GENETIC ALGORITHM

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- WHAT IS GENETIC ALGORITHM?
- WHERE IS GENETIC ALGORITHM USED?
- HOW DOES IT WORK?
- EXAMPLE
- COMPLEXITY AND CODE

WHAT IS GENETIC ALGORITHM?

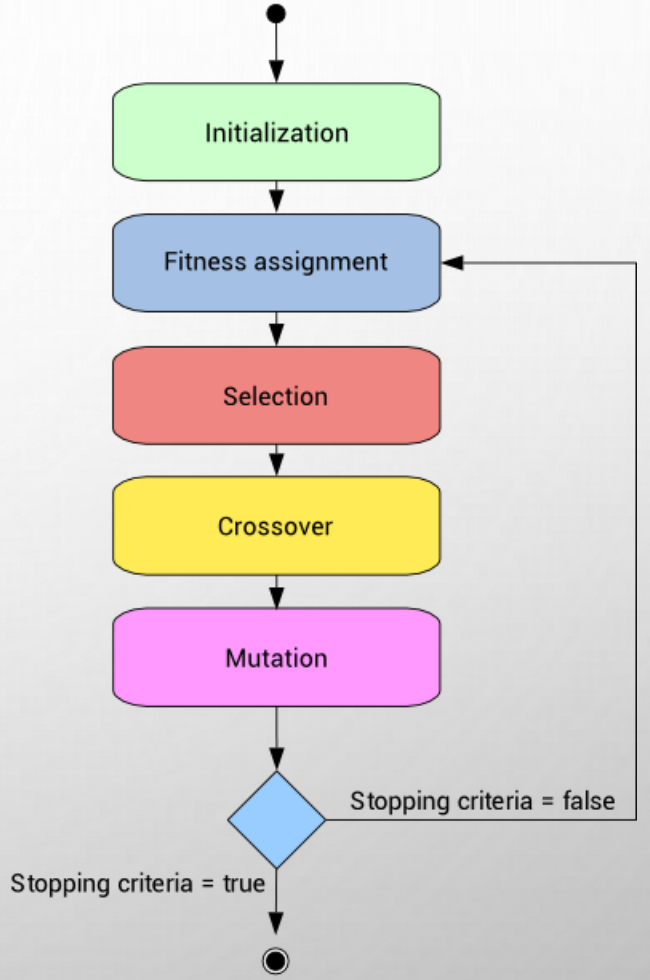
- METHOD FOR SOLVING OPTIMIZATION AND SEARCHING PROBLEMS
- INSPIRED BY DARWIN'S THEORY OF NATURAL EVOLUTION
- SELECTION OF FITTEST INDIVIDUALS FOR NEXT GENERATION

WHERE IS GENETIC ALGORITHM USED?

- OPTIMIZATION
- SEARCHING
- MACHINE LEARNING
- NEURAL NETWORKS
- DNA ANALYSIS

HOW DOES IT WORK?

