

Data Analytics for Composite Engineering

Special topics – ASEN 5519-006

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Office: AERO 353

Lecture time: MWF – 11:45am-12:35pm

Lecture location: AERO N250

Office hours Times and Location: Monday 10:30am-11:30am – AERO 353 and Zoom appointment

Zoom link (when required): _____

Appointments

If you wish to make an appointment, the best way to do this is by email. Please note that I typically need at least 24 hours notice. If you prefer to email me a question, please note that I typically respond to emails on weekday mornings.

Pre-requisite: ASEN 3112 or equivalent required. ASEN 5012 is recommended.

Course descriptions

This course introduces the elements of data sciences, data analytics, and machine learning with a focus and applications in mechanics and composites engineering. The focus will be on the applications of this emerging field for materials development and characterization of composites. The students will be exposed to machine learning approaches such as supervised and unsupervised learning including regression, classification, clustering, and deep learning. Some examples of the methods to be covered are linear regression, logistic regression, k-means, and neural networks. The students will also be trained in programming these algorithms in python and applying them to a set of case studies pertaining to structure-property relations. The course will provide hands-on activities and application examples.

Course outcomes and objectives

- Identify the different machine learning archetypes and understand how to condition data to use them.
- Formulate composite engineering problems and select appropriate machine learning models to solve them
- Create meaningful and descriptive features of materials to maximize the predictive performance of a selected model.
- Critically evaluate the predictions of a machine learning model for over-fitting, range of applicability, uncertainty, and physical plausibility.

Recommended Texts

Data science for engineering applications is a relatively new field that, to date, has not been formalized into an accepted standardized curriculum by the community. Course materials will be synthesized from various sources, but the textbooks below will form the computer science skeleton upon which we will flesh out our engineering treatment. They are both available for free online as downloadable pdfs and are highly recommended as companions to the lectures.

- An Introduction to Statistical Learning, *James Gareth, Daniela Witten, Trevor Hastie, and Robert Tibshirani* (<https://www.statlearning.com/>)
- Doing Bayesian Data Analysis, *John K. Kruschke* 2nd Edition (<https://sites.google.com/site/doingbayesiandataanalysis/>)
- Hands-on Machine Learning with Scikit-Learn & Keras: Concepts, Tools, and Techniques to Build Intelligent Systems by Aurelien Geron
- Make Your Own Neural Network by Tariq Rashid
- Deep Learning by Ian Goodfellow, Yoshua Bengio, and Aaron Courville

Course communication:

- Announcements will be made through Canvas.
- Grades will be posted to Canvas. However, the final grade calculated by Canvas will not correspond to the real grade, which will be calculated separately.
- Students will also be able to use email to communicate with the instructor. Please, start the subject of each email with "ASEN 5519". This will make sure that emails can be identified at the end of the course and no regrading request is neglected.

Lab Assignments

Two assignments and five lab reports will be assigned. Each assignment description will be posted on the course website before the due date. These lab assignments will develop students' skills to build systems similar to those described in the lectures and practical sessions. Each assignment must be submitted in Canvas by the due date and time as described in Canvas.

Final Project

Assignments related to the final project will be due during the second half of the course. Details about each assignment will be posted on the course website prior to its deadline. The goal is to further develop students' skills in conducting and communicating original research.

Grading Scheme

The course is built around a semester-long deep dive into the generation of a multi-task machine learning framework for materials optimization. Project progress will be assessed each week through lab reports tied to the practical session. At the end of the semester, groups will present the resulting framework in a 10 min research presentation.

- Class participations 10%
- Assignments and weekly lab reports 50%
- Final project 40%

Lab Policy

The practical's in this class all build upon one another eventually culminating in a final oral presentation. The assignment from each practical should be uploaded to Canvas before the beginning of the next practical. Late submissions will be penalized exponentially with a half-life of 7 days.

Classroom Behavior

Both students and faculty are responsible for maintaining an appropriate learning environment in all instructional settings, whether in person, remote or online. Those who fail to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation or political philosophy. For more information, see the [classroom behavior](#) policy, the [Student Code of Conduct](#), and the [Office of Institutional Equity and Compliance](#).

