
An orange scroll graphic with a blue outline and decorative scroll ends on the left and right sides.

Genetic Algorithm Search

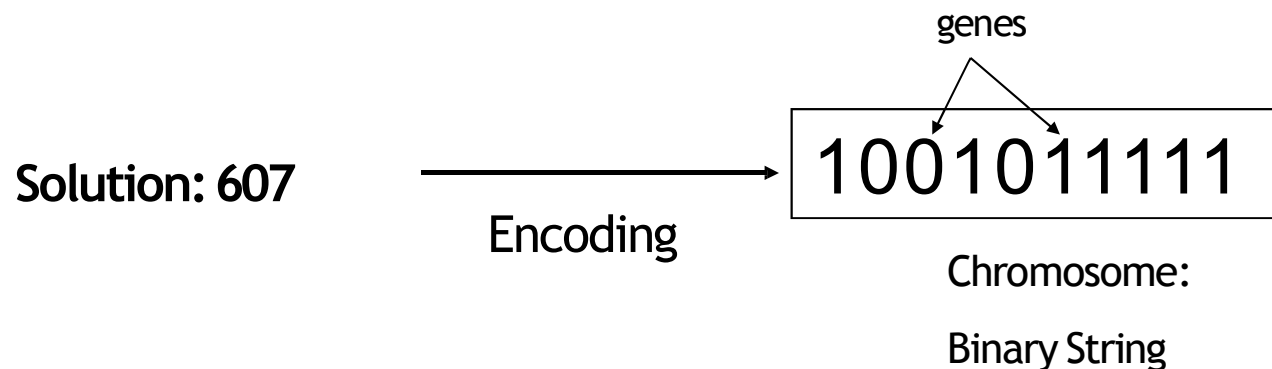
Genetic Algorithms

- Formally introduced in the US in the 70s by John Holland.
- GAs emulate **ideas** from genetics and natural selection and can search potentially large spaces.
- Before we can apply Genetic Algorithm to a problem, we need to answer:
 - How is an individual represented?
 - What is the fitness function?
 - How are individuals selected?
 - How do individuals reproduce?

Genetic Algorithms:

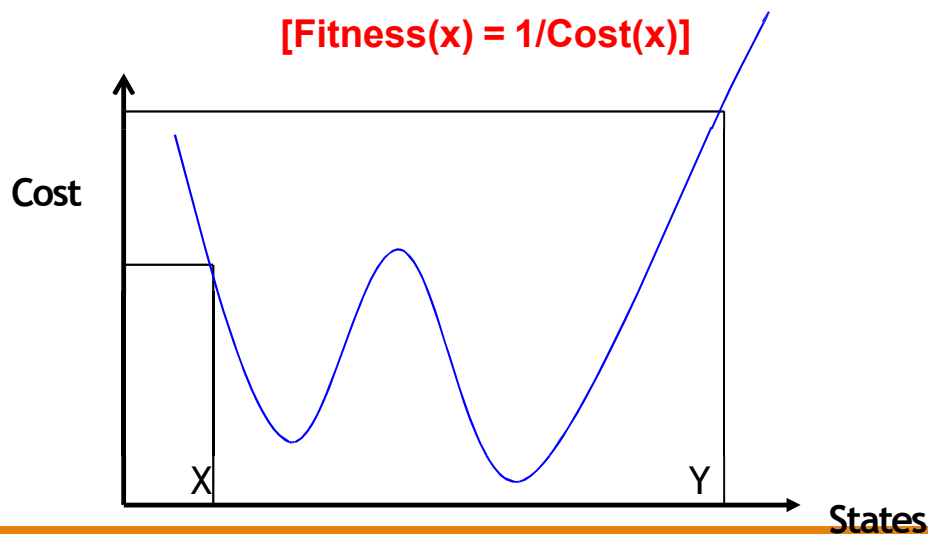
Representation of states (solutions)

- Each state or individual is represented as a string over a finite alphabet. It is also called **chromosome** which Contains **genes**.

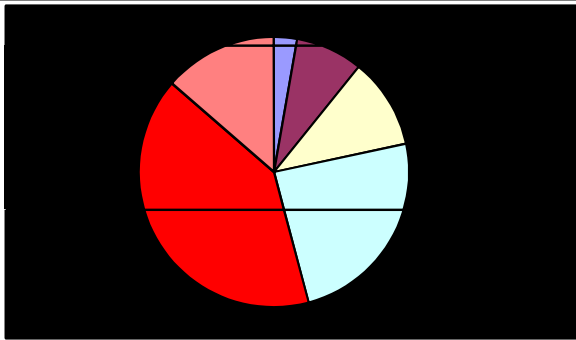


Genetic Algorithms: Fitness Function

- Each state is rated by the evaluation function called **fitness function**. Fitness function should return higher values for better states: **$\text{Fitness}(X)$ should be greater than $\text{Fitness}(Y)$!!**



