Artificial Intelligence 2, Lecture 2, 20101111

Basics of evolutionary algorithms

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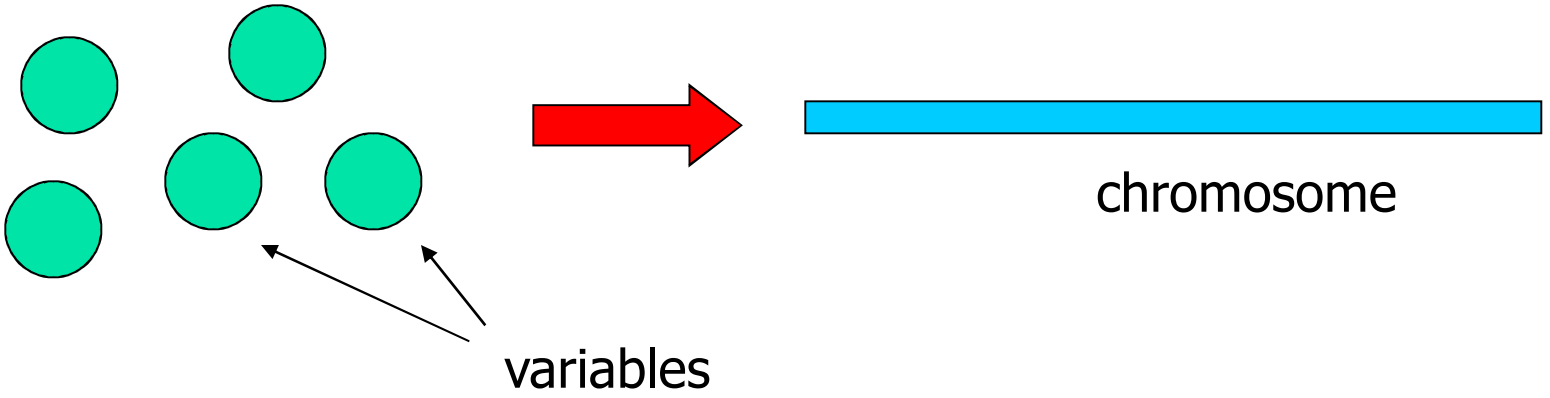
Encoding: the variables of the problem are encoded in strings of digits known as *chromosomes*.



The exact encoding procedure varies from problem to problem – in the simple case of optimization of a function $f(x_1,x_2,x_3,...x_n)$ the variables x_i, $i = 1,...,n$ should be encoded. In more complex problems (e.g. optimization of artificial brains for robots or optimization of neural networks), the specification of the encoding procedure can be much more complicated.

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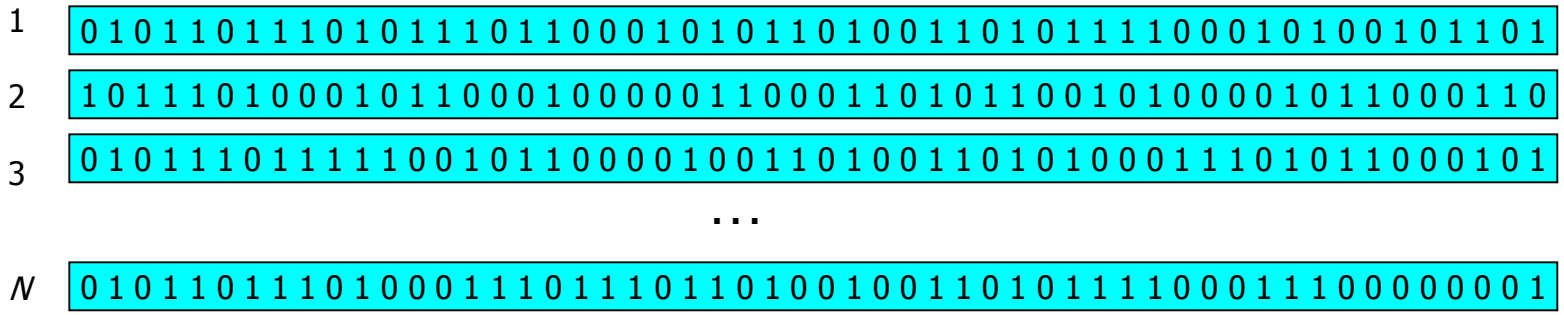
Random initialization of a population containing *N* chromosomes



