

ME4803/8803 Syllabus

Data Foundations for Engineering Applications of Machine Learning 3 - 0 - 0 - 3

Instructor: Dr. Aaron Stebner, aaron.stebner@gatech.edu

Textbook: None, course notes and reading list provided in Canvas/PACE

General Information

Catalog Description

Foundational principles of programming, statistics, linear algebra, data processing, data visualization, and machine learning are introduced. Engineering data sets are used to demonstrate when, why, and how to use or not use machine learning in solving engineering problems.

Pre-Requisites*

ME2016 Computing Techniques, Math 3670 Statistics & Applications (ME majors), or by instructor approval (non-ME majors).

Course Topics:

1. Documenting data analytics/machine learning workflows and programs.
2. Statistical measures used in data analytics and machine learning.
3. Design of Experiments, Data feature engineering, and Sequential Learning
4. Assessing datasets for amenability to machine learning methods
5. Algorithm selection
6. Data analysis
7. Data visualization

Course Objectives:

Objective 1: To provide students with the foundational skills needed to evaluate when, why, and how to use or not use machine learning in solving engineering problems.

Objective 2: To teach the core programming, statistics, linear algebra, and data processing methodologies needed to use machine learning.

Objective 3: To teach students the pitfalls of machine learning through example problems that use engineering datasets.

Objective 4: To train students to rigorously evaluate the performance of machine learning models using uncertainty quantification metrics based upon statistical error, bias, and variance.

Objective 6: Introduce students to machine learning algorithms and software.

Course Outcomes:

- Proficiency in using Python and Jupyter notebooks for performing and documenting data analysis workflows.
- Calculate statistical measures used in modern data analytics and machine learning.
- Understand how and why to use machine learning in aiding design of experiments.
- Assess datasets to determine if statistics-based modeling is appropriate (i.e., test Similarity and Relational Hypotheses).
- Select the best data informatics algorithms to evaluate.
- Extract actionable information from that data through the evaluation and application of appropriate models.
- Effectively communicate to others the impact of these models and how these models guide and optimize an engineering process.

Course Requirements & Grading

4803:

Homework Assignments: 60%

Exams: 40% (2 exams, 20% each)

8803:

Homework Assignments: 40%

Exams: 20% (2 exams, 10% each)

Project Report: 40%

Grading Scale

Your final grade will be assigned as a letter grade according to the following scale:

A	90-100%
B	80-89.99%
C	70-79.99%
D	60-69.99%
F	0-59.99%

Course Materials

All necessary reading materials will be posted on CANVAS.

Academic Integrity

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. For information on Georgia Tech's Academic Honor Code, please visit <http://www.catalog.gatech.edu/policies/honor-code/> or <http://www.catalog.gatech.edu/rules/18/>.

Any student suspected of cheating or plagiarizing on a quiz, exam, or assignment will be reported to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations.

Accommodations for Students with Disabilities

If you are a student with learning needs that require special accommodations, contact the Office of Disability Services at (404)894-2563 or <http://disabilityservices.gatech.edu/>, as soon as possible, to make an appointment to discuss your special needs and to obtain an accommodation letter. Please also e-mail faculty as soon as possible in order to set up a time to discuss your learning needs.

Absence from Class

Class attendance is not required, but is strongly recommended. In the case of medical illness or family emergencies, please work with the Office of VP for Student Life (Dean of Students) with documentation that supports your situation. If the illness or family emergency is deemed serious enough, the Dean's office will then contact me and your other instructors with recommendations on how to proceed. Students who are absent because of participation in a particular religious observance will be permitted to make up the work missed during their absence with no late penalty, provided the student informs me of the upcoming absence, in writing, within the first two weeks of class, and provided the student makes up the missed material within the established timeframe.

Collaboration & Group Work

The course project deliverables are to be submitted as a team. Students are encouraged to seek advice and guidance from people and learning materials outside of the class. Students will be required to submit peer-evaluations as individuals to score the contribution from themselves as well as their team members.

Student-Faculty Expectations Agreement

At Georgia Tech, we believe that it is important to strive for an atmosphere of mutual respect, acknowledgement, and responsibility between faculty members and the student body. See <http://www.catalog.gatech.edu/rules/22/> for an articulation of some basic expectation that you can have of faculty and that faculty have of you. In the end, simple respect for knowledge, hard work, and cordial interactions will help build the environment we seek. Therefore, we encourage you to remain committed to the ideals of Georgia Tech while in this class.

Campus Resources for Students

All students are welcome to visit the makerspaces on campus, including Flowers Invention Studio, IDC, MILL, etc. to get trained on the fabrication tools.

Visit this page https://ctl.gatech.edu/sites/default/files/documents/campus_resources_students.pdf for a list of relevant campus resources available to Georgia Tech students.

Mental Health & Wellness: As a student you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, depression, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance or reduce a student's ability to participate in daily activities. GT offers services to assist you with addressing these and other concerns you may be experiencing. If you or someone you know is experiencing any of the issues noted above, consider utilizing the confidential mental health services available on campus. I encourage you to reach out to GT CARE (www.care.gatech.edu, 404-894-3498) or the Counseling Center (www.counseling.gatech.edu, 404-894-2575) for support. An on-campus counselor or after-hours services are available to assist you.

Day	Topic	Assignment
8/24	Course Intro, Accessing PACE-ICE, Using Jupyter Notebooks	
8/26	Programming Basics and Intro to Python	HW #1
8/31	Review of Linear Algebra used in Machine Learning	
9/2	Statistics and Probabilities used in Machine Learning	HW #2
9/7	Decision Theory and Point Estimation	
9/9	Bias, Variance, Maximum Likelihood Estimator	
9/14	Inference and Hypothesis Testing	
9/16	Numerical Methods Review: Gradient Descent	
9/21	Numerical Optimization: Monte Carlo, Particle Swarm	HW #3
9/23	Design of Experiments	
9/28	Data Visualization: Dimensional Reduction, Scree Plots, Histograms, etc.	HW #4
9/30	Introduction to Machine Learning	
10/5	Wrap-up and Exam 1 review	HW #5
10/7	Exam 1	
10/12	FALL BREAK – NO CLASS	
10/14	Machine Learning Model Training and Uncertainty Estimation	
10/19	ML-Driven Experimental Design (Feature Engineering, Sequential Learning, ...)	
10/21	Logistic Regression	HW #6
10/26	Linear Regression and the use of Regularization	
10/28	Ensemble Algorithms	HW #7
11/2	Support Vector Machines	
11/4	Gaussian Process Modeling	HW #8
11/9	Clustering	
11/16	Deep Neural Networks I	
11/18	Deep Neural Networks II	HW #9
11/23	THANKSGIVING BREAK – NO CLASS	
11/25	THANKSGIVING BREAK – NO CLASS	
11/30	Convolutional Neural Networks	
12/2	Variational Autoencoders	
12/7	Final Exam Review	
12/9-	Final Exam (All) & Project Reports Due (Grads)	