Artificial Intelligence

FALL 2023

Lecture No:8 (A)

Genetic Algorithm

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Genetic Algorithm

8-QUEENS PROBLEM

Biology Concepts

- Population
- Fitness
- Selection
- Crossover
- Mutation

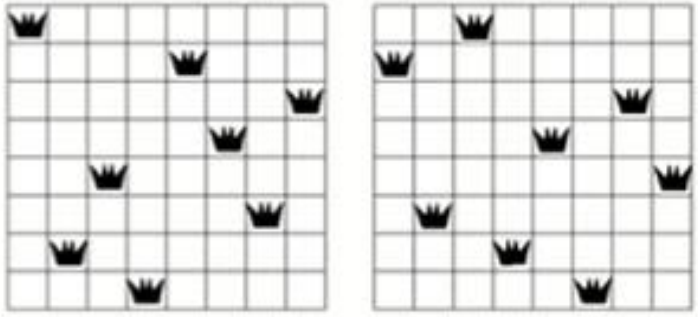
Population

Biology

- Collection of individuals.

Algorithm

- Collection of states.



Fitness

Biology

- More healthy, less prone to diseases.

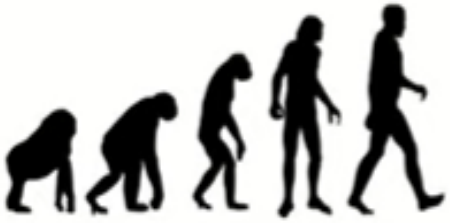
Algorithm

- Closest to the final solution.

Selection

Biology

- Selecting species that are the most biologically fit.



Algorithm

- Selecting states that are closest to the solution (Fittest).

Crossover

Biology

- Mating or Reproducing

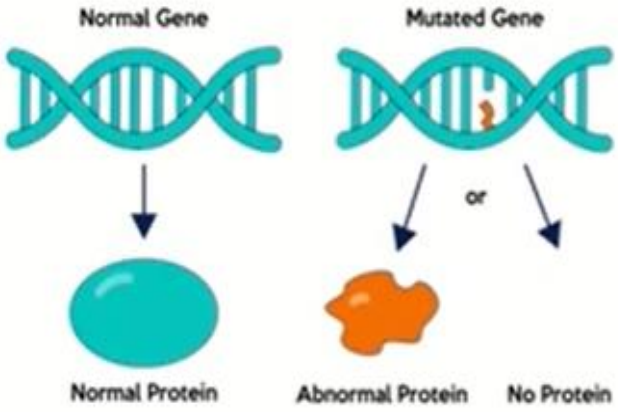
Algorithm

- Interchanging values between selected states.

Mutation

Biology

- Change or variation.



Algorithm

- Alteration.

Before Mutation

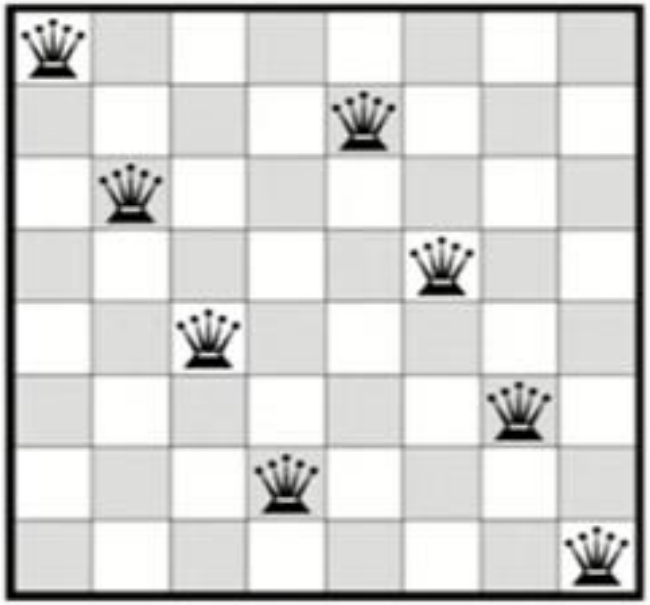
A5	1	1	1	0	0	0

After Mutation

A5	1	1	0	1	1	0

8-Queens Problem

- Arrange 8 queens on a standard chess board in such a way that no queen attacks each other.



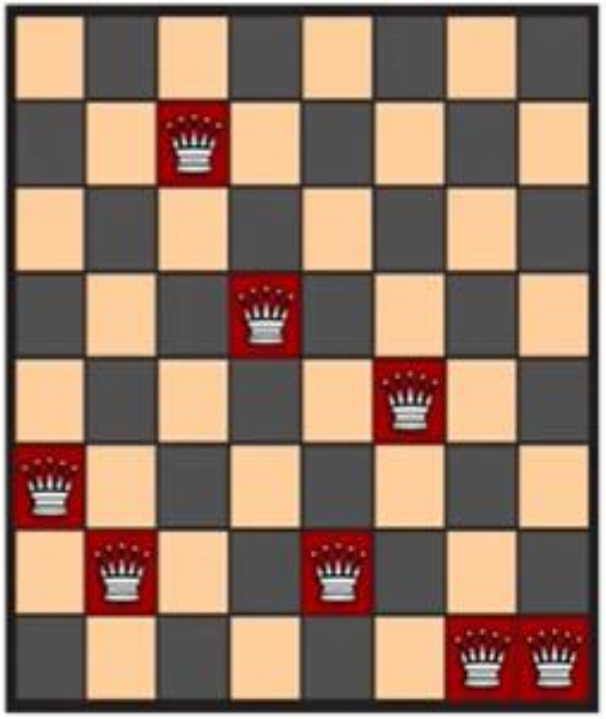
Solving the 8-Queen Problem using the Genetic Algorithm

- Step 1: Representing individuals.
- Step 2: Generating an initial Population.
- Step 3: Applying a Fitness Function.
- Step 4: Selecting parents for mating in accordance to their fitness.
- Step 5: Crossover of parents to produce new generation.
- Step 6: Mutation of new generation to bring diversity.
- Step 7: Repeat until solution is reached.