GA Parent Selection - RouletteWhee



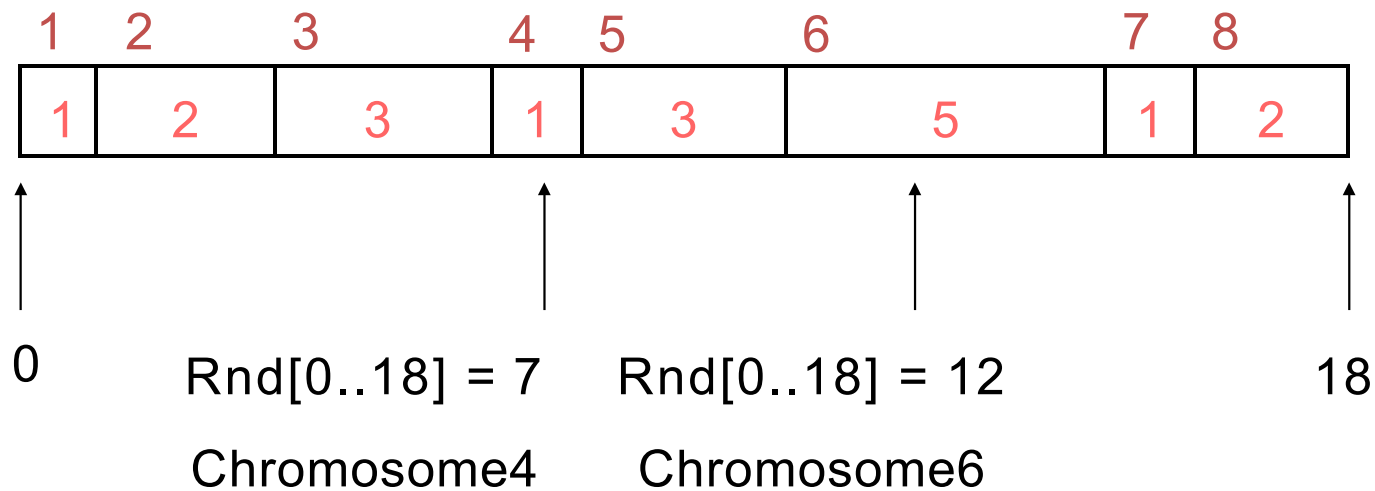
Roulette Wheel Selection

- Sum the fitnesses of all the population members, TF
- Generate a random number. m . between 0 and TF
- Return the **first population member** whose fitness added to the preceding population members is greater than or equal to m

Genetic Algorithms: Selection

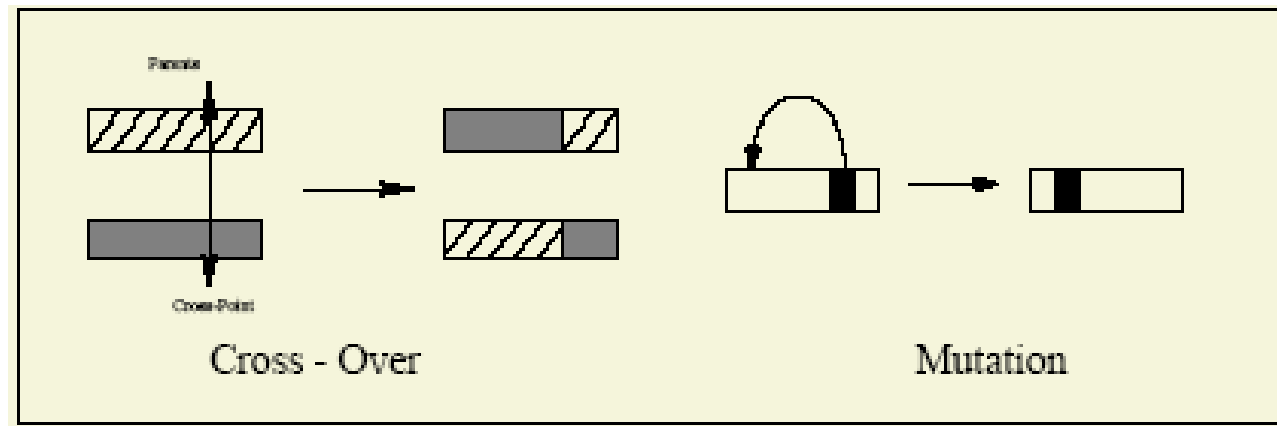
How are individuals selected?

