01. Introduction

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Evolutionary Algorithms

EA is inspired by **biological evolution**:

1. You start with a **population** of random solutions.
2. You **evaluate** how good each one is (fitness).
3. You keep the better ones and let them **reproduce** (crossover/mutate).
4. You repeat the process over many generations.
5. Eventually, the solutions adapt and become very good (intelligent).

Idea: Adaptation is intelligence

- In nature, living beings that **adapt** to their environment are more likely to survive.
- For example, giraffes with longer necks survived because they could reach higher leaves, while shorter-necked ones struggled.
- In the same way, in **evolutionary algorithms**, solutions (like giraffes) adapt over generations. A "good" solution is one that adapts well to the problem.
- So, *being intelligent here means being able to adapt*.

Survival of the fittest

- This is Darwin's principle. It means the best-suited individuals (solutions) survive, while weaker ones die out.
- In evolutionary algorithms:
  - Each "individual" is a possible solution.
  - We test how good it is using a **fitness function** (like a score).
  - Better solutions have a higher chance of being chosen to "reproduce" (crossover, mutate, etc.).
  - Over time, the population improves because the "fittest" solutions dominate.

So, the **core idea** is:
Just like nature, evolutionary algorithms "evolve" solutions through adaptation and survival of the fittest until they solve the problem effectively.

How to use this idea for **optimization**? ?

e.g. Given $\boldsymbol{f(x) = x_1^2 + \sin(x_2) + \log(x_3)}$ Find the max of $\boldsymbol{f(x)}$ given some constraints!

- **Optimization** means: *finding the best solution out of many possible solutions.*
- In math, "best" often means:
  - **Maximum** (the largest value, like profit, accuracy, efficiency)
  - **Minimum** (the smallest value, like cost, error, energy use)

So here, in function: $\boldsymbol{f(x) = x_1^2 + \sin(x_2) + \log(x_3)}$

- We want to **maximize** this function by choosing the best values of $x_1, x_2, and\ x_3$, while following certain **constraints** (rules like $x_3 > 0, x_1 \leq 10$ etc.).

That's why this is an **optimization problem**. We are searching for the **best possible input** that gives the **best output**.

Why Evolutionary Algorithm here?

- For **simple functions**, you could use calculus (take derivatives, set to zero).
- But in real life, optimization problems are often **very complex**:
  - The function may be messy (nonlinear, discontinuous, no derivative).
  - There may be many variables $(x_1, x_2, x_3, \dots \dots \dots, x_n)$.
  - Many local maxima/minima exist (the function has multiple "hills" and "valleys").

Traditional math struggles here → That's where **Evolutionary Algorithms (EAs)** shine.

We are trying to find the *best possible solution (maximum value)* for the given function, and we use evolutionary algorithms because they are powerful when the search space is too complex for classical math.
