**Faculty of Computers and Artificial Intelligence-
Cairo University**

Midterm Exam

Course Name: Soft Computing/ Genetics algorithms

Course Code: CS464

Instructor : Dr. Samar Hesham

Date: 23-11-2022

Duration: 1 hour

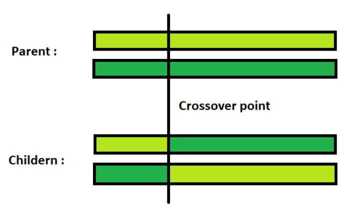
Total marks: 20

Question one:

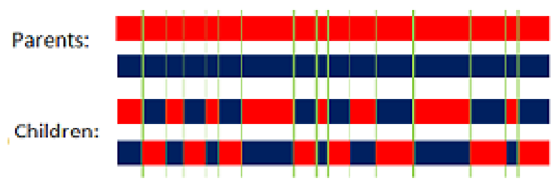
Crossover and mutation are the main operators of a Genetic Algorithm.

a- Differentiate between single-point and multiple-point crossover, on both binary and floating point representations. [2 marks]

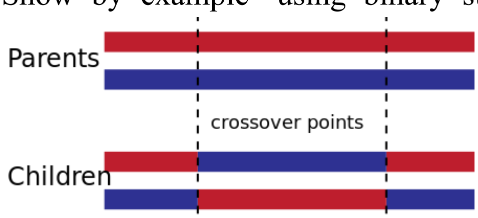
Single point



multi point



b- Show by example- using binary strings- how can a 2-point crossover be carried out.[1 mark}



c- Explain the operation of the mutation operator on both binary and floating point representations. [3 marks]

Binary

Chromosome = bits[1…L]

for(i=1 to L)

{ Generate Random number ri ϵ [0, 1]

if(ri ≤ Pm)

flip bit[i]

elseif(ri > Pm)

no change to bit[i] }

floating point (either uniform or non uniform mutation is accepted)

Question two:

a. According to the schema theorem, what happens to highly fit schemata in successive generations?

What are the effects of selection, crossover and mutation according to the theorem?

Why use crossover and mutation?[3 marks]

Answer:

- Assume total number of chromosomes is PopSize.
- The number of above average individuals abiding by the above average schema S is P.
- f_i : fitness of chromosome *i* in the population of all chromosomes.
- Average fitness of population = $\frac{\sum_{i=1}^{PopSize} f_i}{PopSize} = \overline{F}$

- The average fitness of above average individuals abiding with favorable schema S=

$$F_{av}(S) = \frac{\sum_{j=1}^{P} f_j}{P}$$

  - **where P is the number of individuals abiding by S**

- Let :
  - **m(S, t)** denote the expected no. of individuals matched by schema S at time t.
  - **F** = total fitness of population, F=$\sum_{i=1}^{PopSize} f_i$
  - **m(S, t+1)** denote the expected no. of individuals matched by schema S at time t+1(next iteration).

- $m(S, t+1) = m(S,t) * PopSize * \frac{f_{av}(S)}{F}$

- But F = total fitness
  where $\bar{F} = \frac{F}{PopSize}$, so F= $\bar{F} * PopSize$
- Substitute in (1):
  $m(S, t+1) = m(S,t) * PopSize * \frac{f_{av}(S)}{\bar{F} * PopSize}$
  $m(S, t+1) = m(S,t) * \frac{f_{av}(S)}{\bar{F}}$

Probability of survival schema after xover

$$P_s = 1 - P_c \frac{d(S)}{l-1}$$

Substitute in equation (1):

$$m(S, t+1) = m(S, t) * \frac{f_{av}(S)}{\bar{F}} * \left(1 - P_c \frac{d(S)}{l-1}\right)$$

Equation (2) represents the combined effects of selection and crossover.

Probability of survival schema after mutation

→ probability of destruction of 1 bit: $P_d = P_m$

→ probability of survival of 1 bit:

$$P_s = 1 - P_d = 1 - P_m$$

→probability of survival of schema: [given order of schema o(S)]

$$P_s(S) = (1 - P_m) * (1 - P_m) * \cdots \text{[for o(S) times]}$$

$P_s(S) = (1 - P_m)^{o(S)}$ -- but Pm is a small number

$$P_s(S) \simeq 1 - o(S) P_m$$

So probability of **survival** of a schema after crossover and mutation is:

$$P_s = 1 - P_c \frac{d(S)}{l-1} - o(S)P_m$$

→Substitute in (2):

$$\mathrm{m}(S, t+1) = m(S,t) * \frac{f_{av}(S)}{\bar{F}} * (1 - P_c \frac{d(S)}{l-1} - o(S)P_m)$$

which is called the **Reproductive Schema Growth** Equation

RSG

Why xover and mutation

- ✓ **X over is for Exploration:** Discovering promising areas in the search space,

i.e. *gaining information* on the problem

- ✓ **Mutation is for Exploitation:** Optimizing within a promising area, i.e. *using information*

Question three:

a. Discuss whether there is survival of the fittest in a generational GA. [explain your answer] [2 marks]

No, survival of the fittest won't happen in generational replacement as we create enough individuals to generate pop_size offspring ,each individual survives for **exactly one generation** and the entire set of parents is replaced by the offspring.

