ME 453: Data Science in Manufacturing Quality Control
Homework 4

Assigned: November 10, 2023 Due: November 24, 2023

Homework guidelines:

1. The total number of points is 100. There are also 10 bonus points available from the bonus problems. The assigned points are given beside questions. To get full credit you must SHOW ALL OF YOUR WORK.
2. Bonus points will be used to compensate for lost points in homework assignments.
3. 💻 Indicates the problem which you need to use Python.
4. A complete submission features the following items: (a) a brief report including all figures and results, and explanations of necessary steps taken to obtain them; and (b) and the source code (Python is recommended).
5. Item (a) can be scanned copies of handwritten or typeset reports. Both items shall be submitted through Canvas.

Review the following topics discussed in lecture:

- Control Charts for Attributes (lecture videos 14, 16).

Problem 1 (35 points + 5 points)

A fraction nonconforming control chart with $n = 400$ has the following parameters:

$$\begin{aligned} \text{UCL} &= 0.0962 \\ \text{Centerline} &= 0.0500 \\ \text{LCL} &= 0.0038 \end{aligned}$$

(1) Find the width of the control limits in standard deviation units. (10 points)

(2) What is Type I error of this control chart? (10 points)

(3) Suppose the process fraction nonconforming shifts to 0.15. What is the probability of detecting the shift on the first subsequent sample? (15 points)

(4) [Bonus] 💻 Use software to generate an operating characteristic (OC) curve by varying the fraction nonconforming between 0 and 0.6 in a step of 0.01. (5 points)

Problem 2 (15 points)

A process has an in-control fraction nonconforming of $p = 0.01$.

(1) What sample size would be required for the fraction nonconforming control chart if it is desired to have a probability of at least one nonconforming unit to be at least 0.9? (5 points)

(2) Use the smallest possible sample size that satisfies the requirement in (1) to construct an np control chart. (5 points)

(3) [Bonus] Calculate the Type I error rate for the control chart obtained in (2). (5 points)

Problem 3 (25 points)

A control chart for nonconformities (c chart) is used to monitor a pizza bakery process. The quality characteristic of interest is the number of burnt spots on a pizza. At each sampling time, two pizzas are randomly selected for inspection. The inspection unit is defined as one pizza. The average number of nonconformities per sample when the process is in control is estimated to be two.

(1) Find the appropriate three-sigma control limits for the c chart. (5 points)

(2) What is the probability of type I error for this control chart? (10 points)

(3) What is the sample size? (5 points)

(4) If a u chart is used, what are the three-sigma control limits? (5 points)

Problem 4 (25 points + 5 points)

It is known from Phase I data that we have 40 defects per 1000 products.

(1) One engineer suggests making a quality check every hour by selecting 100 products, how to construct a c monitoring chart? (8 points)

(2) How many products should be checked at each sampling hour in order to obtain a positive lower control limit in c chart? (12 points)

(3) One month later, this engineer decides to inspect 400 products at each sampling hour. Under this new sampling strategy, would you suggest using c chart or u chart for continuously monitoring this process? Justify your answer. (5 points)

(4) [Bonus] For (3), if a u chart is suggested, what is a convenient inspection unit that you would like to suggest? What is the sample size? What are the control limits (CL, UCL, and LCL)? What are c_0 and u_0? (5 points)