

ME 453: Data Science in Manufacturing Quality Control

Fall 2022

3 or 4 Credit Hours

Time: MW 1pm–2:20pm (Central Time)

Room: 106B1 Engineering Hall

Instructor: Dr. Chenhui Shao
Office: 2030 Sidney Lu Mechanical Engineering Building
Email: chshao@illinois.edu
Office Hours: 2:30pm–4pm on Monday or by appointment

Course Website

Canvas. Lecture handouts, homework assignments and solutions, and laboratory manuals will be posted to the website. Class-related announcements will also be made here.

Textbook

The lecture notes and laboratory manuals are self contained. No textbook is required. Recommended references include the following.

- D. C. Montgomery, *Introduction to Statistical Quality Control*, 8th Edition, Wiley, 2019, ISBN: 978-1-119-39930-8.
- K. P. Murphy. *Probabilistic Machine Learning: An Introduction*. MIT press, 2022, ISBN: 9780262046824.
- Academic papers and tutorials as recommended.

Prerequisite

ME 270; IE 300 or STAT 400; and MATH 257 or MATH 415.

Computing

The software we will be using for this course is Python.

Grading Policy

Homework	30%
Laboratory Assignments	35%
Course Project	35%

Your course grade will be based on the weighting scheme presented above. There is no fixed grading scale for this course. Conversion from your percentage score to letter grades will be carried out at the end of the course.

Homework

- There will be approximately six homework assignments during the course. Generally, the homework will be assigned every other Wednesday.
- Homework shall be submitted electronically through Canvas. Scanned copies of handwritten homework are fine.

- No late homework will be accepted.
- The lowest homework grade will be dropped.

Laboratory Assignments

- You will form *Data Analytics Groups* and work on five laboratory sessions. Each group will have three or four members (depending on the final enrollment).
- Lab schedule

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| Lab 1 | Data visualization and simple data analysis |
| Lab 2 | Measurement system analysis |
| Lab 3 | Feature engineering |
| Lab 4 | Classifier design |
| Lab 5 | Image data analysis |

- Students who register for the 3 credit hour session do not need to work on the reports but must work on the other parts of the labs and make equal contributions with other members in the group.
- A contribution statement is required at the end of each lab report.

Course Project

- The same group assignment for the labs applies to the final course project.
- The project topics will be closely related to real-world manufacturing problems. Production data provided by the instructor's industry collaborators will be used.
- The tasks of the final project consist of a project proposal, data analysis, an oral presentation, and a written report. A contribution statement is required at the end of the project report.
- A mock industry review will be adopted for the grading of the final project. Experts from industry and academia will be invited as judges.

Course Outcomes

- Model product quality characteristics using statistical methods.
- Construct control charts to monitor the quality of manufacturing processes.
- Conduct measurement system analysis to evaluate the repeatability and reproducibility of measurement systems.
- Design quality monitoring systems for manufacturing applications.
- Extract monitoring features from high-dimensional sensing data.
- Select the most useful features for quality monitoring.
- Design classifiers to predict product quality using machine learning techniques.

Tentative Course Outline

1. Course overview
2. Modeling of process quality
3. Inferences about quality
4. Methods and philosophies of SPC
5. Control charts for variables
6. Control charts for attributes
7. Measurement system analysis
8. Quality monitoring in modern manufacturing

9. Feature generation
10. Feature selection
11. Bayesian decision
12. Support vector machine
13. KNN classifier
14. Classification trees
15. Gaussian process
16. Neural networks

Course Policy

- You are expected to adhere to all of the rules pertaining to academic integrity outlined in the Student Code (<https://studentcode.illinois.edu>). Failure to do so will result in an automatic F for the course.
- It is expected that each student will be courteous and respectful to all members of the class and will carry him or herself in an orderly manner for the entire duration of the course as outlined in the Student Code (<https://studentcode.illinois.edu>).
- You are encouraged to discuss homework problems with your fellow classmates. But your final answers should be based on your own understanding. Copying others' work is NOT acceptable.

Special Accommodations

To obtain disability-related adjustments and/or auxiliary aids, students with disabilities should contact the course instructor and the Disability Resources and Educational Services (DRES) as soon as possible. To contact DRES, you may visit 1207 S. Oak Street, Champaign, IL 61820; call (217) 333-1970; email disability@illinois.edu; or go to the DRES website, <http://disability.illinois.edu>. Please also schedule a private meeting with the course instructor to discuss your needs and requirements. Please note accommodations are not retroactive to the beginning of the semester but begin the day you contact the course instructor with a current letter of accommodation from DRES.

Support Resources and Supporting Fellow Students in Distress

- As members of the Illinois community, we each have a responsibility to express care and concern for one another. If you come across a classmate whose behavior concerns you, whether in regards to their well-being or yours, we encourage you to refer this behavior to the Student Assistance Center ((217) 333-0050) or online at <https://odos.illinois.edu/community-of-care/referral/>. Based upon your report, staff in the Student Assistance Center reaches out to students to make sure they have the support they need to be healthy and safe.
- Further, as a Community of Care, we want to support you in your overall wellness. We know that students sometimes face challenges that can impact academic performance (examples include mental health concerns, food insecurity, homelessness, personal emergencies). Should you find that you are managing such a challenge and that it is interfering with your coursework, you are encouraged to contact the Student Assistance Center (SAC) (<https://odos.illinois.edu/community-of-care/student-assistance-center/>) in the Office of the Dean of Students for support and referrals to campus and/or community resources.