CSE 4309: Fundamentals of Machine Learning

Fall 2021

Instructor Information

Instructor(s)
Vassilis Athitsos

Office Number
All office hours are conducted online, via Microsoft Teams.

Office Telephone Number
All conversations are conducted via Microsoft Teams.

Email Address
athitsos@uta.edu

Faculty Profile
https://mentis.uta.edu/explore/profile/vassilis-athitsos

Office Hours
MW 11:00am-12:30pm

Course Information

Section Information
CSE 4309, section 001.

Time and Place of Class Meetings

Time: MWF 10:00am-10:50am.

Modality: The course is offered fully online. Students can follow this course both synchronously and asynchronously, and they can switch back and forth between the two options at will. There will be no exams, and 100% of the semester score will be based on homework assignments. Class lectures will be conducted on Microsoft Teams during the scheduled times (MWF 10:00am-10:50am). Live attendance is optional. Students attending live can ask questions and participate in class discussions.

Description of Course Content
This course offers an introduction to machine learning. Topics include Bayes classifiers, linear regression, neural networks and backpropagation, decision trees, clustering, and reinforcement learning. A strong programming background is assumed, as well as familiarity with linear algebra (vector and matrix operations), and knowledge of basic probability theory and statistics. Prerequisites: Admitted into an Engineering Professional Program. C or better in each of the following: CSE 3318, IE 3301 or MATH 3313, and CSE 3380 or MATH 3330.

Student Learning Outcomes
After successfully taking this course, a student should be familiar with standard approaches to machine learning, be able to discuss pros and cons of these approaches, be able to implement basic machine learning methods, and be able to apply basic machine learning methods to real world problems.

Required Textbooks and Other Course Materials
Pattern Recognition and Machine Learning, Christopher M. Bishop, 2006.

Descriptions of major assignments and examinations

All assignments must be submitted via Canvas.

Any assignment that includes the word "tentative" in its title is not finalized. When the contents of an assignment are finalized, the word "tentative" is removed from the title. When an assignment is posted on Canvas, it can be considered as finalized. However, even if an assignment is "finalized", the instructor reserves the right to make changes, so as to fix errors, add clarifications, etc. Such late changes will be announced via e-mail.

- Assignment 1. Due date: Thu 09/02, 5:00pm.
  Topics: review of prerequisite material on algorithms, algebra, calculus, probabilities, programming skills.
- Assignment 2. Due date: Thu 09/16, 5:00pm.
  Topics: probabilities, naive bayes classifiers, Gaussians.
- Assignment 3. Due date: Thu 09/30, 5:00pm.
  Topics: linear regression.
- Assignment 4. Due date: Thu 10/14, 5:00pm.
  Topics: neural networks and backpropagation.
- Assignment 5. Due date: Thu 10/28, 5:00pm.
  Topics: decision trees.
- Assignment 6. Due date: Thu 11/11, 5:00pm.
  Topics: clustering.
- Assignment 7. Due date: Thu 12/02, 5:00pm.
  Topics: Markov Decision Processes, reinforcement learning.

Assignment Policies

There are several assignments in this course. Each assignment may include both programming and written components. No assignment scores will be dropped. The following class policies regarding assignments will be followed:

- **Programming language:** Programming assignments have to be done in Python. Python code needs to run on Anaconda (Python version 3.8.3, numpy version 1.18.5). Any exceptions to these requirements must be provided via e-mail from the instructor or the teaching assistant.
- **On using existing libraries and tools:** The instructor recommends that students do not use existing libraries (except numpy) or existing tools in the programming assignments. The course slides provide sufficient information for students to complete their programming assignments without using special libraries. At the same time, if students want to use such special libraries or other built-in tools, they are allowed to. However, if these libraries or built-in tools do not provide results that match the assignment specifications, then the solutions will be counted as wrong. The instructor will not help the student before the deadline in determining whether any specific libraries/tools are compliant with the assignment specifications, since the recommended approach is to not use such libraries and tools. Oftentimes, existing libraries and tools implement variations of the methods and formulas that are specified in the assignment requirements, and any such variations will not be acceptable.
- **Submissions:** All assignments must be submitted via Canvas.
- **Deadline extensions:** No deadline extensions for the entire class will be provided. The syllabus describes the policy on extensions for individuals. Please note that such extensions

can only be granted for emergencies documented in writing, and only when the student has clearly made efforts to inform the instructor as early as possible.

