Probability
  - Maximum Likelihood
  - The Bayesian approach
    - Priors, Marginal Likelihood, Hyperparameters
- Optimization and Approximation Methods
  - Gradient methods (gradient descent, Newton's method)
  - Laplace estimation
  - Sampling
- Classification
  - Logistic Regression
  - Bayesian Classification, Naive Bayes
  - Nearest Neighbors
  - Support Vector Machines
- Neural Networks
  - Perceptron, Backpropagation
  - Autoencoders
  - "Deep" architectures
- Clustering
  - K-means
  - Mixture Models
  - Expectation Maximization
- Projection Methods
  - Principal Components Analysis
  - Latent Variable Models
- Additional Topics (depending on time and interest)
  - Nonparametric Bayesian methods
    - Gaussian Processes
    - Topic Modeling
  - Boosting

UNIVERSITY POLICIES

Honors Credit:
Students wishing to contract this course for Honors Credit should email me to set up an appointment to discuss the terms of the contact and to sign the Honors Course Contract Request Form.
The Honors College website: https://www.honors.arizona.edu/

Missed Classes (Absence):
The UA's policy concerning Class Attendance and Administrative Drops is available at: http://catalog.arizona.edu/policy/class-attendance-participation-and-administrative-drop

All holidays or special events observed by organized religions will be honored for those students who show affiliation with such religions. Absences pre-approved by the UA Dean of Students office will be honored. See:
http://policy.arizona.edu/human-resources/religious-accommodation-policy

No matter the reason for missing class, the student is *always* responsible for any missed material.

Final Exams:
Final Exam Regulations and Information:
http://registrar.arizona.edu/courses/final-examination-regulations-and-information?audience=students&cat1=10&cat2=31

Final Exam Schedule:
http://www.registrar.arizona.edu/students/courses/final-exams

Audit Policy:
http://catalog.arizona.edu/policy/audit-policy

Accessibility and Accommodations:
At the University of Arizona we strive to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability or pregnancy, you are welcome to let me know so that we can discuss options. You are also encouraged to contact Disability Resources (520-621-3268) to explore reasonable accommodation.

If our class meets at a campus location: Please be aware that the accessible table and chairs in this room should remain available for students who find that standard classroom seating is not usable.

Disability Resource Center. 1221 E. Lowell St. Tucson, Az 85721 Tel: 520-621-3268 (TTY). Fax: 520-621-9423. uadrc@email.arizona.edu

UA SALT Center: http://www.salt.arizona.edu

Student Code of Academic Integrity (a.k.a., Cheating):
Students are encouraged to share intellectual views and discuss freely the principles and applications of course materials. However, graded work/exercises must be the product of independent effort unless otherwise instructed. Students are expected to adhere to the UA Code of Academic Integrity as described in the UA General Catalog. See:
http://deanofstudents.arizona.edu/policies-and-codes/code-academic-integrity

The University Libraries have some excellent tips for avoiding plagiarism available at: http://new.library.arizona.edu/research/citing/plagiarism

*Selling class notes and/or other course materials to other students or to a third party for resale is **not permitted** without the instructor's express written consent*. Violations to this and other course rules are subject to the Code of Academic Integrity and may result in course sanctions. Additionally, students who use D2L or UA email to sell or buy these copyrighted materials are subject to Code of Conduct Violations for misuse of student email addresses. This conduct may also constitute copyright infringement.

Additional Information on conduct:

The Arizona Board of Regents list of Prohibited Conduct (pdf):
https://public.azregents.edu/Policy%20Manual/5-303-Prohibited%20Conduct.pdf

The Arizona Board of Regents Student Code of Conduct (pdf):
https://public.azregents.edu/Policy%20Manual/5-308-Student%20Code%20of%20Conduct.pdf

Policies Against Threatening Behavior:
The Student Code of Conduct (5-308.F.11) dictates that no person or organization may interfere with or threaten University-sponsored classroom activities. The following link provides details about the policy:
http://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students

Non-Discrimination and Anti-Harassment Policy:
http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy

Statements of Inclusion:
Elective name and pronoun usage: This course supports elective gender pronoun use and self-identification; rosters indicating such choices will be updated throughout the semester, upon student request. As the course includes in-class discussion, it is vitally important for us to create an educational environment of inclusion and mutual respect.
Inclusive Excellence is a fundamental part of the University of Arizona's strategic plan and culture. As part of this initiative, the institution embraces and practices diversity and inclusiveness. These values are expected, respected and welcomed in this course.

Office of Diversity: http://diversity.arizona.edu/
Health: https://www.health.arizona.edu/
Counseling: http://www.health.arizona.edu/counseling-and-psych-services

Additional Student Resources:
UA Academic policies and procedures are available at:
http://policy.arizona.edu/
UA Non-discrimination and Anti-harassment policy:
http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy
Student Assistance and Advocacy information is available at:
http://deanofstudents.arizona.edu/student-assistance/students/student-assistance

Confidentiality of Student Records:
http://registrar.arizona.edu/personal-information/family-educational-rights-and-privacy-act-1974-ferpa

Required or Special Materials: None.

Notice of Potentially Offensive Material: None.

Miscellaneous University Policies:

(1) On Dropping Classes:
If you find yourself thinking about dropping this (or any other) class, first make sure that that's what you really want to do. Chatting with the instructor or your academic advisor may help. If you drop within the first four weeks of the semester, there will be no notation on your transcript; it will be as though you'd never enrolled. During the fifth through the eighth weeks, a drop will be recorded on your transcript. You will receive a "WP" (withdrawn passing) only if you were passing the class at the time of your drop. After the eighth week, dropping becomes a challenge, because you need to explain to the instructor and to the dean why you were unable to drop the class during the first half of the semester.

(2) Grades of 'Incomplete':

Office of Curriculum and Registration Grading Policy Manual:
https://www.registrar.arizona.edu/grades/incomplete-i-grade
UA General Catalog's Grades and the Grading System:
http://catalog.arizona.edu/policy/grades-and-grading-system

The university's course catalog contains all of the details about incompletes, but here's the key sentence: "The grade of I may be awarded only at the end of a term, when all but a minor portion of the course work has been satisfactorily completed."

To qualify for an incomplete, a student must have maintained a passing grade for the class until the term is nearly complete, and then, due to an unusual and substantiated cause beyond the student's control, the student is unable to complete the class work. In short, you can't get an "I" just because you aren't happy with your grade

"Subject to Change" Statement:
The instructor reserves the right to change with advance notice where appropriate the content of the course. This right does not apply to the grade, absence or University policies.