Universiti Malaysia PAHANG
Engineering • Technology • Creativity

Artificial Intelligence

Genetic Algorithm

by
Abdul Sahli Fakharudin
Faculty Computer Systems & Software Engineering
sahli@ump.edu.my

Chapter Description

- Expected Outcomes
  - Student able to discuss the concepts of artificial intelligence
  - Student able to review the history of artificial intelligence
  - Student able to discuss the example of artificial intelligence application

- References
  - Negnevitsky, M., Artificial intelligence: a guide to intelligent systems, 2005, Pearson Education

Content #1

- Genetic algorithm concept
- Genetic algorithm steps
- Example implementation

Genetic Algorithms

- In the early 1970s, John Holland introduced the concept of genetic algorithms.

- Using the concept of survival of the fittest where the best species will survive than the lesser one

Genetic Algorithm Steps

- **Step 1:**
  - Represent the problem variable domain as a chromosome of a fixed length, choose the size of a chromosome population N, the crossover probability p_c and the mutation probability p_m .
- **Step 2:**
  - Define a fitness function to measure the performance, or fitness, of an individual chromosome in the problem domain. The fitness function establishes the basis for selecting chromosomes that will be mated during reproduction.

Genetic Algorithm Steps

- **Step 3:**
  - Randomly generate an initial population of chromosomes of size N:

$$x_1; x_2; \ldots; x_N$$

- **Step 4:**
  - Calculate the fitness of each individual chromosome:

$$f(x_1), f(x_2), \ldots, f(x_N)$$

Genetic Algorithm Steps

- **Step 5:**
  - Select a pair of chromosomes for mating from the current population. Parent chromosomes are selected with a probability related to their fitness. Highly fit chromosomes have a higher probability of being selected for mating than less fit chromosomes.
- **Step 6:**
  - Create a pair of offspring chromosomes by applying the genetic operators – ***crossover*** and ***mutation***.

Genetic Algorithm Steps

- **Step 7:**
  - Place the created offspring chromosomes in the new population.

- **Step 8:**
  - Repeat ***Step 5*** until the size of the new chromosome population becomes equal to the size of the initial population, N.

Genetic Algorithm Steps

- **Step 9:**
  - Replace the initial (parent) chromosome population with the new (offspring) population.

- **Step 10:**
  - Go to ***Step 4***, and repeat the process until the termination criterion is satisfied.

Case Study

- Let us find the maximum value of function $(15x - x^2)$ where parameter x varies between 1 to 15. For simplicity, we may assume that x only takes integer value. Thus, table below shows the possible chromosomes that build with only four genes.

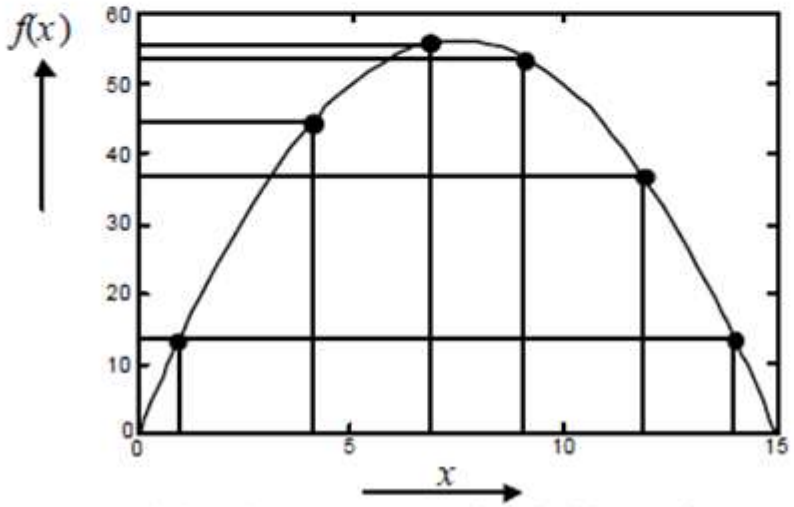
Integer	*Binary code*	*Integer*	*Binary code*	*Integer*	*Binary code*
1	0 0 0 1	6	0 1 1 0	11	1 0 1 1
2	0 0 1 0	7	0 1 1 1	12	1 1 0 0
3	0 0 1 1	8	1 0 0 0	13	1 1 0 1
4	0 1 0 0	9	1 0 0 1	14	1 1 1 0
5	0 1 0 1	10	1 0 1 0	15	1 1 1 1