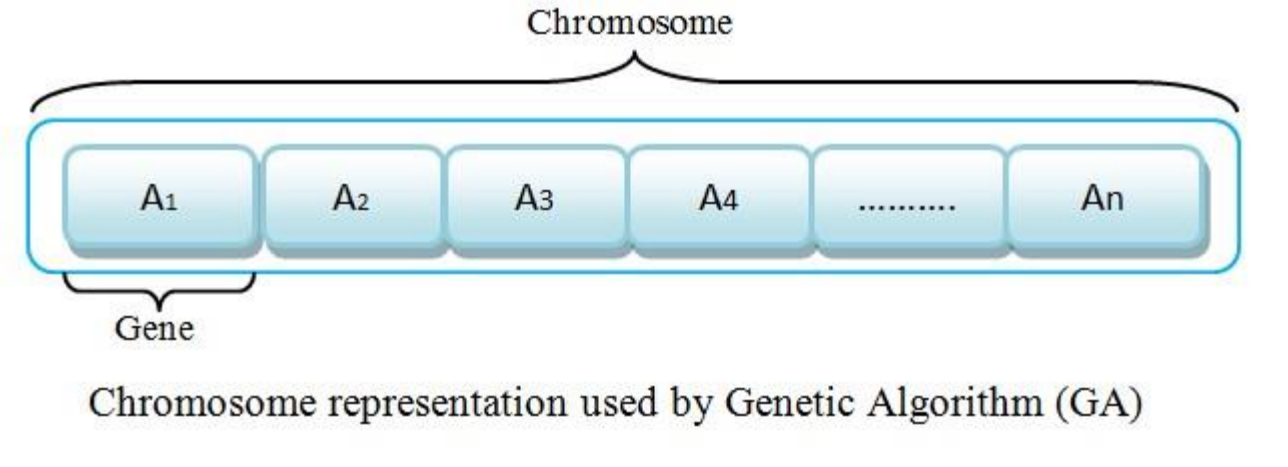
- **STEPS:**
- 1) RANDOMLY INITIALIZE POPULATIONS
- 2) DETERMINE FITNESS OF POPULATION
- 3) UNTIL CONVERGENCE REPEAT:
- A) SELECT PARENTS FROM POPULATION
- B) CROSSOVER AND GENERATE NEW POPULATION
- C) PERFORM MUTATION ON NEW POPULATION
- D) CALCULATE FITNESS FOR NEW POPULATION



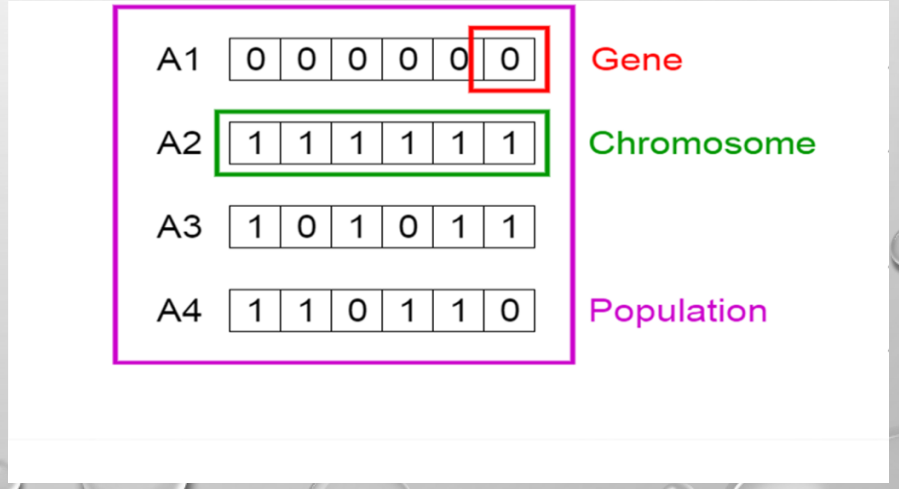
HOW DOES IT WORK?

CHROMOSOME COULD BE :

- BIT STRINGS → (001,010100111,101)
- REAL NUMBERS → (4578, 3578, 9874)
- PERMUTATION CODING → (A_1, A_2, A_3, A_4, A_5, …)
- PROGRAM OF ELEMENT → GENETİC PROGRAMMING



Chromosome representation used by Genetic Algorithm (GA)



