University of Waterloo
Department of Electrical and Computer Engineering
ECE457A: Cooperative and Adaptive Algorithms

Assignment 4 – PSO and ACO

Due date: July 21, 2014 - Midnight

What to hand in: a report that contains:

- The solution for the two written exercises, typed or neatly handwritten
- Zip the assignment report and name it "**Assignment#-Your Project Number#.zip**" such as "**A4-Team5.zip**"
- 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.

1. **[Written Exercise - 5 Marks]** Detection and removal of antipersonnel landmines is, at present, a serious problem of political, economical, environmental and humanitarian dimensions in many countries across the world. Minesweepers: Towards a Landmine-free World is the first international outdoor robotic competition on humanitarian demining. In this competition, each participating team constructs a teleoperated/autonomous unmanned ground/aerial vehicle that must be able to search for underground and aboveground anti-personnel landmines and unexploded ordnances (UXOs). The position and the type of each detected object are visualized and overlaid on the minefield map. The vehicle must be able to navigate through rough terrain that mimics a real minefield.

Assume that an unmanned ground vehicle equipped with landmine detector is scanning the competition arena. This robot tries to build a mine map showing the locations of the detected mines. A major problem is how the robot localizes itself in the field in order to correctly build this mine map. Global localization can be used to compute the absolute position of the robot from measuring the direction of incidence of three actively transmitted beacons as illustrated in Fig. 1.

Active beacons or base stations advertise their coordinates and transmit a reference signal. The mobile robot uses the reference signal to estimate distances to each of the beacons r_i. These distance measurements used to be noisy. Assume that the associated error is given by the following equation:

$$f_i = r_i - \sqrt{(x_i - x_o)^2 + (y_i - y_o)^2}$$

The robot position (x_o, y_o) is the position that minimizes the following objective function:

$$F(x_o, y_o) = \min \sum_{i=1}^{3} f_i^2$$

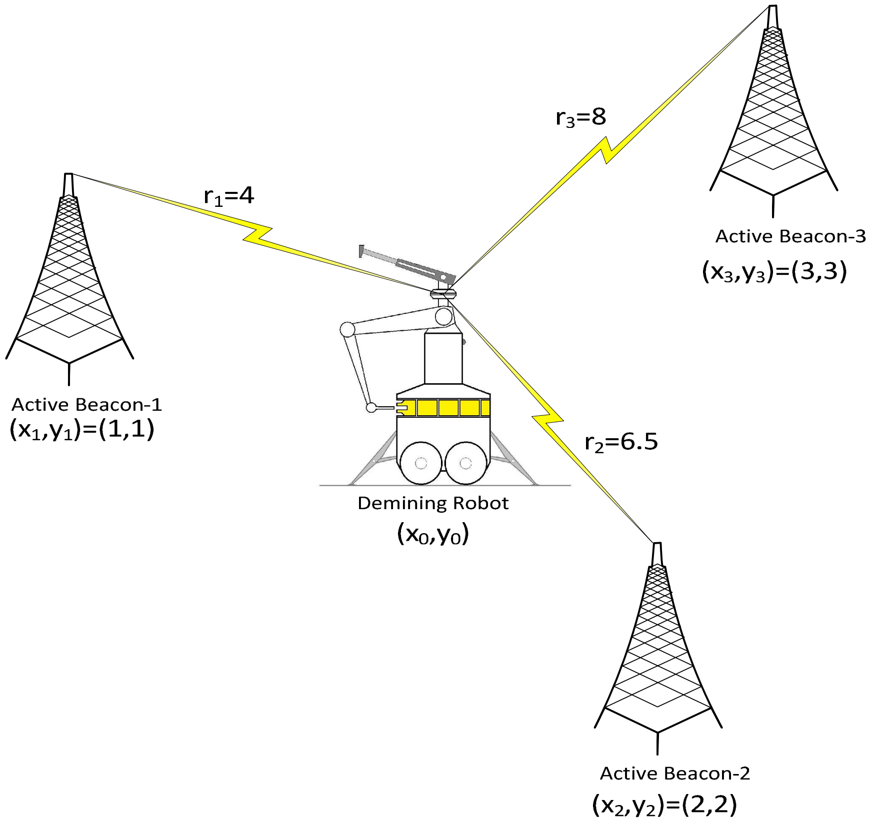


Fig. 1 Mobile Robot Global Localization

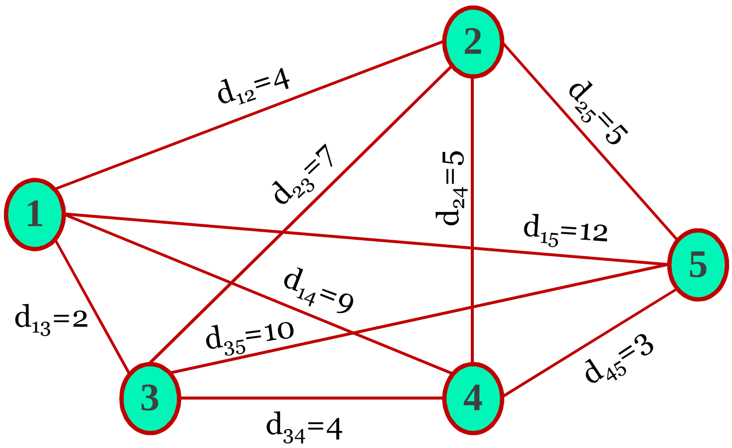
Solve this non-linear optimization problem using PSO to calculate the robot position. Perform two hand iterations using 2 particles (N=2) assuming the following initial positions:

$$\text{Particle-1}: x_o^1 = 1, \qquad y_o^1 = 0$$

$$\text{Particle-2}: x_o^2 = 0.5, \qquad y_o^2 = 1.25$$

Assume also that initial velocity of each particle is zero.

