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Course Syllabus – Fall 2023

Course Information

Course Number/Section	CS/CGS 4314
Course Title	Intelligent Systems Analysis
Term	Fall 2023
Course Location:	HH 2.402
Course Time:	Tuesday/Thursday 5:30pm-6:45pm

Professor Contact Information

Professor	Dr. Golden
Office Phone	972-883-2423 (prefer students contact via email)
Email Address	golden@utdallas.edu
Office Location	GR4814
Office Hours	Tuesday 7pm-7:30pm, Thursday 7pm-7:30pm
Online Resources	Access to important class updates, course materials, exams, and homework assignments are located in Blackboard/ELEARNING.
Teaching Assistant (TA):	Ms. Reyhaneh Hosseinpour

Course Pre-requisites

CS3341 Probability and Statistics (prerequisite) or equivalent
MATH2418 Linear Algebra (prerequisite) or equivalent

Course Description

This advanced machine learning course (taught only once every other year) covers mathematics essential for the mathematical analysis and design of unsupervised, supervised, and reinforcement machine learning algorithms including Neural Network learning machines within a statistical empirical risk minimization framework. This course will help provide you with a deeper understanding of how machine learning algorithms work and help provide you with the skills to read machine learning research papers. Course topics include specification of machine learning algorithms within the Empirical Risk Minimization framework, advanced vector and matrix calculus, stochastic sequences of mixed random vectors. Relevance of stochastic convergence concepts for investigating adaptive learning algorithms and generalization performance. Discussion of Radon-Nikodym probability density notation for representing mixed random vectors. Introduction to Bayesian Networks and Markov random fields. *This course is a required prerequisite for CS/CGS 4315 Intelligent Systems Design (taught Spring 2024, 2026).*

Student Learning Outcomes

1. Students will be able to use singular value decomposition to design supervised and unsupervised learning algorithms.
2. Students will be able to use matrix calculus to design gradient descent type adaptive and batch learning algorithms for supervised, unsupervised, and reinforcement learning problems.
3. Students will be able to use and interpret Radon-Nikodym probability density notation for reading published papers in the machine learning literature.
4. Students will learn how to specify and represent complicated probabilistic models using Bayesian networks and Markov random fields.
5. Students will have an increased ability to read technical published papers in the field of machine learning.

Required Textbooks and Materials
Textbooks and some other bookstore materials can be ordered online or purchased at the UT Dallas Bookstore. The course textbook "Statistical Machine Learning: A Unified Framework" is available in the UTD Library.

Required Texts
Golden, R. M. (2020). *Statistical Machine Learning: A unified framework.* CRC Press. This book will also be used in the course "CS/CGS 4315 Intelligent Systems Design" in Spring 2022 so keep it for next semester!

Required Materials
*All students are required to immediately create a **free** MATHWORKS account. Students will need this account in order to access MATLAB Grader homework problems. (www.mathworks.com). (www.grader.mathworks.com) **Use your UTD email to create your MATHWORKS account!!***

Please note sharing your MATHWORKS login and password is considered a violation of the UTD Honor Code. Students who share their MATHWORKS login and password with anyone for any reason will be subject to academic disciplinary action.

Suggested Course Materials

MATLAB Software. This course is not a computer programming course. Most programming assignments are limited to writing only a few lines of MATLAB code although the class project will require you to write one or more MATLAB functions! The course assignments are not designed to develop your computer programming skills but rather to help you connect the mathematics you learn to the real world in a practical way through computer programming problems. *UTD has a MATLAB license (http://www.utdallas.edu/oit/howto/matlab/) which is **free to UTD students** which you can use to either install MATLAB on your personal computer or access MATLAB remotely.* Although you do not need MATLAB installed on your computer to do the homework assignments, projects, or exams you may find a personal installation of MATLAB very helpful for assignments and especially projects. Here are some helpful hyperlinks.

Getting Started with MATLAB
https://www.mathworks.com/help/matlab/getting-started-with-matlab.html

Introduction to MATLAB for Python Users
https://blogs.mathworks.com/student-lounge/2021/02/19/introduction-to-matlab-for-python-users/

Technical Requirements
In addition to a confident level of computer and Internet literacy, certain minimum technical requirements must be met to enable a successful learning experience. Please review the important technical requirements on the Getting Started with eLearning webpage.

Course Access and Navigation
This course can be accessed using your UT Dallas NetID account on the eLearning website. Please see the course access and navigation section of the Getting Started with eLearning webpage for more information. To become familiar with the eLearning tool, please see the Student eLearning Tutorials webpage. UT Dallas provides eLearning technical support 24 hours a day, 7 days a week. The eLearning Support Center includes a toll-free telephone number for immediate assistance (1-866-588-3192), email request service, and an online chat service.

