Genetic Algorithms

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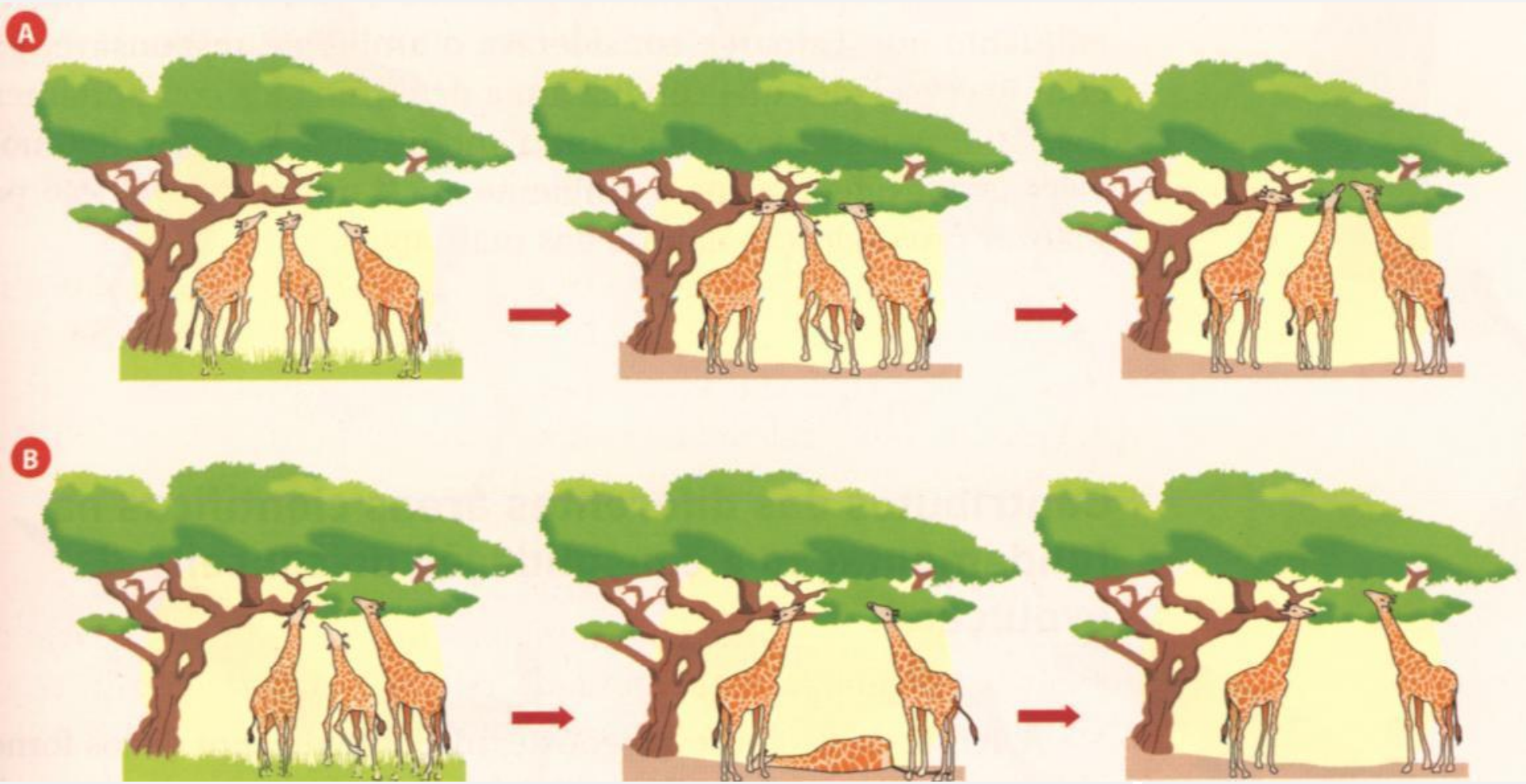
Genetic Algorithms

A unique way to search inspired by Darwinian evolution and “survival of the fittest.”


A
B

Genetic Algorithms

Knowledge Representation:

- States must be represented as strings of equal length which can be arbitrarily subdivided. (i.e. chromosomes)

Search:

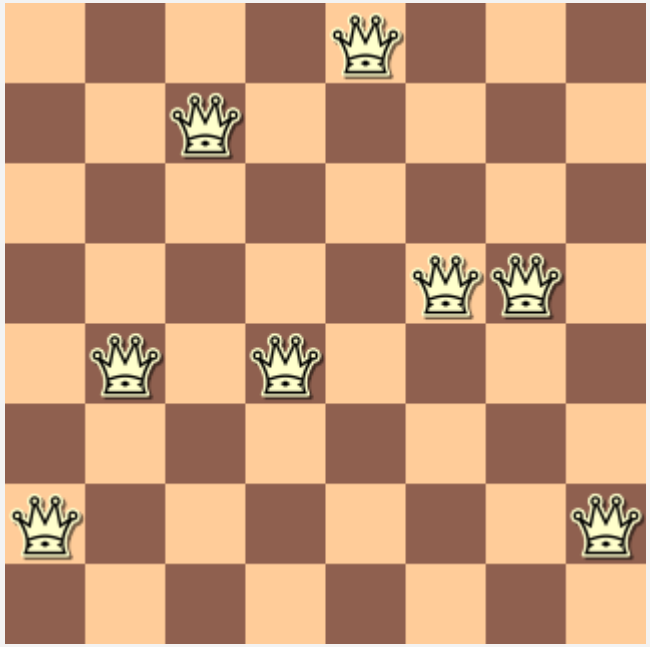
- A **fitness function** is a utility function which describes how good or bad a state is.
- This function decides who survives to mate.

Genetic Algorithm

1. Generate an initial population.
2. Loop:
3. If an individual is a solution, succeed.
4. Weight each individual by fitness.
5. Select (by weight) some pairs to mate.
6. Mate the pairs.
7. Mutate each new individual.
8. Replace the population with offspring.

8 Queens Problem

2 4 7 4 8 5 5 2



Chromosome:

- 8 integers from 1 to 8.

Fitness:

- A solution have 28 non-attacking pairs.
- This individual has 24 non-attacking pairs.
- It's fitness is 24 / 28.

Genetic 8 Queens

Step 1: Generate an initial population.

```
24748552

32752411

24415124

32543213
```

Genetic 8 Queens

Step 2: No individual is a solution, so keep working.

```
24748552

32752411

24415124

32543213
```

Genetic 8 Queens

Step 3: Weight each individual by fitness.

24748552

32752411

24415124

32543213

Genetic 8 Queens

Step 3: Weight each individual by fitness.

`24748552` has 24 non-attacking pairs.

`32752411` has 23 non-attacking pairs

`24415124` has 20 non-attacking pairs

`32543213` has 11 non-attacking pairs

Genetic 8 Queens

Step 3: Weight each individual by fitness.

`24748552` has fitness 24 / 28.

`32752411` has fitness 23 / 28.

`24415124` has fitness 20 / 28.

`32543213` has fitness 11 / 28.

Genetic 8 Queens

Step 3: Weight each individual by fitness.

`24748552` has weight 24 / (24+23+20+11).

`32752411` has weight 23 / (24+23+20+11).

`24415124` has weight 20 / (24+23+20+11).

`32543213` has weight 11 / (24+23+20+11).

Genetic 8 Queens

Step 3: Weight each individual by fitness.

`24748552` has weight 24 / 78.

`32752411` has weight 23 / 78.

`24415124` has weight 20 / 78.

`32543213` has weight 11 / 78.

Genetic 8 Queens

Step 3: Weight each individual by fitness.

`24748552` has weight 31%.

`32752411` has weight 29%.

`24415124` has weight 26%.

`32543213` has weight 14%.

Genetic 8 Queens

Step 3: Weight each individual by fitness.

`24748552` has a 31% chance of getting picked to mate.

`32752411` has a 29% chance of getting picked to mate.

`24415124` has a 26% chance of getting picked to mate.

`32543213` has a 14% chance of getting picked to mate.

Genetic 8 Queens

Step 4: Select some pairs to mate based on their weights.

`24748552` has a 31% chance of getting picked to mate.

`32752411` has a 29% chance of getting picked to mate.

`24415124` has a 26% chance of getting picked to mate.

`32543213` has a 14% chance of getting picked to mate.

Genetic 8 Queens

Step 4: Select some pairs to mate based on their weights.

24748552

32752411

24415124

32543213

The first roll of the (weighted) dice chose this pair.

Genetic 8 Queens

Step 4: Select some pairs to mate based on their weights.

```
24748552

32752411

24415124

32543213
```

The second roll of the (weighted) dice chose this pair.

Genetic 8 Queens

Step 4: Select some pairs to mate based on their weights.

```
24748552

32752411

24415124

32543213
```


This one was not chosen for any pairs, so it will die off.

Genetic 8 Queens

Step 5: Mate the chosen pairs.

24748552

32752411

24415124

32543213

Genetic 8 Queens

Step 5: Mate the chosen pairs.

24748552

32752411

32748552

24752411

24415124

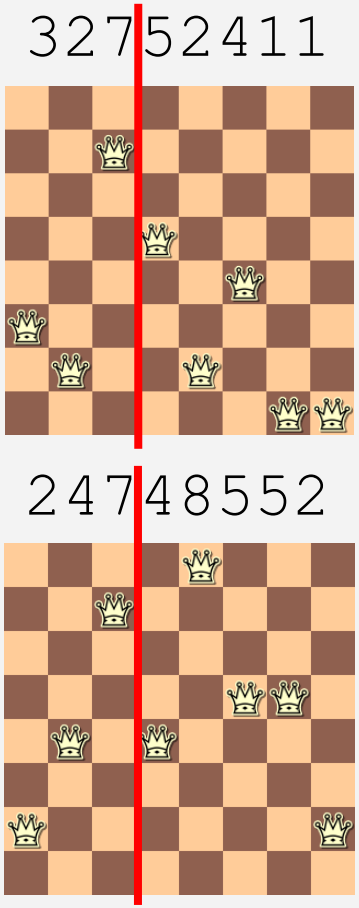
32543213

Genetic 8 Queens

Step 5: Mate the chosen pairs.