Step 1: Representing Individuals

- Formulate an appropriate method to represent individuals of a population.
- Array.
- Index: Column.
- Value: Row.

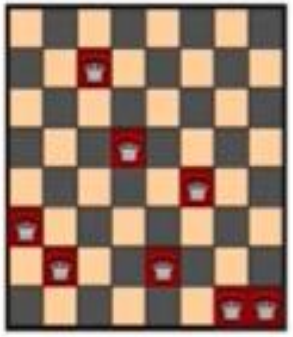
3	2	7	5	2	4	1	1



Step 2: Generate Initial Population

- Generate random arrangements of 8 queens on a standard chess board.

A

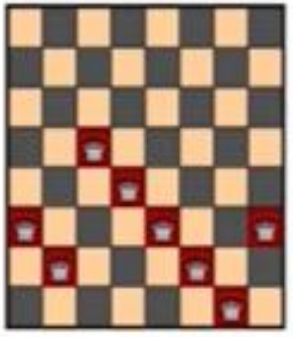


3	2	7	5	2	4	1	1

B

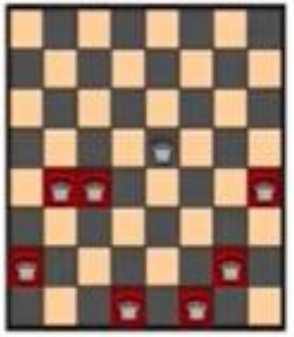
2	4	7	4	8	5	5	2

C



3	2	5	4	3	2	1	3

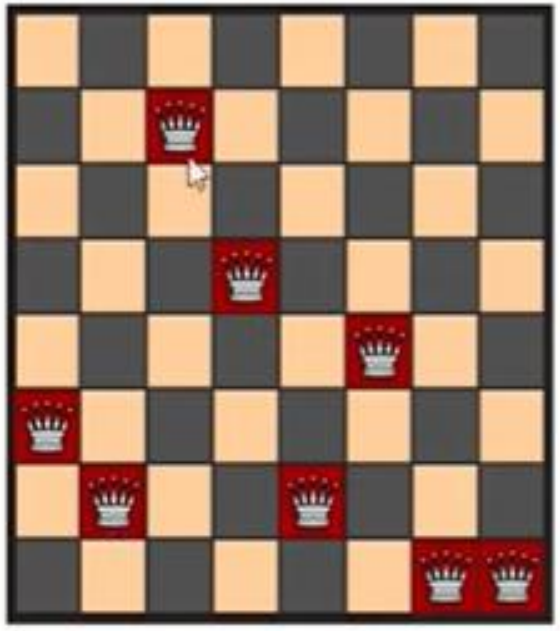
D



2	4	4	1	5	1	2	4

Step 3: Apply Fitness Function

Individual



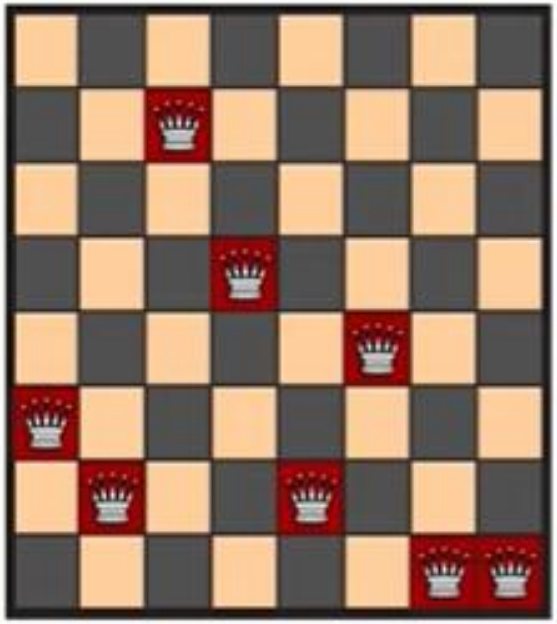
3	2	7	5	2	4	1	1

Fitness = No. of non attacking pairs

- **Queen 1:** 6

Step 3: Apply Fitness Function

Individual



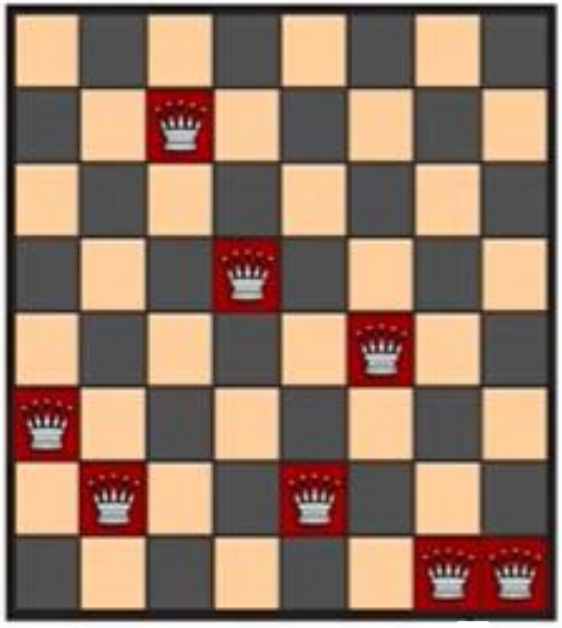
3	2	7	5	2	4	1	1

Fitness = No. of non attacking pairs

- **Queen 1:** 6
- **Queen 2:** 5

