MODULE: 6 / John-Holland

Genetic Algorithms:

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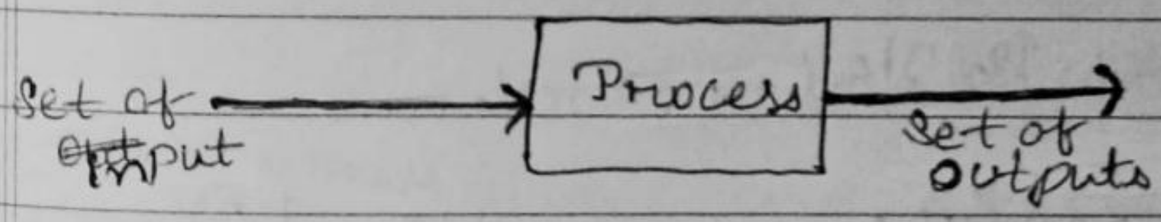
▷ Provides High-Quality Soln. ▷ Adaptive Heuristic
▷ Evolutionary Algo.
▷ Genetics & Natural Selection

→ It is a search-based optimization technique based on the principle of Genetics and Natural selection. It frequently used to find optimal or near-optional solutions to difficult problems which otherwise would take a lifetime to solve.

▫ Frequently used to solve optimization problems in Research and in Machine Learning.

▷ Optimization:- is the process of making something better. / optimal solution. In any process, we have a set inputs and a set of outputs as below:-



* GAs are a subset of a much longer branch of computation known as Evolutionary Computation.

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GA

→ Abstraction of Real Biological Evolution
→ Solve complex problem (like NP Hard

↳ Foces on optimization
↳ population of possible solution for a given problem.

* ⇒ From a group of individuals, the best will ~~st~~ survive. Ex:- A college(Machine) generate output (as Student) but in next process/execution, college will only pick best inputs from last output (It means Assume only '90%' Student will used as a input) Because They are best among ~~that~~ group.

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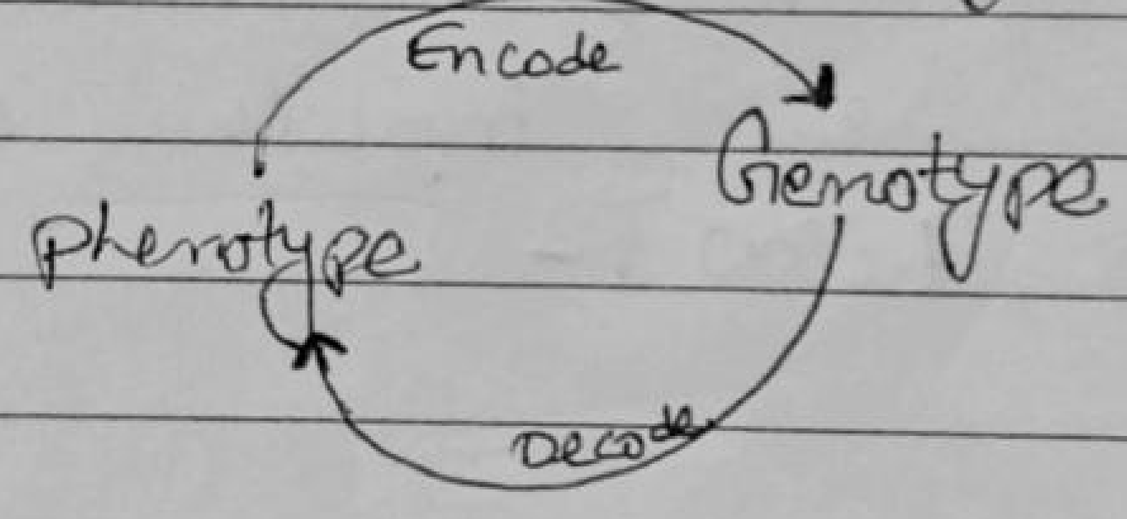

