Cairo University **Final Exam**
Faculty of Computers & Information **Jan 2008**
Dept of Computer Science **Time 2 hrs**

Genetic Algorithms

Answer ALL Qusetions:

1- Crossover and mutation are the main operators of a Genetic Algorithm.
a- Differentiate between single-point and multiple-point crossover, on both binary and floating point representations.
b- Show by example- using binary strings- how can a 2-point crossover be carried out.
c- Explain the operation of the mutation operator on both binary and floating point representations.
d- Discuss the mechanics of non-uniform mutation on floating point representation- Apply using the following function:

$$\Delta(t, y) = y.(1 - r^{(1-t/T)})$$

where r is a random number from [0..1].
(8 points)

2- Taking the reproductive schema growth equation of schema theory,

eta(S, t+1) = eta(S, t). eval(S, t)/ averagePopFitness(t) [1-Pc.d(S)/(m-1)-o(S).Pm]

assume that o(S).Pm = 0 and d(S) = m-1, then the equation becomes:

eta(S, t+1) = eta(S, t). eval(S, t)/ averagePopFitness(t) [1-Pc]

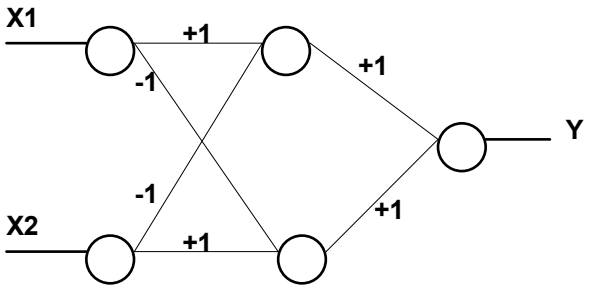
Discuss the mechanics of the algorithm when Pc = 0 and Pc = 1 under the following conditions:
a- low population size
b- high population size
c- Elitism
(8 points)

3- a- Prove that any string of length m is an instance of 2^m different schemas.
b- Define the fitness f of bit string x with length m = 4, to be the integer represented by the binary number x. (eg. f(0011)=3, f(1111)=15). What is the average fitness of the schema 1*** under f? What is the average fitness of schema 0*** under f?
(8 points)

4- Given a population of PopSize Individuals, which are bit-strings of length L. Let the frequency of allele 1 be 0.3 at position *i*, that is 30% of all individuals contains a 1 and 70% a 0. How does this allele frequency change after performing *k* crossover operations with one-point crossover?
(8 points)

5- Calculate the probability that a binary chromosome with length L will not be changed by applying the usual bit-flip mutation with Pm=1/L.
(8 points)

6- Given the following feedforward neural network with weights,



and applying the following activation function,

$$f(x) = \begin{cases} 1 & x > 0 \\ 0 & x \le 0 \end{cases}$$

Compute the outputs Y for inputs (X1, X2) equal to the following,
(0,0), (0,1), (1,0), (1,1).
What function do you think this network emulates.
(8 points)

7- Given the following exemplars to be encoded in a BAM,
X1 = (101010) Y1 = (1100)
X2 = (111000) Y2 = (1010)
a- Compute the weights matrix M.
b- Recall the output of the BAM when presented with X = (111010). Comment on the result.
c- Recall the output of the BAM when presented with X = (000111). Comment on the result.
d- Why do you get a zero in the recall vector and what value [-1 or 1] do you take for it if at the first iteration? On what basis is this taken?

8- Design a fuzzy controller with two input variables:
SPEED with range: 0 to 120 and 5 fuzzy sets: Stopped, Very Slow, Slow, Medium Fast and Fast.
And
DISTANCE with range:0 to 2500 and 5 fuzzy sets: At, Very Near, Near, Medium Far and Far.
The output variable is BRAKE with range: 0% to 100% and fuzzy sets: No, Very Slight, Slight, Medium and Full.
The following fuzzy rules govern the actions of the system:
IF SPEED=Very Slow and DISTANCE=At THEN BRAKE = Full.
IF SPEED= Slow and DISTANCE=At THEN BRAKE = Full.
IF SPEED=Very Slow and DISTANCE=Very Near THEN BRAKE = Medium.
IF SPEED= Slow and DISTANCE=Very Near THEN BRAKE = Medium.
Using a Mamdani approach, show how the output is computed.
(8 points)

9- Show how fuzzy rules that model a particular system can be evolved using genetic algorithms. (**Note: This question is bonus**!)
(6 points) **AMR BADR**