- **Extra credit:** Little extra credit will be provided. Any extra credit opportunities that are provided will be available for all students.
- **Multiple submissions:** If you make multiple online submissions for the same assignment, only the latest submission will be graded.
- **Verifying your submission:** After you submit your solutions, you should download them and make sure that you submitted the correct files. Every semester, several students ask for leniency, claiming that they did the assignment, but accidentally submitted the wrong files. These claims are often legitimate, but, unfortunately, no grade leniency will be accorded to such claims. **It is each student's responsibility to doublecheck their submissions.**
- **In case of Canvas problems:** If, for whatever reason, you cannot submit on Canvas, e-mail your solution to the instructor and the teaching assistant, from your UTA account, BEFORE the submission deadline. The time stamp on your e-mail message will serve as proof that you did the work on time. You still have to offer a convincing explanation as to why you were not able to submit online.
- **Student conduct:** Each student is expected to work on each assignment INDIVIDUALLY and submit his or her own work. The instructor will report to the Office of Student Conduct all violations of this policy, and all cases that are suspicious of such violations.

Late submission policy:

- All assignments are graded out of 100 points. Assignments submitted late will be penalized, at a rate of 1 penalty point per hour. The submission time will be the time shown on Canvas. Any assignment submitted more than 100 hours late will receive no credit.
- Exceptions to late submission penalties will only be made for emergencies documented in writing, in strict adherence to UTA policy. For all such exception requests, the student must demonstrate that he or she made all efforts to notify the instructor as early as possible.
- Computer crashes, network crashes, software or hardware failure, Canvas failure, e-mail failure, will NOT be accepted as justification for late submissions. If you want to minimize chances of a late submission, aim to submit early. You can always revise your submission till the deadline.
- Sometimes students submit the wrong files online. Unfortunately, no credit or waiver of late penalties can be provided in such cases.
- If you find yourself in an emergency situation and can not deliver a homework on time, immediately inform the instructor and teaching assistant, via e-mail. Even if you have a valid reason for delivering late an assignment, you must make a convincing case that you have notified the instructor and teaching assistant as early as possible.

If you want to minimize chances of a late submission, aim to submit early. You can always revise your submission till the deadline.

Assignment Resubmission Policy:

The goal of the resubmission policy is to reward students who persist in understanding the material, even after they have received a low homework score. At the same time, the resubmission policy emphasizes the expectation that, for A-level performance, solutions should be correct at the time of first submission.

These are the rules of the resubmission policy for this semester:

- Students can resubmit any assignment on Canvas until the end of Monday, December 13. Please submit on Canvas, under the appropriate "HW #?? Delay" assignment, and please send an e-mail to the instructor and the TA to let them know (since these submissions can occur any time, we do not regularly monitor for them).

- **For the purposes of making an A, the resubmission will NOT be considered.** As mentioned earlier, the idea is that A-level performance should mean getting it right the first time.
- For the purposes of making a B, the **average** of the resubmission score and the original submission score will be used.
- For the purposes of making a C or a D, the resubmission score will **replace** the original submission score.

Technology Requirements

- Lectures and office hours will be conducted on Microsoft Teams.
- Homework assignments need to be submitted on Canvas. There are significant penalties for late submissions (1 out 100 points deducted per hour past the deadline).
- Live attendance of lectures is NOT required. However, students taking this class assume full responsibility for having adequate Internet connectivity to view lectures (live or recorded), to download slides, to install the required Python version, and to submit assignments on time. Students also assume full responsibility for having access to a computer that is adequate for implementing and running the programming assignments. No accommodations will be provided for students who cannot meet these requirements.

Grading Information

Grading

The semester score will simply be the average of all assignment scores. All assignments will have equal weight.

The final semester score, calculated based on the percentages listed above, will be converted to letter grades based on the following scale:

- A: 90%
- B: 80%
- C: 70%
- D: 60%
- F: below 60%.

The instructor reserves the right to lower these thresholds, based on the distribution of scores. The instructor also reserves the right to lower a student's grade as penalty for violating the requirements of professional and civil conduct, as described in the student conduct section of this syllabus.

Any request for re-grading must be made within 5 days of receipt of that grade. Re-grading can lead to a higher or lower grade, depending on grading errors that are discovered.

There will be little or no extra credit. If there are extra credit opportunities, they will be included as part of the assignments, and they will be available to all students. There will be no make-up opportunities, and there will be no way for individual students to do extra work and improve their grade at the end of the semester.

IMPORTANT: It should be clear to every student that course grades will depend EXCLUSIVELY on the above grading criteria. Students should not request nor expect any other factor to be considered in computing the course grade. For example, factors that will NOT be considered are: need of a better grade to keep financial aid, to stay in the program, to qualify for a job offer, or to graduate. Students are expected to carefully monitor their own performance throughout the semester and seek

guidance from available sources (including the instructor) if they are concerned about their performance and the course grade that they will earn. However, **if the assignment scores are not good enough to warrant the desired grade at the end of the semester, there will be no other recourse for improving the grade**.