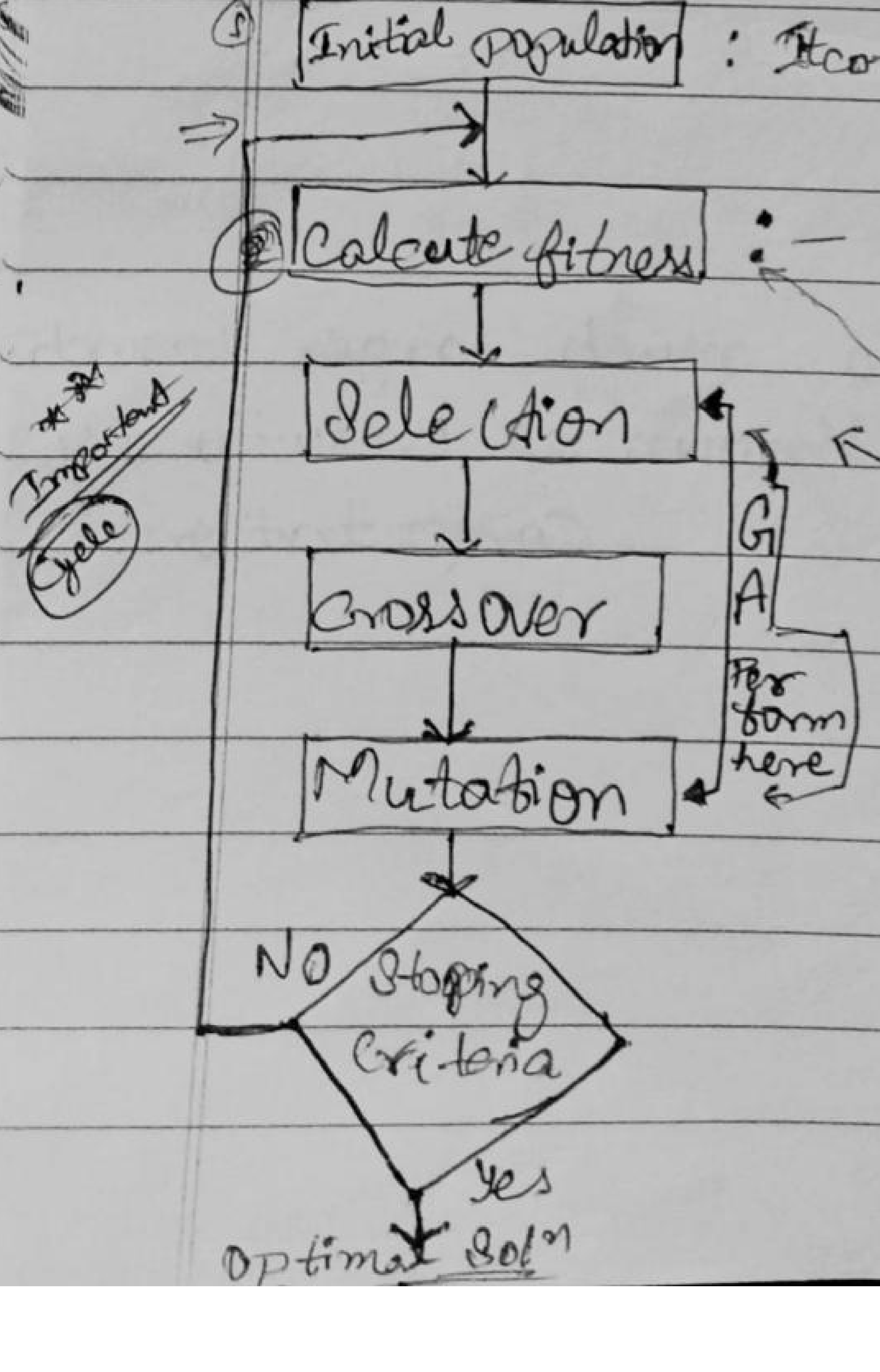

(1) Initial population : It contain Sol^n's but not perfect.

(2) Calcute fitness :- MAKE (1 2 3) :- we need this, but TAKE (1 2 3) :- Availabe this, So '2' check fitness value here 3 value because of '3' alphabet is matched

as a output ↑ (ex) 2nd Sol^n (1) ABCD but MAKE (1) value is (1)

In Selection it check the best suitable Sol^n (predefined) For eg:- (1) TAKE (2) ABCD '3' '1' So, (Selection) will pick (1) Take (due to best in both)

There may be 'n' number of Sol^n. So we pick 'n' number Sol^n with high value (I.P)

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* Genotype :- It is the population in the computation space, the solutions are represented in a way which can be easily understood and manipulated using a computing system

* phenotype :- It is the population in the actual real world solution space in which solutions are represented in a way they are represented in real-world situations.

erators:- 1) Selection Operator :- The idea is to give preference to the individuals with good fitness scores and allow them to pass their genes to succesive generations.

2) Crossover Operator :- It represents mating b/w individuals. Two individuals are selected using selection operator and crossover sites are choosen randomly.

Then the genes at these crossover sites are exchanged thus creating a completely new individual (offspring)

ex:- Parent:1 A B C D E F G H

Parent:2 F G H A D B E A

F G H B C D E A
offspring.

M=6

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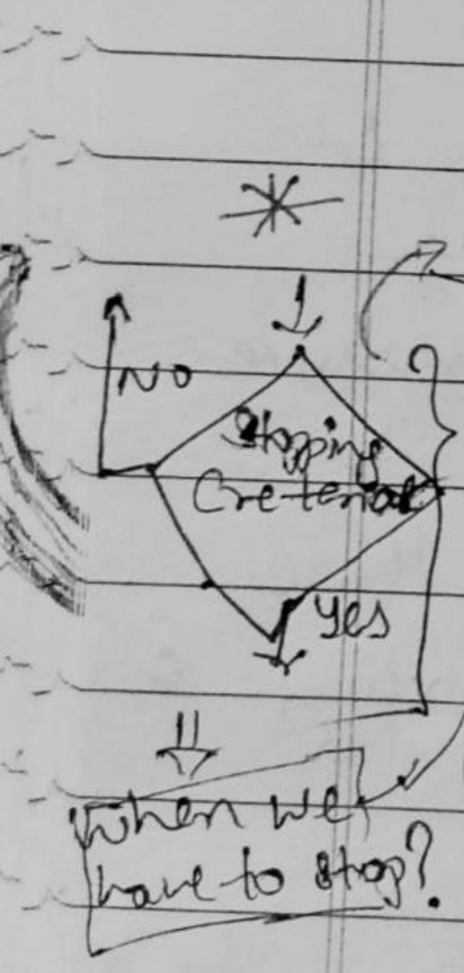
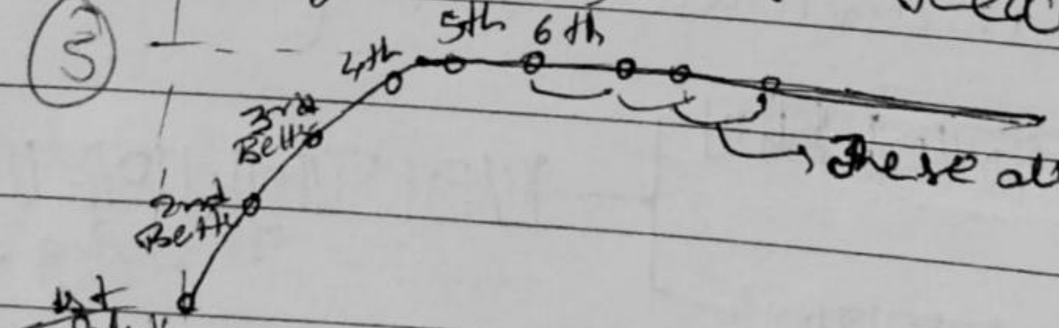
* Genetic Algorithm [Vs] * Traditional Algorithm