Step 3: Apply Fitness Function

Individual



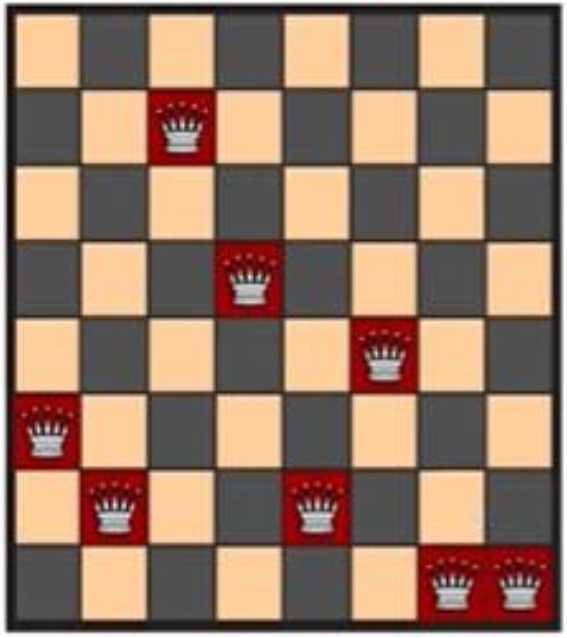
3	2	7	5	2	4	1	1

Fitness = No. of non attacking pairs

- **Queen 1:** 6
- **Queen 2:** 5
- **Queen 3:** 4

Step 3: Apply Fitness Function

Individual



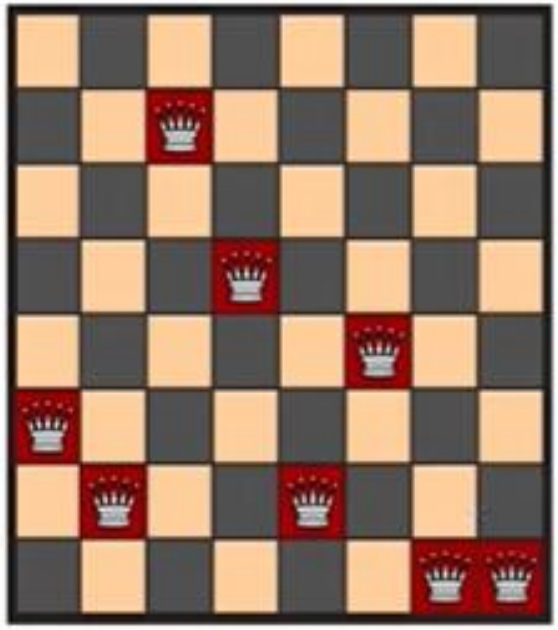
3	2	7	5	2	4	1	1

Fitness = No. of non attacking pairs

- **Queen 1:** 6
- **Queen 2:** 5
- **Queen 3:** 4
- **Queen 4:** 3

Step 3: Apply Fitness Function

Individual



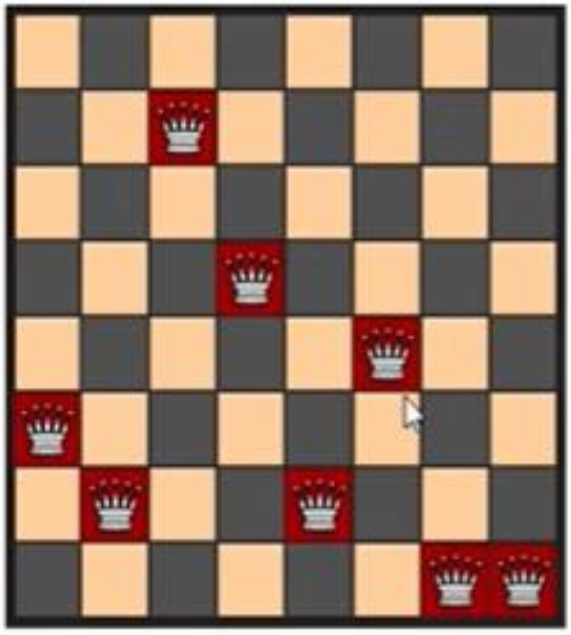
3	2	7	5	2	4	1	1

Fitness = No. of non attacking pairs

- **Queen 1:** 6
- **Queen 2:** 5
- **Queen 3:** 4
- **Queen 4:** 3
- **Queen 5:** 3

Step 3: Apply Fitness Function

Individual



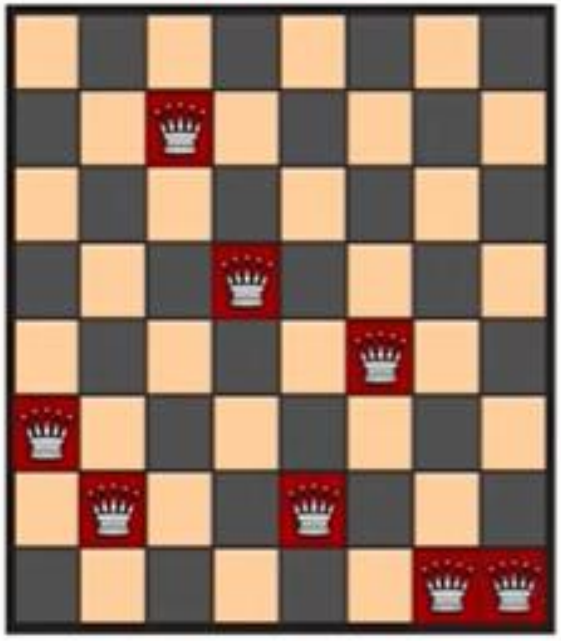
3	2	7	5	2	4	1	1

Fitness = No. of non attacking pairs

- **Queen 1:** 6
- **Queen 2:** 5
- **Queen 3:** 4
- **Queen 4:** 3
- **Queen 5:** 3
- **Queen 6:** 2