Roulette Wheel Selection



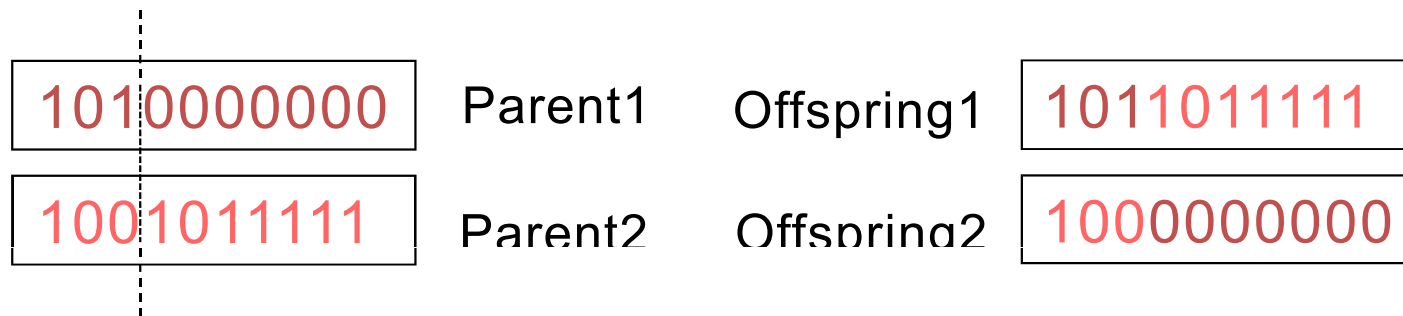
Genetic Algorithms: Cross-Over and Mutation

How do individuals reproduce ?



Genetic Algorithms

Crossover - Recombination

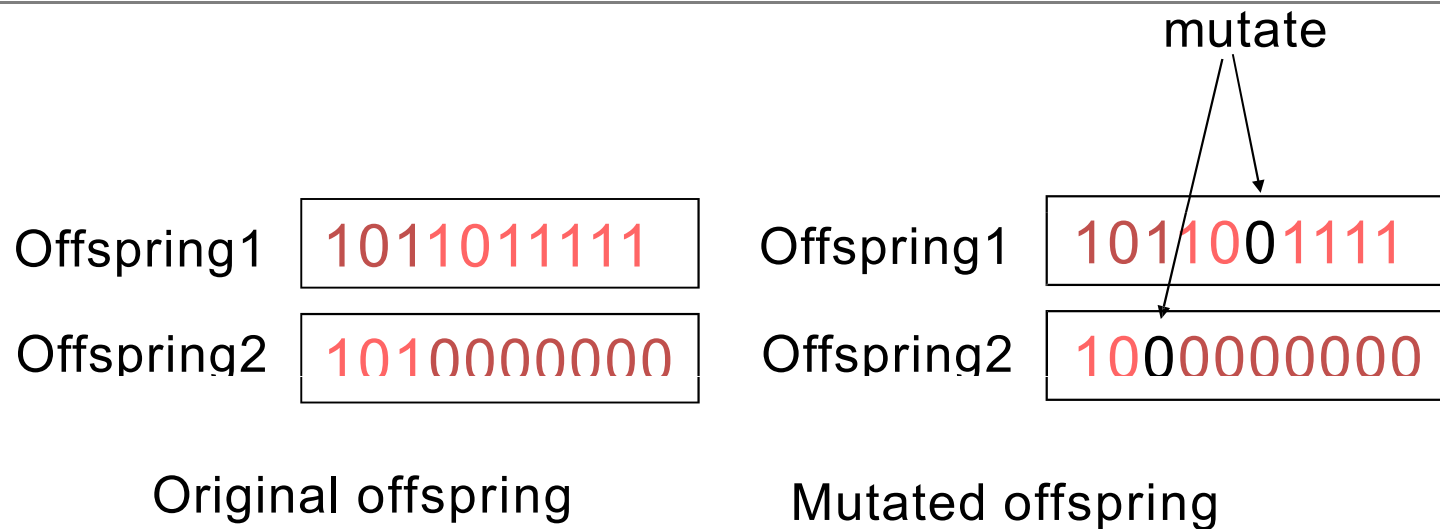


Crossover
single point
- random

With some high probability
(*crossover rate*) apply crossover to
the parents. (*typical values are 0.8 to 0.95*)

