Assignment 3 – Genetic Algorithms

Due date: July 6, 2015 at 11:59PM

What to submit: a report that contains:

- The solution for the first and second written exercises, typed or neatly handwritten.
- Matlab/Octave code for the third programming exercise.
- Zip the assignment report and the source code (including a README file) and name it "**Assignment#-Your Project Number#.zip**" such as "**A3-4.zip**"
- Upload this file to Assignment-3 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]** Hooke's law in physics states that the length *x* of a uniform spring is a linear function of the force *y* applied to it. If we write $y=a+bx$, where *a* is a constant and *b* represents stiffness of the spring. Suppose a particular unstretched spring has a measured length of 6.1 inches (i.e. $x=6.1$ when $y=0$). Forces of 2 pounds, 4 pounds, and 6 pounds are then applied to the spring, and the corresponding lengths are found to be 7.6 inches, 8.7 inches, and 10.4 inches respectively. Use GA to find the constant *a* and stiffness *b* of this spring.

a) Develop a solution representation,

b) Suggest a crossover operator that will be suitable for all instances of this problem,

c) Suggest a mutation operator,

d) Suggest a fitness function (objective function) for this problem,

e) Starting with two individuals (one with coefficients a=1.08 and b=-11.47 and other one with coefficients a=1.75 and b=-5.8), perform two iterations using the representation and crossover operator you provided. In these iterations, perform the crossover operation to produce two children, then for the next generation, select the two individuals that have the best fitness out of the four candidates.

2. **[Written Exercise - 5 Marks]** Maximizing the following nonlinear multimodal function (Fig. 1) can be achieved by evolving the set of *x* and *y* within [0, 10):

$$f(x,y)=\frac{6.452(x+0.125y)(\cos x-\cos 2y)^3}{\sqrt{0.8+(x-4.2)^2+2(y-7)^2}}+3.226y$$

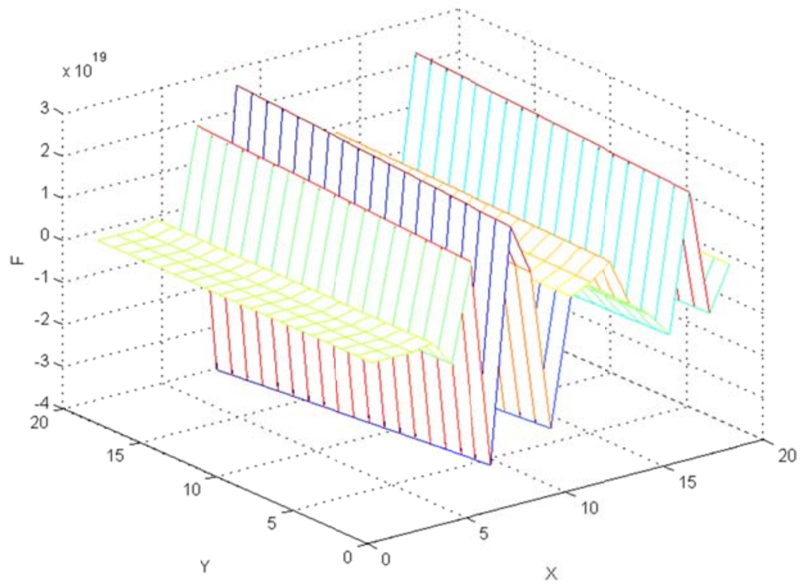

Fig. 1 Nonlinear Multimodal Function

Assume that the parameter set (x, y) is encoded into a chromosome string. Assuming a population of 4 individuals:

a) Using 2 decimal points precision, show the binary encoding of 4 initial individuals.

b) Suggest a crossover operator for this representation and show how it is applied to the examples.

c) Suggest a mutation operator and show how it is applied.

d) Repeat a, b and c for decimal real number encoding.

3. **[Programming Exercise - 5 Marks]** Given **GA-1**, a simple MATLAB program of genetic algorithms that tries to find the maximum of the well-known Easom function:

$$f(x) = -\cos(x)e^{-(x-\pi)^2}, \qquad x \in [-10,10]$$

As shown in Fig. 2, this function has a unique global maximum f_{max}=1, at $x^*=\pi$.

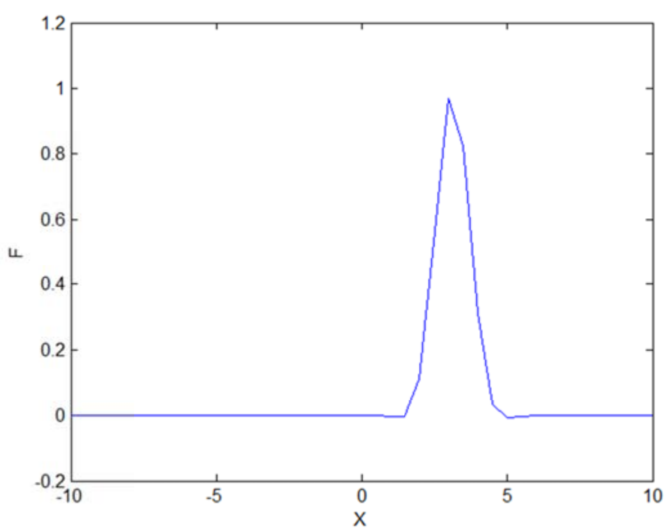

Fig. 2 Easom's Function

In the given MATLAB program, fixed-length 16-bit strings are used. The probabilities of crossover and mutation are respectively:

$$p_c = 0.95, \qquad p_{\text{m}} = 0.05$$

Modify the given program to find the global minimum of the following n-dimensional function

$$f(x) = \sum_{i=1}^{n} |x_i|^{i+1}, \qquad -1 \le x_i \le 1.$$

n is a user-defined variable, i.e. its value can be obtained from the user input or defined in the program.

II. Non-Graded Extra Exercises

1. The given **GA-2** uses Genetic Algorithm toolbox of MATLAB to maximize the function:

$$f(x) = x + \sin(x) + \cos(x)$$

This program implements basic genetic algorithm as follows:

- Step 1. Create an initial population (usually a randomly generated string).
- Step 2. Evaluate all of the individuals (apply some function or formula to the individuals).
- Step 3. Select a new population from the old population based on the fitness of the individuals as given by the evaluation function.
- Step 4. Apply genetic operators (mutation and crossover) to members of the population to create new solutions.
- Step 5. Evaluate these newly created individuals.
- Step 6. Repeat steps 3-6 (one generation) until the termination criteria has been satisfied (usually perform for a certain fixed number of generations.

Run this program and report your observation on the changes of the maximum and the mean of the given function. Write a MATLAB code that implements the GA steps in order to replace the toolbox.

2. The program **GA-3** solves the economic dispatch problem by Genetic Algorithm toolbox of MATLAB. The data matrix should have 5 columns of fuel cost coefficients and plant limits. Run this program and report your observations showing the best and mean value of fitness evaluated for solving the economic dispatch problem using genetic algorithms. Show also the total fuel cost and the transmission losses involved at the end of 233 generations. Write a MATLAB code that implements the GA steps in order to replace the toolbox.