	Genetic Algorithm	Traditional Algorithm
(I)	Genetic & Natural selection	(I) Step by step procedure to solve a given prob
	to solve optimization problem.	
(II)	More Advanced	(II) Not as Advanced
(III)	Used in field such as M.L, A.I.	(3) Used in field as programming, Mathem
(iv)	Probabilistic Rules.	(iv) Fully deterministic Rule
(v)	Search on a population of points	(v) Search on a single poi

* Convergence Test / Termination condition:-



(1) Manual checking :-
(2) Solution found that satisfy objective criteria
(3) Fixed Number of generation :-
(4) Budget limit Reached. (Time or Space in computation)
(5)



These all gives similar to 6th Best so have to stop now.

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6.

Evolutionary Programming

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* An evolutionary computation is a family of algorithms for global optimization inspired by biological evolution, and the sub-field of AI & Soft computing.

⇒ It is used extensively in complex optimization problems and for continious optimization.

Applied:- ◻ path planning ◻ Fuzzy System ◻ Automatic control ◻ Hierarchical Systems ◻ Design & training of N.N/w ◻ The evolution of art. ◻ Game Strategies.

M 6

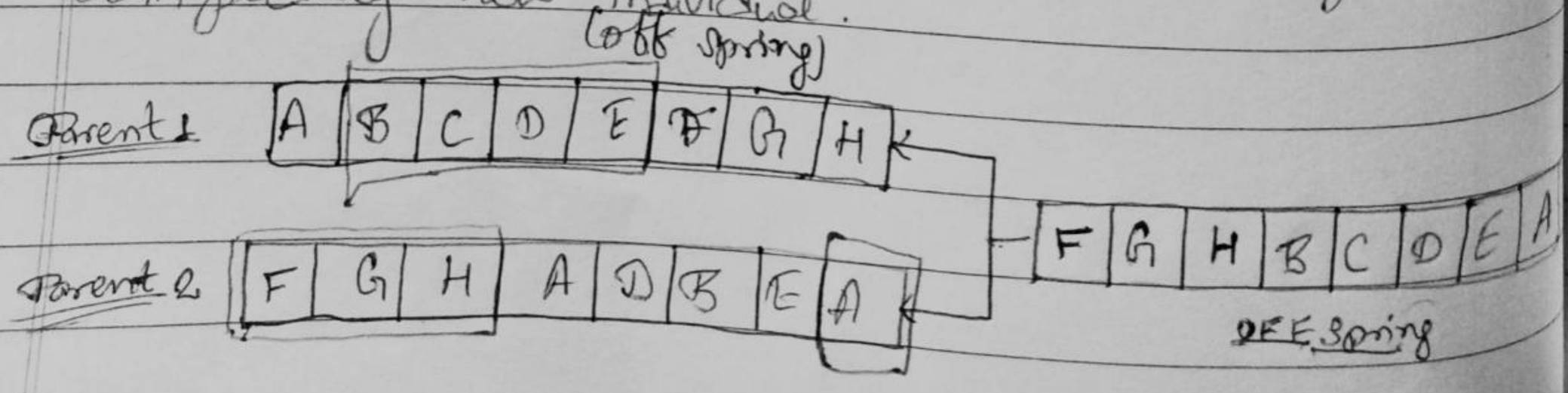
GA:- Operators

Decoding

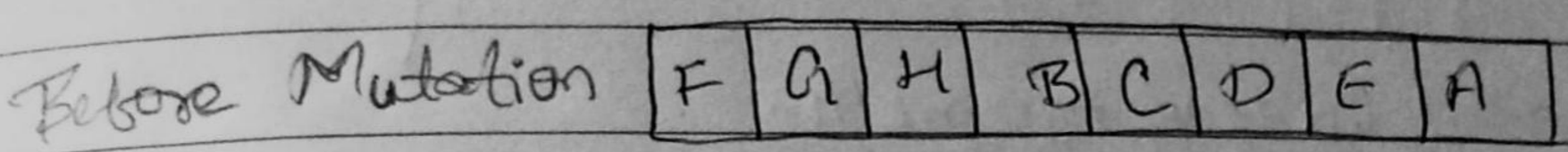
* Encoding:- For simple problems, the phenotype and genotype spaces are the same, However, in most of the cases, the phenotype and genotype spaces are different.
Decoding is a process of transforming a soln from the genotype to phenotype space,
While encoding is a process of transforming from the phenotype to genotype space.
* Decoding should be fast

* Selection:- It is the stage of a genetic algo. in which individual genomes are chosen from a population for later breeding (using the crossover operator).
* The idea is to give preference to the individuals with good fitness scores & allow them to pass their genes to successive generations

* Crossover operator :- This represents mating b/w individuals. Two individuals are selected using selection operator & crossover sites are chosen Randomly. Then the genes at these crossover sites are exchanged thus creating a completely new individual.