- Suppose that size of the chromosomes population N is 6, the crossover probability p_c equals 0.7, and the mutation probability p_m equals 0.001. The fitness function is define by

$$f(x) = 15x - x^2$$

The Fitness Function & Chromosome Location

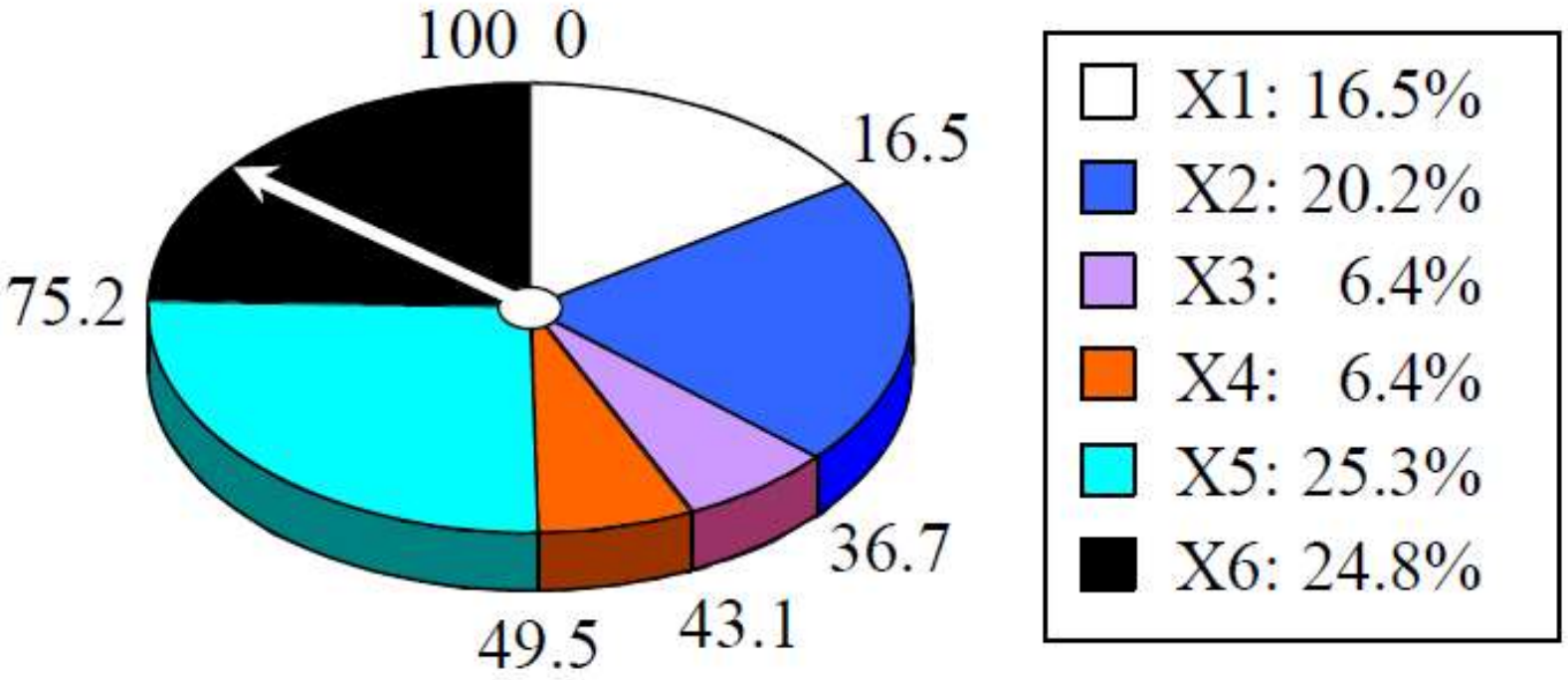
Chromosome label	*Chromosome string*	*Decoded integer*	*Chromosome fitness*	*Fitness ratio, %*
X1	1 1 0 0	12	36	16.5
X2	0 1 0 0	4	44	20.2
X3	0 0 0 1	1	14	6.4
X4	1 1 1 0	14	14	6.4
X5	0 1 1 1	7	56	25.7
X6	1 0 0 1	9	54	24.8