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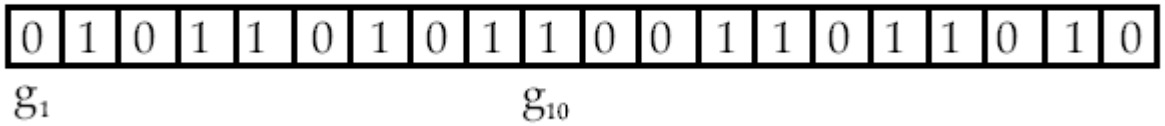

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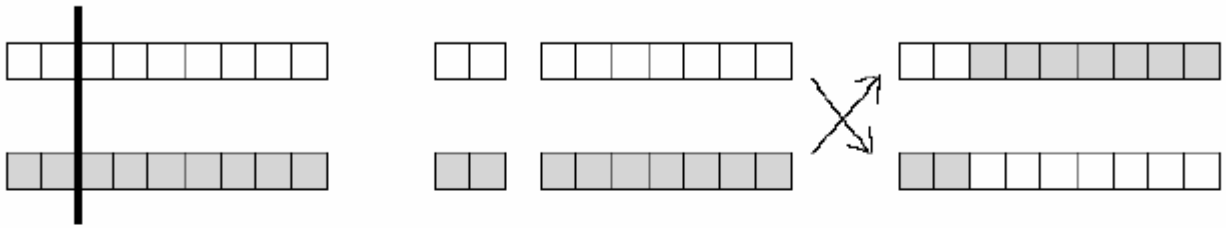
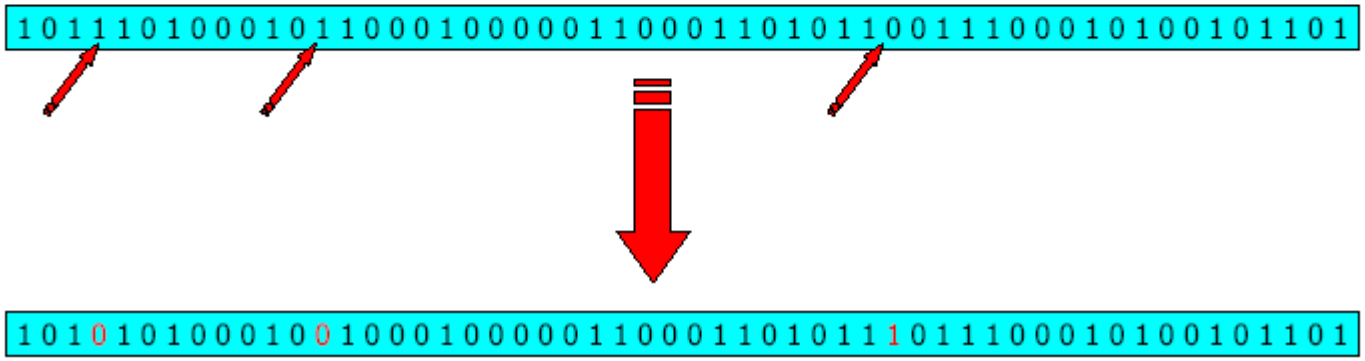
Crossover