* Mutation :- The key idea is to insert random genes in offspring to maintain the diversity in the population to avoid premature convergence. (ex):-

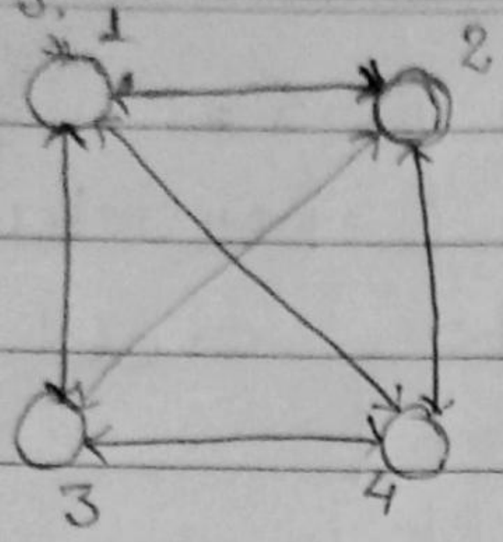


▷ The whole algor. can be summarized :-

1) Random initialize populations 'P'
2) Determine fitness of population
3) Untill convergence repeat :
   a) Select Parents from population
   b) crossover and generate new population
   c) Perform mutation on New population
   d) calculate fitness for New "

6
18P

Travelling Salesman Problem



	1	2	3	4
1	0	10	15	20
2	5	0	25	10
3	15	30	0	5
4	15	10	20	0

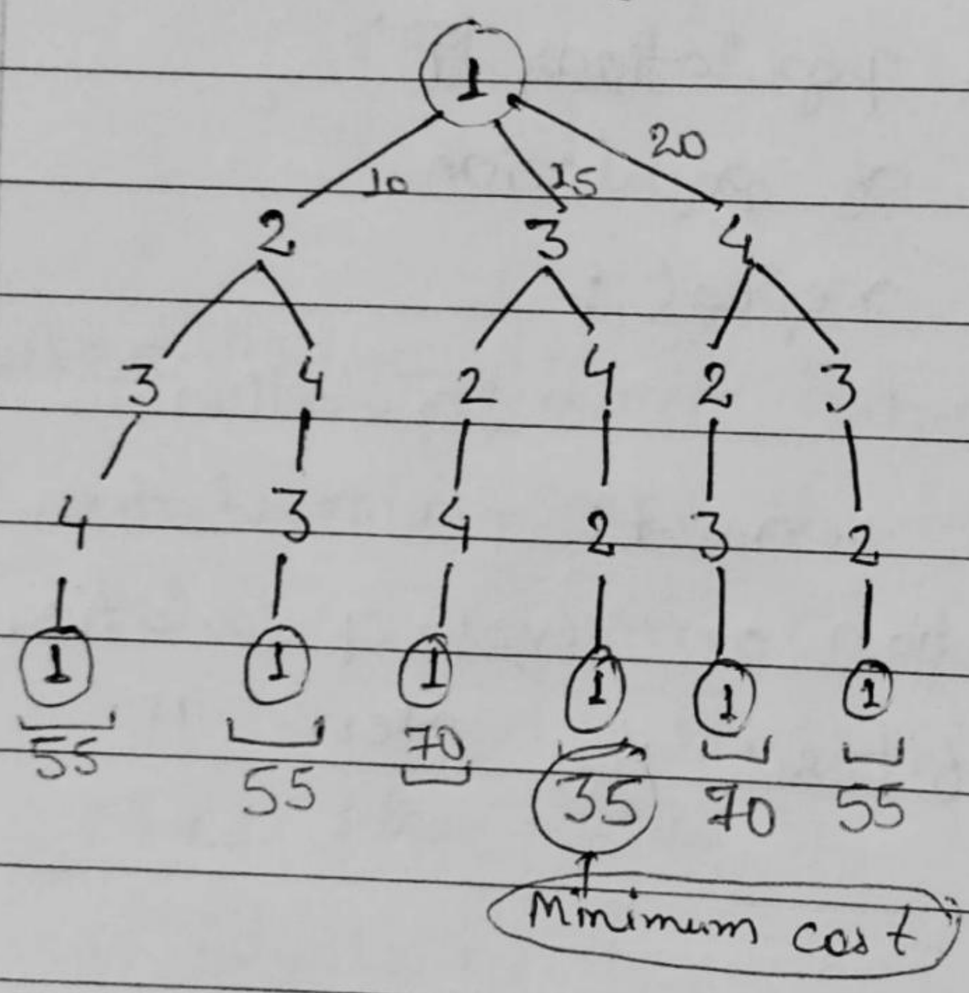
1. 10 + 25 + 5 + 15
3. 15 + 30 + 10 + 15
4. 15 + 5 + 10 + 5
5. 20 + 10 + 25 + 15
6. 20 + 20 + 30 + 5

* Sortest path (Greedy Approach):-

1 —10→ 2 —10→ 4 —20→ 3 —15→ 1

= 55

* Brute-force Method :- (possibility)



* Here, Greedy Method failed:-

Total possibility = $\lfloor n-1$ (factorial)

complexity :- $O(n^n)$

* Not Learnable

GA) Operator

① Encoding :-

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* Binary Encoding :-

A = 5 (100)
B = 10 (150)
C = 15 (200)

M = 25

Each one is called chromosome

(A)	(AB)	(AC)	(BC)
100	110	101	011

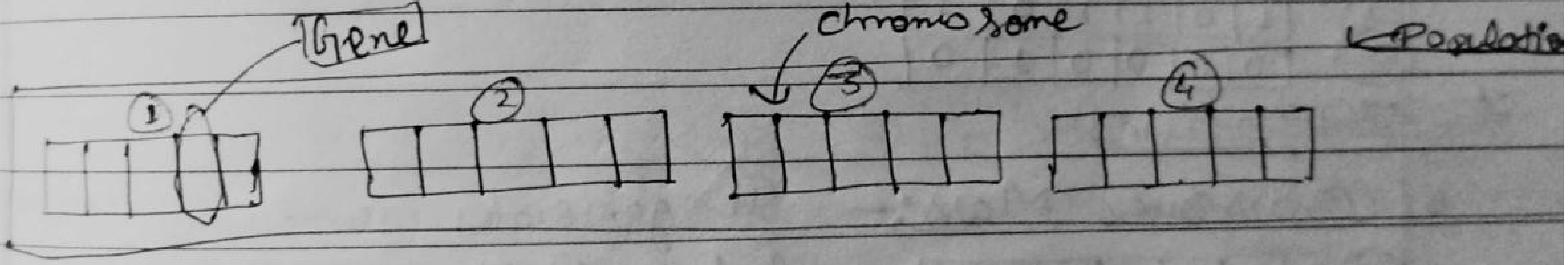
* All are of opn considered (sol^n)