Step 3: Apply Fitness Function

Individual



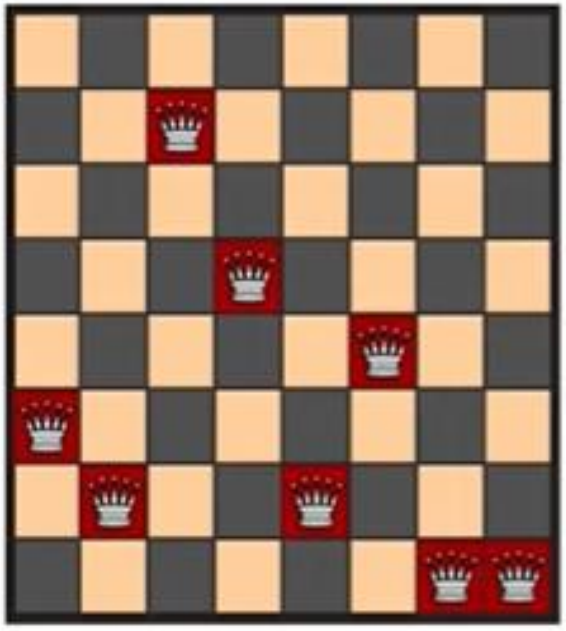
3	2	7	5	2	4	1	1

Fitness = No. of non attacking pairs

- **Queen 1:** 6
- **Queen 2:** 5
- **Queen 3:** 4
- **Queen 4:** 3
- **Queen 5:** 3
- **Queen 6:** 2
- **Queen 7:** 0

Step 3: Apply Fitness Function

Individual



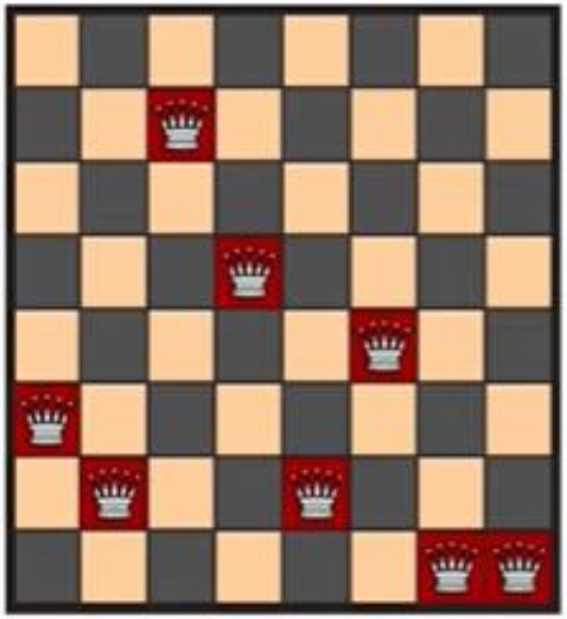
3	2	7	5	2	4	1	1

Fitness = No. of non attacking pairs

- **Queen 1:** 6
- **Queen 2:** 5
- **Queen 3:** 4
- **Queen 4:** 3
- **Queen 5:** 3
- **Queen 6:** 2
- **Queen 7:** 0
- **Queen 8:** 0