Mutation



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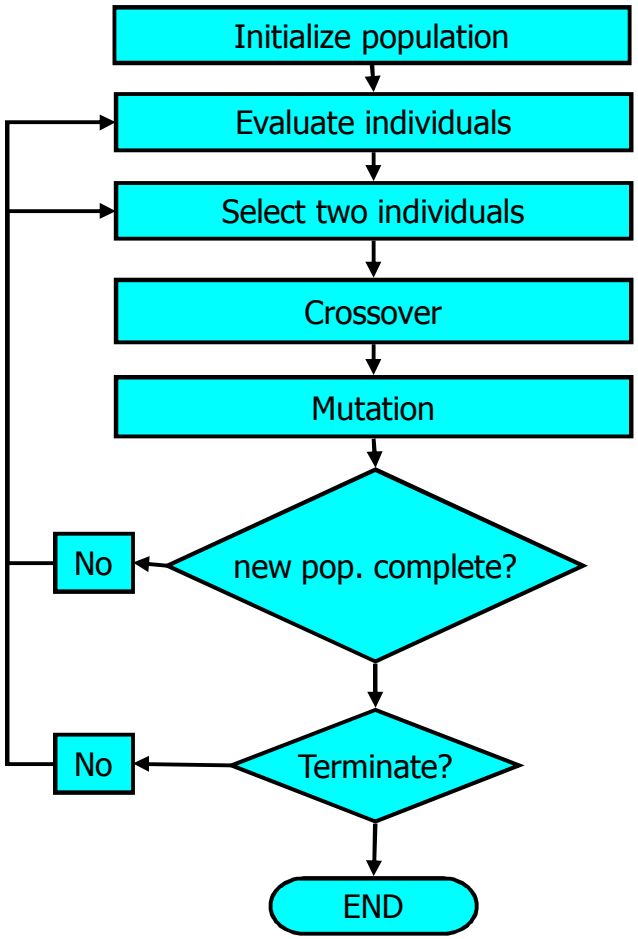

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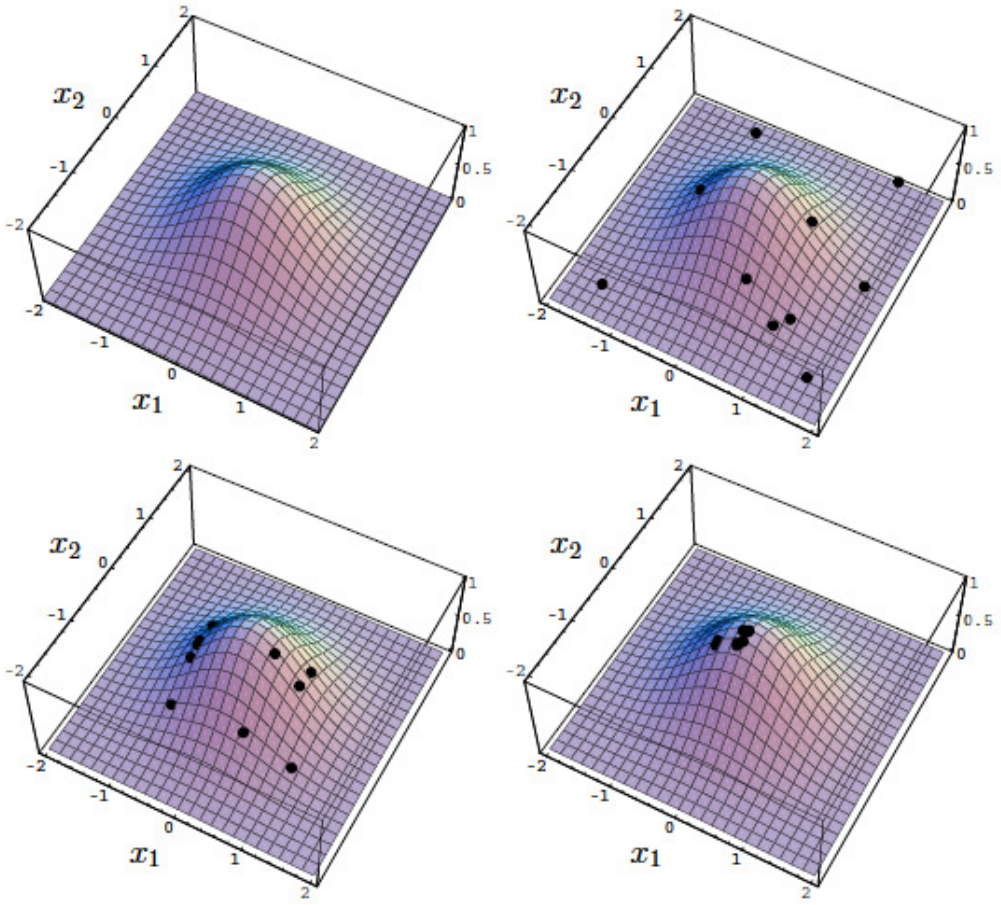