FITNESS FUNCTION

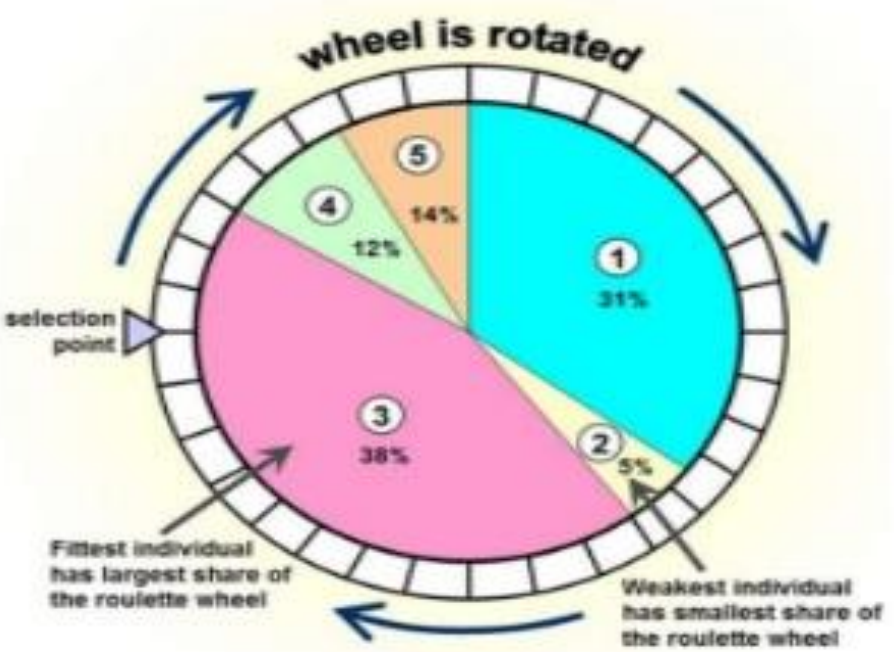
- the fitness function determines how fit an individual is and the ability of an individual to compete with other individuals.
- ıt gives a **fitness score** to each individual.
- the probability that an individual will be selected for reproduction is based on its fitness score.

SELECTION

- the idea of **selection** phase is to select the fittest individuals and let them pass their genes to the next generation.

- There are a lot of methods to selection but the famoust one is ROULETTE WHEEL

Roulette Wheel Selection



Better chromosomes have high probability to be selected as new parents. The probability of each individual chromosome getting selected is given by the equation.

$$P_i = \frac{f_i}{\sum_{j=1}^{N} f_i}$$

where,

f_i is the fitness of the individual i in the population

N is the number of individuals in the population

HOW DOES IT WORK?

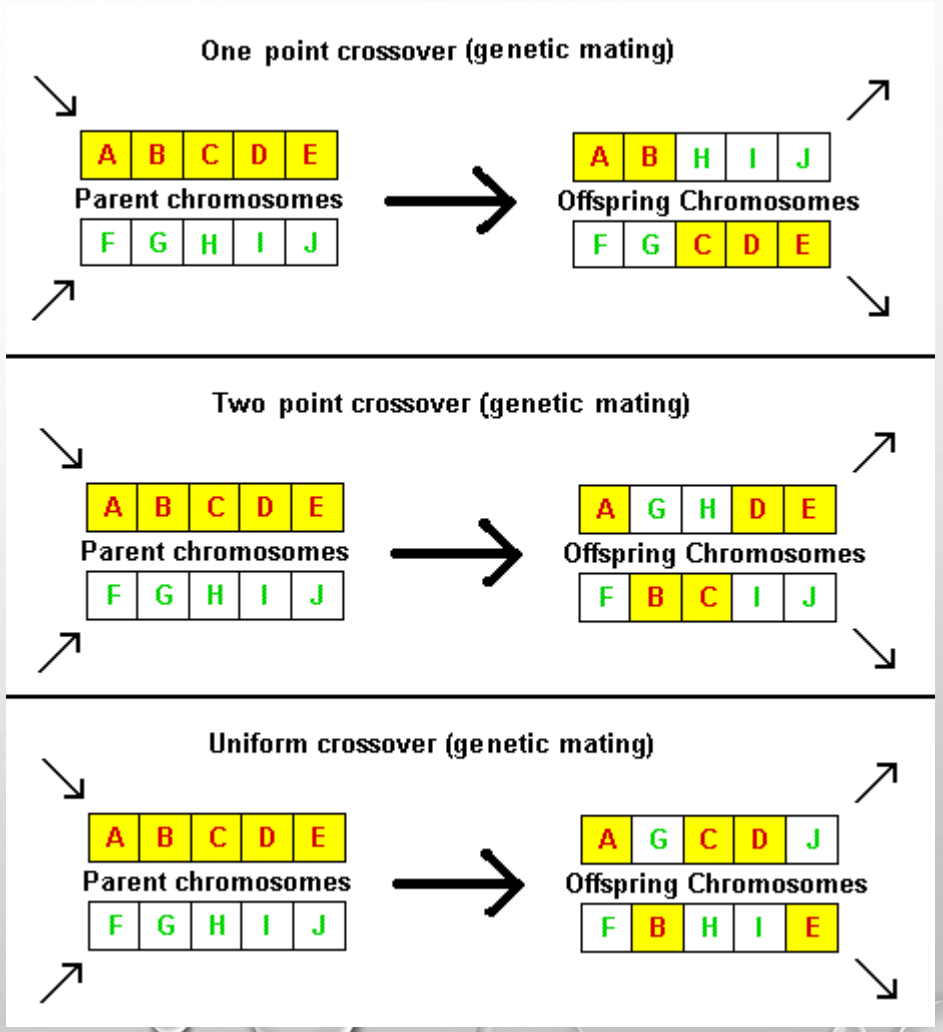
CROSSOVER:

