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Subject :- Soft Computing

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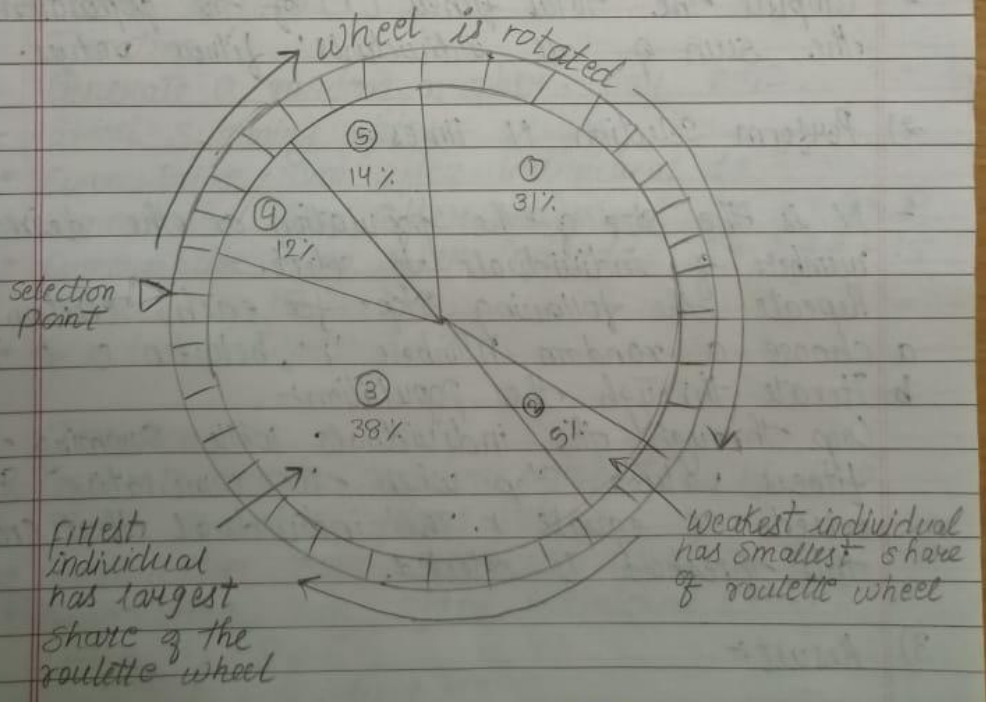
Q1) Explain the following technologies used in selection operator of Genetic Algorithm in detail :-

a) Roulette wheel selection

- Roulette wheel selection is a widely used selection mechanism in genetic algorithm (GA) & evolutionary computation.
- It is a probabilistic selection method that mimics a roulette wheel to choose individuals from a population based on their fitness values.



Roulette Wheel Selection

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Purpose:-
- The purpose of roulette wheel selection is to assign a higher probability of selection to individuals with better fitness scores, promoting their genetic material in future generations.
- It maintains a balance between exploration & exploitation.

Steps for Roulette Wheel Selection :-

1) Calculate Fitness & total expected value:-

- Assign a fitness value to each individual.
- Compute the total fitness (T) of the population as the sum of all individuals' fitness values.

2) Perform Selection N times :-

- N is the size of the population or the desired number of individuals to select.
- Repeate the following steps for each selection:

a Choose a random number 'r', between 0 & T

b Iterate through the population:-
Loop through the individuals while summing their fitness values. Stop when the cumulative sum exceeds or equals r. The individual that crosses this threshold is selected.

3) Result:-

- The algorithm selects individuals probabilistically based on their fitness values, favouring those with highest fitness.

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Example:- Suppose we have a population of 4 individuals with the following fitness values:-

Individual	fitness
1	5
2	3
3	7
4	5

1) Calculate total fitness (T):-
$T = 5+3+7+5 = 20$

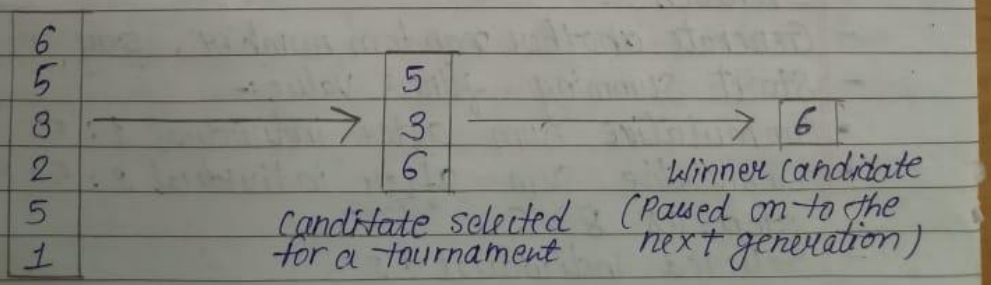
2) Perform selection
Iteration 1:-
- Generate a random number, say $r = 12$.
- Start summing fitness values:-
  - Cummulative sum after individual 1: 5
  - Cummulative sum after individual 2: $5+3 = 8$
  - Cummulative sum after individual 3: $8+7 = 15$
  stop, as $15 \geq 12$
- Selected individual: 3

