Introdução à Meta-heurística

Evolutionary Algorithms

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Introduction

Introduction

- Methods inspired by Darwin's theory of evolution were first proposed in 1859.
- In the '60s: Genetic Algorithms (and Evolutionary Programming) x Evolutionary Strategies.
- 1992: Genetic Programming.
- In the '90s: formulas combined with the name Evolutionary Computing or Evolutionary Algorithms.

Introduction

Historically, different types of Evolutionary Algorithms (EAs) have been associated with different types of representation:

- Strings vectors: Genetic Algorithms;
- Real-Number Vectors: Evolutionary Strategies;
- Finite state machines: Evolutionary Programming;
- Trees: Genetic Programming.

These differences are irrelevant and the best strategy is:

- Choose a suitable representation for the problem;
- Choose genetic operators that are appropriate to the chosen representation.

Evolutionary Biology

Evolutionary Biology

- Evolution is the change in the genetic characteristics of a population from one generation to the next. This change happens through gene mutation and parent gene recombination.
- Natural selection is its main causative agent.
- Chromosomes carry hereditary information from an organism and can be divided into genes.

Evolutionary Biology

- A gene is a region of DNA that controls an inherited trait.
- **Genotype:** Genetic material contained in a cell or organism.
- **Phenotype:** Physical or biochemical characteristics of an organism that can be observed, and which are determined by genotype and by environmental influences.
- **Fitness:** Probability of reproduction of an individual.

