# Assignment 3 – Genetic Algorithms

Due date: June 30, 2014 - Midnight

**What to hand in**: 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-Team4.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.

1. **[Written Exercise - 4 Marks]** Maximizing the following nonlinear multimodal function (Fig. 1) can be achieved by evolving the set of $x$ and $y$ within [0, 10):

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

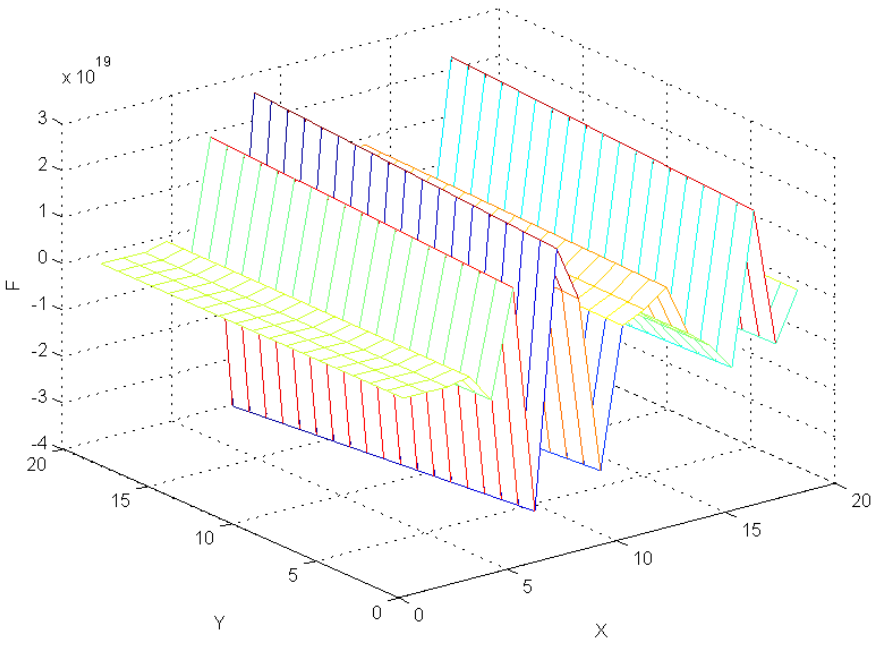


Fig. 1 Nonlinear Multimodal Function

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

a) Using binary encoding with precision four places after the decimal point, show examples 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 floating point encoding.

2. **[Written Exercise - 3 Marks]** MCQs and T/F: Choose the correct answer for each of the following questions. Please write a justification for your choice showing all steps and calculations. Answers without justification will be considered wrong.

a) Given two binary strings 00000000000 and 00010000100. If a 1-point crossover with a recombination point between the first and the second "1" bits of the second string occurs, disruption will occur and neither parent will survive crossover.

- TRUE
- FALSE

b) Given a binary string 1101001100101101 and another binary string *yxyyxyxxyyyxyxxy* in which the values 0 and 1 are denoted by *x* and *y*. The offspring that result from applying 1-point crossover on two strings at a randomly selected recombination point is:

- *yxxyyyxyxxy*11010 and *yxyyx*01100101101
- 11010*yxxyyyxyxxy* and *yxyyx*01100101101
- 11010*yxxyyyxyxxy* and 01100101101*yxyyx*
- None of the above

c) Given the following parents: 1100010<u>1 01</u>011<u>000 0</u>110<u>1010</u> and <u>0</u>010<u>010</u>0 10<u>111</u>001 0<u>111</u>1000

The resultant offspring after performing uniform crossover is:

- 11000101 01111000 01111010 and 10101100 10011001 01101000
- 01000100 01111000 01111010 and 10100100 10011001 01101100
- 01000101 01111000 01111010 and 10100100 10011001 01101000
- None of the above

d) For 1-point and 2-point crossover, the schemata which have bits that are close together on the string encoding are more likely to be disrupted by crossover.

- TRUE
- FALSE

e) Generational gap (G) is a parameter that controls the fraction of the population to be replaced in each generation. In steady-state genetic algorithms, G is directly proportional to the population size.

- TRUE
- FALSE

f) Given the following population:

| Population | Individual 1 | Individual 2 | Individual 3 | Individual 4 | Individual 5 |
|---|---|---|---|---|---|
| Fitness | 12 | 25 | 8 | 53 | 10 |

Rank-based selection attempts to remove problems of Fitness-Proportionate Selection (FPS) by basing selection probabilities on relative rather than absolute fitness. Assume that ranking process is linear ranking as follows:

$$p(r) = 2 - SP + (SP - 1).\frac{(r-1)}{(N-1)}$$

where $N$ is the number of individuals in the population, $r$ is the rank associated with each individual in this population (least fit individual has $r$=1, the fittest individual $r$=$N$). $SP$ is the selection pressure (assume $SP$=1.5). What will be the selected individual if we use linear ranking-based selection?

- o Individual 1
- o Individual 2
- o Individual 3
- o Individual 4
- o Individual 5

3. **[Programming Exercise - 3 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. 1, this function has a unique global maximum $f_{max}$=1, at $x^*$= π.

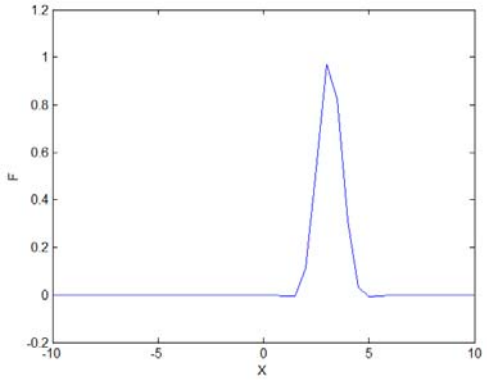


**Fig. 1** Easom's Function

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

$$p_c = 0.95, \qquad p_m = 0.05$$

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

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

- **Non-Graded Extra Exercises**

a) 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.

b) 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.