Communication

This course utilizes online tools for interaction and communication. Some external communication tools such as regular email and a web conferencing tool may also be used during the semester. For more details, please visit the Student eLearning Tutorials webpage for video demonstrations on eLearning tools.

Academic Calendar

Assignments & Academic Calendar **Lectures and Dates**	**Lecture Topics and Module** *(There is a lecture note handout which provides detailed information about lecture note modules which are referenced using notation such as "M1" or "M2")*
8/21, 8/23	Empirical Risk Minimization for Supervised, Unsupervised, and Reinforcement Learning. Matrix Notation. Gradient Descent Methods. Introduction to MATLAB. SML Design Process. (M1, M2)
9/5, 9/7	Continuous Functions (M12). Using the Matrix Chain Rule to Derive Gradient Descent Learning Algorithms (M13a). First look at why Gradient Descent Works using the matrix Taylor Series Expansion (M16).
8/31, 9/2	Supervised Learning Machine Design of gradient descent algorithms for Feedforward nets without hidden units (M3, M14)
9/12	Using Vector Calculus to derive Stopping Criteria for Checking Convergence to local and global minimizers (M17, M18, M19). Homework 1 Due September 10.
9/14	Supervised Learning Machine Design for Feedforward nets without hidden units using SVD (M11).
9/19	Exam 1
9/21	Supervised Learning Machine Design (Nonlinear Deep Learning) (M4). Matrix Calculus for Deep Learning Neural Network including some signal flow graph notation (M13b).
9/26	Automatic feature selection using regularization (M5). Supervised Recurrent nets for learning Event Sequences (M6).
9/28, 10/3	Unsupervised Learning (M7). Unsupervised Learning Machine Design using SVD (M10). Value Function Reinforcement Learning (M8)
10/5	Relevance of Mixed Random Variables and the Radon-Nikodym density.(M22). Introduction to Adaptive Learning: Relevance of Random Variables and Expectation for adaptive learning as well as empirical risk functions. Adaptive search direction approximations of expected search directions. Empirical risk function approximations of true risk (M23).
10/10, 10/12	Adaptive Learning, Generalization, and Concentration Inequalities, (M23). Stochastic sequences (M24). Homework 2 Due October 15.
10/17	Introduction to Project.
10/19	Exam 2.
10/24, 10/26	Policy Gradient Reinforcement Learning (M9). Adaptive learning for logistic regression example. Adaptive learning for one layer hidden unit feedforward network example.
10/31, 11/2, 11/7	Stochastic Convergence Concepts (M25, M26). Law of Large Numbers and the Empirical Risk function. Importance Sampling. Central Limit theorem for approximating distributions of averages.
11/9	Probability Models and Learnability (M27, M28).
11/14	Gibbs Distributions. Linear Exponential Family (M28).
11/20 to 11/26	Thanksgiving Holidays
11/29	Bayesian networks (M29)
12/5, 12/7	Markov Random Fields (M30, M31). Homework Set 3 Due 12/10.
Final Exam Week	**Final Project Due 12/17. Cumulative Final Exam.**

Exams: Important Information
The three exams (Exam 1, Exam 2, and Final Exam) will be held at the UTD testing center. Students are responsible for signing up for their exams at the UTD testing center. You may bring a printed copy of the course text book "Statistical Machine Learning" or you may bring printouts of any sections of the book to the exam. If the notes are typed, then the font size can not be smaller than 11 pt font size. The margins should be 1 inch margins. You can have the notes on both sides of the page. You will not have access to your answers to the homework or past exams via the computer when you go to the testing center. You are only permitted to take the exam at the UTD testing center. We will be double-checking that your check-in and check-out exam times correspond to MATLAB grader problem answer times.

Grading Policy
Grading Scale: A (85% , 100%], B (70%, 85%], C (55%, 70%], D (40%, 55%], F[0%,40%]
Instructor reserves right to make adjustments to this grading scale as he deems fit.

Homework 1	10%
Exam 1	20%
Homework 2	10%
Exam 2	20%
Homework 3	10%
Final Project (technically this is a Homework Assignment which is more complex)	10%
Final Exam	20%

Machine Learning Data Analysis of Grades
After the semester has ended and the grades have been submitted, your answers to homework, exam, and project questions will be analyzed by machine learning algorithms. Your identity in this data set will be deleted so the relationship of your responses and your identity will be totally removed. If you wish, however, you can send an email to golden@utdallas.edu up to 30 days after the last day of class (e.g., after grades have been submitted) and request that your data be omitted from the machine learning data analysis. The machine learning data analyses will be used to advance research into improving student learning and help make this course a better experience for future students.