Step 3: Apply Fitness Function

Individual



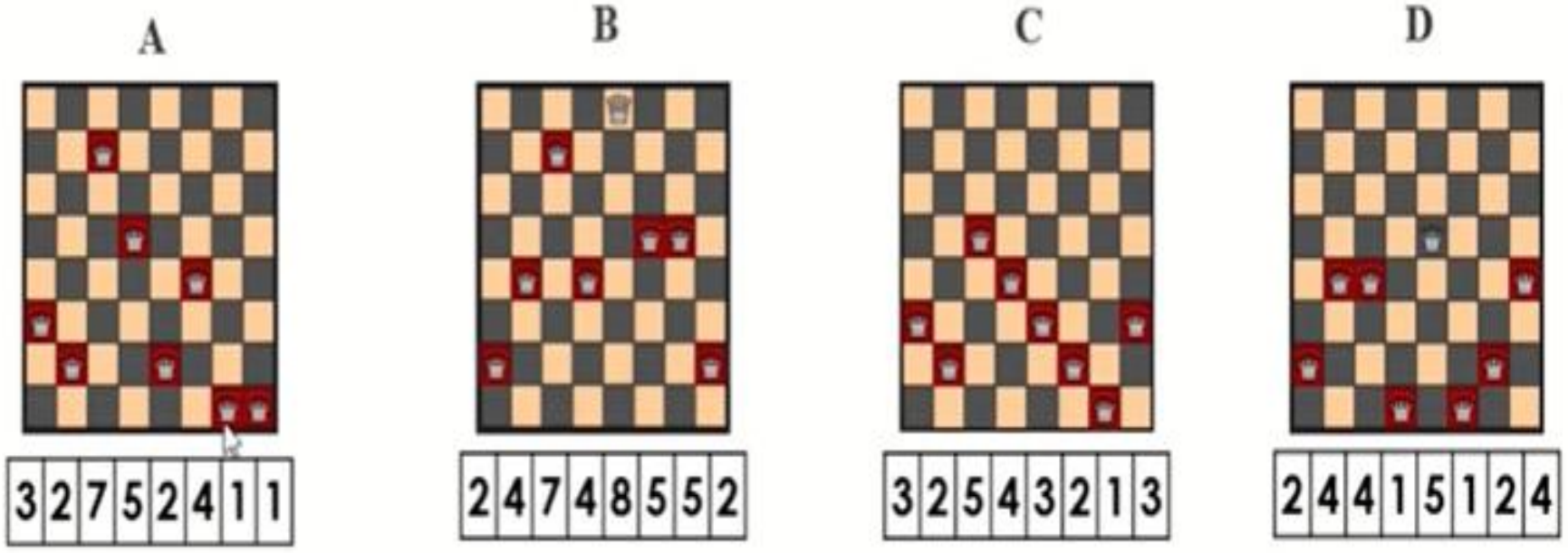
3	2	7	5	2	4	1	1

Fitness = No. of non attacking pairs

- **Queen 1:** 6
- **Queen 2:** 5
- **Queen 3:** 4
- **Queen 4:** 3
- **Queen 5:** 3
- **Queen 6:** 2
- **Queen 7:** 0
- **Queen 8:** 0
- **Total:** 23

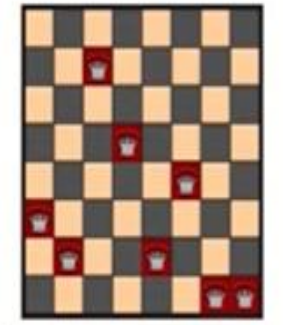
Step 3: Apply Fitness Function (Cont.)

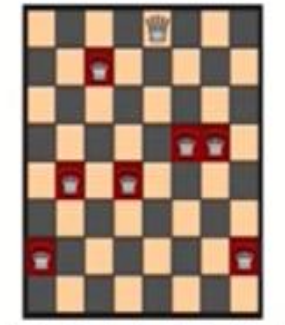
- Individuals

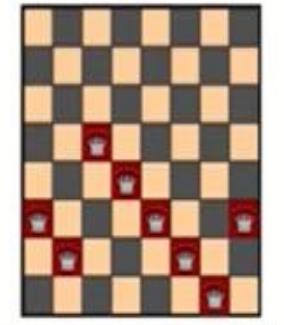


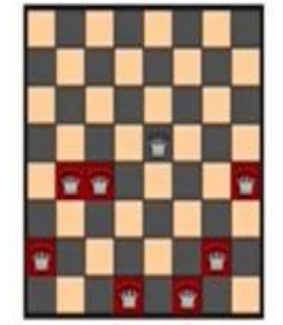
Step 3: Apply Fitness Function (Cont.)

- Individuals





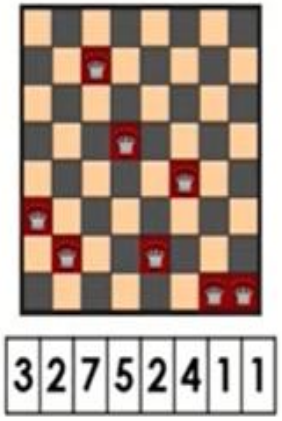
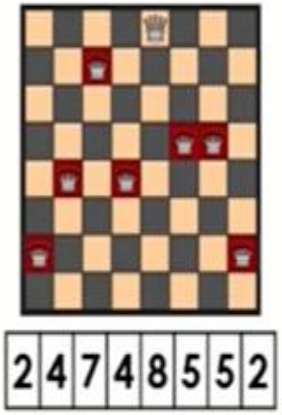
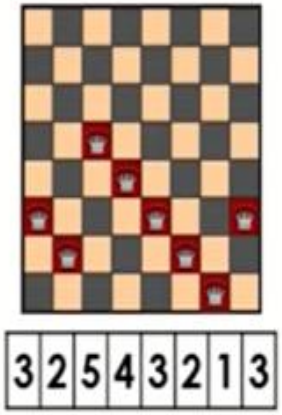
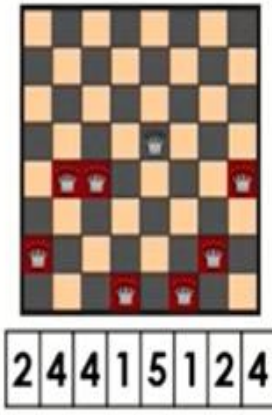