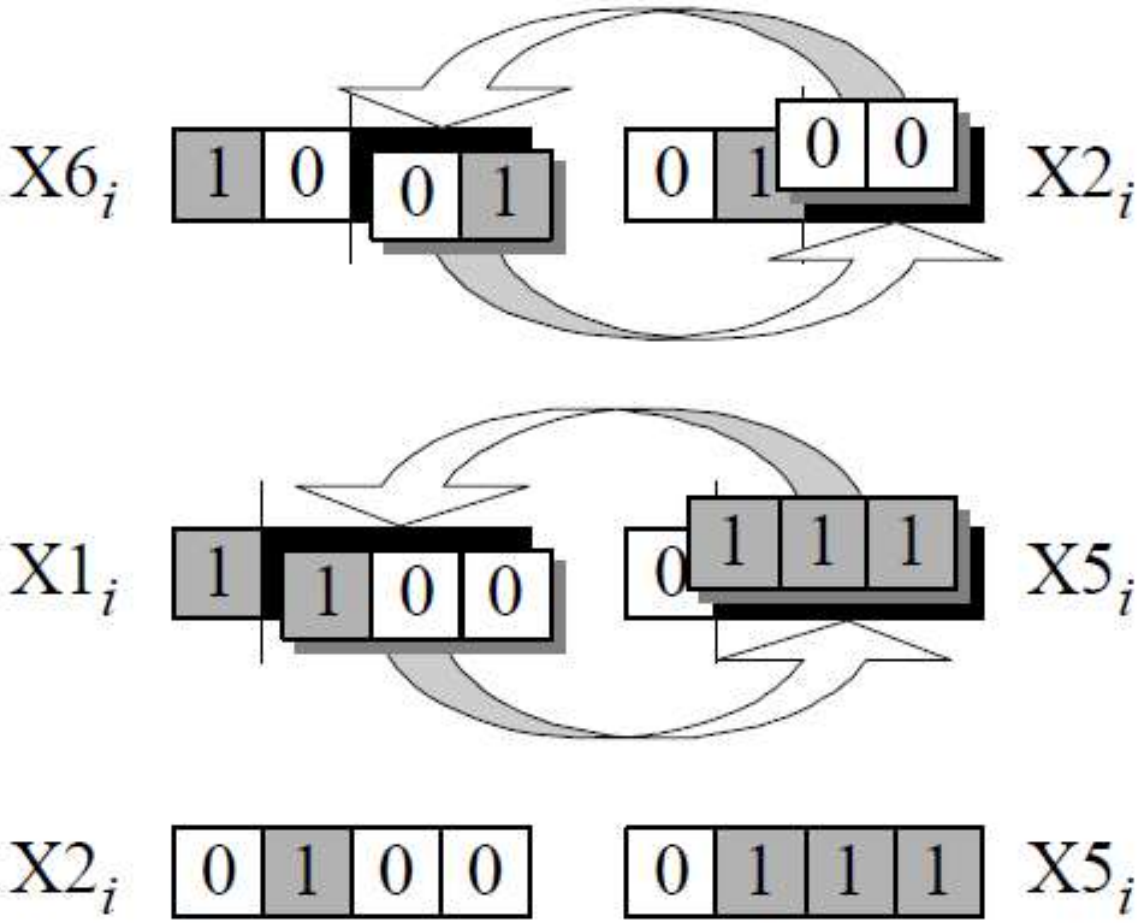
(*a*) Chromosome initial locations.