Example :- $f(x) = x^3$; $0 \le x \le 255$

→ 8-bit digit [1 0 0 1 1 0 1 1] 155. [1 1 1 1 1 1 1 1] 255

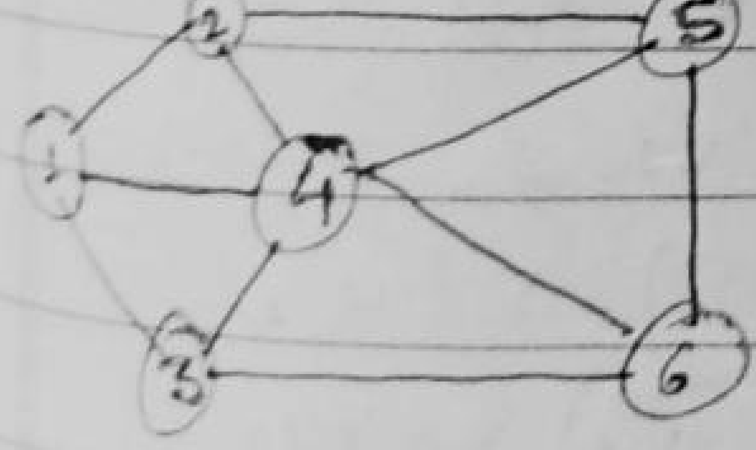
* All possible sol^n / or used Bi… are known as Chromosome

→ A collection of chromosome is known as 'Population'



* Fitness evaluation :- Fitness Function [or] Objective function

* Salesman problem →



	Path	Fitness value
Path 1 :-	1 2 5 6 4 3 1	18
Path 2 :-	1 2 5 4 6 3 1	20
Path 3 :-	1 2 4 5 6 3 1	12
Path 4 :-	1 2 5 6 3 4 1	17

optimal / Best sol^n

* 0-1 Knapsack problem

A − 5 (100), B − 10 (150)
C − 15 (200),

Bag [or] capacity = 25

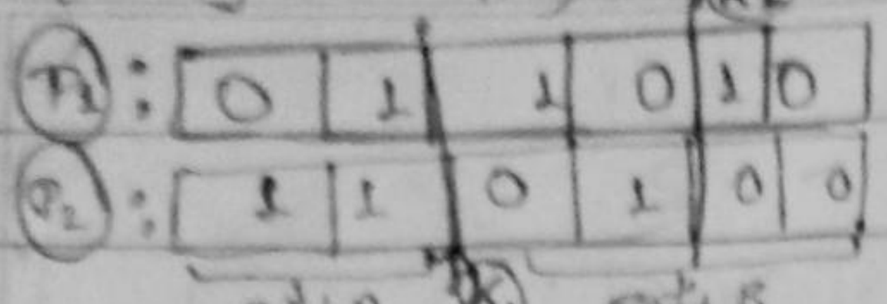
	Chromosome	Weight	P…
(A)	100	5	10…
(AB)	110	15	25…
(AC)	101	20	3…
(BC)	011	25	3…
(ABC)	111	30 ✗	4…

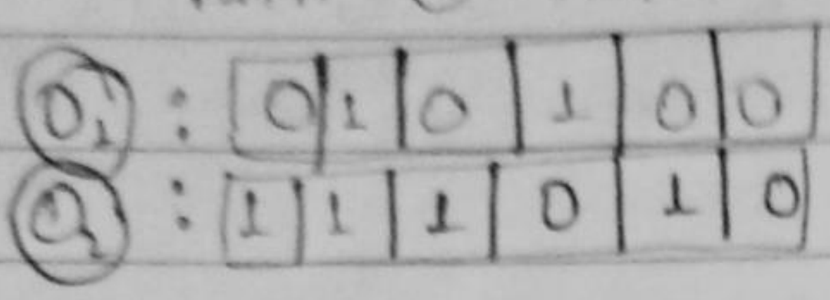
Optimal Best sol^n → (BC)

Operators (GA).

→ Crossover.

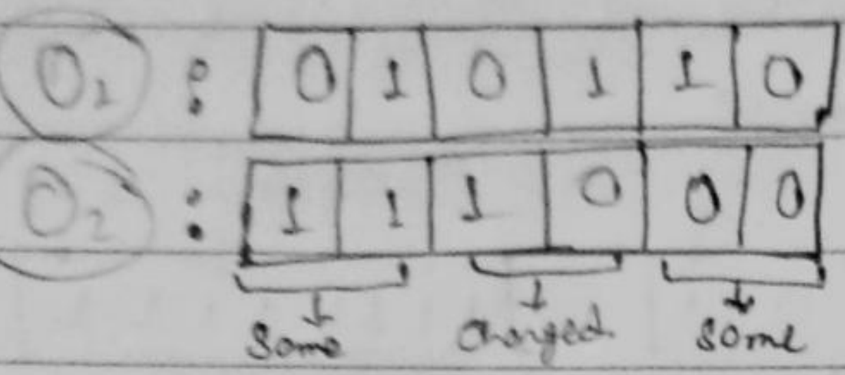
(Binary coded GA)