- Fitness

A	B	C	D
23	24	11	20

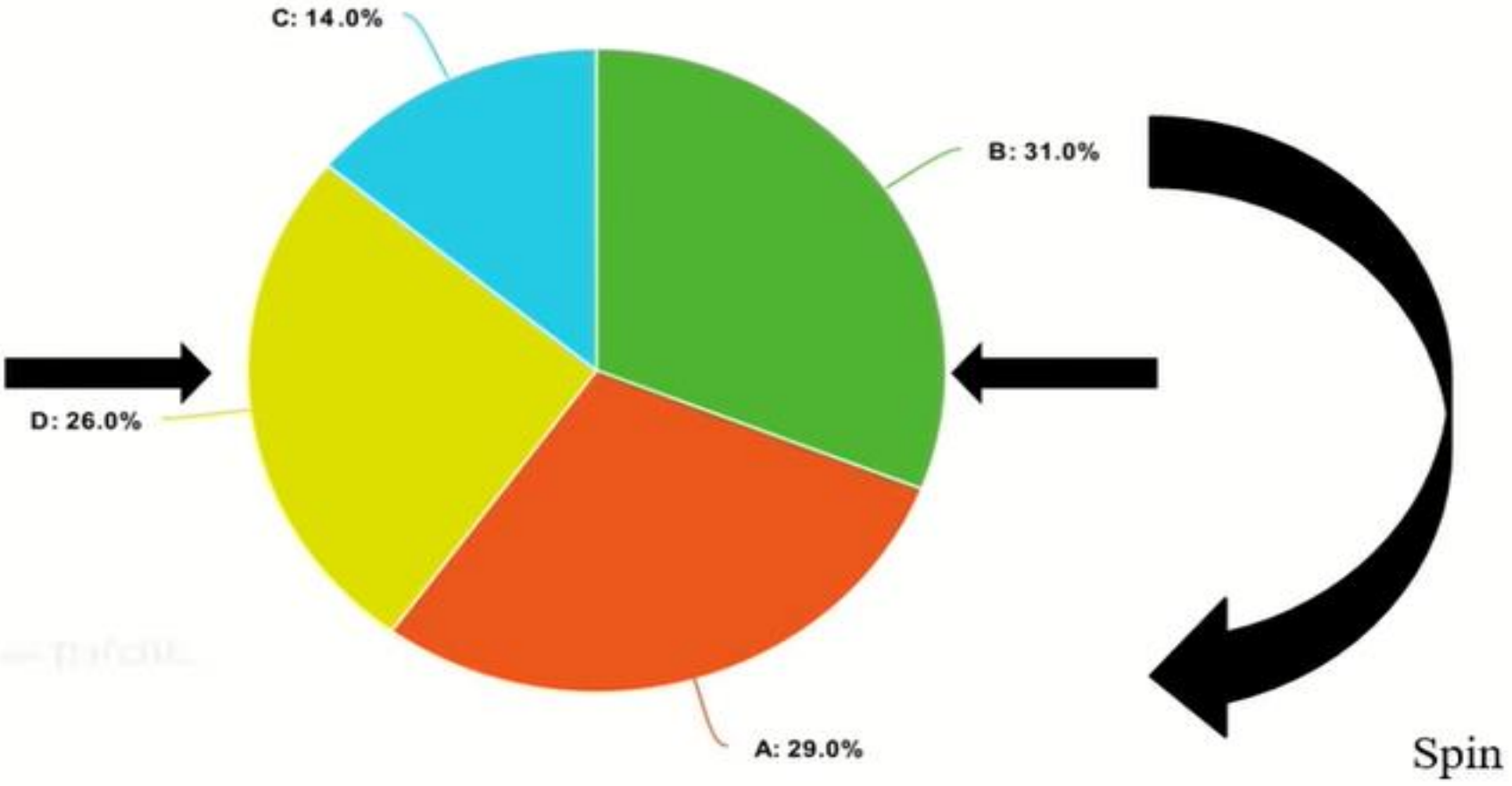
Step 3: Apply Fitness Function (Cont.)

	A	B	C	D
Individuals	 3 2 7 5 2 4 1 1	 2 4 7 4 8 5 5 2	 3 2 5 4 3 2 1 3	 2 4 4 1 5 1 2 4
Fitness	23	24	11	20
Fitness %	29%	31%	14%	26%

