Assignment 4 – PSO and ACO

Due date: July 20, 2015 at 11:59PM

What to submit: a report that contains:

- The solution for the first and second written exercises, typed or neatly handwritten.
- Name the assignment report "**Assignment#-Your Project Number#.pdf**" such as "**A4-5.pdf**"
- Upload this file to **Assignment-4** drop box available on UW LEARN.
- Anything handed in after the due date will be penalized by 50% for each 24 hours of lateness.

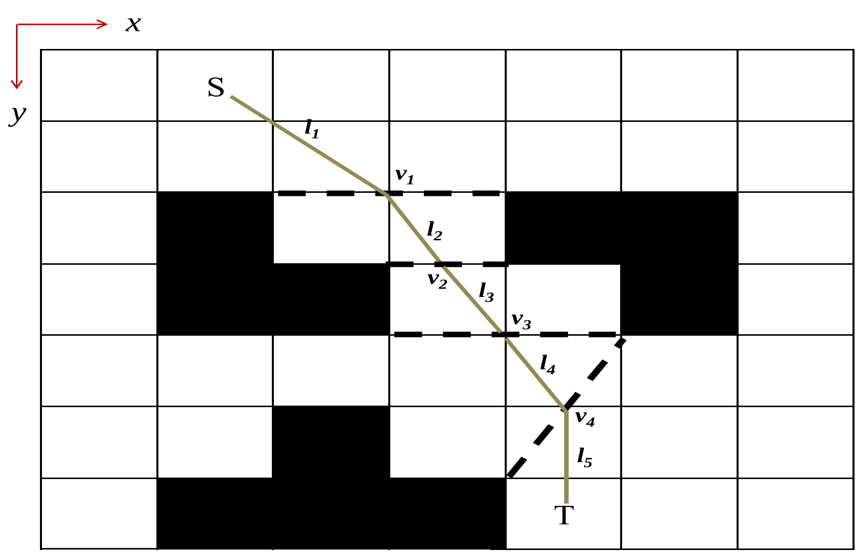
I. Graded Exercises

1. **[Written Exercise - 5 Marks]** Path planning is a process to compute a collision-free path for a robot from a start position (S) to a given goal position (T), amidst a collection of obstacles. Different approaches have been proposed to solve the problem of path planning. The following approach is one possible approach to solve this problem:

Step 1: MAKLINK graph theory to establish the free space model of the mobile robot;

Step 2: utilizing the Dijkstra algorithm to find a sub-optimal collision-free path;

Step 3: utilizing the PSO algorithm to optimize the location of the sub-optimal path so as to generate the globally optimal path.



In the above figure, assume that the suboptimal path found by Dijkstra algorithm is $S \rightarrow v_1 \rightarrow v_2 \rightarrow v_3 \rightarrow v_4 \rightarrow T$. This path is just a sub-optimal path because it passes only through the middle points of those free MAKLINK lines. The dotted lines represent the free of obstacles MAKLINK lines. The black cells represent the grown obstacles.

Assume that the environment is discretized using 7x7 grid model. Each cell is 1x1 unit length. The following table shows the coordinates of each point included in the sub-optimal path.

Point	x	y
S	1.5	0.5
v_1	3	2
v_2	3.5	3
v_3	4	4
v_4	4.5	5
T	4.5	6.5

The total length of the sub-optimal path $= l_1 + l_2 + l_3 + l_4 + l_5$

$$l_1 = \sqrt{(x_{v1} - x_s)^2 + (y_{v1} - y_s)^2} = \sqrt{(3 - 1.5)^2 + (2 - 0.5)^2} = 2.12$$

$$l_2 = \sqrt{(x_{v2} - x_{v1})^2 + (y_{v2} - y_{v1})^2} = 1.12$$

$$l_3 = \sqrt{(x_{v3} - x_{v2})^2 + (y_{v3} - y_{v2})^2} = 1.12$$

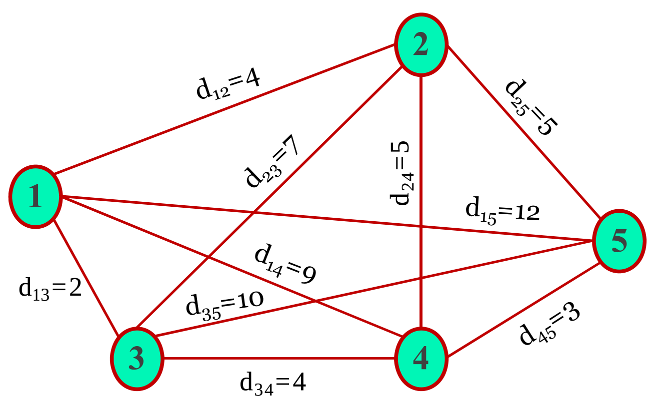
$$l_4 = \sqrt{(x_{v4} - x_{v3})^2 + (y_{v4} - y_{v3})^2} = 1.12$$

$$l_5 = \sqrt{(x_T - x_{v4})^2 + (y_T - y_{v4})^2} = 1.5$$

The total length of the sub-optimal path =6.98 units

Perform two hand iterations to show how to use PSO to obtain a better solution. Select your own values for the parameters.

