Term	Class No.	Units	Days & Times	Room	Mode
Fall 2019	CS599-6 EE599-4	3	TuTh 11:10 - 12:25	SBS-Raul H. Castro, Rm 333	Face-to-face

Enrollment Requirements

Pre-requisites: linear algebra, calculus, programming experience.

Course Websites

http://bblearn.nau.edu
https://github.com/tdhock/cs599-fall2019

Instructor(s)

Dr. Toby Dylan Hocking
Email: Toby.Hocking@nau.edu
Office Hours: Tuesday and Wednesday, 3-4pm, 90-210 (SICCS building behind sprouts).

Course Purpose

This course covers advanced topics in machine learning, which is the domain of computer science concerned with algorithms that learn from experience, and adapt to patterns in large data sets. In contrast to other courses at NAU that emphasize basic theory and use of standard machine learning algorithms (e.g. INF504), the focus of this course is on recent papers from the machine learning literature. Students will learn how to read textual and mathematical descriptions of machine learning algorithms, then code the algorithms themselves, in order to reproduce results from the literature. A primary purpose is to get students ready for machine learning research projects.

Course Student Learning Outcomes

Upon successful completion of this course, students will be able to demonstrate the following competencies:

- **LO1**: Remember, Understand, and Explain the foundational concepts of machine learning, including optimization, regularization, and cross-validation.
- **LO2:** Analyze and critique research papers, as is done in peer review.
- **LO3**: Create pseudocode for machine learning algorithms, based on textual or mathematical descriptions of the algorithms.
- **LO4**: Create executable code that implements machine learning algorithms, based on algorithms described using pseudocode.
- **LO5**: Analyze real-world data sets using machine learning algorithms, and reproduce result figures from the literature.

Assignments / Assessments of Course Student Learning Outcomes

Learning outcomes are assessed through (1) homeworks which will be due the day before each class, (2) presentations of research papers and (3) independent coding projects. Homeworks and presentations assess student ability to describe and explain foundational concepts in machine learning (LO1) and to analyze/critique research papers (LO2). Paired coding projects assess student ability to create code for machine learning algorithms (LO3-4), and to reproduce results from the literature (LO5).

Grading System

A weighted sum of assessment components is used to determine your final grade in the course:

- Homeworks: **20**%
- Presentations: **20**%
- Class participation / attendance: **20**%
- Individual coding projects: **40**%

Grades will be assigned using the weighted sum described above using this scale:
A ≥ 90%, **B** ≥ 80%, **C** ≥ 70%, **D** ≥ 60%, **F** < 60%.

There is no "curve". Each student's grade is based on their own outcomes assessments and not affected by the grades of other students. Extra credit opportunities may present themselves throughout the semester and will be announced during class meetings. Mistakes in grading do happen, and students are encouraged to discuss such concerns with the instructor during office hours.

Readings and Materials

We will refer to one primary textbook in this class:

Elements of statistical learning by Hastie, Tibshirani, Friedman. Free PDF available on https://web.stanford.edu/~hastie/ElemStatLearn/ All data sets freely available in R package ElemStatLearn

Another textbook which would be acceptable for projects is *Machine Learning: A probabilistic perspective* by Kevin Murphy, who provides code to re-do all figures. However since the textbook code is available in MATLAB, you would have to code the figure / analysis in another language.

Students will also need access to a computer with internet access to download and read machine learning research papers.

Presentations

Each student will sign up to present two papers from a list provided on the course web site. Presentations must be 30 minutes (with 5 minutes for questions) and include detailed and specific descriptions of:

- problem setting and proposed solution
- theoretical and/or empirical contributions relative to previous work
- strengths and weaknesses of the paper
- ideas for future work

Presentations will be judged/graded on how completely they address the points above.

Homework

The goal is for each student to read each paper which will be presented in class BEFORE the class in which it will be presented. To enforce this goal, homework questions about the content of the next day's paper will be due on BBLearn the day before each class (Monday or Wednesday). Two times per semester (at mid-term and final) I will randomly select five of the homeworks to grade. For each student the lowest scoring homework will be dropped, i.e. only the top four out of the five graded homeworks will count toward the final grade.