Iteration 2:-
- Generate another random number, say $r = 6$.
- Start summing fitness value:-
  - Cummulative sum after individual 1: 5
  - Cummulative sum after individual 2: $5+3 = 8$
  stop, as $8 \geq 6$
- Selected individual: 2

Repeat until N individuals are selected.

b) Tournament Selection :-

- An ideal selection strategy should be such that it is able to adjust its selective pressure & popula diversity so as to fine-tune GA search performa
- Unlike, the Roulette wheel selection, the tournament selection strategy provides selective pressure by holding a tournament competition among Nu individuals.
- The best individual from the tournament is the one with the highest fitness, who is the winner of Nu.
- Tournament competition & the winner are then inserted into the mating pool.
- The tournament competition is repeated until the mating pool for generating new offspring is filled.
- The mating pool comprising the tournament winner has higher average population fitness.
- The fitness difference provides the selection pressure, which drives GA (Genetic Algorithm) to improve the fitness of the succeeding genes. This method is more efficient & leads to an optimal solution.
- Example



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() Rank-based selection:-

- The Roulette wheel will have a problem when the fitness values differ very much.
- If the best chromosome fitness is 90%, its circumference occupies 90% of roulette wheel, & then other chromosomes have too few chances to be selected.
- Rank Selection ranks the population & every chromosome receives fitness from the ranking.
- The worst has fitness 1 & the best has fitness N.
- It results in slow convergence but prevents too quick convergence.
- It also keeps up selection pressure when the fitness variance is low. It preserves diversity & hence leads to a successful search.
- In effect, potential parents are selected & a tournament is held to decide which of the individuals will be the parent.

Steps for Rank-Based selection:-

1 Rank the population:-
- Rank all individuals in the population based on their fitness values.
- Assign ranks such that the individual with the highest fitness gets the highest rank.

2 Parent Selection:- There are two approaches to select parents:-

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Approach 1:- Probability-based selection

- Select two individuals at random approaches from the population.
- Generate a random number R between 0 & 1.
- Compare R with a predefined threshold r (eg r=0.5)
  - If R<r, select the first individual as parent.
  - If R≥r, select the second individual as the parent.
- Repeat this process to select the second parent.

Approach 2:- Deterministic Comparison

- select two individuals at random from the population.
- Compare their fitness values or rank.
  - The individual with the higher rank become parent.
- Repeat this process to select the 2nd parent.
- Example:-

Individual	Fitness	Rank (Descending order)
A	90	1
B	70	2
C	50	3
D	80	4

1 Randomly select two individuals, say A & C.
2 Generate a random number R, eg:- R = 0.4
3 If R<r (eg r = 0.5), select A; otherwise select C
4 Repeat to select the 2nd parent.

Q2) Explain the following techniques used in cross over operator of Genetic Algorithm in detail:-

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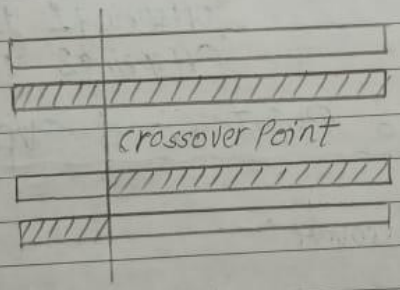
Single-Point Crossover.

- A single crossover point is selected randomly on the parent chromosome.
- The genetic material from the start of the chromosome to the crossover point is taken from one parent, & remaining part is taken from the other parent.
- It is simple & computationally efficient but may not explore the solution space effectively for some problem.



chromosome 1	11011 | 00100110 10
chromosome 2	11011 | 11 0000 1111 0
offspring 1	11011 | 1100001111 0
offspring 2	11011 | 00100110 10

Single Point Crossover

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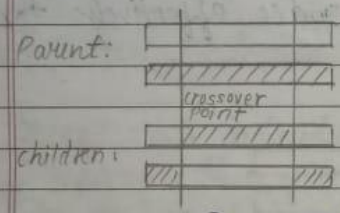
b) Two-Point Crossover :-

- In two-point crossover, two crossover points are selected, this is a specific case of a N-point crossover technique.
- Two random points are chosen on individual chromosome (strings) & the genetic material is exchanged at these points.



chromosome1	11011/00100/110110
chromosome2	10101/11000/011110
offspring1	11011/11000/110110
offspring2	10101/00100/011110

- Two Point Cross-Over.

c) Uniform Crossover :-

- Each gene (bit) is selected randomly from one of the corresponding genes of the parent chromosome.
- Use tossing of a coin as an example technique.

Parent:

000000000000000000

11111111111111111111

Children:

10001101010010011101

01110010101101100010