Stochastic Search: Genetic Algorithms

Mutation



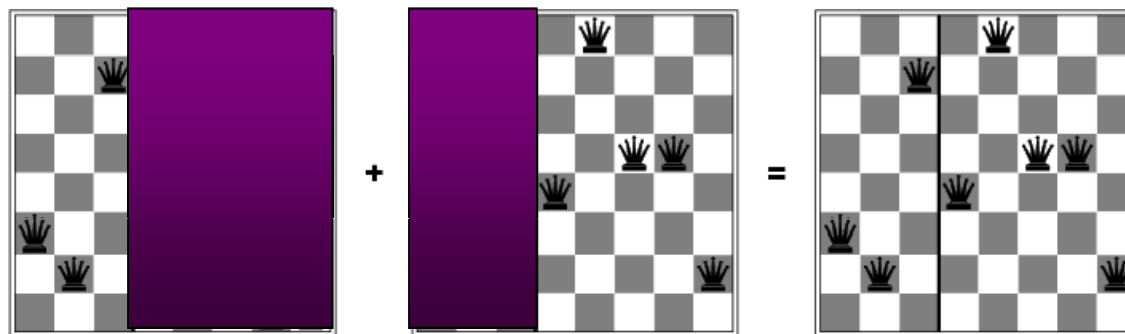
With some small probability (the *mutation rate*) flip each bit in the offspring (*typical values between 0.1 and 0.001*)

Genetic Algorithms

Algorithm:

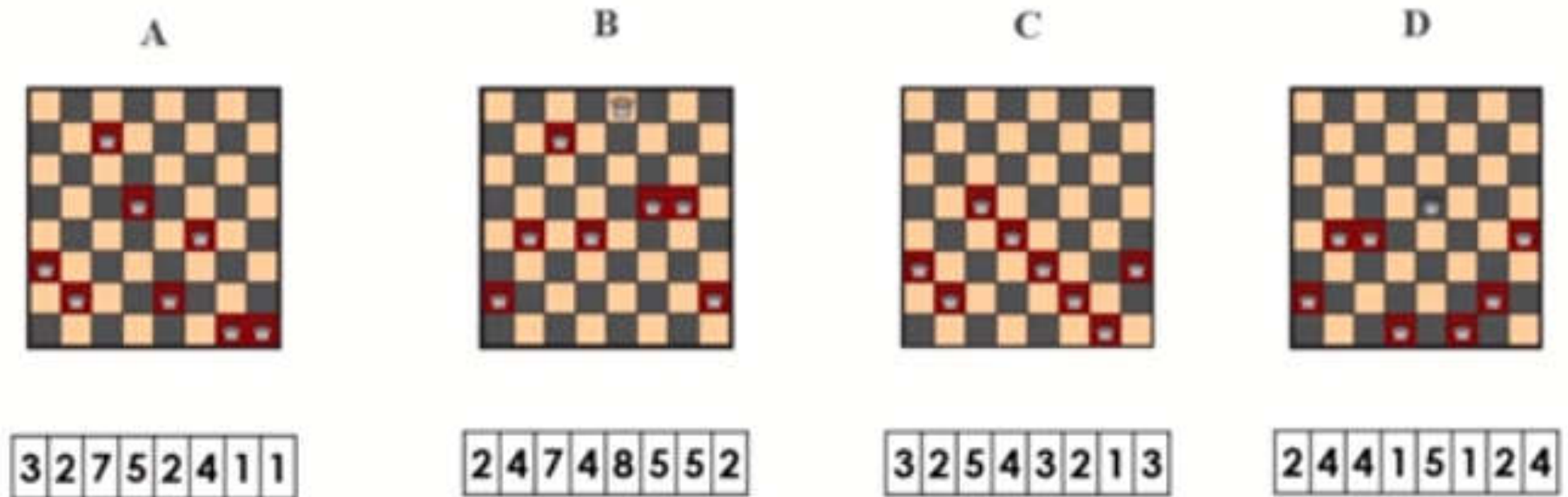
1. Initialize population with p Individuals at random
2. For each Individual h compute its fitness
3. While $\text{max fitness} < \text{threshold}$
do Create a new generation P_s
4. Return the Individual with highest fitness

Genetic algorithms

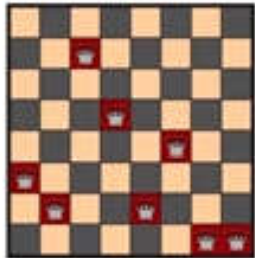
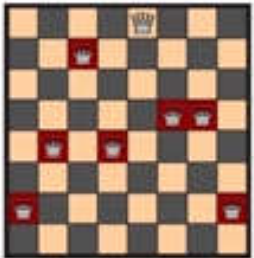
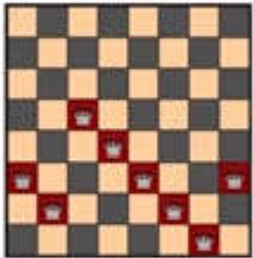
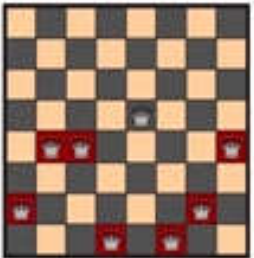


