Term	Class No.	Units	Days & Times	Room	Mode
Fall 2020	CS599-TODO	3	TODO	TODO	Face-to-face

Enrollment Requirements

Suggested/soft pre-requisites: linear algebra, calculus, some experience programming in a high-level language with vector/matrix data types and operations (e.g. MATLAB, R, Python numpy).

Course Websites

http://bblearn.nau.edu
https://github.com/tdhock/cs499-599-fall2020

Instructor(s)

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

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 supervised machine learning algorithms (for labeled data), the focus of this course is on unsupervised learning algorithms (for unlabeled data). Students will learn how to read textual and mathematical descriptions of machine learning algorithms, then code the algorithms themselves and/or use a reference implementation (e.g. R and Scikit-Learn). In CS599 students will also learn how to code R packages and compare their code with reference implementations in software packages such as.

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 such as optimization and regularization.
- **LO2:** Analyze the structure of a data set / problem, then propose an appropriate unsupervised machine learning algorithm.
- **LO3**: Understand and create pseudocode for explaining how unsupervied learning algorithms work.

- **LO4**: Analyze real-world data sets using reference implementations of unsupervised learning algorithms.
- **LO5**: Evaluate unsupervised learning algorithms in terms of optimization objective and prediction error, using tables and graphical displays/plots.

For graduate students only:

- **LO6:** Create executable code that implements unsupervised learning algorithms, based on pseudocode and textual/mathematical descriptions.
- **LO7:** Create R packages to distribute/document/test code that implements machine learning algorithms.
- **LO8:** Compare your implementation with a reference implementation.

Assignments / Assessments of Course Student Learning Outcomes

Daily attendance quizzes and midterm and final exams assess student ability to describe and explain foundational concepts in machine learning (LO1), to analyze problems and propose appropriate algorithms (LO2), and to create pseudocode from statistical models and optimization problems (LO3).

Individual homework coding projects assess student ability to analyze real-world data sets using reference implementations of unsupervised learning algorithms (LO4), to evaluate algorithms (LO5), to implement algorithms (LO6), to create R packages (LO7), and to compare implementations (LO8).

Grading System

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

- Mid-term exam: **10**%
- Final exam: **10**%
- Class participation quizzes: **10**%
- Individual homework coding projects: **70% (14 projects, 5% each)**

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

Regarding the theory, we will refer to two textbooks:

Machine learning: a probabilistic perspective by Murphy. Free e-book available from NAU library. http://ebookcentral.proquest.com/lib/nau-ebooks/reader.action?docID=3339490

Elements of statistical learning by Hastie, Tibshirani, Friedman. Free PDF available on https://web.stanford.edu/~hastie/ElemStatLearn/

Regarding details about how to implement algorithms in R packages: (graduate students only)

R packages by Wickham, http://r-pkgs.had.co.nz/

Class participation quizzes

During each class there will be an attendance quiz based on the content of the previous lecture/reading. It will be graded on a three point scale: 0=absent, 1=incorrect, 2=partially correct, 3=correct. No make-ups.

Individual coding homeworks

There will be several individual coding projects assigned as homework (see schedule below). In each coding project you are expected to write some code to implement and analyze machine learning algorithms. You will be required to submit a report with tables and/or graphical figures that analyze your algorithm. Grades will be based on the clarity and correctness of report (including figures), clarity and correctness of code.

Class Outline and Tentative Schedule

The tentative schedule (subject to change), with readings from the Deep Learning book.

		Tuesday		Thursday	Reading/Projects
Week 1	**Jan 14**	Applications of unsupervised learning	**Jan 16**	Vectors and Matrices	2.1-2.5 Homework 1 Due
Week 2	**Jan 21**	R coding and plotting	**Jan 23**	cont.	Ch. 3 Homework 2 Due
Week 3	**Jan 28**	Clustering 1: K-means, Mixture models	**Jan 30**	cont.	Ch. 4 Homework 3 Due
Week 4	**Feb 4**	Clustering 2: Hierarchical clustering	**Feb 6**	cont.	Ch. 5 Homework 4 Due
Week 5	**Feb 11**	Clustering 3: spectral clustering	**Feb 13**	cont.	 Homework 5 Due
Week 6	**Feb 18**	Bayesian non-param. 1 Chinese Rest. Proc.	**Feb 20**	cont.	Ch. 6 Homework 6 Due
Week 7	**Feb 25**	Bayesian non-param 2 Indian Buffet Proc.	**Feb 27**	cont.	 Homework 7 Due
Week 8	**Mar 3**	Review	**Mar 5**	Mid-term exam.	
Week 9	**Mar 10**	Changepoint 1: Binary segmentation	**Mar 12**	cont.	 Homework 8 Due
Week 10	**Mar 17**	Changepiont 2: Optimal segmentation	**Mar 19**	cont.	 Homework 9 Due
Week 11	**Mar 24**	Changepoint 3: Hidden markov models	**Mar 26**	cont.	Ch. 7 Homework 10 Due
Week 12	**Mar 31**	Dim Reduc 1: Principal Components Analysis	**Apr 2**	cont.	Ch. 8 Homework 11 Due
Week 13	**Apr 7**	Dim Reduc 2: Sparse PCA	**Apr 9**	cont.	Ch. 9 Homework 12 Due
Week 14	**Apr 14**	Dim Reduc 3: t-SNE	**Apr 16**	cont.	Ch. 10 Homework 13 Due
Week 15	**Apr 21**	Dim Reduc 4: autoencoders	**Apr 23**	cont.	Ch. 11 Homework 14 Due
Week 16	**Apr 28**	READING	**Apr 30**	WEEK	

Course Policies

The following policies will apply to this course:

- Attendance is required and will be recorded via quizzes. For an excused absence, students must request a classes missed memo by contacting Student Life at 928-523-5181 or student.life@nau.edu. Students should provide the reason for their absence, the dates of absence, and the date they expect to return to class. Students should also bring in or attach to their email documentation of their reason for absence. Appropriate documentation may include a note from a health care provider, hospital discharge paperwork, an obituary or funeral program, or other documentation that indicates the nature and dates of the absence.
- 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 students during the coding projects, but is it NOT OK to copy from other students, nor from other sources (e.g. code found on the internet). 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