Distance Learning Student Resources
Online students have access to resources including the McDermott Library, Academic Advising, The Office of Student Access Ability, and many others. Please see the eLearning Current Students webpage for more information.

Server Unavailability or Other Technical Difficulties
The University is committed to providing a reliable learning management system to all users. However, in the event of any unexpected server outage or any unusual technical difficulty which prevents students from completing a time sensitive assessment activity, the instructor will provide an appropriate accommodation based on the situation. Students should immediately report any problems to the instructor and also contact the online eLearning Help Desk. The instructor and the eLearning Help Desk will work with the student to resolve any issues at the earliest possible time.

Class Materials

The Instructor may provide class materials that will be made available to all students registered for this class as they are intended to supplement the classroom experience. Some of these materials may be downloaded during the course, however, these materials are for registered students' use only. Classroom materials may not be reproduced or shared with those not in class, or uploaded to other online environments except to implement an approved Office of Student Access Ability accommodation. Failure to comply with these University requirements is a violation of the Student Code of Conduct.

Class Participation

Regular class participation is expected. Students who fail to participate in class regularly are inviting scholastic difficulty. A portion of the grade for this course is directly tied to your participation in this class. It also includes engaging in group or other activities during class that solicit your feedback on homework assignments, readings, or materials covered in the lectures (and/or labs). Class participation is documented by faculty. Successful participation is defined as consistently adhering to University requirements, as presented in this syllabus. Failure to comply with these University requirements is a violation of the Student Code of Conduct.

Class Recordings

Students are expected to follow appropriate University policies and maintain the security of passwords used to access recorded lectures. Unless the Office of Student Access Ability has approved the student to record the instruction, students are expressly prohibited from recording any part of this course. Recordings may not be published, reproduced, or shared with those not in the class, or uploaded to other online environments except to implement an approved Office of Student Access Ability accommodation. Failure to comply with these University requirements is a violation of the Student Code of Conduct.

The instructor may record meetings of this course. These recordings will be made available to all students registered for this class if the intent is to supplement the classroom experience. If the instructor or a UTD school/department/office plans any other uses for the recordings, consent of the students identifiable in the recordings is required prior to such use unless an exception is allowed by law.

Course Policies

Make-up exams

Exams are scheduled at particular dates and times because solutions are posted in a timely manner. If you are unable to attend an exam, please contact the instructor using the email address golden@utdallas.edu *before* the exam is scheduled to minimize grade penalties. If you can not contact the instructor before the exam, then you should still try to contact the instructor after the exam to discuss the situation.

Extra Credit

There is no extra credit.

Late Homework and Late Exams

Homework and exam assignments are due at a particular date and time. Homework and exam assignments will still be accepted up to 24 hours after the assignment deadline date but your class

participation grade will be severely penalized. Assignments received after the 24 hour deadline date will not be graded because solutions are posted in a timely manner and it would not be fair to other students in the class to not receive homework and exam solutions on time.

Special Assignments
None

Classroom Citizenship

- Try to attend the class lectures. You will find this challenging class easier and more valuable if you attend the lectures. We will try to record some or all of the lectures but recording of lectures is not guaranteed.
- You are strongly encouraged to collaborate in groups on the homework assignments. However, each student submits their own homework assignment.
- ***You are not permitted to collaborate with your fellow students or anyone during the class exams.*** Collaboration with fellow students or anyone on the class exams is a violation of the Comet Creed below.
- The library has a limited number of EBOOK copies of the class text available which can be read on-line so please try to quickly return your copy of the class textbook (close your brower window when you are finished).
- Post your questions about homework problems in the TEAMS chat window so that the answers by the TA can be seen by other students. Do not email questions about the homework directly to the professor or the TA.

Comet Creed
This creed was voted on by the UT Dallas student body in 2014. It is a standard that Comets choose to live by and encourage others to do the same:

"As a Comet, I pledge honesty, integrity, and service in all that I do."

Academic Support Resources
The information contained in the following link lists the University's academic support resources for all students.
Please go to Academic Support Resources webpage for these policies.

UT Dallas Syllabus Policies and Procedures
The information contained in the following link constitutes the University's policies and procedures segment of the course syllabus. Please review the catalog sections regarding the credit/no credit or pass/fail grading option and withdrawal from class.

Please go to UT Dallas Syllabus Policies webpage for these policies.
The descriptions, policies, and timelines contained in this syllabus are subject to change at the discretion of the Professor.