CEE 5290/CS 5722/ORIE 5340 Heuristic Methods for Optimization
Homework 5: Statistical Comparisons and Cellular Networks
Assigned: Fri, September 30th, 2011
Due: Fri Oct 7, 2011 -
TA Office Hours Tue 3:00 – 4:30pm, Wed 10:00 – 11:00 am, Thu 3:00-4:30pm in Hollister 203
Prof.Shoemaker Office Hours: Tues ,Wed, Fri 2:30-3:30

Readings: Class handouts on statistical testing and cellular network lecture. Also refer to the "Probability and Statistics Review" and "Hypothesis Testing MATLAB" documents under the Course Documents folder on Blackboard

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1. **Statistical Comparisons:** The table below shows the objective function value for the best solution in each trial for three different algorithms applied to the same problem:

Trial	SA	GA	GS
1	91.94	147.90	47.66
2	77.13	97.88	150.53
3	10.93	39.76	97.04
4	18.6	204.48	82.62
5	28.63	488.83	99.89
6	86.52	113.00	76.52
7	64.58	141.97	87.84
8	22.23	53.76	51.73
9	59.75	408.20	147.51
10	134.11	226.95	115.98
Mean	59.44	192.27	95.73
Std. Dev	39.52	148.35	34.90

(i). Make a boxplot for the data provided above (Use the Matlab command BOXPLOT). Comment on your plot: How do the means and variances compare for each of the algorithms? Are there any outliers? Which algorithm performed the best in your opinion and why?

(ii). Plot empirical CDF's for the data above using the plotting position formula provided in class (i/[n+1]). Comment on your plot: Which algorithm appears to perform the best? Is there any evidence of *stochastic dominance*?

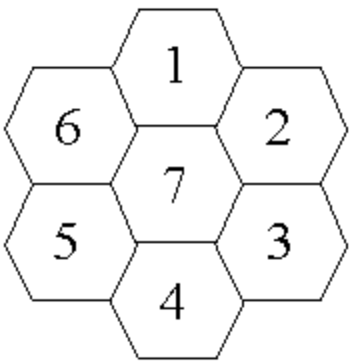
(iii). Perform all pairwise comparisons (three in all) of mean objective function value of best solution using a two-sample t-test. State your hypothesis. Report your test statistic and p-values for each comparison. At $\alpha = 0.05$ what is your conclusion for each test? NOTE: to choose Ha, test if the means are the same at first, then do hypothesis test to see if one mean is higher than the other.

(iv). If you were told that SA and GS had the same starting solution in each trial would you perform a different test for comparing these two algorithms? Explain why or why not. If you decide to perform another test state your hypothesis and report its p-value and your conclusions at $\alpha = 0.05$. Compare your test results to those in (iii).

(v). Perform non-parametric comparisons for all pairwise tests performed in (iii). Report your test statistic and p-values for each comparison. At $\alpha = 0.05$ what is your conclusion for each test? Compare your test results to those in (iii). NOTE: P-value is the probability of obtaining the test statistic observed or higher. If P-value is lower than your alpha (rejection region), then you reject the null hypothesis.

(vi). Summarize your comparisons by different methods. Are your conclusions different in each case? Based on the tests above which algorithm would you pick as the preferable one? Explain your reasons.

2. **Cellular Networks problem (no programming required)**: Consider the following cellular network with interference matrix I and Traffic Vector shown below:



$$I = \begin{array}{cc} & \begin{array}{ccccccc} 1 & 2 & 3 & 4 & 5 & 6 & 7 \end{array} \\ \begin{array}{c} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \end{array} & \begin{bmatrix} 5 & 2 & 0 & 0 & 0 & 2 & 2 \\ 2 & 5 & 2 & 0 & 0 & 0 & 2 \\ 0 & 2 & 5 & 2 & 0 & 0 & 2 \\ 0 & 0 & 2 & 5 & 2 & 0 & 2 \\ 0 & 0 & 0 & 2 & 5 & 2 & 2 \\ 2 & 0 & 0 & 0 & 2 & 5 & 2 \\ 2 & 2 & 2 & 2 & 2 & 2 & 5 \end{bmatrix} \end{array}$$

Traffic Vector = [1 2 2 1 2 2 4]

I is the interference matrix. Hence if **I** = [a_{kj}], then a_{kj} is the number of channels that must be in between cell *k* and cell *j* to avoid interference. So if $a_{kj} = 4$, there must be three channels between the channel in cell *k* and the channel in cell *j*. Hence if channel 1 is in cell *k*, then the channel in cell *j* must be 5 or greater.

a) Provide a solution/channel assignment that has no conflicts. (You can pick the number of channels – try to keep the number of channels to a minimum). Describe this by a matrix with rows for cells and columns for channels, as was done in Prof. Wicker's lecture.

b) Let your objective function be the number of conflicts due to interference. What is the value of the objective function for the channel allocation following (on the next page) if we are trying to minimize the number of conflicts?

Channels

0	0	1	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	1	0	0	0	1	0	0
0	0	1	0	1	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1	0	0	0	0	0
0	0	1	0	0	0	1	0	0	0	0	0	0
0	0	0	1	0	0	0	0	0	0	0	0	1
1	0	0	0	1	0	0	0	0	1	0	0	1

c) How many decision variables are in channel allocation in part (b). i.e. how many decision variables are in a problem with 7 cells and 13 channels?

d) Extra challenge (not graded and not extra credit). Since this is a small problem, you can figure out the minimum number of channels required to avoid interference. Is this minimum number = 17?