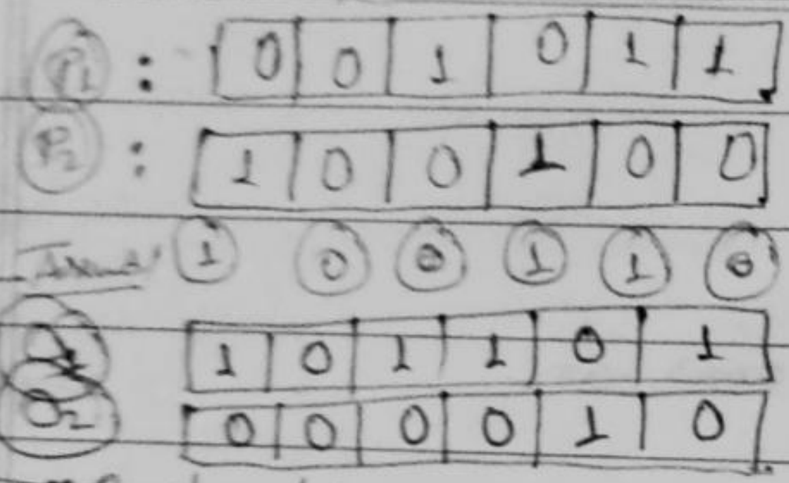
Cross :- 

(*) Single point crossover.
(*) Multi-point crossover.

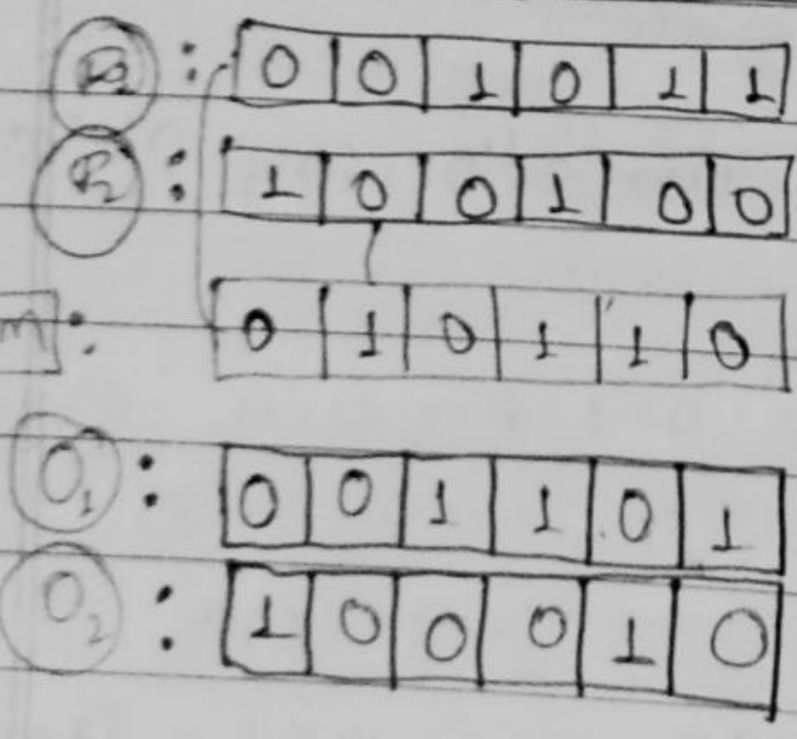
Some NEW flavour & Not same as (P1) (P2)



- Uniform crossover :- In this, we Tosing a 'coin' if result is (1) then change, else (0) No change



- Crossover Mask :- It generates randomly '0' & '1':



And :- (1) if CM=0 Copy the value of Parent (1) (1) (2) CM=1 then take Parent (P2) value & copy.

(O2) Rule :- To fill (O2) we do same vice-versa. means. CM=1 Copy the (P2) value, CM=1 Copy the (P1) values.

(Cont.) Operations

Mutation

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- Offspring: | 0 | 1 | 1 | 0 | 0 | 1 |
- MP (μ): | 0 | 1 | 0 | 0 | 0 | 1 |

* MP(μ) = '0' then Don't flip or change that value.

- Mo: | 0 | 0 | 1 | 0 | 0 | 0 |

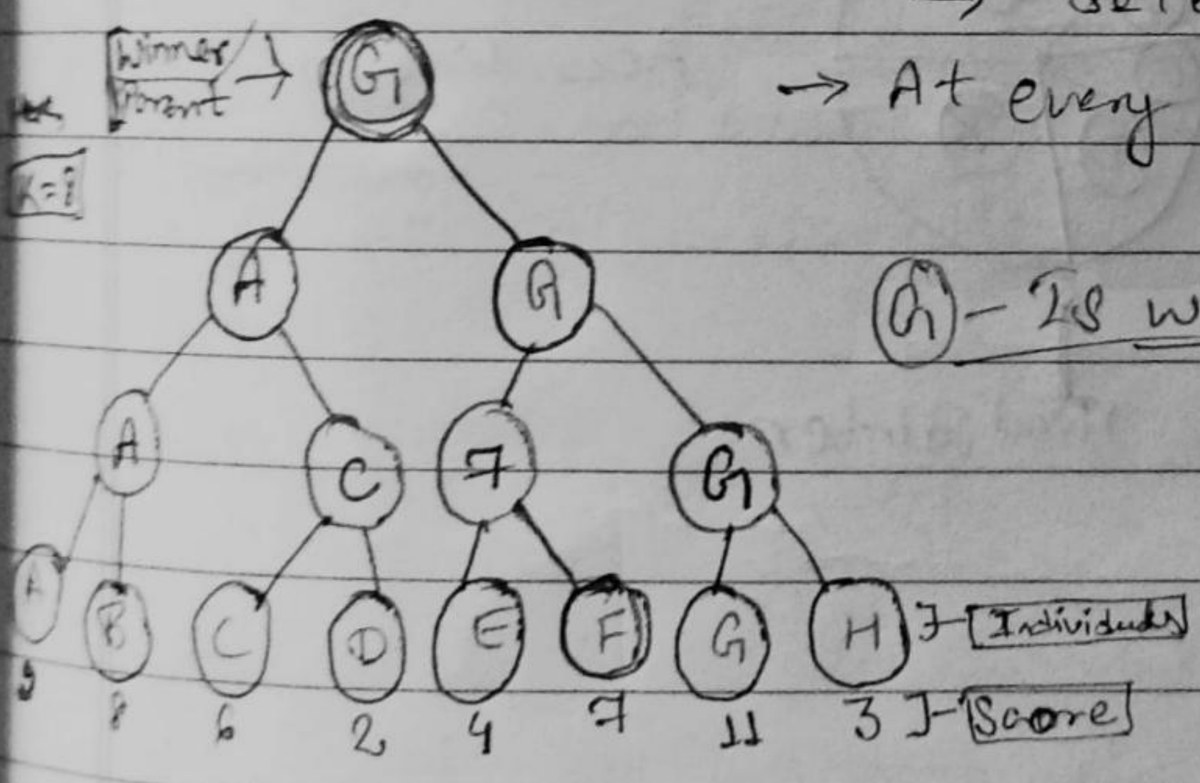
- 2nd Technique :- ① Just Select Randomly "Two" bit in (offspring)
② Just Interchange Both in NEW (Mo)