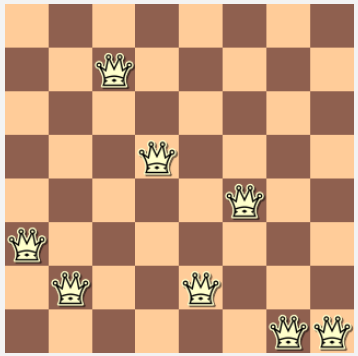
```
24748552          32748552

32752411          24752411

24415124          32752124

32543213          24415411
```

Crossover (Mating)

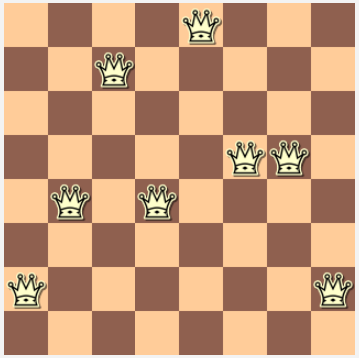


Crossover (Mating)

32752411

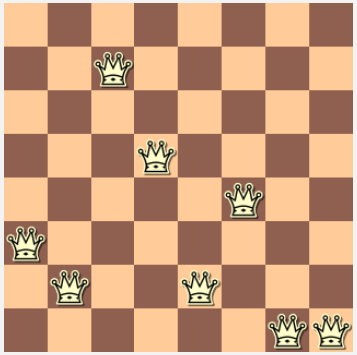


24748552

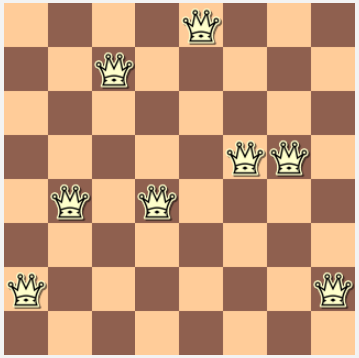


Crossover (Mating)

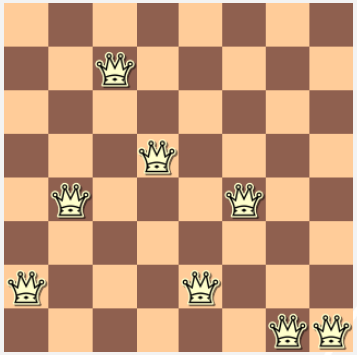
32752411



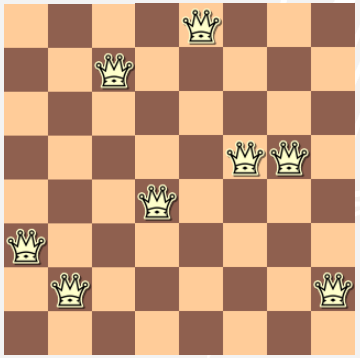
24748552



24752411



32748552



Genetic 8 Queens

Step 6: Randomly mutate each new individual.

24748552	32748552
32752411	24752411
24415124	32752124
32543213	24415411

Each gene has a 10% chance of changing (i.e. being replaced by a different, random number from 1 to 8).

Genetic 8 Queens

Step 6: Randomly mutate each new individual.

24748552	32748552
32752411	24752411
24415124	32752124
32543213	24415411

Each gene has a 10% chance of changing (i.e. being replaced by a different, random number from 1 to 8).

Genetic 8 Queens

Step 6: Randomly mutate each new individual.

24748552	32748152
32752411	24752411
24415124	32252124
32543213	24415417

Each gene has a 10% chance of changing (i.e. being replaced by a different, random number from 1 to 8).

Genetic 8 Queens

Step 7: Replace the population with its offspring.

24748552	32748152
32752411	24752411
24415124	32252124
32543213	24415417

Genetic 8 Queens

Step 7: Replace the population with its offspring.

24748552	32748152
32752411	24752411
24415124	32252124
32543213	24415417

Genetic 8 Queens

Step 7: Replace the population with its offspring.

```
32748152

24752411

32252124

24415417
```

Genetic 8 Queens

Step 2: No individual is a solution, so keep working.

```
32748152

24752411

32252124

24415417
```

Genetic Algorithms

- As with all problems, how you represent the chromosomes and what fitness function you choose has a huge effect on the results.
- Good for optimization problems, such as finding circuit layouts (i.e. placing all the parts of an integrated circuit on a microchip such that they take up minimal space, use minimal power, etc.)