SGA: A hands-on example (setup)

Toy optimization problem:

- Search space: binary strings of length 6
- Objective: maximize the number of 1s

Representation:

$$x = b_1 b_2 b_3 b_4 b_5 b_6, \quad b_i \in \{0, 1\}$$

Fitness function:

$$f(x) = \text{number of 1s in } x$$

Takeaway

The example is simple on purpose — to isolate SGA mechanics.

Step 2: Evaluate fitness

Compute fitness for each individual:

Individual	String	$f(x)$
x_1	1 0 1 0 0 1	3
x_2	0 1 0 1 1 0	3
x_3	1 1 0 0 0 0	2
x_4	0 0 1 1 0 1	3

The initial population consists of four individuals $\{x_1, x_2, x_3, x_4\}$ sampled at initialization.

Fitness introduces a **ranking bias** into the population.

Takeaway

Fitness converts problem structure into selection pressure.

Step 3: Selection

Using fitness-proportional selection:

▶ Higher fitness $\Rightarrow$ higher chance of reproduction

▶ Low-fitness individuals may still survive

Assume selected parents:

$$(x_1, x_2), \quad (x_4, x_1)$$

Takeaway

Selection biases reproduction — but does not create new solutions.

Step 4: Crossover

mix the two solutions (will learn strategies later):

$$x_1 = 1\,0\,1 \mid 0\,0\,1$$
$$x_2 = 0\,1\,0 \mid 1\,1\,0$$

Offspring:

$$y_1 = 1\,0\,1\,1\,1\,0$$
$$y_2 = 0\,1\,0\,0\,0\,1$$

Takeaway

Rcombining existing building blocks.

Step 5: Mutation

Apply random bit-flip mutation based on specified probability:

$$y_1 = 1\,0\,1\,1\,1\,0 \;\Rightarrow\; 1\,0\,1\,\mathbf{0}\,1\,0$$

Mutation:

- ▶ introduces new genetic material
- ▶ prevents population collapse

Takeaway

Mutation is small, random, and essential.

Step 6: Replacement

Form the next generation by replacing some or all parents:

Individual	String	$f(x)$
y_1	1 0 1 0 1 0	3
y_2	0 1 0 0 0 1	2
x_2	0 1 0 1 1 0	3
x_4	0 0 1 1 0 1	3

This completes **one SGA generation**.

Takeaway

Evolution = repeat evaluation, selection, variation, replacement.