2. **[Written Exercise - 5 Marks]** Consider solving the following instance of the Travelling Salesman Problem (TSP):



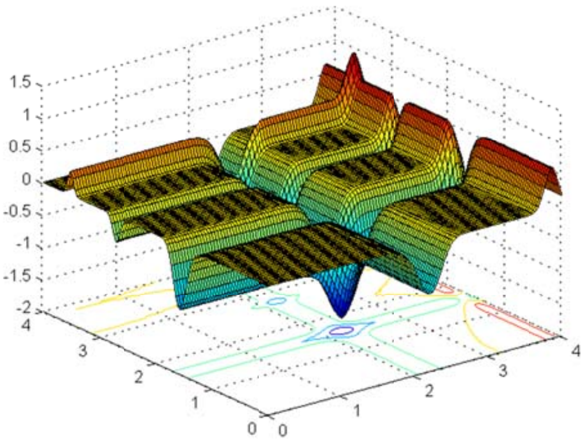
Starting from node 1 and using 2 ants, perform two iterations to show how to solve this problem using Ant System (AS) algorithm. Select your own values for the parameter and explain the basis for your selection.

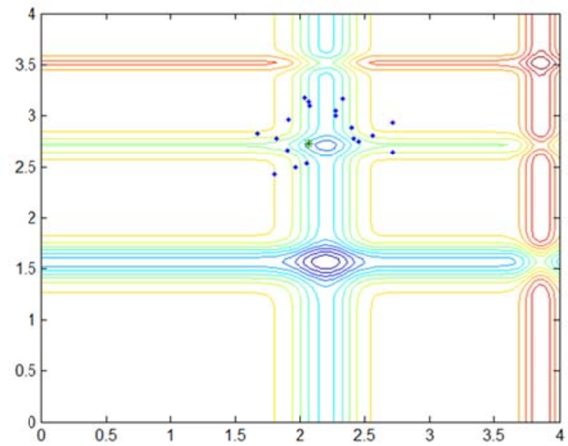
II. Non-Graded Exercises

Run the following projects, tune the different parameters of the search algorithm (PSO/ACO) and report your observation.

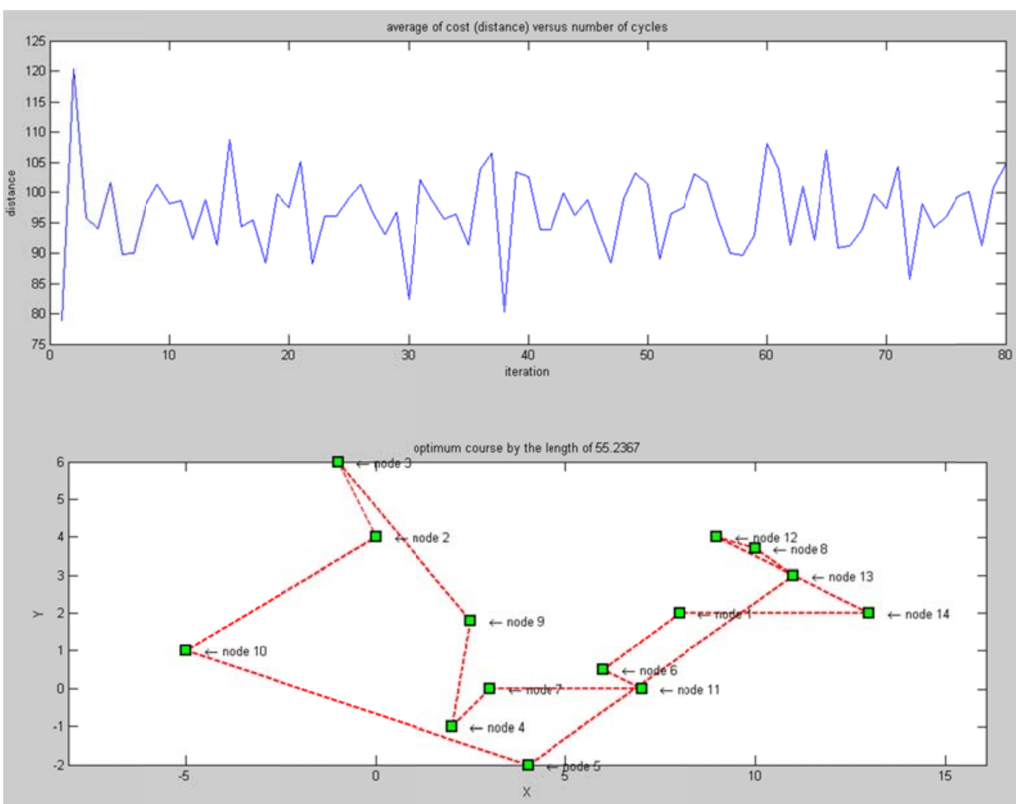
a) The given Matlab code **FunctionOpt.m** implements PSO to find the global minimum of Michaelwicz's 2D function:

$$f(x,y) = -\sin(x)\sin^{20}\left(\frac{x^2}{\pi}\right) - \sin(y)\sin^{20}\left(\frac{2y^2}{\pi}\right)$$





b) **ShortestPath** is a project that illustrates how to use Ant Colony Optimization (ACO) to determine the shortest path. The average distance is plotted against the number of ant cycles. The optimum distance was found to be 55.2367 as shown below.



c) **QAP.m** is a MATLAB code that illustrates how to use ACO to solve the Quadratic Assignment Problem (QAP). In QAP, given a number of n activities assigned to n locations. A distance is specified among each pair of locations, and weight or flow is specified among pairs of activities (representing transfer of data, material, etc.) The problem is to assign all activities to different locations (permutation) with the goal of minimizing the sum of the distances multiplied by the corresponding flows (Quadratic: cost function depends on multiplication of distances by flows).

The code implements the QAP to assign n departments to n unique sites.

Output: Cheapest Cost: 87
Assignments: 365
Assignment

Dept 1 to Site 1	Dept 4 to Site 3	Dept 7 to Site 7
Dept 2 to Site 2	Dept 5 to Site 5	Dept 8 to Site 6
Dept 3 to Site 4	Dept 6 to Site 8	

Source: S. Sumathi and P. Surekha. *Computational Intelligence Paradigms: Theory and Applications using MATLAB*. CRC Press, 2010.