Name: ______________________________________ ID: _______________

Cairo University
Faculty of Computers and Artificial Intelligence
Subject: **Genetic Algorithms**
Subject Code: **CS464**
Examiner(s): **Cherry Ahmed**

Mid-term exam
Semester: 1st
Date: **17/11/2019**
Duration: **1 hour**

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30

Question 1: Genetic Algorithms: [15 points]

Part 1: Suppose a genetic algorithm uses chromosomes of the form x = abcdefgh with a fixed length of eight genes. Each gene can be any digit between 0 and 9. Let the fitness of individual x (to be maximized) be calculated as:

$$f(x) = (a + b + c + d) - (e + f + g + h),$$

and let the initial population consist of four individuals with the following chromosomes:

x1 = 6 5 4 1 3 5 3 9
x2 = 8 7 1 2 6 6 0 1
x3 = 2 3 9 2 1 2 8 5
x4 = 4 1 8 5 2 0 9 4

a) **Evaluate the fitness of each individual, showing all your workings, and arrange them in order with the fittest first and the least fit last.** [3 pts]

x1 = 6 5 4 1 3 5 3 9 = (6+ 5+ 4+ 1) -(3 +5+ 3+ 9)= -4 [0.5 pt]
x2 = 8 7 1 2 6 6 0 1 = (8+7+1+2) – (6+6+0+1) = 5 [0.5 pt]
x3 = 2 3 9 2 1 2 8 5 = (2+3+9+2)- (1+2+8+5) = 0 [0.5 pt]
x4 = 4 1 8 5 2 0 9 4 = (4+1+8+5)- (2+0+9+4) = 3 [0.5 pt]
Rank: x2 , x4, x3, x1 [1 pt]

b) **Perform the following crossover operations:**

i) **Cross the fittest two individuals using one–point crossover at the middle point.** [2 pts]

x2 = 8 7 1 2 6 6 0 1 → 8 7 1 2 2 0 9 4 [1 pt]
x4 = 4 1 8 5 2 0 9 4 → 4 1 8 5 6 6 0 1 [1 pt]

ii) **Cross the second and third fittest individuals using a uniform crossover (points b, d, and f).** [2 pts]

x3 = 2 3 9 2 1 2 8 5 → 2 1 9 5 1 0 8 5 [1 pt]
x4 = 4 1 8 5 2 0 9 4 → 4 3 8 2 2 2 9 4 [1 pt]

c) By looking at the fitness function and considering that genes can only be digits between 0 and 9, <u>find</u> the chromosome representing the optimal solution (i.e. with the maximum fitness). <u>Find</u> the value of the maximum fitness. [2 pts]

chromosome = 9 9 9 9 0 0 0 0 [1 pt]
fitness = 36 – 0 = 36 [1 pt]

d) By looking at the initial population of the algorithm can you say whether it will be able to reach the optimal solution using only the crossover operator (without the mutation operator)? Explain your answer. [2 pts]
It can't reach optimal solution without mutation [1 pt] because the optimal solution in (c) require the first gene for example to be 9, which is not present in any of the individuals in the initial population, and same for other genes in optimal solution. Crossover won't be able to get new genes that are not present in initial population. [1 pt]

<u>Part 2:</u> A genetic algorithm has a population size of 5. The first generation has the individuals I1->I5. Assuming fitness values [10, 2, 5, 7, 4] for [I1, I2, I3, I4, I5] respectively:

a) What is the probability that I5 gets selected for reproduction if roulette wheel selection is used? [2 pts]
p(I5) = 4/28 = 1/7

b) What is the probability that I5 gets selected for reproduction if rank selection selection is used? [2 pts]

