Statistics for Engineering, 4C3/6C3

Assignment 3

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Note: Assignment objectives

- Demonstrate an understanding of tests for differences, both paired and unpaired.
- Correctly calculate and interpret confidence intervals.
- Find limits for monitoring charts, and understand their purpose.

Question 1 [12]

Similar, but different from the 2012 final exam.

A company has been producing a polymer for the past 5 years. There are plenty of historical data available, two values per day, that give the conversion of the raw material monomer to the final product, the polymer. An engineering team has just finished a sequence of experiments to test whether a cheaper catalyst, **B**, has any effect on product conversion when compared to the existing catalyst, **A**.

The engineers created a set of $N = 8$ experiments over the 4 days, where they tested the catalyst in an alternating manner: these are experiments 13 to 20 in the table below, together with the resulting conversion.

Experiment	Catalyst used	Conversion [%]	Experiment	Catalyst used	Conversion [%]
1	**A**	85	11	**A**	84
2	**A**	78	12	**A**	80
3	**A**	81	13	**B**	76
4	**A**	79	14	**A**	79
5	**A**	97	15	**B**	71
6	**A**	70	16	**A**	76
7	**A**	87	17	**B**	86
8	**A**	74	18	**A**	75
9	**A**	89	19	**B**	92
10	**A**	77	20	**A**	83

1. Describe why the 8 experiments, numbered 13 to 20, could show a misleading result when trying to test the difference between catalysts **A** and **B** using only those 8 data points.
2. Draw a table to show how *you* would have allocated the choice of catalyst **A** or **B** for runs 13 to 20 over those 4 days.
3. Calculate the confidence interval that engineering team would have calculated from only those 8 data points.
4. Given that this experimental work has already been completed, show the first steps of the calculations you could do to extract some additional value from these data. Use the other data in the table to demonstrate your method.

Question 2 [16]

A major aim of many engineers is/will be to reduce the carbon footprint of their company's high-profile products. Next week your boss wants you to evaluate a new raw material that produces 2.6 $\dfrac{\text{kg CO}_2}{\text{kg product}}$ less than the current material, but the final product's brittleness must be the same as achieved with the current raw material. This is a large reduction in CO_2, given your current production capacity of 51,700 kg of product per year. Manpower and physical constraints prevent you from running a randomized test; you don't have a suitable database of historical data either.

One idea you come up with is to use to your advantage the fact that your production line has three parallel reactors, TK104, TK105, and TK107. They were installed at the same time, they have the same geometry, the same instrumentation, *etc*; you have pretty much thought about every factor that might vary between them, and are confident the 3 reactors are identical. Typical production schedules split the raw material between the 3 reactors. Data on the website contain the brittleness values from the three reactors for the past few runs on the current raw material.

1. Which two reactors would you pick to run your comparative trial on next week?
2. 600-level students: see the question below, where you use pairing to answer the same question.

Question 3 [600 level students: 8]

Repeat the above question, but assume samples of raw material were split in thirds and each third was run in one of the reactors.

Use a paired test and calculate the confidence interval for the reactor combinations to answer the question: which two reactors would you pick to run your comparative trial on next week?

Question 4 [3]

Final exam, 2012: Describe why *and* how real-time control charts* can save companies money in processes where there is a long time delay from the point of production until getting the lab results back from quality control testing.

* We've been calling them monitoring charts, but "control charts" is also a term that is used.

Question 5 [9 = 2 + 2 + 1 + 1 + 3]

Final exam, 2012: A filling line in our company fills bottles by weight. The main quality criterion is to ensure the fill weight is stable over time, around the target of 300 mg. Using data from many days of operation, the standard deviation of fill weights was determined to be 21.7 mg and it remains constant, since the equipment has weekly maintenance.

1. Calculate the Shewhart chart control limits that could be used to monitor the fill weights.
2. A basic Shewhart chart is really not the best choice to monitor the fill weights. Explain why not, and what can be used instead.
3. Calculate the lower and upper control limit for an EWMA chart using $\lambda = 0.1$.
4. Calculate the lower and upper control limit for an EWMA chart using $\lambda = 0.9$.
5. Comment on the Shewhart and two EWMA limits you have calculated in this question, and explain why their numeric values make sense in the context of this monitoring problem.

END