Expectations for Out-of-Class Study

Beyond the time required to attend each class meeting, students enrolled in this course should expect to spend an additional minimum of 9 hours per week of their own time in course-related activities, including reading required materials and completing assignments. Significantly more time may be needed for people having difficulties understanding the material, having a relatively weak mathematical or programming background, or having a relatively weak background in the prerequisite materials for this course.

Grade Grievances

Any appeal of a grade in this course must follow the procedures and deadlines for grade-related grievances as published in the current University Catalog.

Class Participation

Class participation during lectures is optional, and will not be considered for the course grade. At the same time, students are highly encouraged to participate, by asking questions, as well as answering questions by the instructor. Class participation can be an important resource for students who have difficulty understanding any part of the course material.

Student Conduct

Students are expected to be professional and civil in their language and conduct:

- During lectures.
- During office hours.
- In any oral, written or electronic communication with the instructor and TAs.
- In assignment submissions.

For any student violating this policy, the instructor reserves the right to impose any grading penalties that the instructor considers appropriate, including a failing grade for the class, regardless of any other aspects of student performance. Examples of violations include language that is vulgar, insulting, disrespectful or threatening, making noise or talking with other students during lectures, disrupting lectures in any way, or making it difficult for other students to follow lectures in any way.

Course Schedule

The list of topics for future lectures is tentative, and will be updated as needed.

Lectures Schedule

- Lecture 1: Wed 08/25 - Syllabus Overview, Introduction.
    - Slides: Overview of course syllabus. PPT, PDF.

    - Slides: Using Microsoft Teams and Microsoft Stream. PPT, PDF.
    - Slides: Introduction. PPT, PDF.
    - Book reading: Chapter 1.
- Lecture 2: Fri 08/27 - Introduction.
    - Slides: Introduction. PPT, PDF.
    - Book reading: Chapter 1.
- Lecture 3: Mon 08/30 - Probability Distributions, Probability Densities, Gaussians.
    - Slides: Background on probabilities. PPT, PDF.
    - Book reading: Chapters 1, 2.
- Lecture 4: Wed 09/01 - Probability Distributions, Probability Densities, Gaussians.
    - Slides: Background on probabilities. PPT, PDF.
    - Book reading: Chapters 1, 2.
- Lecture 5: Fri 09/03 - Probability Distributions, Probability Densities, Gaussians, Bayesian Classifiers.
    - Slides: Background on probabilities. PPT, PDF.
    - Slides: Bayes classifiers, naive Bayes. PPT, PDF.
    - Book reading: Chapters 1, 2.
- Lecture 6: Wed 09/08 - Bayesian Classifiers, Bayesian Estimation
    - Slides: Bayes classifiers, naive Bayes. PPT, PDF.
    - Slides: Frequentist and Bayesian estimation. PPT, PDF.
    - Book reading: Chapters 1, 2.
- Lecture 7: Fri 09/10 - Bayesian Estimation, Linear Regression.
    - Slides: Frequentist and Bayesian estimation. PPT, PDF.

- Slides: Linear Regression. PPT, PDF.
- Book reading: Chapters 1, 2.

- FRIDAY SEPTEMBER 10: CENSUS DATE.
- Lecture 8: Mon 09/13 - Linear Regression.
  - Slides: Linear Regression. PPT, PDF.
  - Book reading: Chapter 3.1.
- Lecture 9: Wed 09/15 - Linear Regression.
  - Slides: Linear Regression. PPT, PDF.
  - Book reading: Chapter 3.1.
- Lecture 10: Fri 09/17 - Linear Regression.
  - Slides: Linear Regression. PPT, PDF.
  - Book reading: Chapter 3.1.
- Lecture 11: Mon 09/20 - Linear Regression, Neural Networks.
  - Slides: Linear Regression. PPT, PDF.
  - Slides: Neural Networks part 1, Introduction. PPT, PDF.
  - Book reading: Chapter 3.1 (linear regression), Chapter 5 (neural networks).
- Lecture 12: Wed 09/22 - Neural Networks.
  - Slides: Neural Networks part 1, Introduction. PPT, PDF.
  - Book reading: Chapter 5 (neural networks).
- Lecture 13: Fri 09/24 - Neural Networks.
  - Slides: Neural Networks part 2, Training Perceptrons and Multiclass Problems. PPT, PDF.
  - Book reading: Chapter 5 (neural networks).