Offspring :- | 0 | 1 | 1 | 0 | 0 | 1 |

Mo :- | 0 | 0 | 1 | 0 | 1 | 1 |

* Tourament Selection *

→ Selection of Individual; (Ex) Total 100 ⇒ Selected 10
N << Np
→ At every Tournament only one Individue Seleted (called Winner/Parent)



G1 - Is winner;

Se 1
M=6

Roulette wheel - Reproduction
(Selection)

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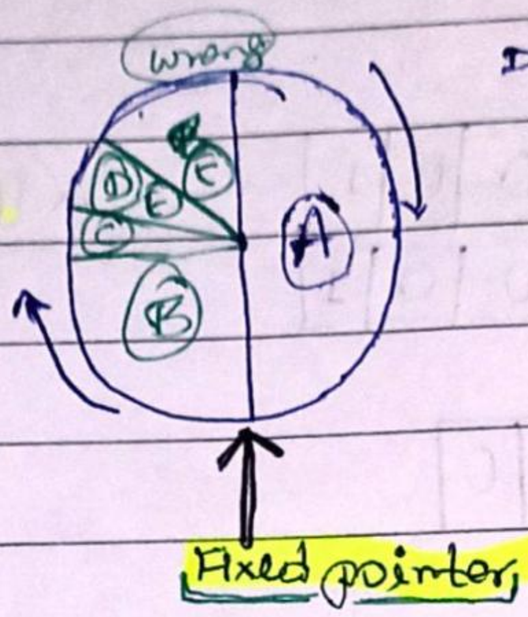
* Select the Best, Leave the Rest

▷ Selection directly ∝ Fitness Proportional

C	F	
A	5	50%
B	2	20%
C	0.5	5%
D	1.5	15%
E	1	10%
	10	



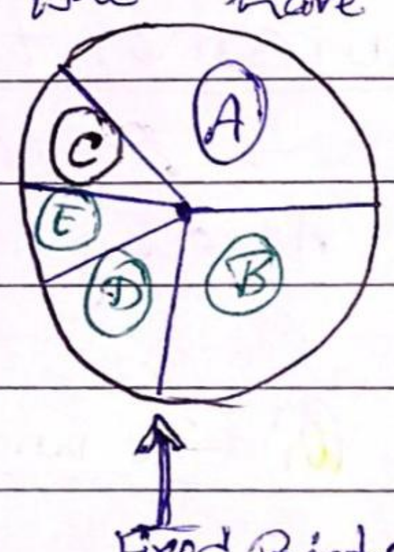
▷ It just Move wheel (clockwise) & the pointer point Individual Area during stop condition not ?

* Fitness ∝ Area ∝ Selection

▷ Rank Based Selection :-

* We Provide Rank All Individual from (1 to N), 1 rank get who have 'low score'.

	C	F	Rank	
5/15 ×100	A	5	5	= 33.33%
4/15 ×100	B	2	4	= 26.67%
1/15 ×100	C	0.5	1	= 6.67%
3/15 ×100	D	1.5	3	= 20%
2/15 ×100	E	1	2	= 13.33%
			15	



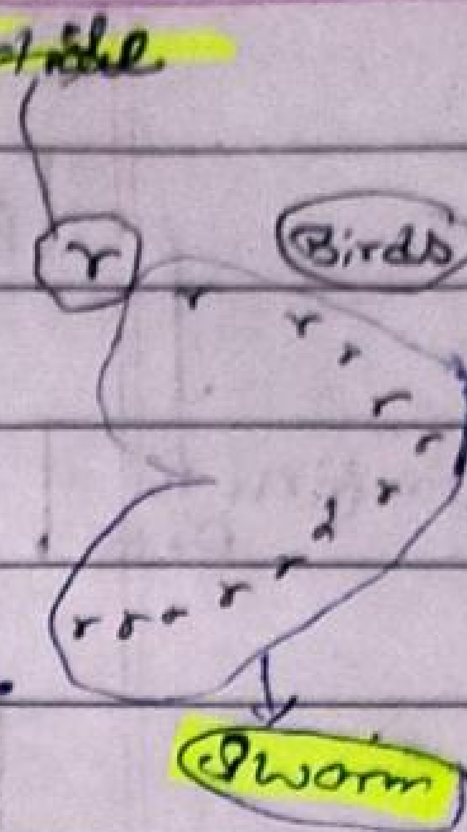
* Wheel Area Divided According to Rank of Percentage (%)

GA/ [illegible] Algo :-

Particle Swarm Optimisation

PSO

- **Particle** — * An Individual
- **Swarm** — * A Group of (x).
- **Optimization** — * The Best result.



