ISE 599 Advanced Topics on System Monitoring and Causal Inference with Complex Engineering Data
Units: 3
Time: TThu 2-3:20PM; Room: SOS B4
Spring 2022

Instructor: Prof. Q. Huang
Office: GER 216C
Office Hours: Thursday 9:30-10:50AM
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Zoom link for the first week of the class: https://usc.zoom.us/j/99622957514

Semester Calendar

Classes Begin	Monday	January 15
MLK Day	Monday	January 17
President's Day	Monday	February 17
Project Proposal &Presentation	**Tuesday, March 8,**	
Midterm Exam	**Thursday, March 10**	
Spring Break:	**March 13-20**	
Final Project Report and Presentation	**April 26 & 28,**	
Classes End	Friday	April 29
Final Exam,	**No final exam**	

Course Description

This course aims to introduce the state of art methodologies on system monitoring and causal inferences with complex data. Advanced statistical and machine learning methods and their applications will be introduced. This course will help students lay a solid foundation in the concepts, methods, and algorithms needed to do research and applications in engineering data analytics. It will cover the following modules:

- Module 1 - Process Monitoring, Change Detection, and Diagnosis of Control Charts
- Module 2: Causal Inference for Engineering Process Diagnosis
- Module 3: Functional Data Analytics
- Module 4: Causal Inference through Active Learning, Computer Experiments, and Uncertainty Quantification
- Module 5: Engineering Informed Machine Learning

Learning Objectives

- Identify and define the goal of system monitoring and causal inference;
- Formulate system monitoring and causal inference problems with complex data;
- Identify and choose proper statistical and machine learning methods;
- Understand and conduct advanced data analysis

Prerequisite(s): ISE 610 or 525 (or special approval)

Course Notes
- This course will be graded in letter.
- Lecture slides and other class information will be posted on Blackboard.

Technological Proficiency and Hardware/Software Required

Using statistical software is mandatory in your class project and some of your homework assignments. At your convenience, you could choose R, Python, or Matlab.

Required Readings and Supplementary Materials
No textbook requirement. Supplementary materials and lecture notes will be provided.

Description and Assessment of Assignments

There will be homework assignments for topic and a semester-long class project and research paper. The semester paper may involve individual or team work and will accounts for 30% of the course grade. Student teams will be required to present and submit a semester research paper in which they either implement state-of-the-art models or conduct independent research on one or a combination of the following topics: change detection and causal inference through advanced analysis of complex data.

The topic and methods used in the paper are expected to be consistent with those studied in the course. Each paper must involve non-trivial data analysis and synthesis. Data will not be provided, thus students are expected to obtain their own sources.

At the end of the semester, students must submit a complete research paper including their comprehensive analysis and formalized model development.

For the class project, please form a team of two or three students. In the final project report, all team members should sign and state that they contribute to their project roughly equally. Every member will receive the same grade on the project.

All reports should be typewritten and printed out for handing in. The report should not exceed 20 pages. (12 point, double space, Appendix does not count to 20 pages.) The report must have a professional appearance. Clarity and thoroughness of the analysis, and good use of the English language, including grammar, spelling and punctuation, are considered in grading the project.

Grading Breakdown

Assessment Tool (assignments)	Points	% of Grade
Homework		30%
Midterm exam on (in class)		30%
Class project		40%
Project proposal & presentation		
Final project and presentation		
TOTAL		100%

Grading Scale
(Optional – the following is only an example of what one might look like if included)
Course final grades will be determined using the following scale

A	93-100		C	67-69
A-	87-92		C-	63-66
B+	82-86		D	60-62
B	78-81		F	59 and below
B-	75-77			
C+	70-74			

Assignment Submission Policy
- Project Proposal and Presentation
- For **on-campus** students, assigned homework will be collected **in class**. **During pandemic we only accept electronic submission**. Homework is due one week after it was assigned. *No late homework will be accepted in general.*

Additional Policies
- Midterm exam can be taken on or before the scheduled exam date.
- Both exams will be closed book, closed notes. One page (8 ½ x 11) formula sheet can be used. Be sure to bring your calculator. There will be ABSOLUTELY NO SHARING among students of books, formula sheets, or calculators.
- Please show steps in your work in order to gain partial or full credits.
- If you believe there was an error in the grading of an exam, then you can submit the entire exam to the instructor requesting to re-grade. This must be done *within one week* from the date the exam was returned. The entire exam will be re-graded, so that you may gain, or lose, points by resubmitting.
- During class time, please *turn off* all cell phones.
- Students are responsible for all information conveyed during class and on Blackboard (www.uscden.net). It is the student's responsibility to make sure they are receiving their emails related to the class.
- Always bring your textbook to class! Also bring your calculator, notebook, pencils/pens, eraser, and course syllabus.
- If there is any discrepancy between class policy and DEN or USC policy, we will follow DEN/USC policy.

