IND E 528 Predictive Analytics for Systems Engineers
Syllabus

A. Course Information

a. IND E 528
b. Predictive Analytics for Systems Engineers
c. 3 Credits
d. Winter/Spring
e. Tuesdays 4:30 - 7:20 PM
f. Location: SIG 433
g. Instructor: Dan Li, dli27@uw.edu
h. Office Hour: By appointment

B. Course Content

Course description/course overview: This course will focus on formulating and solving prediction problems in engineering systems using data-driven methods. Examples of problems will be drawn from real-world manufacturing, logistics and supply chain, healthcare, and transportation systems. The emphasis will be on the use of advanced machine learning techniques, which will cover dimensionality reduction, functional data analysis, model selection, supervised learning, and unsupervised learning. Supervised learning will include representative models from both non-parametric statistical learning (e.g., kernel methods, generalized additive models, etc.) and deep learning (e.g., convolutional neural networks, recurrent neural networks, etc.). Causal analysis and time series forecasting will be briefly discussed.

Learning objectives: By the end of the course, students should be able to:

a. Formulate prediction problems that arise in a variety of complex real-world engineering systems, including but not limited to manufacturing, logistics and supply chain, healthcare, and transportation domains.
b. Select, implement, and justify appropriate machine learning methods to predict the behaviors and outcomes of the formulated system-level problems.
c. Analyze and evaluate method predictions with consideration to modeling assumptions, data availability and quality, generalizability to broader problems, and transferability to related problems.
d. Communicate predictive analytics methods, results, and interpretations clearly and effectively in both oral presentations and written reports.

Course materials: Programming is mandatory in this class. Python is the recommended language for homework assignments, course projects, and exams. R is also accepted.

While there are no required textbooks for this class, there are some useful resources. As possible, lecture materials will be made available on the Canvas website unless noted otherwise.

- Gareth James, Daniela Witten, Trevor Hastie, and Robert Tibshirani. 2017. *An Introduction to Statistical Learning with Applications in Python*. https://www.statlearning.com/
- Ronald Kneusel, 2021. *Practical Deep Learning: A Python-Based Introduction*. No Starch Press.
- Piotr Kokoszka and Matthew Reimherr. 2017. *Introduction to Functional Data Analysis*. Chapman

and Hall/CRC.

Prerequisite: IND E 527 or equivalent

C. Grading

Assignment weight/point distribution:

a. Homework: 40% (10% each for four assignments)
b. Take-home Exam: 20%
c. Group Project: 40% (10% for proposal presentation, 15% for final presentation, and 15% for final report)

D. Course Schedule: Topical Outline

Week	Class Topic
1	Overview and Introduction; Examples of Engineering Systems Prediction Problems
2	System-Level Pattern & Regime Discovery
3	Classification and Regression
4	Model Selection, Regularization, and Generalization; Project Proposal Presentation
5	Smoothing and Functional Data Foundations
6	PCA and Functional PCA
7	Representation Learning and Deep Learning
8	Time Series and Data-Driven Dynamics
9	Bayesian Modeling and State-Space Estimation
10	Final Project Presentation

E. Course Policies

During Class

- The lecture notes and supporting materials will be made available before each class. However, the lecture notes may be updated after class; therefore, always check Canvas for the latest version.
- You are expected to participate actively in the class. Questions are highly encouraged. (*Online students: Each class meeting generally includes a live in-person lecture which is also recorded for future asynchronous learning. Synchronous participation by attending online (Zoom) lectures is encouraged but not required. Asking questions, answering questions, or commenting on course material via the online discussion board is also encouraged.*)

- All course material (including HW assignments and project details) will be available on Canvas.
- The project presentations have to be given at pre-assigned times during regular lecture hours, and it is your responsibility to figure out alternate arrangements in case these times do not work for you. No recorded videos will be considered in lieu of 'live' presentations. *(Online students: For the project presentations, you are encouraged to give them at pre-assigned times during the regular lecture hours. However, this is not required, and you can instead upload recorded presentations by their due dates.)*
- You have a responsibility to help create a classroom environment where all may learn. This means that you will treat other members of the class with courtesy.
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AI Policy

You are encouraged to use AI tools to support learning (e.g., understanding concepts, debugging, or exploring alternatives), but AI may not be used to generate **complete or substantially complete** homework and projects. **AI is prohibited from generating exam solutions**. Any use of AI must be explicitly disclosed, including how it was used; undisclosed or sole reliance on AI will be treated as academic misconduct.

