Cairo University
Faculty of Computers and Artificial Intelligence
Midterm Exam

Department: Computer Science
Course Name: Soft Computing **Date: 30/11/2021**
Course Code: CS464 **Duration: 1 hour**
Instructor(s): Sabah Sayed **Pages: 4**
Name: …… **ID:** …… **Total Marks:** **/150**

Answer all questions

Question 1: *Genetic Algorithm [120 marks]*

Consider the Travelling Salesman Problem. Given the following distance matrix for 8 cities and 3 chromosomes:

C1: 4 6 8 3 1 7 2 5
C2: 1 4 6 2 5 3 7 8
C3: 8 4 6 3 1 2 5 7

	1	2	3	4	5	6	7	8
1	0	13	44	56	34	21	48	25
2	13	0	39	15	45	63	32	17
3	44	39	0	20	11	19	23	12
4	56	15	20	0	8	14	19	16
5	34	45	11	8	0	32	60	43
6	21	63	19	14	32	0	15	13
7	48	32	23	19	60	15	0	27
8	25	17	12	16	43	13	27	0

a) Calculate the fitness of the 3 chromosomes (10 pt)

C1: 4 6 8 3 1 7 2 5	14 + 13+12+44+48+32+45+8	216
C2: 1 4 6 2 5 3 7 8	56+14+63+45+11+23+27+25	264
C3: 8 4 6 3 1 2 5 7	16+14+19+44+13+45+60+27	238

b) How can you use the **Rank** selection technique given your fitness values in (a)? (20 pt)

1. Rank the chromosomes descending C2: 1, C3: 2, C1: 3
2. Sum of all ranks is = 1+2+3=6
3. Compute the probabilities as:
   C2: 1/6= 0.17
   C3: 2/6 = 0.33
   C1: 3/6 = 0.50
4. Apply roulette wheel on those probabilities.(generate random number and check the ranges of chromosomes to select one of them)

c) Can the traditional (single point) crossover be used in this problem? Why? (10 pt)

No, because the encoding/representation is permutation where the order of genes is important OR No, single point crossover will produce invalid chromosomes where some genes will be repeated and others will be disappeared

d) Suggest and apply another crossover technique to the first and second chromosomes.

order-1 crossover (5 pt)
Suppose the shaded area is (randomly selected set)

C1: 4 6 8 3 1 7 2 5 Offsprig1: 2 5 8 3 1 7 4 6 (5 pt)
C2: 1 4 6 2 5 3 7 8 Offsprig2: 3 1 6 2 5 7 4 8 (5 pt)

e) Show how mutation can be performed on the third chromosome using 2 different methods. (15 pt)

Note: Student can take any two genes and perform only 2 methods

C3: 8 4 6 3 1 2 5 7 using swap method: 8 1 6 3 4 2 5 7
C3: 8 4 6 3 1 2 5 7 using insert method: 8 4 1 6 3 2 5 7
C3: 8 4 6 3 1 2 5 7 using invertion method: 8 1 3 6 4 2 5 7

f) For this problem, Can you predict whether the genetic algorithm will be able to reach the optimal solution using only the crossover operator (without the mutation operator)? Explain your answer.

Yes, it may reach (10 pt)
Because all gene values are presented in the initial population (10 pt)

g) Suggest and explain a replacement strategy to be used.

Any choice of Generational / Steady State / Elitist (Elitism) strategy (5 pt)
(5 pt) for explanation

- 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
- Steady-state Replacement (SSGA):
  - Specific number (K) of individuals are selected for reproduction, and offspring replace their parents in the next generation
- Elitist Strategy (Elitism):
  - It is steady-state replacement, but keep best-so-far individuals

h) What is the purpose of Island Genetic Algorithm (I-GA)? Explain the I-GA types

The purpose is to *parallelize the GA* to run on multicore machines, clusters or GPU where each Island represents a separate GA with a separate sub-population (10 pt)
Based on the selection and replacement strategies, Island GAs can be grouped into two classes of algorithms:

1. Static island GAs: A **topology** is used to determine migration paths
2. Dynamic island GAs: Migration decisions are made **probabilistically** **(10 pt)**

Question 2: ***Genetic Programming [30 marks]***

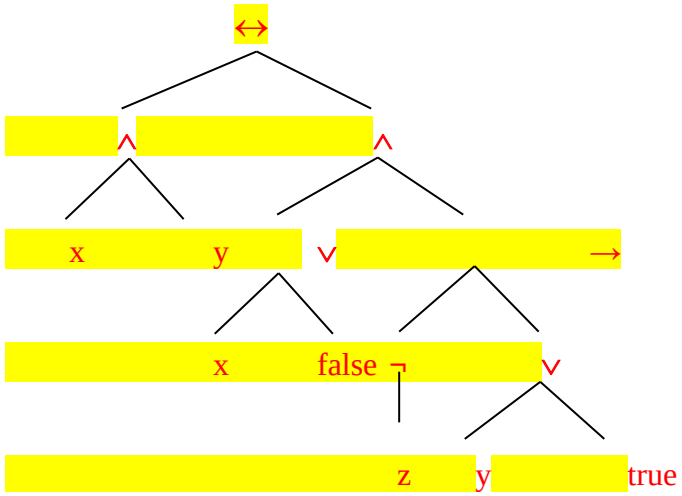
a) Compare between the chromosome in Genetic Algorithm and Genetic Programming.

GA	GP
Linear structure	Non-linear structure (tree)
Fixed size	Variable size (in width and depth)

b) A program uses genetic programming for solving a problem where an example individual of the population is:

$(x \wedge y) \leftrightarrow ((x \vee \text{false}) \wedge ((\neg z) \rightarrow (y \vee \text{true}))$

i. Show the representation of the individual as a parse tree.



ii. Is genetic programming better than random generation of programs? Why is that?

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