***TYPES*:**

ONE POINT

TWO POINT

UNIFORM



HOW DOES IT WORK?

MUTATION:

- **Some of the bits in the child chromosome can be changed**

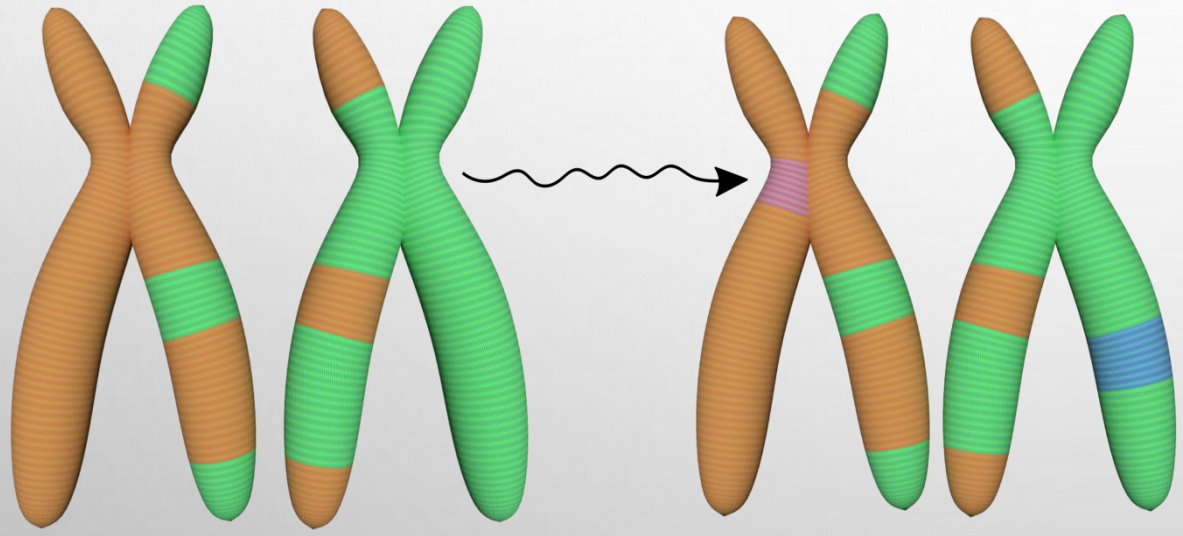


Figure 4: Mutation

EXAMPLE

- **CHROMOSOME STRUCTURE :**
- CH = (G0, G1, G2, G3, G4, G5, G6, G7) , 0<= G <=9

- **FITNESS FUNCTION :**
- F(CH) = (G0 + G1) − (G2 + G3) + (G4 + G5) − (G6 + G7)
- FIND CHROMOSOMES WITH THE HIGHEST FITNESS.
- CH[OPTIMUM] = (9 + 9) − (0 + 0) + (9 + 9) − (0 + 0) = 36