Has the effect of “jumping” to a completely different new part of the search space (quite non-local)

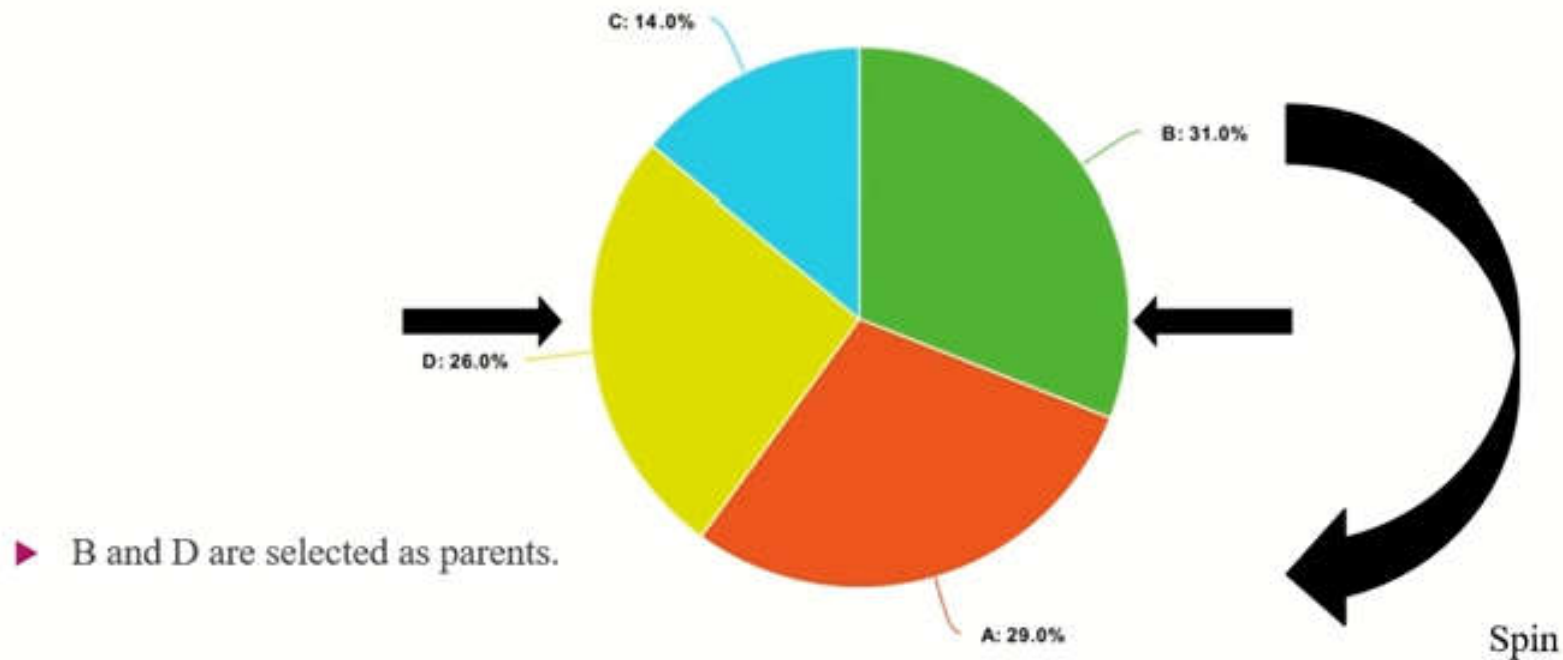
Genetic algorithms



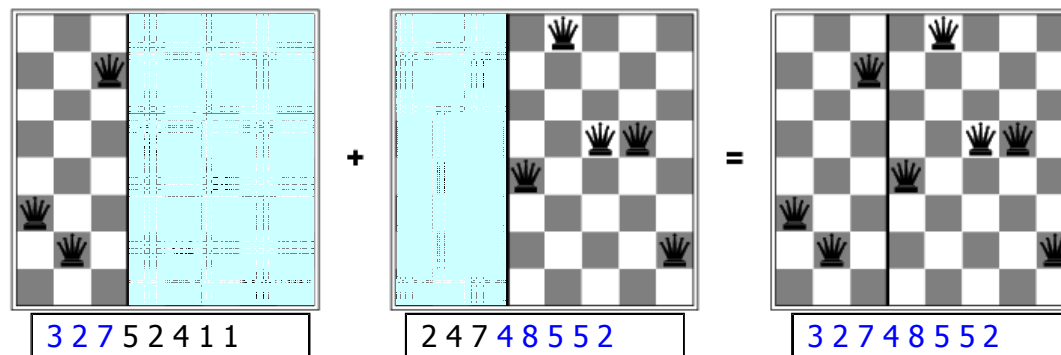
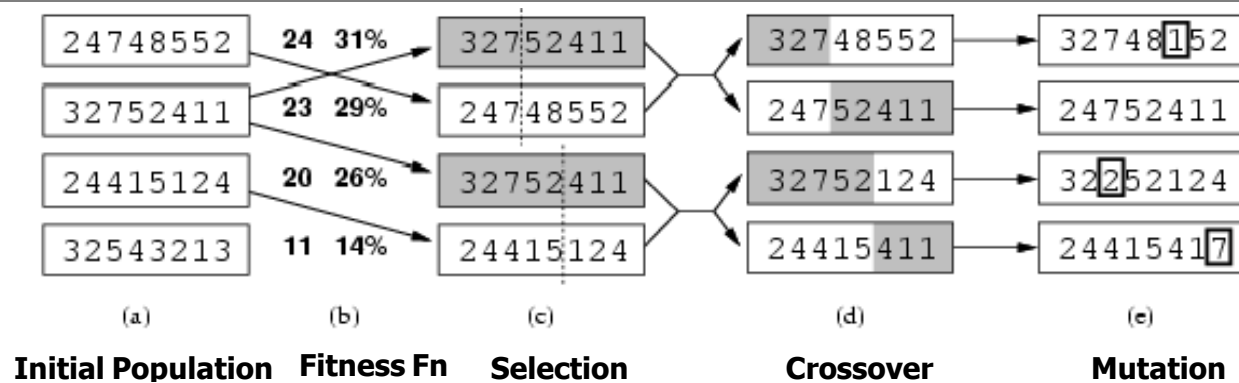
Genetic algorithms – Fitness Calculation

	A	B	C	D																																
► Individuals																																				
	<table><tr><td>3</td><td>2</td><td>7</td><td>5</td><td>2</td><td>4</td><td>1</td><td>1</td></tr></table>	3	2	7	5	2	4	1	1	<table><tr><td>2</td><td>4</td><td>7</td><td>4</td><td>8</td><td>5</td><td>5</td><td>2</td></tr></table>	2	4	7	4	8	5	5	2	<table><tr><td>3</td><td>2</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>3</td></tr></table>	3	2	5	4	3	2	1	3	<table><tr><td>2</td><td>4</td><td>4</td><td>1</td><td>5</td><td>1</td><td>2</td><td>4</td></tr></table>	2	4	4	1	5	1	2	4
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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%																																

Genetic algorithms – Parent Selection (Stochastic Universal Sampling)