- Lecture 14: Mon 09/27 - Neural Networks.
    - Slides: Neural Networks part 3, Backpropagation. PPT, PDF.
    - Book reading: Chapter 5.
- Lecture 15: Wed 09/29 - Neural Networks.
    - Slides: Neural Networks part 3, Backpropagation. PPT, PDF.
    - Slides: Decision Trees. PPT, PDF.
    - Book reading: Chapter 5, Section 14.4.
- Lecture 16: Fri 10/01 - Decision trees
    - Slides: Decision Trees part 1, basic definitions. PPT, PDF.
    - Book reading: Section 14.4.
- Lecture 17: Mon 10/04 - Decision trees
    - Slides: Decision Trees part 1, basic definitions. PPT, PDF.
    - Book reading: Section 14.4.
- Lecture 18: Wed 10/06 - Decision trees
    - Slides: Decision Trees part 1, basic definitions. PPT, PDF.
    - Book reading: Section 14.4.
- Lecture 19: Fri 10/08 - Decision Trees.
    - Slides: Decision Trees part 2, practical issues. PPT, PDF.
    - Book reading: Sections 14.4.
- Lecture 20: Mon 10/11 - Decision Trees.
    - Slides: Decision Trees part 2, practical issues. PPT, PDF.
    - Book reading: Sections 14.4.
- Lecture 21: Wed 10/13 - Nearest Neighbors.

- Slides: K-Nearest Neighbor Classification. PPT, PDF.

- Lecture 22: Fri 10/15 - Clustering, EM Algorithm.
  - Slides: Clustering. PPT, PDF.
- Lecture 23: Mon 10/18 - Clustering, EM Algorithm.
  - Slides: Clustering. PPT, PDF.
- Lecture 24: Wed 10/20 - Clustering, EM Algorithm.
  - Slides: Clustering. PPT, PDF.
- Lecture 25: Fri 10/22 - Clustering, EM Algorithm.
  - Slides: Clustering. PPT, PDF.
- Lecture 26: Mon 10/25 - Clustering, EM Algorithm.
  - Slides: Clustering. PPT, PDF.
- Lecture 27: Wed 10/27 - Clustering, EM Algorithm.
  - Slides: Clustering. PPT, PDF.
- Lecture 28: Fri 10/29 - Clustering, EM Algorithm.
  - Slides: Clustering. PPT, PDF.
- Lecture 29: Mon 11/01 - Markov Decision Processes.
  - Slides: Markov Decision Processes part 1, basic definitions. PPT, PDF.
- Lecture 30: Wed 11/03 - Markov Decision Processes.
  - Slides: Markov Decision Processes part 2, utilities of states and the Bellman Equation. PPT, PDF.
- Lecture 31: Fri 11/05 - Markov Decision Processes.
  - Slides: Markov Decision Processes part 2, utilities of states and the Bellman Equation. PPT, PDF.

- FRIDAY NOVEMBER 05: LAST DAY TO DROP CLASSES. Submit requests to advisor prior to 4:00 pm.

- Lecture 32: Mon 11/08 - Markov Decision Processes.

    - Slides: Markov Decision Processes part 3, algorithms for computing state utilities and optimal policies. PPT, PDF.

- Lecture 33: Wed 11/10 - Markov Decision Processes.

    - Slides: Markov Decision Processes part 3, algorithms for computing state utilities and optimal policies. PPT, PDF.

 Lecture 34: Fri 11/12 - Reinforcement Learning.

- Slides: Reinforcement Learning. PPT, PDF.

 Lecture 35: Mon 11/15 - Reinforcement Learning.

- Slides: Reinforcement Learning. PPT, PDF.

 Lecture 36: Wed 11/17 - Reinforcement Learning.

- Slides: Reinforcement Learning. PPT, PDF.

 Lecture 37: Fri 11/19 - Reinforcement Learning.

- Slides: Reinforcement Learning. PPT, PDF.

 Lecture 38: Mon 11/22 - (Optional Material) Convolutional Neural Networks.

- Slides: Convolutional Neural Networks. PPT, PDF

 Lecture 39: Mon 11/29 - (Optional Material) Convolutional Neural Networks.

- Slides: Convolutional Neural Networks. PPT, PDF

- Extra material: A high-level presentation on AI, machine learning, and deep learning. PPT, PDF.

- Link: A course from Stanford.

- Link: Slides from the Stanford course.

 Lecture 40: Wed 12/01 - (Optional Material) Topics to be decided.

 Lecture 41: Fri 12/03 - (Optional Material) Topics to be decided.

 Lecture 42: Mon 12/06 - (Optional Material) Topics to be decided.