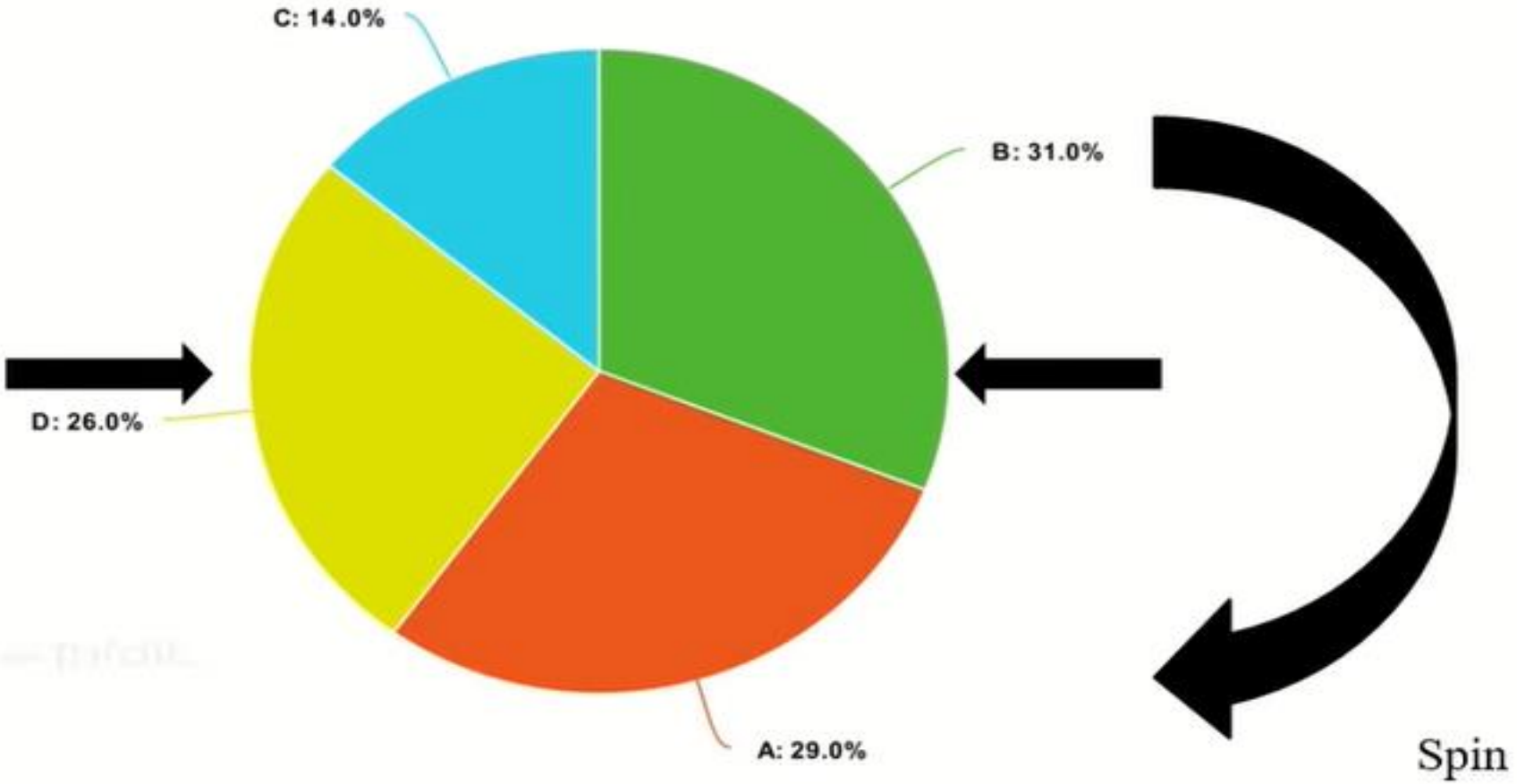
Step 4: Selection

- There are various methods of selection.
- Roulette Wheel, Tournament, Rank, etc.
- Stochastic Universal Sampling (SUS).
- Population is divided on a wheel according to their respective percentages of fitness and two fixed points are placed.
- Wheel is spun and those individuals are selected at which the fixed points are pointing when the wheel stops.

Step 4: Selection (Cont.)

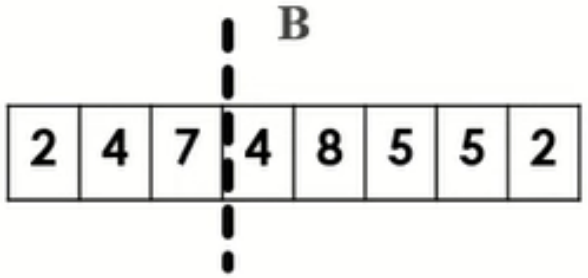


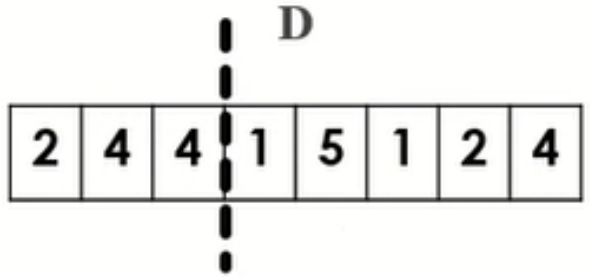
Step 4: Selection (Cont.)



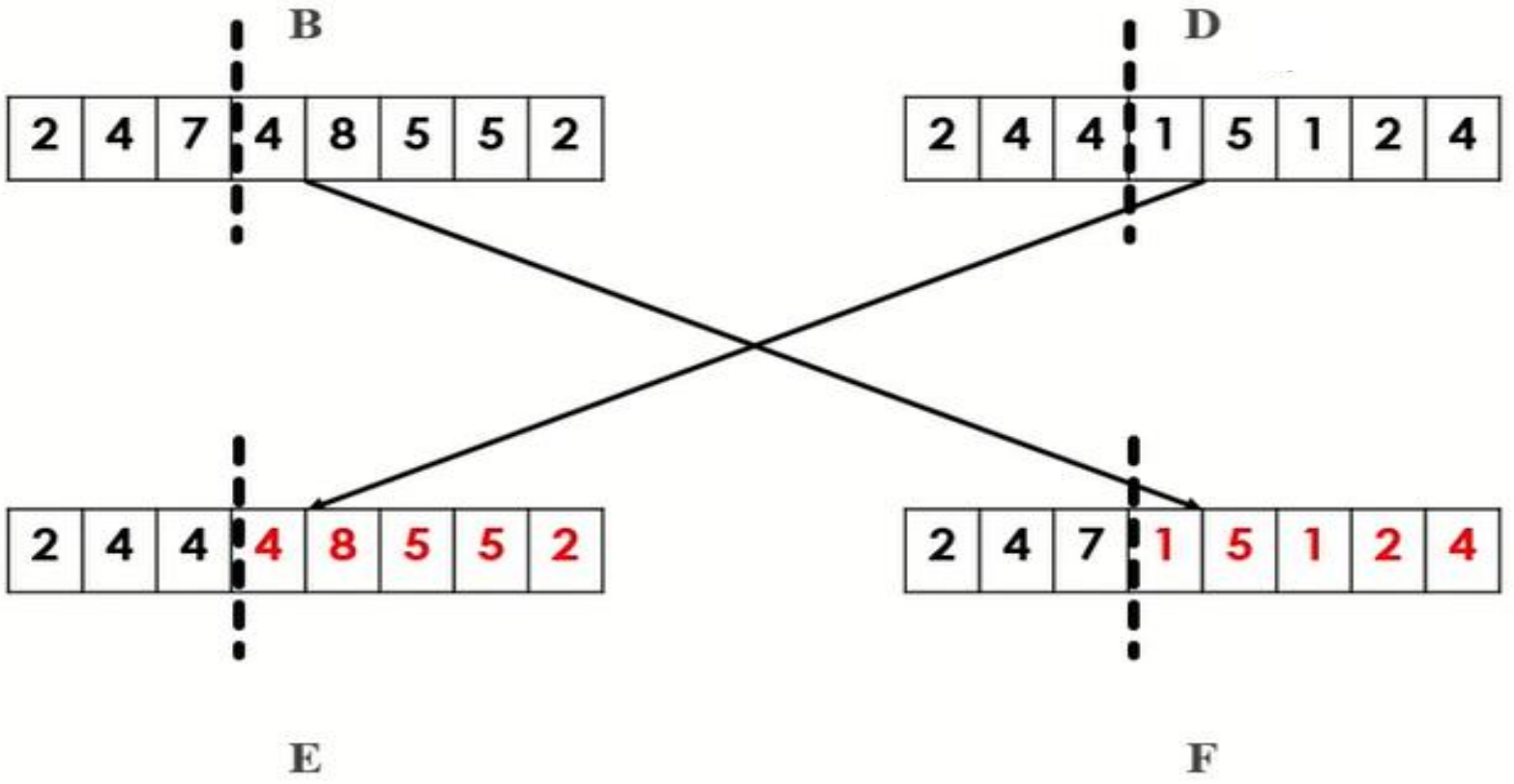
- B and D are selected as parents.