Selection: Roulette Wheel

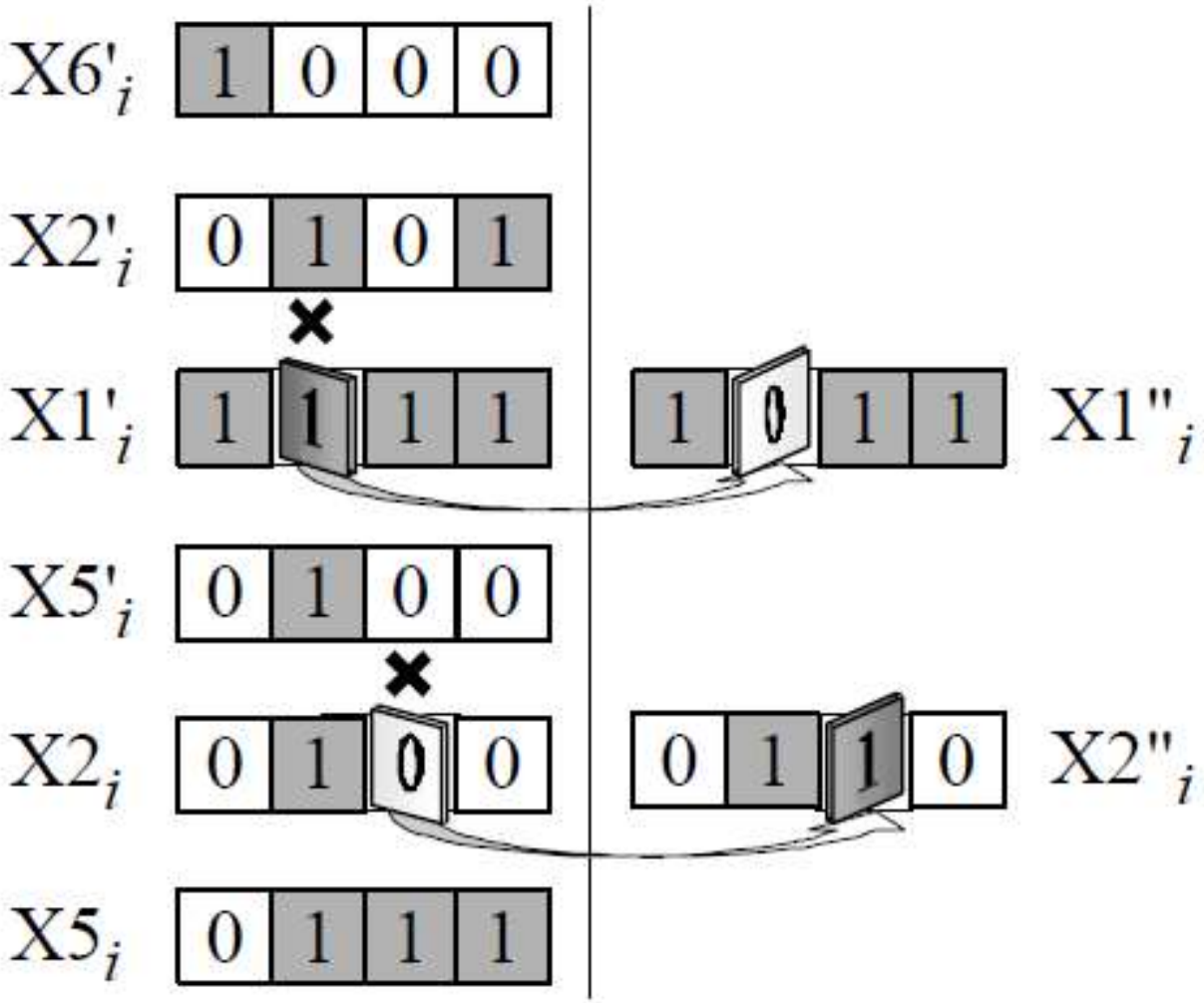
- Chromosome selection technique: Roulette wheel