THERE WILL BE NO FINAL EXAM

Assignments Schedule

- Assignment 1. Due date: Thu 09/02, 5:00pm.
  Topics: review of prerequisite material on algorithms, algebra, calculus, probabilities, programming skills.

- Assignment 2. Due date: Thu 09/16, 5:00pm.
  Topics: probabilities, naive bayes classifiers, Gaussians.

- Assignment 3. Due date: Thu 09/30, 5:00pm.
  Topics: linear regression.

- Assignment 4. Due date: Thu 10/14, 5:00pm.
  Topics: neural networks and backpropagation.

- Assignment 5. Due date: Thu 10/28, 5:00pm.
  Topics: decision trees.

- Assignment 6. Due date: Thu 11/11, 5:00pm.
  Topics: clustering.

- Assignment 7. Due date: Thu 12/02, 5:00pm.
  Topics: Markov Decision Processes, reinforcement learning.

Institutional Information

UTA students are encouraged to review the below institutional policies and informational sections and reach out to the specific office with any questions. To view this institutional information, please visit the Institutional Information page (https://resources.uta.edu/provost/course-related-info/institutional-policies.php) which includes the following policies among others:

- Drop Policy
- Disability Accommodations
- Title IX Policy
- Academic Integrity
- Student Feedback Survey
- Final Exam Schedule

Additional Information

Face Covering Policy
While the use of face coverings on campus is no longer mandatory, all students and instructional staff are strongly encouraged to wear face coverings while they are on campus. This is particularly true inside buildings and within classrooms and labs where social distancing is not possible due to limited space. If a student needs accommodations to ensure social distancing in the classroom due to being at high risk they are encouraged to work directly with the Student Access and Resource Center to assist in these accommodations. If students need masks, they may obtain them at the Central Library, the E.H. Hereford University Center's front desk or in their department.

Attendance
At The University of Texas at Arlington, taking attendance is not required but attendance is a critical indicator of student success. Each faculty member is free to develop his or her own methods of evaluating students' academic performance, which includes establishing course-specific policies on attendance. As the instructor of this section, I have established the following attendance policy: Attendance is NOT mandatory for lectures. Attendance in lectures will NOT be used in calculating the semester grade. However, students are responsible for the material covered in the lectures. Lecture recordings will be available online for students to review at any time.

However, while UT Arlington does not require instructors to take attendance in their courses, the U.S. Department of Education requires that the University have a mechanism in place to mark when Federal Student Aid recipients "begin attendance in a course." UT Arlington instructors will report when students begin attendance in a course as part of the final grading process. Specifically, when assigning a student a grade of F, faculty report must the last date a student attended their class based on evidence such as a test, participation in a class project or presentation, or an engagement online via Canvas. This date is reported to the Department of Education for federal financial aid recipients.

Academic Success Center
The Academic Success Center (ASC) includes a variety of resources and services to help you maximize your learning and succeed as a student at the University of Texas at Arlington. ASC services include supplemental instruction, peer-led team learning, tutoring, mentoring and TRIO SSS. Academic Success Center services are provided at no additional cost to UTA students. For additional information visit: Academic Success Center. To request disability accommodations for tutoring, please complete this form.

The IDEAS Center (https://www.uta.edu/ideas/) **(**2nd Floor of Central Library) offers **FREE** tutoring and mentoring to all students with a focus on transfer students, sophomores, veterans and others undergoing a transition to UT Arlington. Students can drop in or check the schedule of available peer tutors at www.uta.edu/IDEAS, or call (817) 272-6593.

The English Writing Center (411LIBR)
The Writing Center offers **FREE** tutoring in 15-, 30-, 45-, and 60-minute face-to-face and online sessions to all UTA students on any phase of their UTA coursework. Register and make appointments online at the Writing Center (https://uta.mywconline.com). Classroom visits, workshops, and specialized services for graduate students and faculty are also available. Please see Writing Center: OWL for detailed information on all our programs and services.

The Library's 2nd floor Academic Plaza (http://library.uta.edu/academic-plaza) offers students a central hub of support services, including IDEAS Center, University Advising Services, Transfer UTA and various college/school advising hours. Services are available during the library's hours of operation.

Librarian to Contact

Each academic unit has access to Librarians by Academic Subject that can assist students with research projects, tutorials on plagiarism and citation references as well as support with databases and course reserves.

Emergency Phone Numbers

Enter the UTA Police Department's emergency phone number into your own mobile phone. In case of an on-campus emergency, call the UT Arlington Police Department at **817-272-3003** (non-campus phone), **2-3003** (campus phone). You may also dial 911. Non-emergency number 817-272-3381.