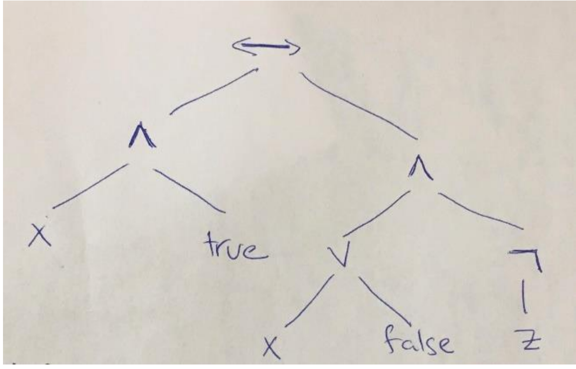
Rank of individuals: I1(rank=5), I4(rank=4), I3(rank=3), I5(rank=2), I2(rank=1)
p(I5) = rank/(n*(n-1)) = 2/(5*4) = 0.1

** If the student assumed this is a minimization problem, give him the grade <u>only if</u> he stated his assumption and solved both of (a) and (b) based on that.

<u>Question 2: Genetic Programming:</u> [5 points]

A program uses genetic programming for solving a problem where an example individual of the population is : $(x \wedge \text{true}) \leftrightarrow ((x \vee \text{false}) \wedge (\neg z))$

a) **Represent the individual as a parse tree.** **[2 pts]**



b) **State the function and terminal sets presented in this individual.** **[2 pts]**

function set = { V , Λ , ¬ , ⟷} **[1 pt]**

Terminal set = { x , z , true , false} **[1 pt]**

c) **Is genetic programming better than random generation of programs? Why is that? [1 pt]**

Yes, [0.5 pt] **because the fitness function guides the search to find better programs.** [0.5 pt]

Question 3: Fuzzy Logic: [10 points]

Consider a problem with 2 input variables; size and weight, and 1 output variable; quality, with the following lingustic term sets associated:

size: small {0,0,10}, large {0,10,10}
weight : small {0,0,10}, large {0,10,10}
quality: bad {0,0,50}, medium {0,50,100}, good {50,100,100}

The rule base:

- **R1: if size is small and weight is small then quality is bad**
- **R2: if size is small and weight is large then quality is medium**
- **R3: if size is large and weight is small then quality is medium**
- **R4: if size is large and weight is large then quality is good**

Find the crisp value of the output quality given size=2 and weight =2.5.
Note: use weighted average method for defuzzification.

Step 1: Fuzzification: (total 4 pt)

size = 2

small fuzzy set: Line 1: point1 (0,1) , point2 (10,0)

slope = -1/10

y = -x/10 + b → b =1

Line1 eqn.: y = -x/10 + 1 [1 pt]

substitute by size = 2 → μ_S(size=2) = 0.8 [0.5 pt]

large fuzzy set: Line 1: point1 (0,0) , point2 (10,1)

slope = 1/10

y = x/10 + b → b =0

Line2 eqn.: y = x/10 [1 pt]

substitute by size = 2 → μ_L(size=2) = 0.2 [0.5 pt]

weight = 2.5

same fuzzy sets, so same line1 & line2 equations

Line1 eqn.: y = -x/10 + 1

substitute by weight = 2.5 → μ_S(weight=2.5) = 0.75 [0.5 pt]

Line2 eqn.: y = x/10

substitute by weight = 2.5 → μ_L(weight=2.5) = 0.25 [0.5 pt]

Step 2: Inference: (total 3 pt)

R1: if (0.8 Λ 0.75) → 0.75 μ_B(quality)

R2: if (0.8 Λ 0.25) → 0.25 μ_m(quality)

R3: if (0.2 Λ 0.75) → 0.2 μ_m(quality)

R4: if (0.2 Λ 0.25) → 0.2 μ_G(quality)

Step 3: Defuzzification: (total 3 pt)

centroid(bad) = (0+0+50)/3 = 16.7 [0.5 pt]

centroid(medium) = (0+50+100)/3 = 50 [0.5 pt]

centroid(good) = (50+100+100)/3 = 83.3 [0.5 pt]

Z* = (0.75*16.7 + 0.25*50+ 0.2*50 + 0.2*83.3)/(0.75+0.25+0.2+0.2)

12.525 + 12.5 + 10 + 16.66 / 1.4

= 36.9 ≃ 37 [1.5 pt]

Good Luck