Cairo University
Faculty of Computers and Artificial Intelligence
Midterm Exam

Department: Computer Science
Course Name: Soft Computing **Date: 17/11/2019**
Course Code: CS464 **Duration: 1 hour**
Instructor(s): Sabah Sayed **Pages: 4**
Name: ..... **ID:** ..... **Total Marks:** **/100**

Answer all questions

Question 1: *Genetic Algorithm [60 marks]*

a) *[10 marks]* Write a basic algorithm for Genetic Algorithm.

```
Simple_Genetic_Algorithm()
{
    Initialize the Population;
    Calculate Fitness Function; // Evaluate Individuals …

    While(Fitness Value != Optimal Value) // Continue Evolution …
    {
        Selection; //Natural Selection, Survival Of Fittest …
        Crossover; //Reproduction, Propagate favorable characteristics …
        Mutation; //Mutation …
        Calculate Fitness Function;
    }
}
```

b) *[10 marks]* State five different representation (encoding) used in a Genetic algorithm and Discuss how the different representations affect the other operators mainly crossover and mutation operators.

Binary (Gray) encoding, Integer encoding, character (String) encoding, floating point encoding, Permutation encoding.
Binary (Gray), Integer, and character (String) encoding have no effect on Mutation or Crossover but floating point encoding affects on Mutation (Uniform/Non-Uniform Mutation), and Permutation encoding affects on Mutation(Swap Mutation) and affects on Crossover (Order1 Crossover).

c) *[10 marks]* Discuss the different strategies adopted for Replacement.
Three replacement schemas:

1. Generational Replacement (GGA):
   Mate enough individuals to generate pop_size offspring each individual survives for **exactly one generation**. the entire set of parents is replaced by the offspring
2. Steady-state Replacement (SSGA):
   Specific number (K) of individuals are selected for reproduction, and offspring replace their parents in the next generation
3. Elitist Strategy (Elitism):
   It is steady-state replacement, but keep best-so-far individuals. To keep the best solution so far from being thrown away by crossover or mutation, the elitism option is used to keep one or more of the best solutions discovered so far and copy them to the next generation.

d) *[10 marks]* How to apply the Roulette Wheel Selection and Tournament Selection for:

i. The best individuals have the lowest fitness

Roulette wheel Selection: uses the 1 - fitness or 1/fitness portion in selection

Tournament Selection: selects the individual with minimum fitness

ii. The best individuals have the highest fitness

Roulette wheel Selection: uses the fitness portion in selection

Tournament Selection: selects the individual with maximum fitness

e) *[10 marks]* The following chromosome has eight genes with values in range [-5,5], Show the chromosome after performing a **uniform mutation** on the **fourth** gene, knowing that the random numbers generated for the operation: r1 = 0.3, r2 = 1.7.

2.3	-1.1	4	2.5	-2	3.1	1.4	4.9

r1 = 0.3, which is <0.5

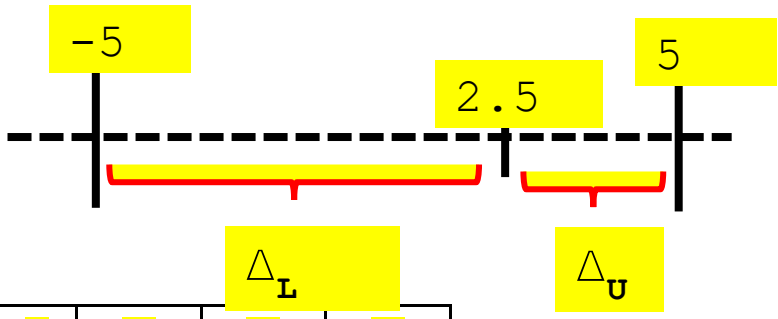
Then Δ = ΔL

ΔL = 2.5 – (-5) = 7.5

r2 = 1.7

so g4 = g4 – 1.7

= 2.5 – 1.7= 0.8



2.3	-1.1	4	0.8	-2	3.1	1.4	4.9

f) *[10 marks]* In the Island GA, One extra operator is added

i. What is this operator? Mention the four properties should be specified in its policy?

Migration

Migration policies specify:

1- A communications topology, which determines the migration paths between islands
2- A migration rate, which determines the frequency of migration
3- A selection mechanism, to decide which individuals will migrate
4- A replacement strategy, to decide which individual of the destination island will be replaced

ii. Compare between the two classes of Island GA.

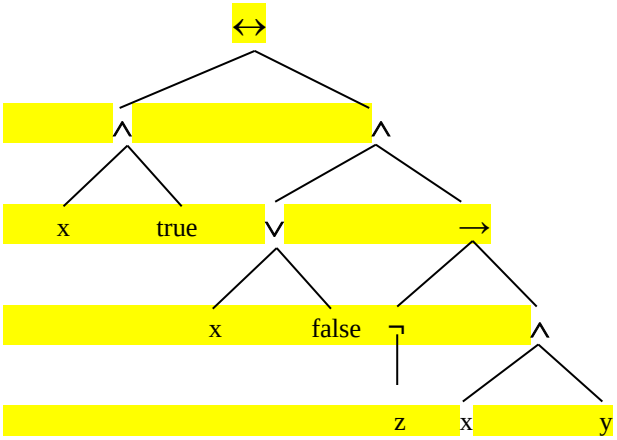
Based on the selection and replacement strategies, Island GAs can be grouped into two classes of algorithms:

- Static island GAs
  A topology is used to determine migration paths so the selection and replacement strategies are Deterministic
  - A good migrant replaces a bad individual
  - A good migrant replaces a randomly selected individual
  - A randomly selected migrant replaces a bad individual
  - A randomly selected migrant replaces a randomly selected individual
- Dynamic island GAs
  Migration decisions are made probabilistically
  - Migration occurs at a probability
  - Destination island is probabilistically selected
  - Destination islands may use an acceptance strategy
    - An immigrant is probabilistically accepted if its fitness is better than the average fitness of the island

Question 2: *Genetic Programming [20 marks]*

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

a) *[5 marks]* Represent the individual as a parse tree.



b) *[5 marks]* State the function and terminal sets presented in this individual.

Function set = {∧, ∨, ¬, →, ↔}
Terminal set = {x, y, z, true, false}

c) *[5 marks]* Mention two differences between Genetic Programming and Genetic Algorithm chromosomes.

1. In GA, chromosomes are *linear* structures (bit strings, integer string, permutations) But GP uses tree shaped chromosomes which are *non-linear* structures.
2. In GA, the size of the chromosomes is **fixed** but Trees in GP may **vary** in depth and width.

d) *[5 marks]* Is genetic programming better than random generation of programs? Why?
Yes,
The key lies in that GP uses a fitness measure to determine which functions survive to reproduce in each generation

Question 3: *Fuzzy Logic [20 marks]*

Consider a problem with two input variables, **size** and **weight**, and one output variable, **quality,** with the following fuzzy sets:
size: small **S** {0, 0, 10}, large **L** {0, 10, 10} in range [0 .. 10]
weight: small **S** {0, 0, 100}, large **L** {0, 100, 100} in range [0 .. 100]
quality: bad **B** {0, 0, 0.5}, medium **M** {0, 0.5, 1}, good **G** {0.5, 1, 1} in range [0 .. 1]

The rule base:
R1: if size is S and weight is S then quality is B
R2: if size is S and weight is L then quality is M
R3: if size is L and weight is S then quality is M
R4: if size is L and weight is L then quality is G

Find the crisp value of quality given size= 2 and weight =25