Figure 3.7: *The progress of a GA searching for the maximum of the function* $f(x_1, x_2) = e^{-x_1^2 - x_2^2}$. *The upper right panel shows the initial population, whereas the lower left and lower right panels show the population after two and 25 generations, respectively.*

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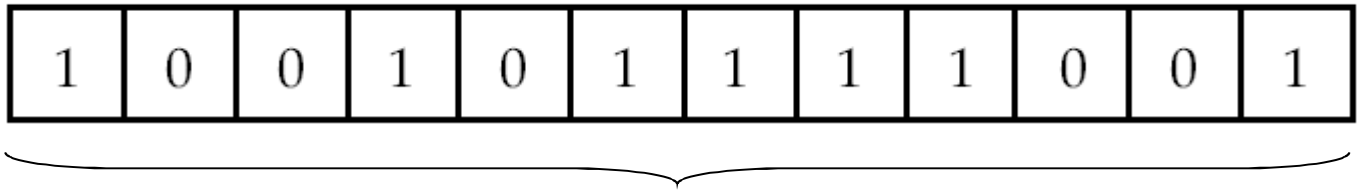
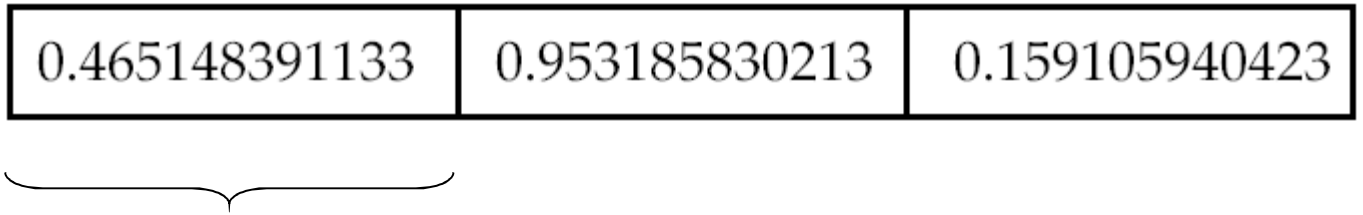