Individual coding projects with input from a partner

There will be two individual coding projects: one due at the mid-term, another due at the end of the term. The aim of each coding project is to reproduce a result figure from the

machine learning literature. In each coding project there will be weekly milestones due Friday, and a 100 point grading rubric:

- Week 1: choose two possible papers/figures and write a PDF description (including pseudocode) of how to the original authors computed their results and created their figures. Include a copy of the original figure (with citation) and write at least one paragraph for each of: problem setting, data sources, algorithms studied (including baselines). 20 points.
- Week 2: present your two choices to your partner. Write an opinion about what you think your partner should choose. Write at least one paragraph for each choice, discussing the strengths/weaknesses of each. 10 points.
- Week 3: begin coding your implementation for your chosen figure, submit your preliminary code to a github repo. Include your PDF from week one. 10 points.
- Week 4: continue working on your figure, and code review your partner's github repo. Write suggestions in a PDF file and send it to me and your partner. 10 points.
- Week 5: your figure and code are due along with a report explaining exactly what you did (explain what happened if you were unable to exactly reproduce the figure) 30 points.
- Week 6: run your partner's code and write a report explaining whether or not you could reproduce your partner's results. 10 points for your report about your partner, 10 points if your code was reproducible by your partner.

For the first coding project (mid-term) it is recommended to choose two figures from Elements of Statistical Learning by Hastie et al (for which data sets are available). For the second coding project you need to choose two figures from the machine learning research papers presented in class. If the paper does not provide a detailed enough description of the data sets and algorithms used, you should email the authors to ask for more details; otherwise choose another paper.

Class Outline and Tentative Schedule

The tentative schedule (subject to change) includes lectures in the first two weeks of class, and then

		Tuesday		Thursday
Week 1	**Aug 27**	Applications of machine learning	**Aug 29**	Sample presentation and figure
Week 2	**Sep 3**	Data visualization with ggplot2 and data.table in R	**Sep 5**	Reproducibility
Week 3	**Sep 10**	Two presentations	**Sep 12**	One presentation
Week 4	**Sep 17**	Two presentations	**Sep 19**	**One presentation and workshop on project 1 week 1**
Week 5	**Sep 21**	Two presentations	**Sep 23**	**One presentation and workshop on project 1 week 2**
Week 6	**Sep 30**	etc	**Oct 1**	**project 1 week 3**
Week 7	**Oct 8**	etc	**Oct 10**	**project 1 week 4**
Week 8	**Oct 15**	etc	**Oct 17**	**project 1 week 5**
Week 9	**Oct 22**	etc	**Oct 24**	**project 1 week 6**
Week 10	**Oct 29**	etc	**Oct 31**	**project 2 week 1**
Week 11	**Nov 5**	etc	**Nov 7**	**project 2 week 2**
Week 12	**Nov 12**	etc	**Nov 14**	**project 2 week 3**
Week 13	**Nov 19**	etc	**Nov 21**	**project 2 week 4**
Week 14	**Nov 26**	Coding workshop	**Nov 28**	Thanksgiving
Week 15	**Dec 3**	Reading week	**Dec 5**	**project 2 week 5**
Week 16	**Dec 10**	NA	**Dec 12**	**project 2 week 6**

Course Policies

The following policies will apply to this course:

- Attendance is required and will be recorded at the end of the class.
- There will be no make-ups or late work accepted.
- There may be extra credit assignments given.
- **Cheating and plagiarism are strictly prohibited**. All work you submit for grading must be your own -- for the coding projects this means that you are not allowed to copy code that you found on the web, and submit that code as your own. The point of the coding projects is for you to take the time to learn how to code the machine learning algorithms and reproduce result figures from scratch. It is OK to discuss intellectual aspects with other groups during the coding projects, but is it NOT OK to copy from other groups. During coding projects you will compare your code with other existing implementations, which is OK as long as you cite the source of the code that you used (which will typically be indicated in the assignment). All academic integrity violations are treated seriously. Academic integrity violations will result in penalties including, but not limited to, a zero on the assignment, a failing grade in the class, or expulsion from NAU.
- Electronic device usage must support learning in the class. All cell phones, PDAs, music players and other entertainment devices must be turned off (or in silent mode) during lecture, and may not be used at any time. Laptops or workstations (if present) are allowed for note-taking and activities only during lectures; no web surfing or other use is allowed. I devote 100% of my attention to providing a high-quality lecture; please respect this by devoting 100% of your attention to listening and participating.
- Grades will be entered in BBLearn but your final grade will be calculated in Excel using the grading system described above and then entered in LOUIE. Your final course grade will **not** necessarily appear in BBLearn. Please check LOUIE for your final grade.
- Email to the instructor and teaching assistants must be respectful and professional. Specifically, all emails should:
    - Contain a salutation, (for example, “Dear Dr. Hocking” or “Dear Professor H”)
    - Contain a closing, (for example, “Best, Jane Doe”)
    - The body should contain complete sentences and correct grammar including correct usage of lowercase and uppercase letters. Composing emails on a mobile device is **not** an excuse for poor writing.

  - The body of your message should also be respectful and explain the full context of the query.
  - The subject should be prefixed with "CS/EE599" so that the message can be easily identified or placed in an auto-folder. The subject should also use lower case and upper case correctly.
  - Although email will typically be answered quickly, you should allow up to three (3) business days for a response.
  - If you have a question that would require a long response or you have a lot of questions, please come to office hours or schedule an appointment with the instructor.
- Visiting the instructor(s) during office hours is encouraged! I am happy to talk about the class, careers, research, and topics related (even loosely) to this course.
- Anonymous feedback via the "parking lot." I will distribute post-it notes at the end of class. Please write (1) the concept you most clearly understood during the lecture, and (2) the concept that you had the most difficulty understanding. I will use the feedback to adapt future lectures.
- The Academic Success Centers offer free tutoring and academic support to improve your study skills and review course material in a number of engineering and math courses. You can schedule an appointment by visiting nau.edu/asc, calling the Academic Success Center at 928-523-7391 or swinging by Dubois Center - room 140.

Appendix A. UNIVERSITY POLICY STATEMENTS

ACADEMIC INTEGRITY

NAU expects every student to firmly adhere to a strong ethical code of academic integrity in all their scholarly pursuits. The primary attributes of academic integrity are honesty, trustworthiness, fairness, and responsibility. As a student, you are expected to submit original work while giving proper credit to other people's ideas or contributions. Acting with academic integrity means completing your assignments independently while truthfully acknowledging all sources of information, or collaboration with others when appropriate. When you submit your work, you are implicitly declaring that the work is your own. Academic integrity is expected not only during formal coursework, but in all your relationships or interactions that are connected to the educational enterprise. All forms of academic deceit such as plagiarism, cheating, collusion, falsification or fabrication of results or records, permitting your work to be submitted by another, or inappropriately recycling your own work from one class to another, constitute academic misconduct that may result in serious disciplinary consequences. All students and faculty members are responsible for reporting suspected instances of academic misconduct. All students are encouraged to complete NAU's online academic integrity workshop available in the E-Learning Center and should review the full academic integrity policy available at https://policy.nau.edu/policy/policy.aspx?num=100601.

COURSE TIME COMMITMENT

Pursuant to Arizona Board of Regents guidance (Academic Credit Policy 2-224), for every unit of credit, a student should expect, on average, to do a minimum of three hours of work per week, including but not limited to class time, preparation, homework, and studying.

