Lab 1 - Implementing A Simple Evolutionary Algorithm

CSE, SUSTech

Outline of This Lecture

- Teaching Assistant
- A Simple Evolutionary Algorithm (EA)
- How Does a Simple EA Work
- Highlights of This Simple EA
- Does The Population Size Matter?
- Illustrate The Results!

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A Simple Evolutionary Algorithm (EA)

1. Generate the initial population P(0) at random;
2. Set i ← 0; // Generation counter
3. REPEAT
   a. Evaluate the fitness of each individual in P(i);
   b. Select parents from P(i) based on their fitness in P(i);
   c. Generate offspring from the parents using crossover and mutation to form P(i + 1);
   d. i ← i + 1;
4. UNTIL halting criteria are satisfied

How Does a Simple EA Work - Example

Let's use the simple EA to maximise the function

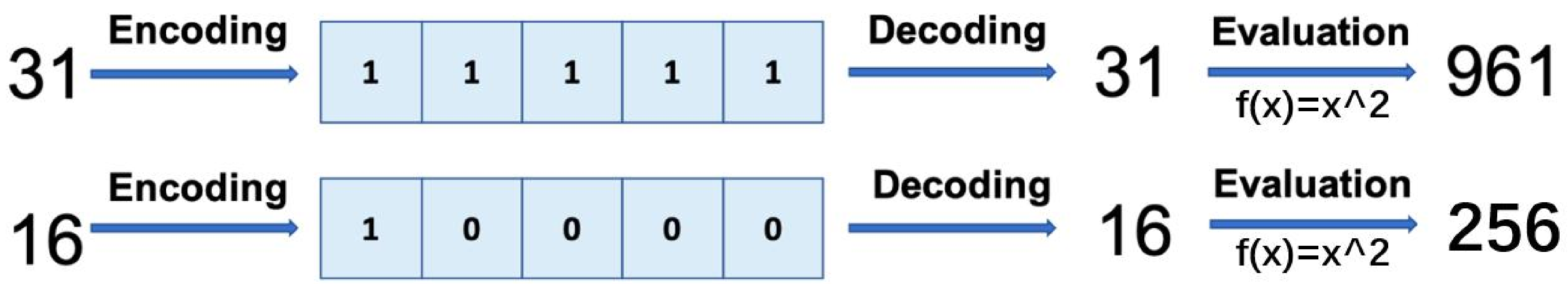
$$f(x) = x^2$$

with x in the integer interval [0, 31], i.e., $x = 0, 1, \cdots, 30, 31$.

How Does a Simple EA Work - Representation

The first step of EA applications is encoding, i.e., the representation of chromosomes:

- We adopt binary representation for integers.
- Five bits are used to represent integers up to 31.



How Does a Simple EA Work I

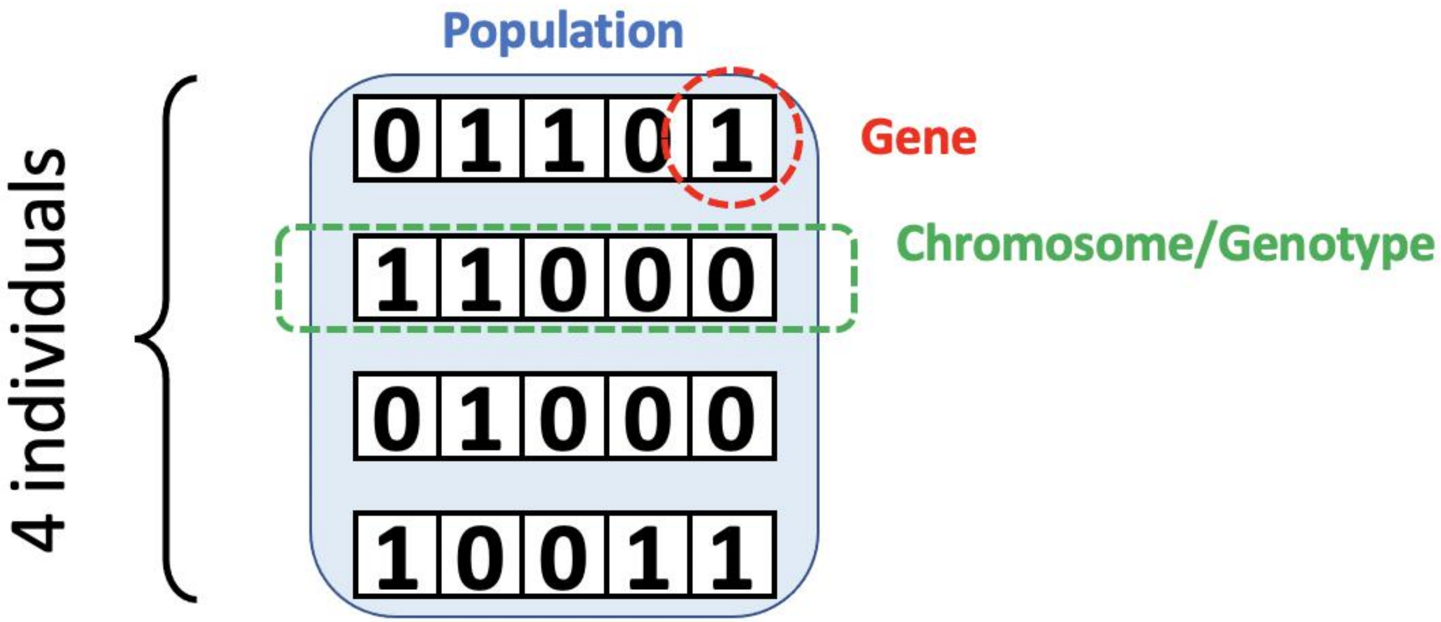
Assume that the population size is 4.

