STA3XX Statistical Process and Quality Control

Catalog Description

An introductory course in statistical process control(SPC). Topics include modeling process quality, control charts for variables and attributes, cumulative sum and exponentially weighted moving average and other univariate control charts, process capability index, and acceptance sample techniques. Some recent developments of SPC methods and several special topics in the applications of SPC in the non-manufacturing industry are also covered. The emphasis will be on applications, rather than technical derivations. Students will make substantial use of the statistical computer programs in the class.

Pre-requisites

B or better in MAT 125.

Textbook and Coverage

- **Textbooks (Optional):**
    - *Introduction to Statistical Quality Control* (any edition), by Douglass Montegomery, Wiley.
    - *Introduction to Statistical Process Control*, by Peihua Qiu, CRC Press.
- **Class notes:** Weekly notes will be provided.
- **Coverage:** See the list of tentative topics.

Assessments

- **Attendance and Participation:** (10%) Attendance to class is mandatory. Participating in class discussions is required.
- **Weekly Assignments:** (40%) There will be weekly assignments (except for week #1).
- **Midterm exam:** (20%) There will be a written midterm exam.
- **Individual Term Project:** (total 30%) There will be an individual term project focusing on applications of one or more SPC techniques in a specific field such as business, finance, healthcare, environmental science, etc. The project includes translating real-world problems to analytic questions, data analysis using appropriate SPC methods and justification of the selection of the SPC methods, summarizing the results, and writing a formal statistical report.

Suggested Weekly Topics

Week 1: Introduction and Probability Review

- Introduction to SPC
    - Concepts of SPC and Quality

- Quality Improvement in Business Environment
- SPC as an analytic tool in the big data era
- Software
  - Install R, Rstudio, and LaTex.
  - Create a SAS Account to use SAS OnDemand (SAS Studio)
- Review of Probability Distributions
  - Continuous distributions: normal related distributions
  - Discrete distributions: binomial and Poisson distributions

Week 2: Numeric Characteristics of Processes and Inferences

- Sampling distributions about sample means and proportions
- Distribution of process characteristics and parameter estimation
- One- and two-sample problems
- Type I and type II error
- Operating characteristic (OC) curve

Week 3: Methods of Statistical Process Control

- Quality Variation: Random and Assignable Causes
- Components of statistical control chart
- Types control charts: variable and attributes
- Implementing SPC
- SPC in the Non-manufacturing industry such as financial and environmental, etc.

Week 4: Control Chart for Variable

- Definitions
  - ARL - average run length
  - LSL and USL - Lower and upper specification limits
  - PCI - Process capability index
- Charting $\bar{x}$ and R (range)
- Charting $\bar{x}$ and s (standard deviation)
- Shewhart Control Chart
- Case study

Week 5: Control Chart for Attributes

- Control chart for proportions: p-chart
- Control chart for counts/frequencies: c-chart
- Control chart of counts/frequencies: u-charts
- Choices between variables and attributes control charts
- Case studies: Implementation control charts

Week 6: Process Capability Analysis

- Process capability analysis using a histogram
- Process capability indexes (PCI)
  - Basic C_p - first-generation PCI
  - C_{pk} and C_{pm} - second-generation PCIs
  - C_{pkm} -Third generation PCI
- Process capability analysis using a control chart
- Setting specification limits for discrete processes
- Natural tolerance limits of a process

Week 7: CUSUM and EWMV Control Charts

- CUMSUM control chart
- EWMV control chart
- MA control chart
- Case studies

Week 8: Other Univariate Process Control Techniques

- SPC for short production runs
- Modified and acceptance control charts
- Monitoring multiple stream processes
- Monitoring auto-correlated processes
- Change-point models in the process monitoring
- Case studies

Week 9: Acceptance Sampling

- The rationale of acceptance-sampling
- Single-sample plans for attributes
- Double, multiple, and sequential sampling
- Acceptance sampling for variables
- Continuous sampling
- Case studies

Week 10: New Developments in SPC

- Strategies for developing new PCIs and control charts
- Bootstrap specification limits determination
- PCIs as algorithms of feature extraction
- Auto-correlated PCI processes
- PCI-based scalable algorithms for anomaly detection
- Open problems - potential research topics

Week 11: SPC in Business and Financial Processes

- SPC for non-normal processes

- Modeling and monitoring various KPIs
- Supplier selection using quality metrics
- One-sided
- Application of PCI-based algorithms in financial risk modeling
  - unsupervised risk detection with constraints
  - supervised risk detection: generalized additive modeling
- Case studies

Week 12: SPC in Environmental Processes

- Definition of numerical characteristics of interests in an environmental process
- Skewed and left-censored environmental process modeling
- one-sided PCIs and control charts
- Heterogeneous dependent and independent processes - PCI standardization
- SPC techniques for monitoring various environmental processes.
- Real-time anomaly detection, correction, prediction in environmental processes
- Case studies

Week 13: SPC in Healthcare and Clinical Processes

- Status of the healthcare performance monitoring, control, and prediction
- Quantifying and modeling of healthcare processes
- SPC technique selection and assignable cause identification
- Control chart in healthcare and public health surveillance
- Misuse of SPC in healthcare processes

Week 14: Project Report

- Finalizing the term project report.