DISRUPTIVE BEHAVIOR

Membership in NAU's academic community entails a special obligation to maintain class environments that are conductive to learning, whether instruction is taking place in the classroom, a laboratory or clinical setting, during course-related fieldwork, or online. Students have the obligation to engage in the educational process in a manner that does not breach the peace, interfere with normal class activities, or violate the rights of others. Instructors have the authority and responsibility to address disruptive behavior that interferes with student learning, which can include the involuntary withdrawal of a student from a course with a grade of "W". For additional information, see NAU's

disruptive behavior policy at https://nau.edu/university-policy-library/disruptive-behavior.

NONDISCRIMINATION AND ANTI-HARASSMENT

NAU prohibits discrimination and harassment based on sex, gender, gender identity, race, color, age, national origin, religion, sexual orientation, disability, or veteran status. Due to potentially unethical consequences, certain consensual amorous or sexual relationships between faculty and students are also prohibited. The Equity and Access Office (EAO) responds to complaints regarding discrimination and harassment that fall under NAU's Safe Working and Learning Environment (SWALE) policy. EAO also assists with religious accommodations. For additional information about SWALE or to file a complaint, contact EAO located in Old Main (building 10), Room 113, PO Box 4083, Flagstaff, AZ 86011, or by phone at 928-523-3312 (TTY: 928-523-1006), fax at 928-523-9977, email at equityandaccess@nau.edu, or via the EAO website at https://nau.edu/equity-and-access.

TITLE IX

Title IX is the primary federal law that prohibits discrimination on the basis of sex or gender in educational programs or activities. Sex discrimination for this purpose includes sexual harassment, sexual assault or relationship violence, and stalking (including cyber-stalking). Title IX requires that universities appoint a "Title IX Coordinator" to monitor the institution's compliance with this important civil rights law. NAU's Title IX Coordinator is Pamela Heinonen, Director of the Equity and Access Office located in Old Main (building 10), Room 113, PO Box 4083, Flagstaff, AZ 86011. The Title IX Coordinator is available to meet with any student to discuss any Title IX issue or concern. You may contact the Title IX Coordinator by phone at 928-523-3312 (TTY: 928-523-1006), by fax at 928-523-9977, or by email at pamela.heinonen@nau.edu. In furtherance of its Title IX obligations, NAU will promptly investigate and equitably resolve all reports of sex or gender-based discrimination, harassment, or sexual misconduct and will eliminate any hostile environment as defined by law. Additional important information about Title IX and related student resources, including how to request immediate help or confidential support following an act of sexual violence, is available at http://nau.edu/equity-and-access/title-ix.

ACCESSIBILITY

Professional disability specialists are available at Disability Resources to facilitate a range of academic support services and accommodations for students with disabilities. If you have a documented disability, you can request assistance by contacting Disability

Resources at 928-523-8773 (voice), 928-523-6906 (TTY), 928-523-8747 (fax), or dr@nau.edu (e-mail). Once eligibility has been determined, students register with Disability Resources every semester to activate their approved accommodations. Although a student may request an accommodation at any time, it is best to initiate the application process at least four weeks before a student wishes to receive an accommodation. Students may begin the accommodation process by submitting a self-identification form online at https://nau.edu/disability-resources/student-eligibility-process or by contacting Disability Resources. The Director of Disability Resources, Jamie Axelrod, serves as NAU's Americans with Disabilities Act Coordinator and Section 504 Compliance Officer. He can be reached at jamie.axelrod@nau.edu.

RESPONSIBLE CONDUCT OF RESEARCH

Students who engage in research at NAU must receive appropriate Responsible Conduct of Research (RCR) training. This instruction is designed to help ensure proper awareness and application of well-established professional norms and ethical principles related to the performance of all scientific research activities. More information regarding RCR training is available at https://nau.edu/research/compliance/research-integrity.

SENSITIVE COURSE MATERIALS

University education aims to expand student understanding and awareness. Thus, it necessarily involves engagement with a wide range of information, ideas, and creative representations. In their college studies, students can expect to encounter and to critically appraise materials that may differ from and perhaps challenge familiar understandings, ideas, and beliefs. Students are encouraged to discuss these matters with faculty.

Updated 8/20/2018