Course Schedule: A Weekly Breakdown

	Topics/Daily Activities	Readings/Preparation	Deliverables
Week 1	Course Introduction and Overview **1. Module 1 - Process Monitoring, Change Detection, and Diagnosis of Control Charts** 1.1 Review of Univariate Control Charts-I	HW#1	
Week 2	Review of Univariate Control Charts-II 1.2 Multivariate Control Charts: Chi-square control chart and T-square Control chart		
Week 3	1.3 Multivariate CUSUM and EWMA Control Charts 1.4 Multivariate Attribute Control Charts	HW#2	
Week 4	1.5 Multivariate Regression Adjustment Control Charts and Dimension Reduction 1.6 Diagnosis of Control Charts **2. Module 2: Causal Inference for Engineering Process Diagnosis** 2.1 Brief Review of Causal Inference Through Design of Experiments 2.2 Advanced Topics of Experimental Design-I 2.2.1 Two-way layout with fixed effects 2.2.2 Two-factor random effects		
Week 5	2.2.3 Two-factor mixed effects 2.3 Advanced Topics of Experimental Design-II 2.3.1 Two-Stage Nested Design 2.3.2 Nested Design with Cross Factors 2.3.3 Split-plot Design (vs. Nested Design) 2.4 Engineering Process Diagnosis -I: Single Dominant Error Source	HW#3	
Week 6	Engineering Process Diagnosis -I: Single Dominant Error Source 2.5 Engineering Process Diagnosis -II: Multiple Independent Error Sources 2.6 Engineering Process Diagnosis -III: Multiple Confounding Error Sources	HW#4	
Week 7	**3. Module 3: Functional Data Analytics** 3.1 Functional Data Modeling 3.2 Functional Principal Component Analysis 3.3 Functional Regression Models and Applications	HW#5	**Project Proposal**
Week 8	**4. Module 4: Causal Inference through Active Learning, Computer Experiments, and Uncertainty Quantification** 4.1 Active Machine Learning -I		

	4.2 Active Machine Learning -II		
Week 9	Self-Learning Module: Topics from Students	HW#6	
Week 11	4.3 Introduction of Computer Experiment Design 4.4 Gaussian Process Modeling for Computer Experiment Design		
Week 12	4.5 Gaussian Process Modeling via Spectral Decomposition 4.6 Gaussian Process Model Estimation and Uncertainty Quantification	HW#7	
Week 13	4.7 Computer Model Calibration -I 4.8 Computer Model Calibration – II		
Week 14	**5. Module 5: Engineering Informed Machine Learning** 5.1 Learning Through Engineering Effect Equivalence -I : Modeling with Lurking Variables and Application in 3D Printing 5.2 Learning Through Engineering Effect Equivalence II: Optimal Compensation in 3D Printing 5.3 Learning Through Engineering Effect Equivalence III: Transfer Learning and Application in 3D Printing		
Week 15	5.4 Cross-Domain Model Learning and Application in Nanomanufacturing 5.5 Engineering informed Learning of Nanostructure Growth Processes	HW#8	
Week 16	Final Project Presentation		**Final Project Report**
FINAL			

Statement on Academic Conduct and Support Systems

Academic Conduct:

Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, "Behavior Violating University Standards" policy.usc.edu/scampus-part-b. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on Research and Scholarship Misconduct.

Students and Disability Accommodations:

USC welcomes students with disabilities into all of the University's educational programs. The Office of Student Accessibility Services (OSAS) is responsible for the determination of appropriate accommodations

for students who encounter disability-related barriers. Once a student has completed the OSAS process (registration, initial appointment, and submitted documentation) and accommodations are determined to be reasonable and appropriate, a Letter of Accommodation (LOA) will be available to generate for each course. The LOA must be given to each course instructor by the student and followed up with a discussion. This should be done as early in the semester as possible as accommodations are not retroactive. More information can be found at osas.usc.edu. You may contact OSAS at (213) 740-0776 or via email at osasfrontdesk@usc.edu.

Support Systems:

Counseling and Mental Health - (213) 740-9355 – 24/7 on call
studenthealth.usc.edu/counseling
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

National Suicide Prevention Lifeline - 1 (800) 273-8255 – 24/7 on call
suicidepreventionlifeline.org
Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-9355(WELL), press "0" after hours – 24/7 on call
studenthealth.usc.edu/sexual-assault
Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office for Equity, Equal Opportunity, and Title IX (EEO-TIX) - (213) 740-5086
eeotix.usc.edu
Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

Reporting Incidents of Bias or Harassment - (213) 740-5086 or (213) 821-8298
usc-advocate.symplicity.com/care_report
Avenue to report incidents of bias, hate crimes, and microaggressions to the Office for Equity, Equal Opportunity, and Title for appropriate investigation, supportive measures, and response.

The Office of Student Accessibility Services (OSAS) - (213) 740-0776
osas.usc.edu
OSAS ensures equal access for students with disabilities through providing academic accommodations and auxiliary aids in accordance with federal laws and university policy.
USC Campus Support and Intervention - (213) 821-4710
campussupport.usc.edu
Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity, Equity and Inclusion - (213) 740-2101
diversity.usc.edu
Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call
dps.usc.edu, emergency.usc.edu
Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety - UPC: (213) 740-6000, HSC: (323) 442-120 – 24/7 on call
dps.usc.edu

Non-emergency assistance or information.

Office of the Ombuds - (213) 821-9556 (UPC) / (323-442-0382 (HSC)
ombuds.usc.edu
A safe and confidential place to share your USC-related issues with a University Ombuds who will work with you to explore options or paths to manage your concern.

*Occupational Therapy Faculty Practice - (323) 442-33*40 or otfp@med.usc.edu
chan.usc.edu/otfp
Confidential Lifestyle Redesign services for USC students to support health promoting habits and routines that enhance quality of life and academic performance.