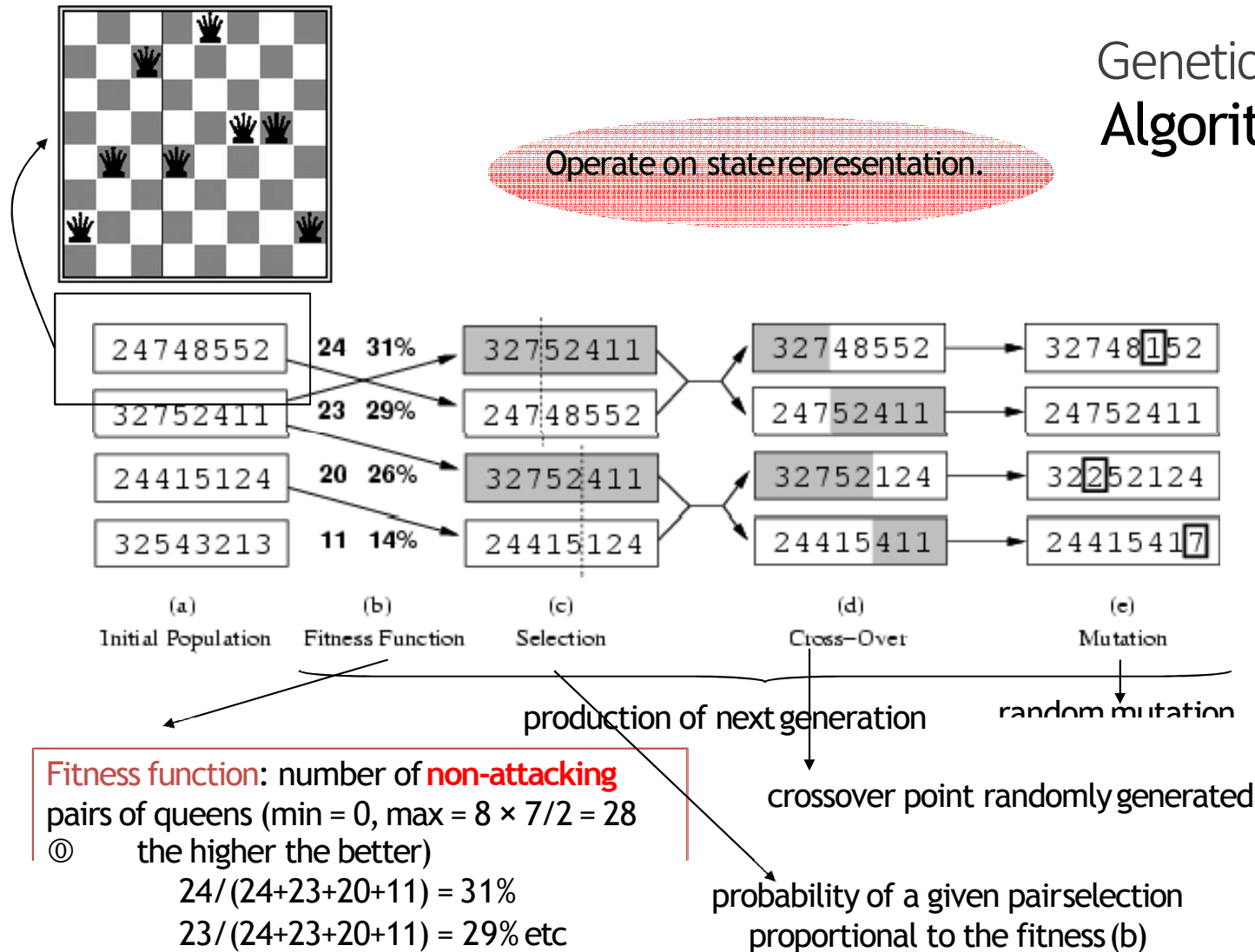


Genetic Algorithm (cont.)



Genetic Algorithm

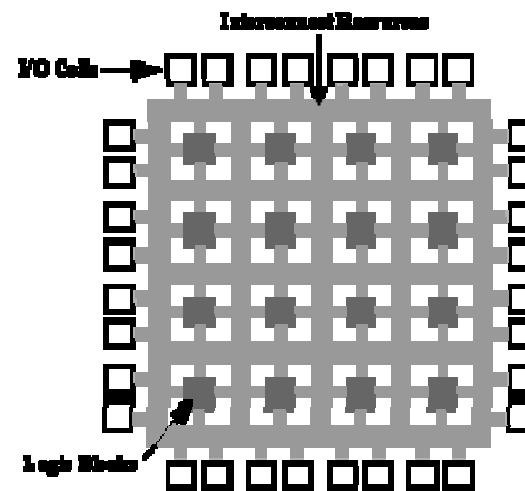
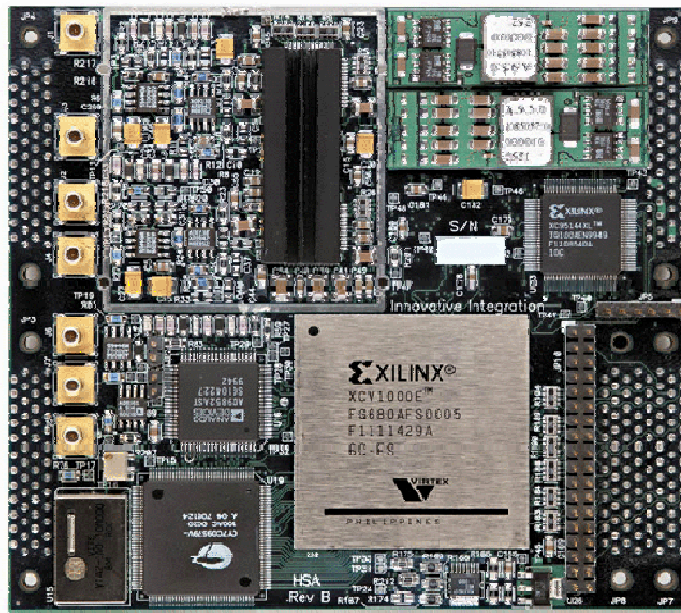
Operate on state representation.