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



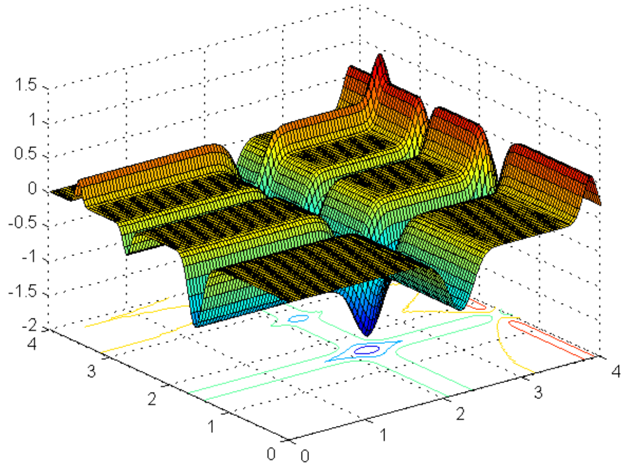
Starting from node 1 and using 2 ants, perform two iterations to show how to solve this problem using ACS algorithm. Select your own values for the parameter and explain the basis for your selection.

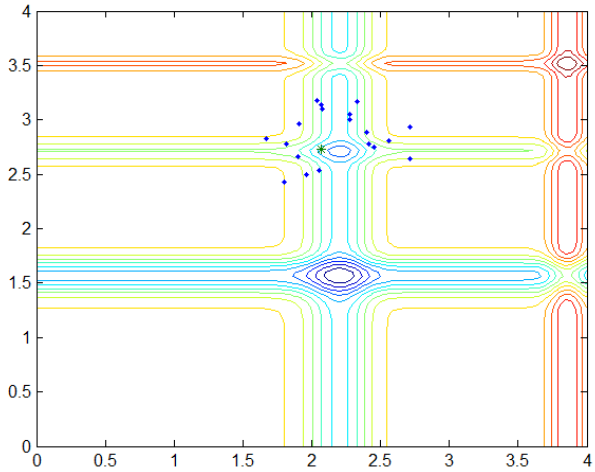
- **Non-Graded Extra Exercises**

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

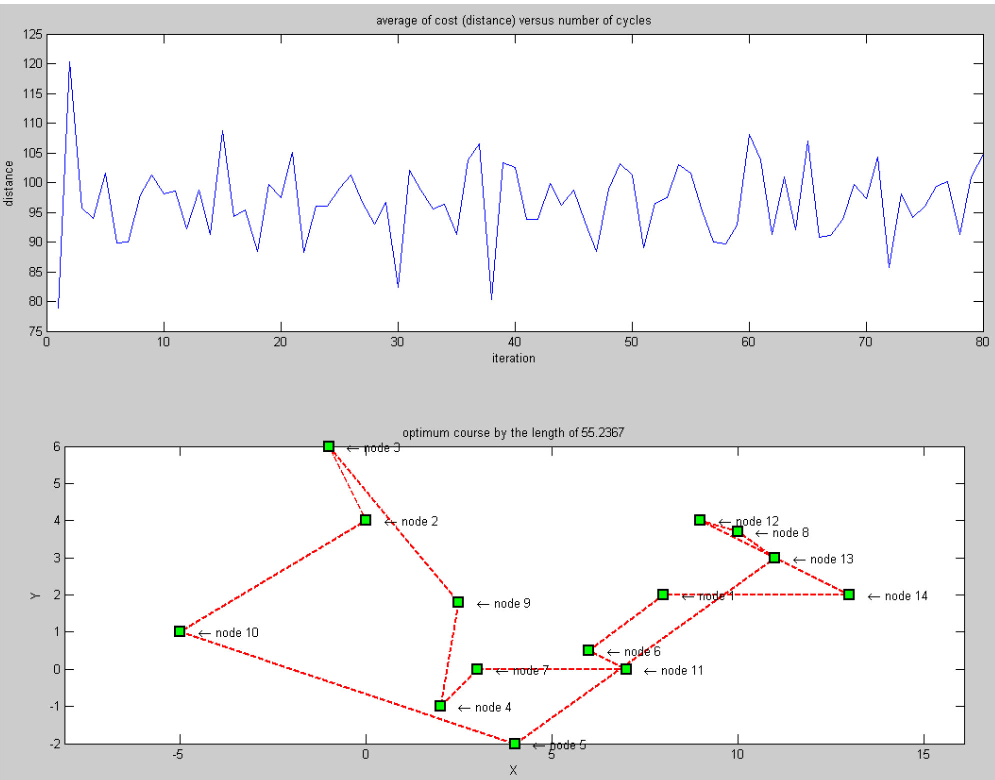
a) The given Matlab code **FunctionOpt.m** implements PSO to find the global minimum of Michaelwicz’s 2D function:

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





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.