Evolutionary Algorithms

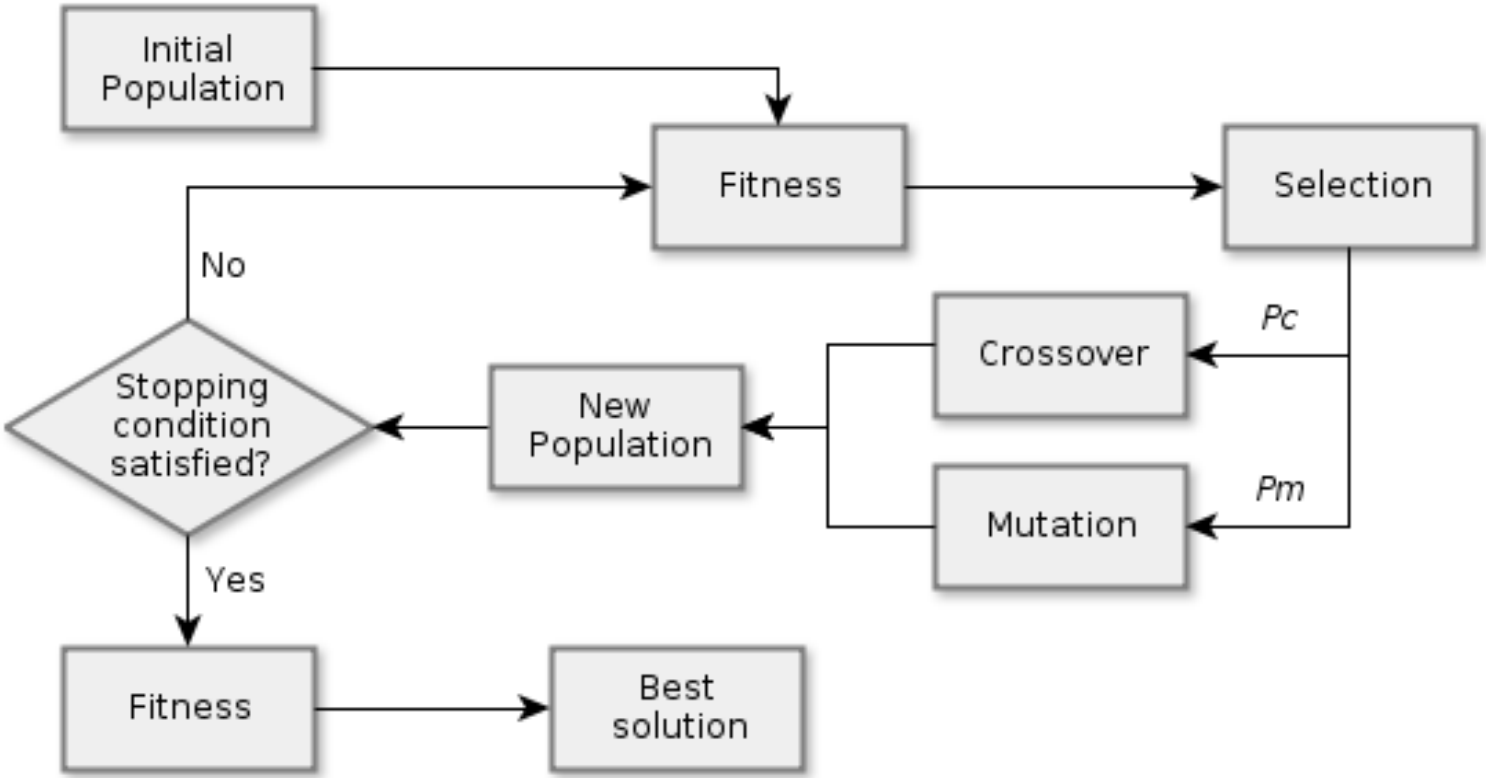
Evolutionary Algorithms

Basic Ideas

- EAs are iterative procedures that involve a population of individuals.
- Each individual represents a candidate solution to a given problem.
- **At each iteration (generation):** The best individuals are selected according to a fitness function.
- **Genetic operators** are applied to the selected individuals, aiming to produce new individuals (children).
- New individuals are evaluated using **fitness**.

Evolutionary Algorithms

Evolutionary Algorithms



Evolutionary Algorithms

Motivation

- Some application examples: Engineering, games, circuit design, financial models, bioinformatics, modelling, etc.
- Parallel processing.
- Provide robust and adaptive solutions.
- Automatic program code evolution.
- Global search.

Evolutionary Algorithms

Motivation

What makes EAs robust for a wide variety of applications?

- The algorithm itself is the same for any problem.

- Three important components should be defined Good solution found or the maximum number of generationsaccording to the problem:

- Representation of individuals;
- Fitness;
- Genetic operators.

Evolutionary Algorithms

Application - Travelling Salesman Problem (TSP)

- **Representation of individuals:** A vector of integers or characters, representing a permutation between cities: A F C E D B G.
- **Fitness Function:** Path length.
- **Genetic operators:** Restrictions should be considered.

Evolutionary Algorithms

Application - Travelling Salesman Problem (TSP)

Pseudocode:

1. Generate city permutations randomly;
2. Evaluate each one (Fitness);

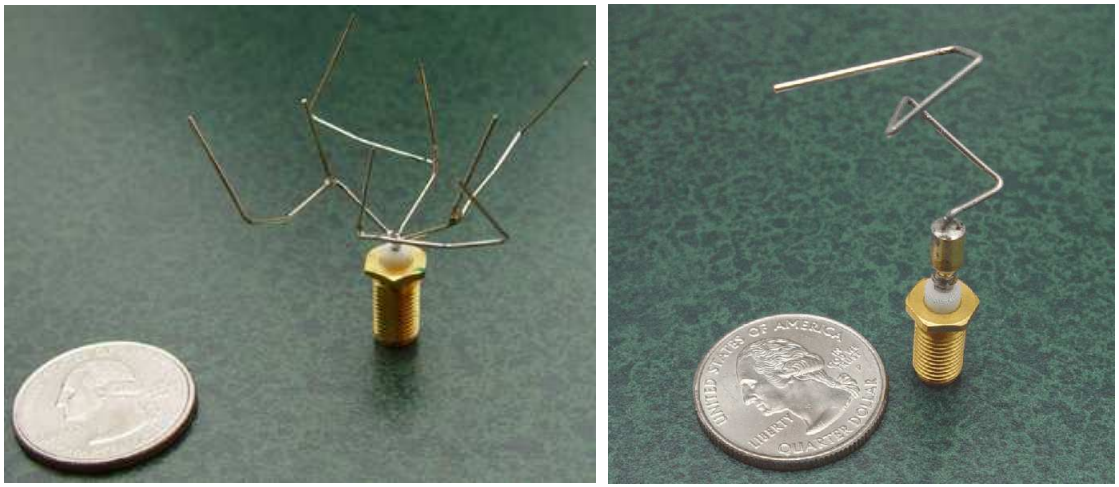
REPEAT

3. Select better permutations for reproduction;
4. Create new permutations (crossover and mutation);
5. Evaluate new permutations;

UNTIL (Good solution found or the maximum number of generations).

Evolutionary Algorithms

Hornby et al 2006.
Automated Antenna Design with Evolutionary Algorithms.
American Institute of Aeronautics and Astronautics.



(a) (b)

Figure: (a) the best evolved antenna for the initial gain pattern requirement, ST5-3-10; (b) the best evolved antenna for the revised specifications, ST5-33-142-7.

References

References

- Lecture notes based on material by Ph.D. Gisele Pappa (UFMG).