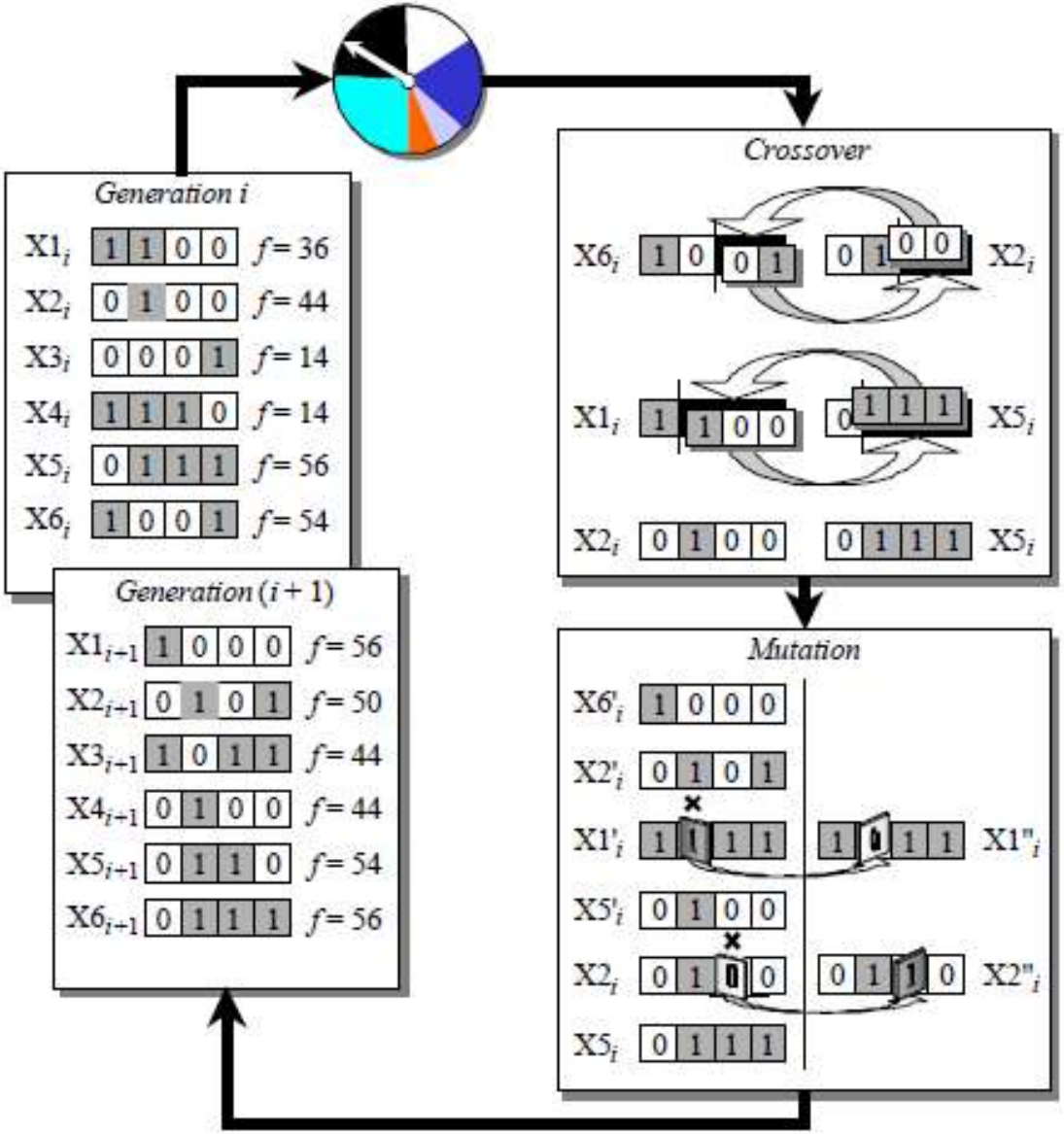
Crossover



Mutation


X6'i
1 0 0 0
X2'i
0 1 0 1
X1'i
1 1 1 1
1 0 1 1
X1"i
X5'i
0 1 0 0
X2i
0 1 0 0
0 1 1 0
X2"i
X5i
0 1 1 1

The Genetic Algorithm Cycle



Conclusion of The Chapter

- Conclusion #1
  - Ten complete steps to implement genetic algorithm
- Conclusion #2
  - Chromosome represent the possible solution of the problem
- Conclusion #3
  - Two main genetic operator :- cross-over and mutation