PSO :- Solves very difficult computation problem.

- Population Based Stochastic Algo.
- It Inspired by Social behaviour of bird flocking or fish Schooling.

Genetic Algo VS PSO Algo 'Similarities' :-

1. Random population
2. Fitness value
3. Update population.

PSO don't contain GA operator i.e (Crossover) & (mutation)

- PSO Algo/Pseudo-Code :-

- PBest :- Personal Best
- GBest :- Global Best.
- C_1 or C_2 = Learning factor.
- rand() = (0-1) function.
- present [] = position of a particle.

```
For each particle
    Initialize particle.
END;
Do
    For each particle
        Calculate fitness value
        If the fitness value is better than the 'pBest' in history.
            Set current value as the new 'pBest'.
    END.
    Choose the particle with the best fitness value of all Particles, as the 'gBest'.
    For each particle
        Calculate particle velocity = V[] = V[] + C1 x rand() * (pBest[] - present[]) + C2 * rand() * (gBest[] - present[])
        Update particle position = present[] = present[] + V[]
    END;
While max iteration or min error criteria is not attained.
```

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Optimization Technique

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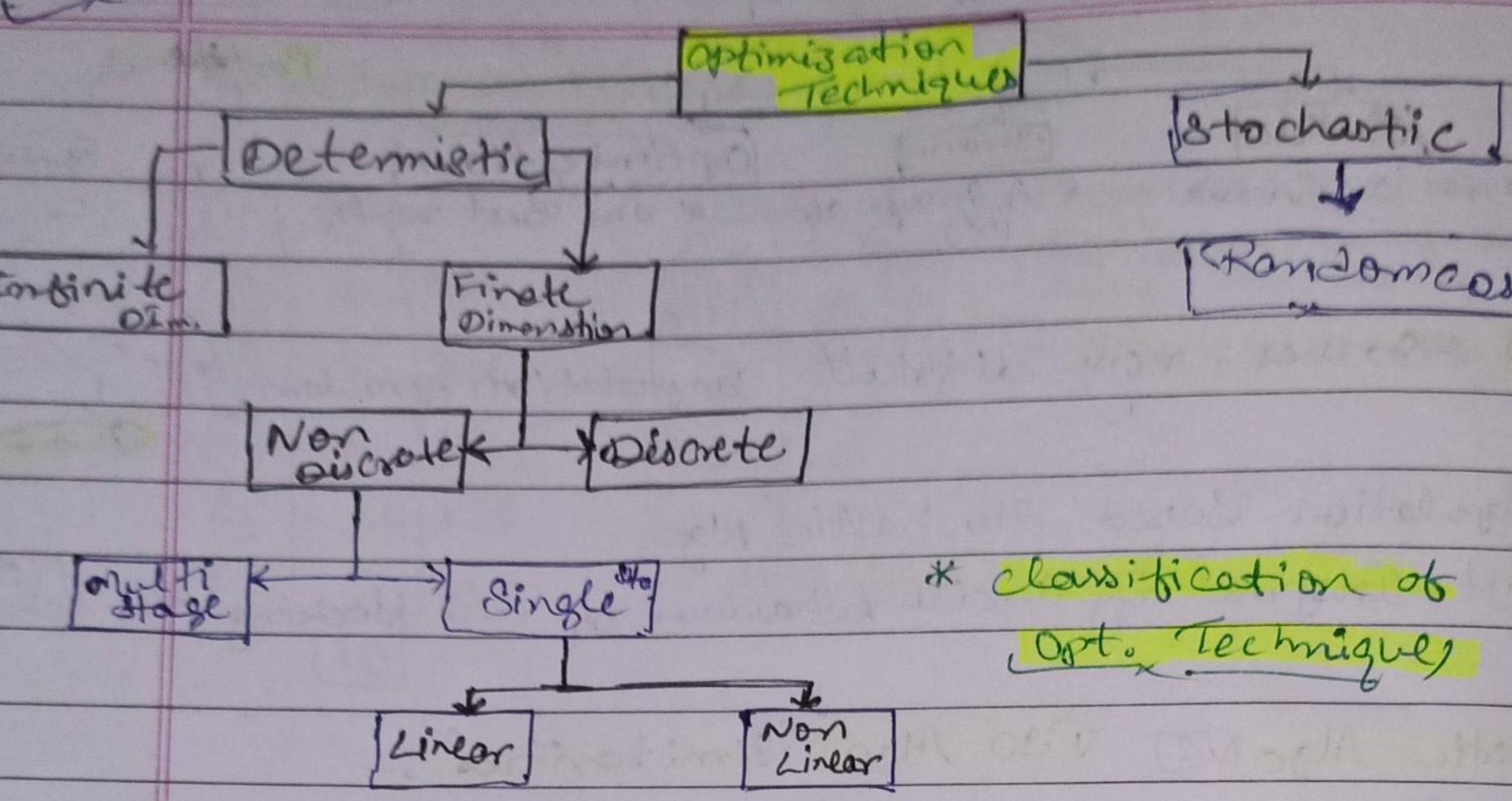

* classification of Opt. Technique

* Benefits OF GA:-

- easy to Understand
- Modular, Separate for applicath.
- Supports multi-Objective optimization.
- Flexible in forming building blocks for Hybrid Apps.
- Good for Noisy Environment
- Inherently parallled and easily distributed
- Has Substantial History and range for use.