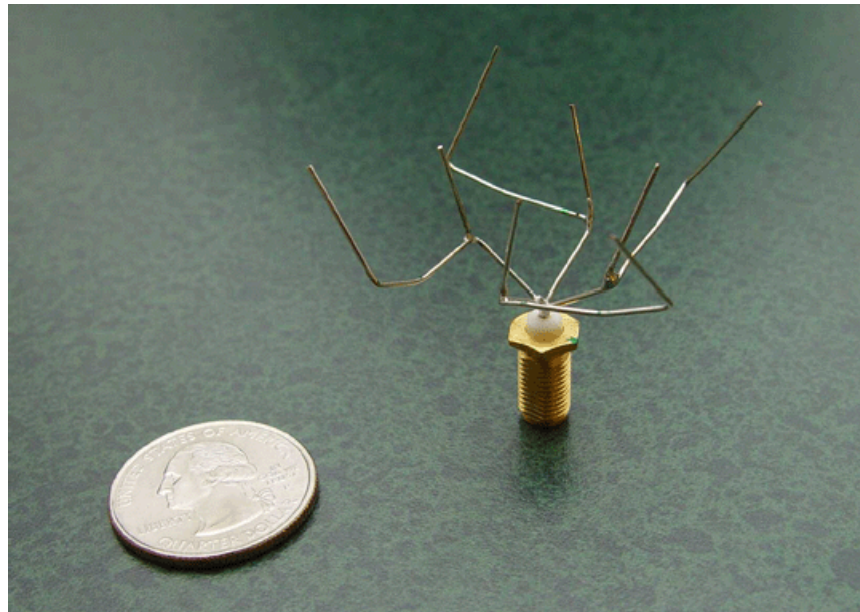
GA is a good *no clue* approach to problem solving

- GA is superb if:
 - Your space is loaded with lots of weird bumps and local minima.
 - GA tends to spread out and test a larger subset of your space than many other types of learning/optimization algorithms.
 - You don't quite understand the underlying *process* of your problem space.
 - You have lots of processors
 - GA's parallelize very easily!

Evolvable Circuits



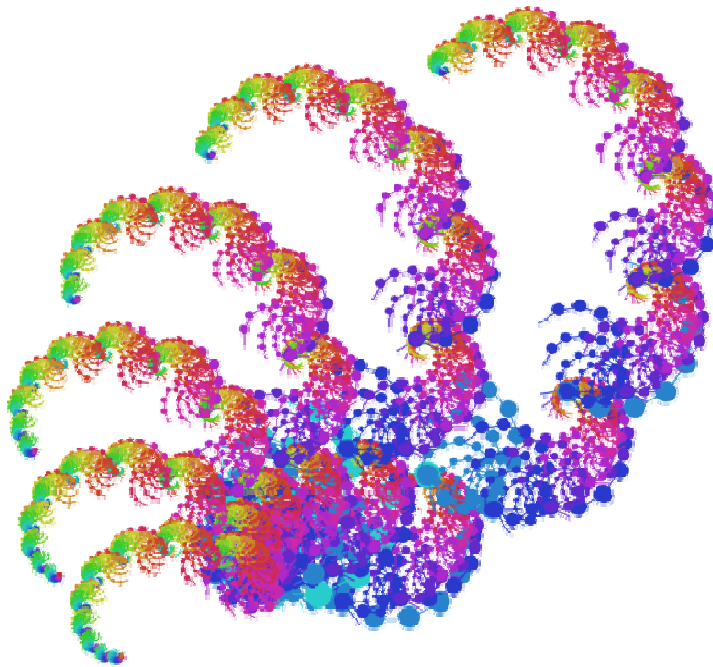
Antenna for NASA



Car Design

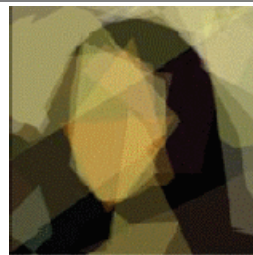


Evolutionary Arts

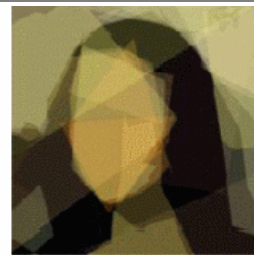


What is the major challenge?

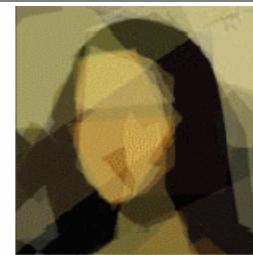
Evolving Mona Lisa



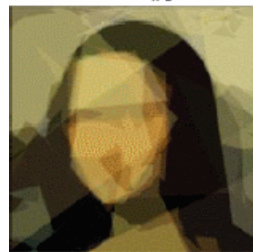
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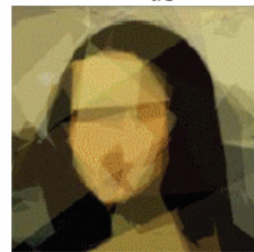
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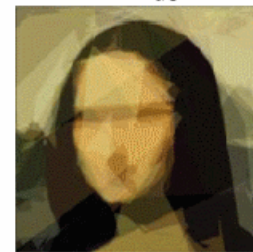
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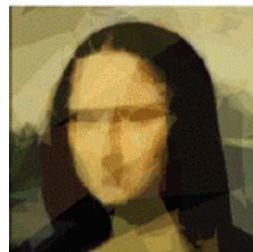
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