$$x = -d + \frac{2d}{1 - 2^{-k}}(2^{-1}g_1 + \cdots + 2^{-k}g_k),$$



$$x = -d + 2dg,$$

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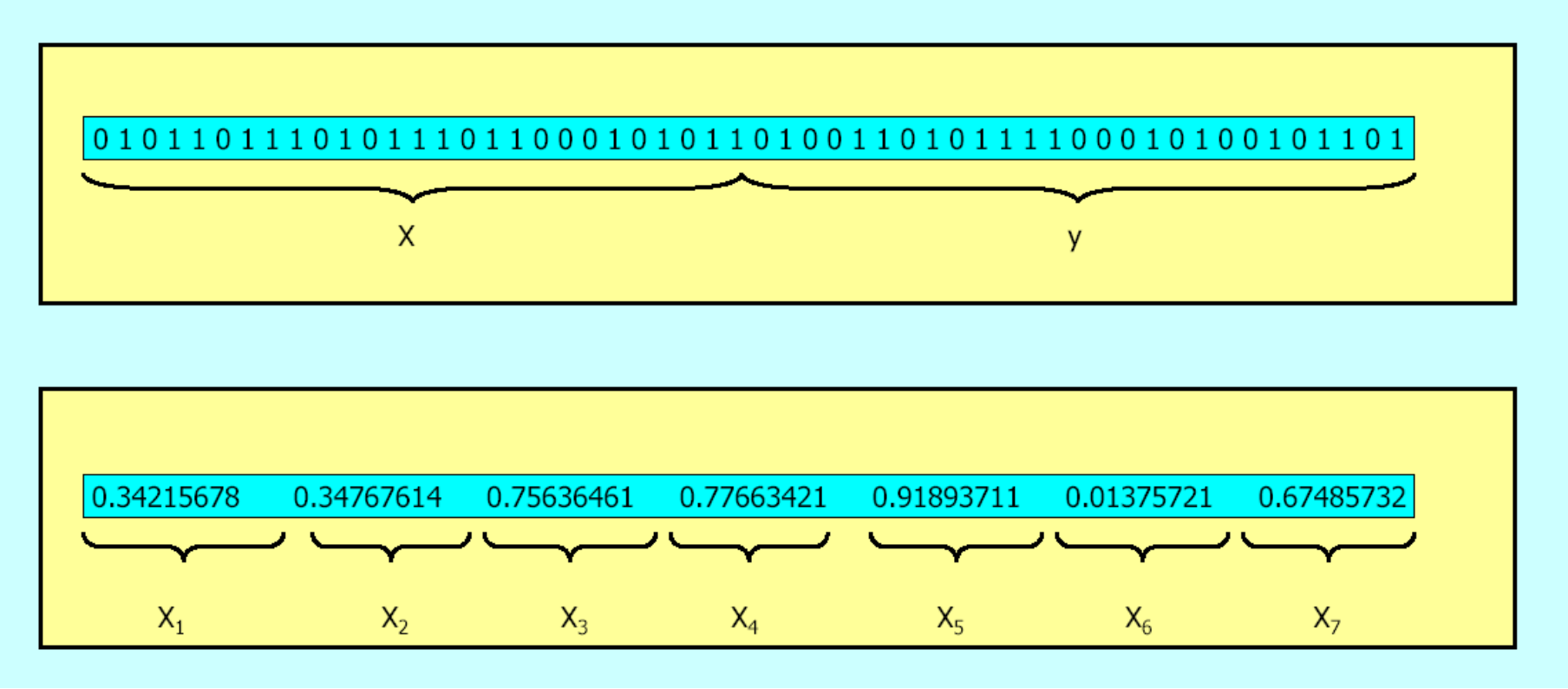

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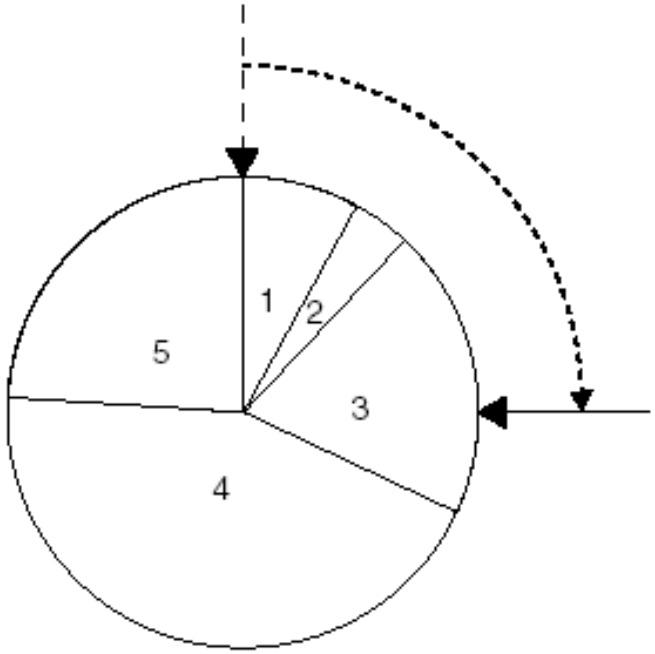

Figure 3.8: *Roulette-wheel selection in a population consisting of five individuals, described in detail in Example 3.3.*

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Roulette wheel selection

Example 3.3 (p. 49)

- Individual 1: F_1 = 2.0
- Individual 2: F_1 = 1.0
- Individual 3: F_1 = 5.0
- Individual 4: F_1 = 11.0, etc.
- Individual 5: F_1 = 6.0

$$\sum_{i=1}^{5} F_i = 25$$

2/25

$$\phi_1 = 0.08,$$

$$\phi_2 = 0.08 + 0.04 = 0.12$$

$$\phi_3 = 0.32,$$

(0.12 + 0.20)

- Example: r = 0.25 => j = 3 etc.