Question four:

a. 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?[2 marks]

   Using only Crossover will not change frequency of the allele only mutation can change the frequency

b. 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.[1 mark]

   1-1/L

Question five:

a. Assume we want to maximize the following function

$F(x)= x^4+x^2+10$ for the range x€[0,63]. Design the system with popsize=4 and preform GA operators until reaching Generation 1. (put your assumptions).[3 marks]

The student will initialize any four binary chromosomes with size = 6 and

Preform GA operators

Applying fitness function at G0

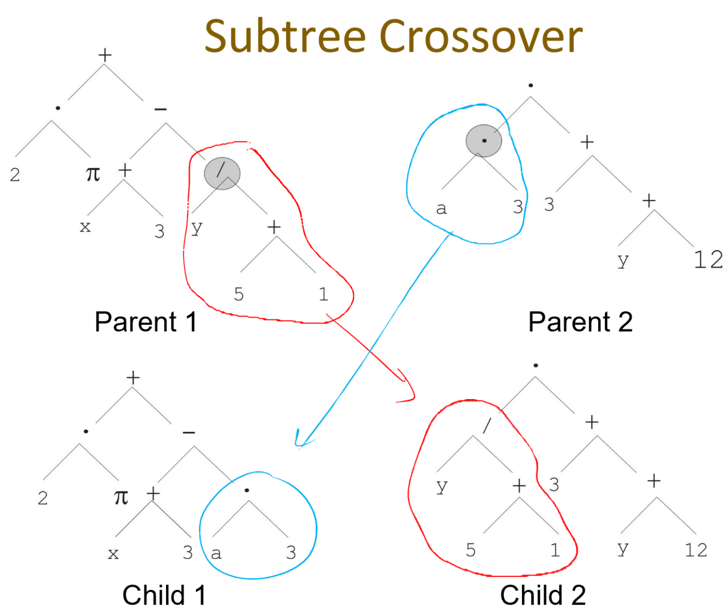
Selection (both tournament and roulette wheel accepted)

Xover (single or multi point are accepted)

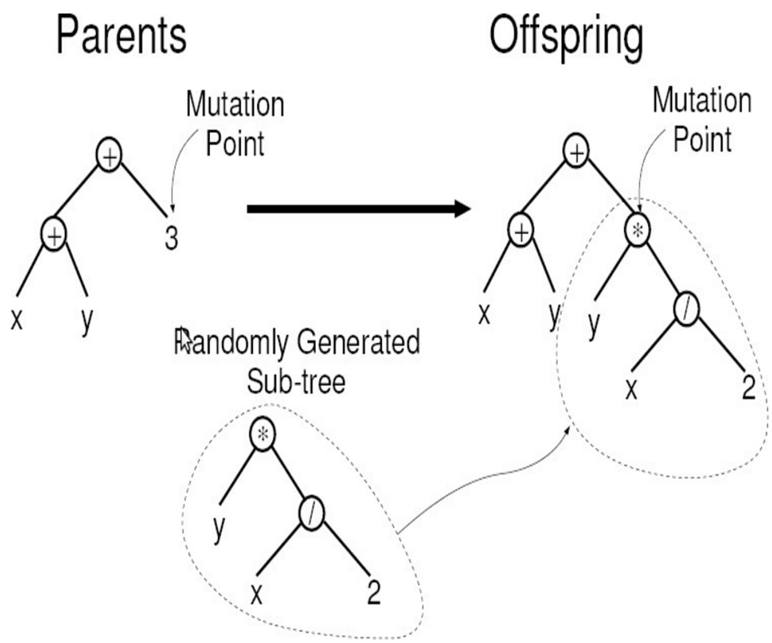
Mutation

Using the initialized chromosomes

b. Using examples ,discuss the crossover and mutation operators in Genetic programming.[3 marks]



Mutation


Parents
Offspring
Mutation Point
3
x
y
Mutation Point
x
y
y
x
2
Randomly Generated Sub-tree
y
x
2