1. Generate initial population at random, e.g.,

   01101, 11000, 01000, 10011.

   These are chromosomes (染色体) or genotypes (基因型).

How Does a Simple EA Work II



How Does a Simple EA Work III

2. Calculate fitness value for each individual.
   a) Decode the individual into an integer (called phenotypes 表现型),

      01101 → 13
      11000 → 24
      01000 → 8
      10011 → 19

   b) Evaluate the fitness according to $f(x) = x^2$,

      01101 → 13 → 169
      11000 → 24 → 576
      01000 → 8 → 64
      10011 → 19 → 361

How Does a Simple EA Work IV

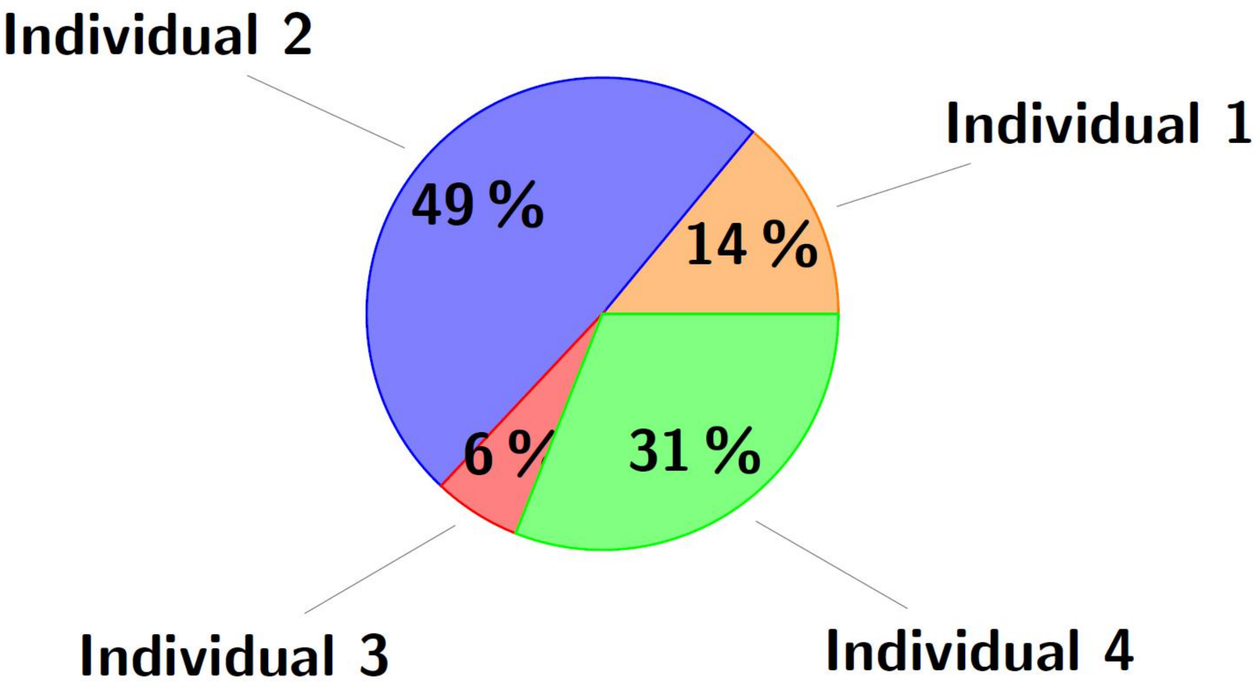
3. Select two individuals for crossover based on their fitness.
   a) If roulette-wheel selection is used, then

$$p_i = \frac{f_i}{\sum_j f_j}.$$

Two offspring are often produced and added to an intermediate population. Repeat this step until the intermediate population is filled. In our example,

$p_1(13) = 169/1170 = 0.14$ $p_2(24) = 576/1170 = 0.49$
$p_3(8) = 64/1170 = 0.06$ $p_4(19) = 361/1170 = 0.31$

How Does a Simple EA Work V



b) Assume we have crossover(01101, 11000) and crossover(10011, 11000). We may obtain offspring 01100 and 11001 from crossover(01101, 11000) by choosing a random crossover point at 4, and obtain 10000 and 11011 from crossover(10011, 11000) by choosing a random crossover point at 2.
Now the intermediate population is 01100, 11001, 10000, 11011.

How Does a Simple EA Work VI

4. Apply mutation to individuals in the intermediate population with a small probability.A simple mutation is bit-flipping. For example, we may have the following new population P(1) after random mutation:

   01101, 11001, 00000, 11011

   The initial population is:

   01101, 11000, 01000, 10011.

5. Goto Step 2 if not stop.

Highlights of This Simple EA

- Binary representation of individuals.
- Roulette-wheel selection.
- One point crossover.
- Bit-flipping mutation.
- Replacement: the current population will be replaced by the new population of the same size.

Does The Population Size Matter?

- Let’s try the following: vary the population size:
  - ✓Vary the population size μ = 4, 10.
  - ✓At each generation, record the best solution in the current population and its fitness.
  - ✓At each generation, record the best-so-far solution and its fitness.

Illustrate The Results!

- Plot 4 figures:
  - ✓x-axis: current evaluation number. y-axis: best-so-far fitness value.
  - ✓x-axis: current evaluation number. y-axis: fitness value of the best individual of current population.