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(1, 1)	(1, 2)	(1, 3)	(1, 4)	(1, 5)
(2, 1)	(2, 2)	(2, 3)	(2, 4)	(2, 5)
(3, 1)	(3, 2)	(3, 3)	(3, 4)	(3, 5)
(4, 1)	(4, 2)	(4, 3)	(4, 4)	(4, 5)
(5, 1)	(5, 2)	(5, 3)	(5, 4)	(5, 5)

Figure 3.9: *Tournament selection, with tournament size equal to two, in a population consisting of five individuals, described in detail in Example 3.4.*

$$p_1 = \frac{1}{25}(1 + 2p_{\text{tour}} + 6(1 - p_{\text{tour}})) = \frac{1}{25}(7 - 4p_{\text{tour}}) = 0.152.$$

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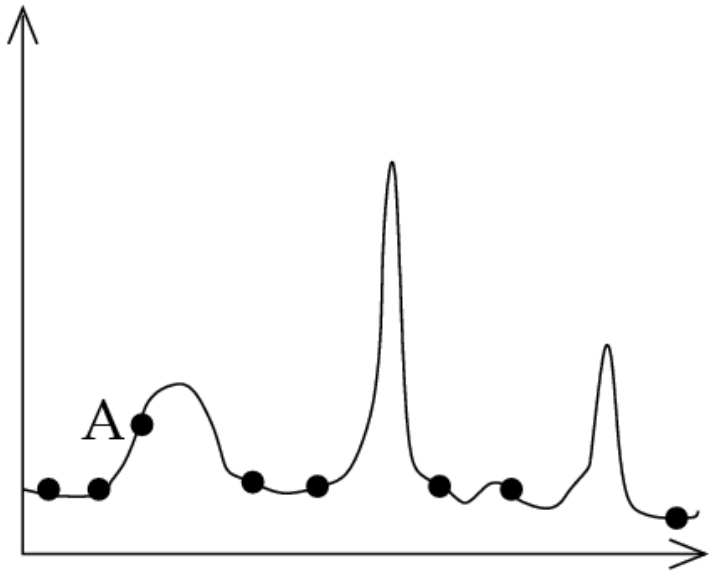
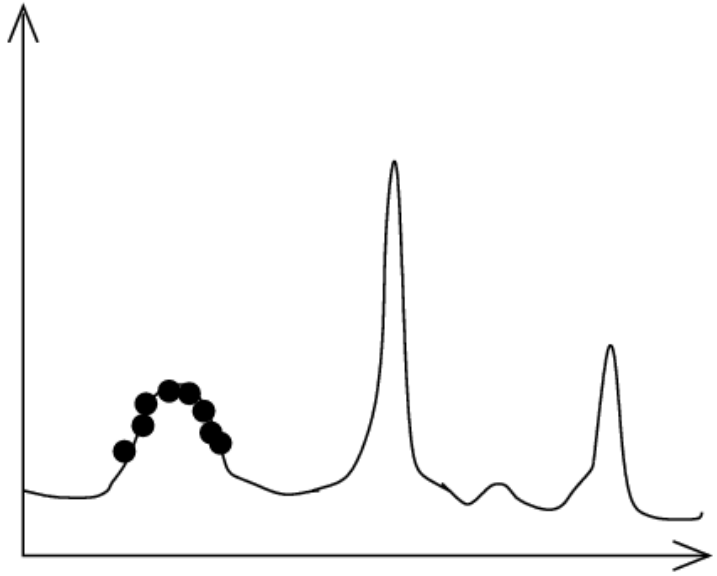
Premature convergence:





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Fitness ranking:

$$f(i) = (N + 1 - R(i)).$$

$$f(i) = f_{\max} - (f_{\max} - f_{\min}) \left(\frac{R(i) - 1}{N - 1} \right).$$

