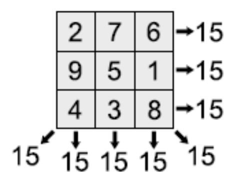
IE 504- Heuristic Methods (Fall 2019)
Homework #3
Due date: January 3, Friday @ 23:55

- Submit your assignment (report, any supporting files) as a single .zip file through LMS.
- This is an individual homework.

Question 1. (40 points). Given distinct n^2 integers (from 1 to n^2) over a matrix $n*n$, a magic square of order n is an arrangement such that the n numbers in all rows, all columns, and both diagonals sum to the same constant. No polynomial-time algorithm exists for this problem. A magic square exists for all $n > 2$. The figure below shows a magic square for $n = 3$. The constant sum in every row, column, and diagonal is called the magic sum M. The magic sum has the value $M(n) = (n^3 + n)/2$. For magic squares of order $n = 3, 4, 5, \ldots$, the magic constants are 15, 34, 65, 111, 175, 260, and so on.



Suppose that you are going to develop a **Genetic Algorithm** to generate a magic square.

a. Propose a solution representation for this problem.
b. How will you evaluate the quality (fitness) of a given chromosome?
c. Describe a strategy to select parent chromosomes for reproduction.
d. Propose one mutation and one crossover operator. Describe how you will consider feasibility in applying these operators.

Question 2. (20 points). Suppose that you want to set the initial temperature for your SA based on a preliminary experiment, in which you set the temperature to a very large value, apply geometric cooling with a parameter of 0.99, and ran 20 iterations. The objective function values obtained in your preliminary experiment are provided below. In the actual implementation, you want to accept about 90% of the non-improving solutions at the beginning of the algorithm. How would you set your initial temperature based on this sample (i.e., describe your approach)? According to your approach, what should be the initial temperature value for this particular example?

Iteration	Objective value	Iteration	Objective value
1	650	11	650
2	550	12	645
3	645	13	755
4	800	14	760
5	825	15	725
6	900	16	710
7	700	17	820
8	750	18	800
9	725	19	550
10	700	20	570

Question 3. (40 points). Find at least one article that presents and applies an innovative strategy to a classical metaheuristic algorithm that we covered during this semester (such as tabu search, simulated annealing, genetic algorithms, ant colony, variable neighborhood search etc.). The innovative strategy can involve a. developing an adaptive version of a classical metaheuristic (e.g., Lü&Hao (2010)) or b. applying a cooperative parallelization scheme (similar to Crainic et al. (2004) that we discussed in class on December 20). It is recommended that you find a paper that applies such a strategy on an optimization problem that is familiar with all of you (e.g., knapsack, bin packing, scheduling, assignment, routing, etc.).

a. Briefly describe the problem and the main algorithm.

b. Describe the innovative strategy in a detailed way. What does it work and how is it implemented?

c. Discuss the effectiveness of the strategy based on the computational results.

d. **(Bonus: 20 points)** Make a brief presentation (10 minutes) in class on December 17 regarding parts a-c above.

e. Do not forget to submit the paper and please use your own words in answering the questions above.

References

Lü, Z., & Hao, J. K. (2010). Adaptive tabu search for course timetabling. *European Journal of Operational Research*, *200*(1), 235-244.

Crainic, T. G., Gendreau, M., Hansen, P., & Mladenović, N. (2004). Cooperative parallel variable neighborhood search for the p-median. *Journal of Heuristics*, *10*(3), 293-314.