Requirements for COVID-19

As a matter of public health and safety, all members of the CU Boulder community and all visitors to campus must follow university, department and building requirements and all public health orders in place to reduce the risk of spreading infectious disease. CU Boulder currently requires COVID-19 vaccination and boosters for all faculty, staff and students. Students, faculty and staff must upload proof of vaccination and boosters or file for an exemption based on medical, ethical or moral grounds through the MyCUHealth portal.

The CU Boulder campus is currently mask-optional. However, if public health conditions change and masks are again required in classrooms, students who fail to adhere to masking requirements will be asked to leave class, and students who do not leave class when asked or who refuse to comply with these requirements will be referred to Student Conduct and Conflict Resolution. For more information, see the policy on classroom behavior and the Student Code of Conduct. If you require accommodation because a disability prevents you from fulfilling these safety measures, please follow the steps in the "Accommodation for Disabilities" statement on this syllabus.

If you feel ill and think you might have COVID-19, if you have tested positive for COVID-19, or if you are unvaccinated or partially vaccinated and have been in close contact with someone who has COVID-19, you should stay home and follow the further guidance of the Public Health Office (contacttracing@colorado.edu). If you are fully vaccinated and have been in close contact with someone who has COVID-19, you do not need to stay home; rather, you should self-monitor for symptoms and follow the further guidance of the Public Health Office (contacttracing@colorado.edu). {Faculty: insert your procedure here for students to alert you about absence due to illness or quarantine. Because of FERPA student privacy laws, do not require students to state the nature of their illness when alerting you. Do not require "doctor's notes" for classes missed due to illness; campus health services no longer provide "doctor's notes" or appointment verifications.}

Accommodation for Disabilities

If you qualify for accommodations because of a disability, please submit your accommodation letter from Disability Services to your faculty member in a timely manner so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities in the academic environment. Information on requesting accommodations is located on the [Disability Services website](#). Contact Disability Services at 303-492-8671 or dsinfo@colorado.edu for further assistance. If you have a temporary medical condition, see [Temporary Medical Conditions](#) on the Disability Services website.

Preferred Student Names and Pronouns

CU Boulder recognizes that students' legal information doesn't always align with how they identify. Students may update their preferred names and pronouns via the student portal; those preferred

names and pronouns are listed on instructors' class rosters. In the absence of such updates, the name that appears on the class roster is the student's legal name.

Honor Code

All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the [Honor Code](#). Violations of the Honor Code may include, but are not limited to: plagiarism, cheating, fabrication, lying, bribery, threat, unauthorized access to academic materials, clicker fraud, submitting the same or similar work in more than one course without permission from all course instructors involved, and aiding academic dishonesty. All incidents of academic misconduct will be reported to Student Conduct & Conflict Resolution (honor@colorado.edu); 303-492-5550). Students found responsible for violating the [Honor Code](#) will be assigned resolution outcomes from the Student Conduct & Conflict Resolution as well as be subject to academic sanctions from the faculty member. Additional information regarding the Honor Code academic integrity policy can be found on the [Honor Code website](#).

Sexual Misconduct, Discrimination, Harassment and/or Related Retaliation

CU Boulder is committed to fostering an inclusive and welcoming learning, working, and living environment. University policy prohibits sexual misconduct (harassment, exploitation, and assault), intimate partner violence (dating or domestic violence), stalking, protected-class discrimination and harassment, and related retaliation by or against members of our community on- and off-campus. These behaviors harm individuals and our community. The Office of Institutional Equity and Compliance (OIEC) addresses these concerns, and individuals who believe they have been subjected to misconduct can contact OIEC at 303-492-2127 or email cureport@colorado.edu. Information about university policies, [reporting options](#), and support resources can be found on the [OIEC website](#).

Please know that faculty and graduate instructors have a responsibility to inform OIEC when they are made aware of any issues related to these policies regardless of when or where they occurred to ensure that individuals impacted receive information about their rights, support resources, and resolution options. To learn more about reporting and support options for a variety of concerns, visit [Don't Ignore It](#).

Religious Holidays

Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. In this class, **email me within the first two weeks of the semester so we can arrange the accommodations in advance.**

See the [campus policy regarding religious observances](#) for full details.