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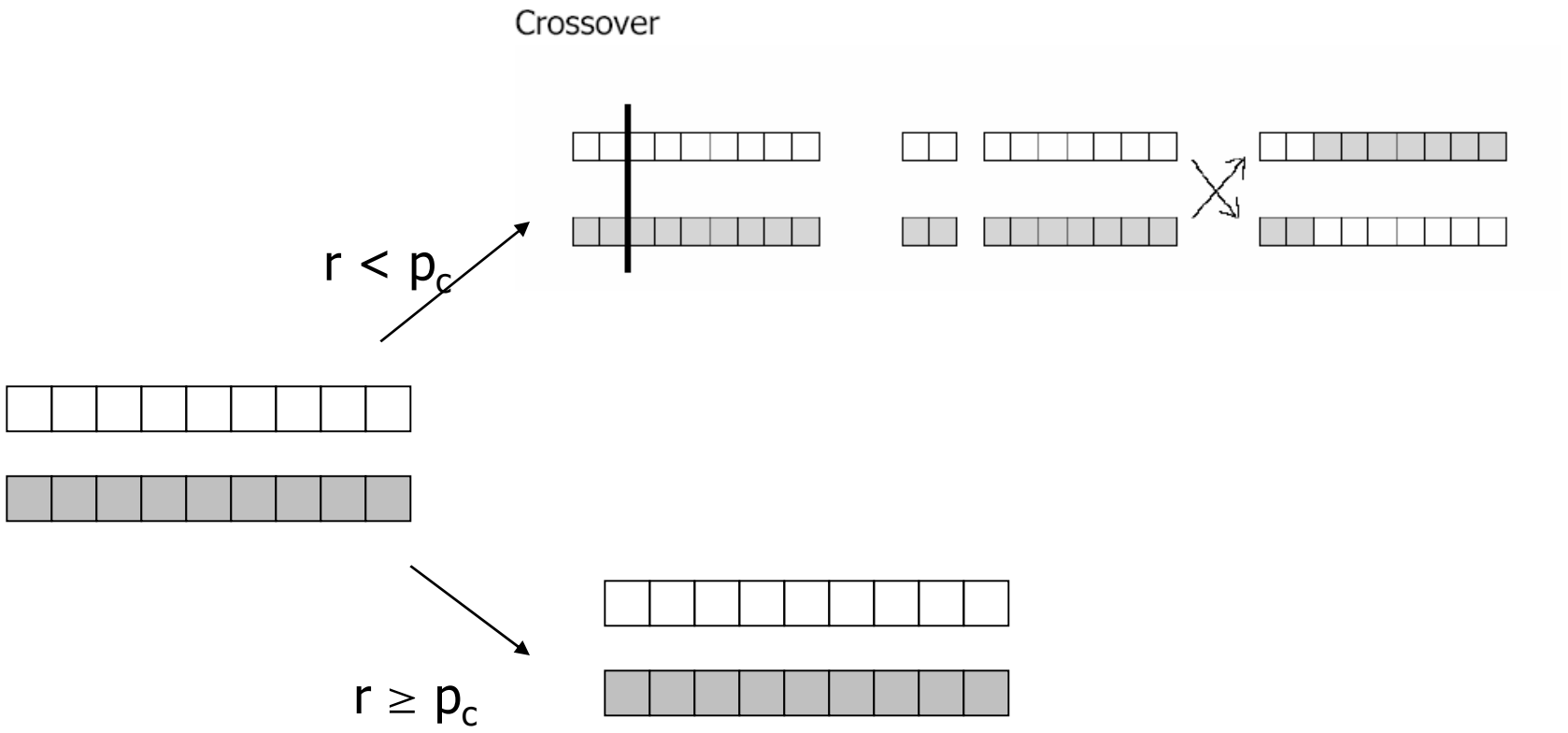