Assignments, Final Project, and Exam

- Homework assignments can be finished in groups of no more than 3 students or individually. Only one student in the group submits the assignment. In the assignment, you must list the contribution of each group member.
- Whether and how AI was used must be disclosed in each assignment or project submission.
- Final Project can be finished in groups of no more than 3 students or individually. Standards will be consistent across different group sizes.
- The take-home exam will take place in week 6 or 7. You will have one week to finish the exam (similar to an assignment format, no countdown). You must finish the exam independently (using AI, copying other people's solutions, or letting other people copy your solutions for the exam will be reported).

Religious Accommodations:

Washington state law requires that UW develop a policy for accommodation of student absences or significant hardship due to reasons of faith or conscience, or for organized religious activities. The UW's policy, including more information about how to request an accommodation, is available at Religious Accommodations Policy (https://registrar.washington.edu/staffandfaculty/religious-accommodations-policy/). Accommodations must be requested within the first two weeks of this course using the Religious Accommodations Request form (https://registrar.washington.edu/students/religious-accommodations-request/)."

Accommodations & Access:

If you have already established accommodations with Disability Resources for Students (DRS), please communicate your approved accommodations to me at your earliest convenience so we can discuss your needs in this course. If you have not yet established services through DRS, but have a temporary health condition or permanent disability that requires accommodations (conditions include but not limited to; mental health, attention-related, learning, vision, hearing, physical or health impacts), you

are welcome to contact DRS at 206-543-8924 or uwdrs@uw.edu or disability.uw.edu. DRS offers resources and coordinates reasonable accommodations for students with disabilities and/or temporary health conditions. Reasonable accommodations are established through an interactive process between the student, instructor, and DRS. It is the policy and practice of the University of Washington to create inclusive and accessible learning environments consistent with federal and state law.

Academic Integrity:

Engineering is a profession demanding a high level of personal honesty, integrity and responsibility. Therefore, it is essential that engineering students, in fulfillment of their academic requirements and in preparation to enter the engineering profession, adhere to the College of Engineering Statement of Principles.

Specifically, for the homework assignments, you are encouraged to discuss the problems with the instructor before submission. You can also discuss the problems with your classmates, but *your submissions must clearly reflect your own, original work*. For the take-home exam, you can only discuss the questions with the instructor; discussions with your classmates are not allowed.

Any student in this course suspected of academic misconduct (e.g., cheating, plagiarism, or falsification) will be reported to the College of Engineering Dean's Office and the University's Office of Community Standards and Student Conduct to initiate the student conduct process. *Any student found to have committed academic misconduct may receive a zero for their grade on the impacted academic work (e.g., assignments, exams, etc.), and academic consequences, with the possibility of expulsion.* If the student is found not responsible, the student will receive a grade based on the standard grading criteria for that assignment or exam.

Title IX:

UW, through numerous policies, prohibits sex- and gender-based violence and harassment, and we expect students, faculty, and staff to act professionally and respectfully in all work, learning, and research environments. For support, resources, and reporting options related to sex- and gender-based violence or harassment, visit UW Title IX's webpage (https://www.washington.edu/titleix/), specifically the Know Your Rights & Resources guide (https://www.washington.edu/titleix/files/2020/08/KYRR-guide-8-10-2020-LINKED.pdf).

If you choose to disclose information to me about sex- or gender-based violence or harassment, I will connect you (or the person who experienced the conduct) with resources and individuals who can best provide support and options. You can also access those resources directly:

- Confidential: Confidential advocates (https://www.washington.edu/sexualassault/support/advocacy/) will not share information with others unless given express permission by the person who has experienced the harm or when required by law.
- Private and/or anonymous: SafeCampus (https://www.washington.edu/safecampus/) provides consultation and support and can connect you with additional resources if you want them. You can contact SafeCampus anonymously or share limited information when you call.

Please note that some senior leaders and other specified employees have been identified as "Officials Required to Report." (https://www.washington.edu/titleix/title-ix-officials-required-to-report/) If an Official Required to Report learns of possible sex- or gender-based violence or harassment, they are required to call SafeCampus and report all the details they have in order to ensure that the person who experienced harm is offered support and reporting options (https://www.washington.edu/titleix/resources/).

Privacy:

Some aspects of the course will take place over zoom. While students are encouraged to turn on their cameras if they are able, there is no requirement or penalty for keeping your camera off. For any session that is recorded on Zoom, the recording will capture the presenter's audio, video and computer screen. The recordings will only be accessible to students enrolled in the course to review materials. These recordings will not be shared with or accessible to the public. The University and Zoom have FERPA-compliant agreements in place to protect the security and privacy of UW Zoom accounts. Students who **do not** wish to be recorded should:

- Choose a Zoom username that does not include any personal identifying information like their name or UW Net ID; and
- Not share their computer audio or video during their Zoom sessions.

Land Acknowledgement:

The University of Washington acknowledges the Coast Salish peoples of this land, the land which touches the shared waters of all tribes and bands within the Suquamish, Tulalip and Muckleshoot nations."