- CH1 = (6, 5, 4, 1, 3, 5, 3, 2)
- CH2 = (8, 7, 1, 2, 6, 6, 0, 1)
- CH3 = (2, 3, 9, 2, 1, 2, 8, 5)
- CH4 = (4, 1, 8, 5, 2, 0, 9, 4)

- F(CH) = (G0 + G1) − (G2 + G3) + (G4 + G5) − (G6 + G7)

- CH1 = (6 + 5) - (4 + 1) + (3 + 5) - (3 + 2) = 9
- CH2 = (8 + 7) - (1 + 2) + (6 + 6) - (0 + 1) = 23
- CH3 = (2 + 3) - (9 + 2) + (1 + 2) - (8 + 5) = -16
- CH4 = (4 + 1) - (8 + 5) + (2 + 0) - (9 + 4) = -19

CHROMOSOME	GENE	FITNESS
CH2	(8, 7, 1, 2, 6, 6, 0, 1)	23
CH1	(6, 5, 4, 1, 3, 5, 3, 2)	9
CH3	(2, 3, 9, 2, 1, 2, 8, 5)	-16
CH4	(4, 1, 8, 5, 2, 0, 9, 4)	-19

CROSSOVER :

- PARENT CHROMOSOMES
- CH2 = (8, 7, 1, 2, | 6, 6, 0, 1)
- CH1 = (6, 5, 4, 1, | 3, 5, 3, 2)

SINGLE POINT CROSSOVER

- CHILD CHROMOSOMES
- CHILD1 = (8, 7, 1, 2, **3**, **5**, **3**, **2**)
- CHILD2 = (6, 5, 4, 1, **6**, **6**, **0**, **1**)

- PARENT CHROMOSOMES
- CH1 = (6, 5, | 4, 1, 3, 5, | 3, 2)
- CH3 = (2, 3, | 9, 2, 1, 2, | 8, 5)

TWO POINT CROSSOVER

- CHILD CHROMOSOMES
- CHILD3 = (6, 5, 9, 2, 1, 2, 3, 2)
- CHILD4 = (2, 3, 4, 1, 3, 5, 8, 5)

- PARENT CHROMOSOMES
- CH2 = (8, **7**, 1, 2, **6**, **6**, 0, **1**)
- CH3 = (2, **3**, 9, 2, **1**, **2**, 8, **5**)

UNIFORM CROSSOVER

- CHILD CHROMOSOMES
- CHILD5 = (8, **3**, 1, 2, **1**, **2**, 0, **5**)
- CHILD6 = (2, **7**, 9, 2, **6**, **6**, 8, **1**)

CHROMOSOME	GENE	FITNESS
CH2	(8, 7, 1, 2, 6, 6, 0, 1)	23
child2	(6, 5, 4, 1, 6, 6, 0, 1)	17
child1	(8, 7, 1, 2, 3, 5, 3, 2)	15
CH1	(6, 5, 4, 1, 3, 5, 3, 2)	9
child5	(8, 3, 1, 2, 1, 2, 0, 5)	6
child6	(2, 7, 9, 2, 6, 6, 8, 1)	1
child3	(6, 5, 9, 2, 1, 2, 3, 2)	-2
child4	(2, 3, 4, 1, 3, 5, 8, 5)	-5
CH3	(2, 3, 9, 2, 1, 2, 8, 5)	-16
CH4	(4, 1, 8, 5, 2, 0, 9, 4)	-19

THE TIME COMPLEXITY

- THE COMPLEXITY OF GENETIC ALGORITHM IS USUALLY DEPENDS ON :

- POPULATION NUMBER
- LENGTH OF CHROMOSOME
- THE FITNESS FUNCTION
- SELECTION
- CROSSOVER