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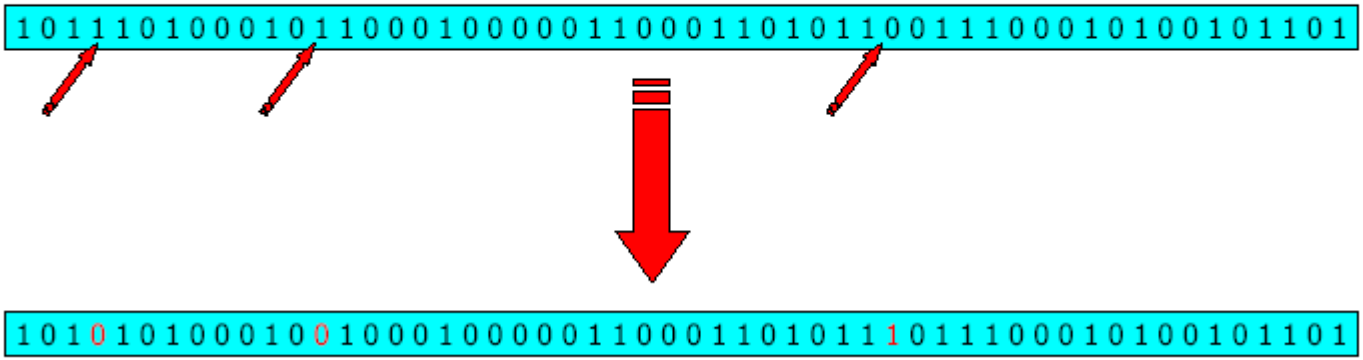
Mutation



Note: EVERY gene is checked. If, for a given gene, $r < p_{mut}$, the gene mutates ($r \in [0,1]$).

Typical value for pmut: ~1/m, where m is the number of genes in the chromosome.

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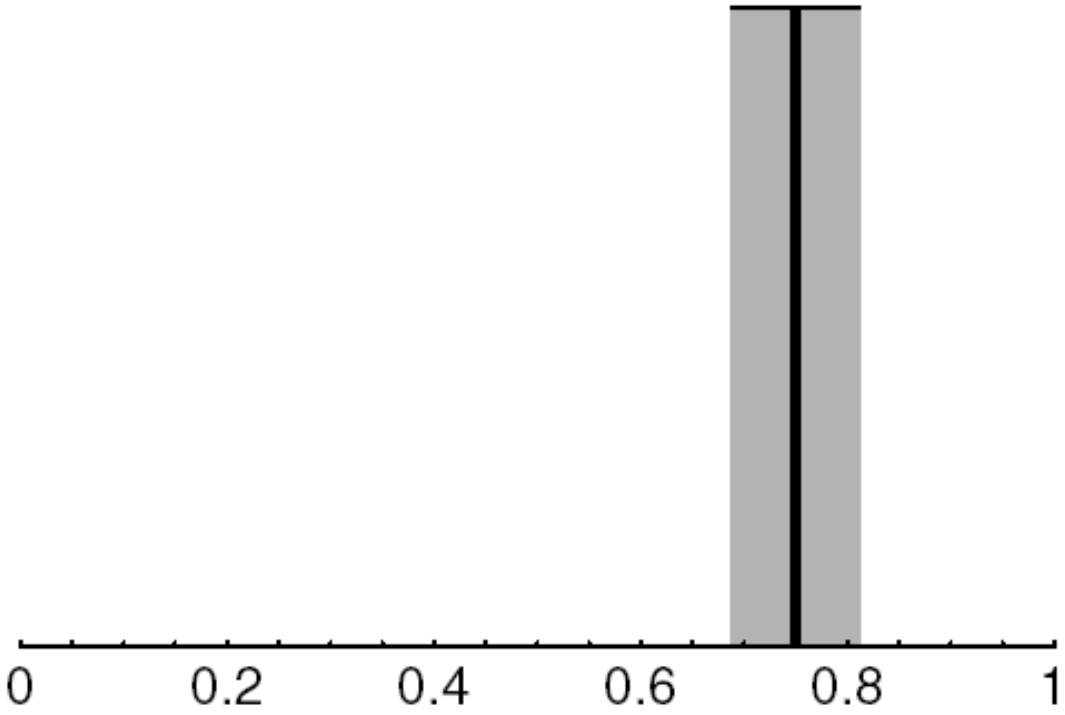

(Uniform) creep mutation

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Creep mutations: (example of implementation, in connection with real-number encoding)

0.23131541	0.59182321	0.98148176	0.01987612	0.59176192	0.19857612

For each gene, check(as usual) whether or not the gene should be mutated (using p_{mut})

If the gene should be mutated, check whether or not creep mutations should be used (using p_{creep})

If yes, carry out a creep mutation:

$g \rightarrow g' = g - C_r/2 + C_r\, r$ (example)

If no, carry out an ordinary mutation:

$g \rightarrow g' = \text{rand}$

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