Step 5: Crossover

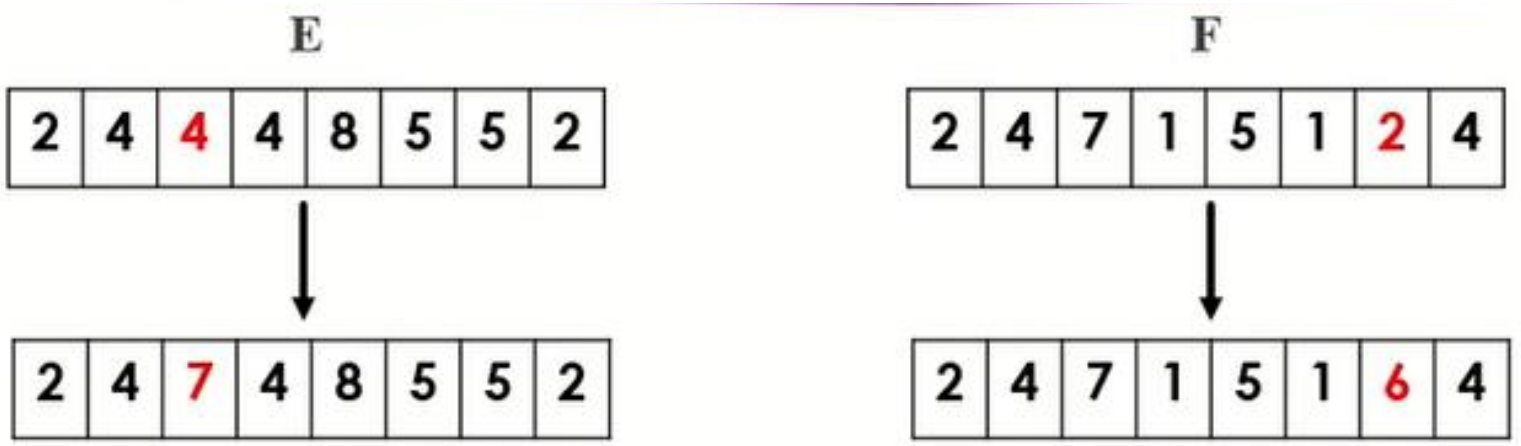




Step 5: Crossover (Cont.)



Step 6: Mutation



Step 6: Mutation (Cont.)

E

2	4	4	4	8	5	5	2

↓

2	4	7	4	8	5	5	2

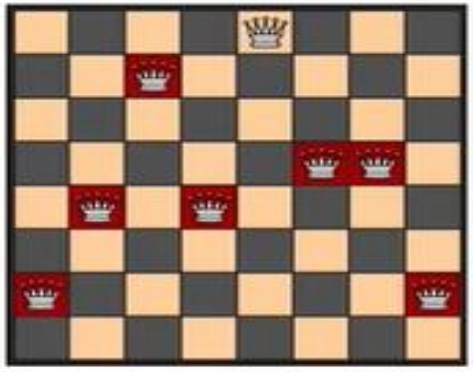
F

2	4	7	1	5	1	2	4

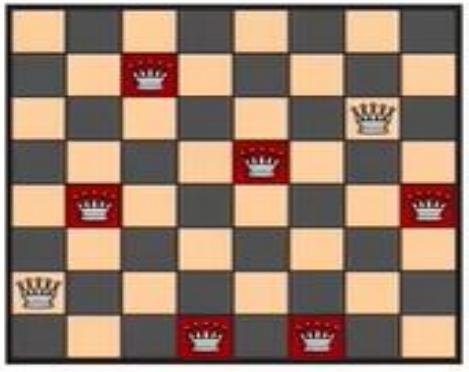
↓

2	4	7	1	5	1	6	4

G



H



Step 7: Repeat

- All steps are repeated until best solution is reached.
- Best solution = Highest fitness score (28 in this case).

Class Task:

A	2	3	4	7	5	1	3	6
B	3	1	5	5	2	8	6	7
C	2	2	3	4	5	6	8	4
D	3	3	1	2	1	4	5	3
E	1	6	7	3	6	4	3	7
F	2	2	1	4	5	7	8	3

Summary

- Method of representation is formulated.
- Random initial population is generated.
- Fitness Function is applied.
- Selection of parents.
- Crossover of parents to produce next generation.
- Mutation to bring diversity.
- All steps are repeated until solution is reached.