Evolutionary algorithms and Novelty Search

Dominika Zogatová

FJFI ČVUT

27.06.2021

1. Evolutionary algorithms
2. Novelty Search
3. Our approach
4. Results

Evolutionary algorithms

- Natural evolution
- Selection, reproduction, recombination and mutation
- Simplistic from biology point of view, these algorithms are complex enough to provide powerful search tool
- Optimize for fitness value

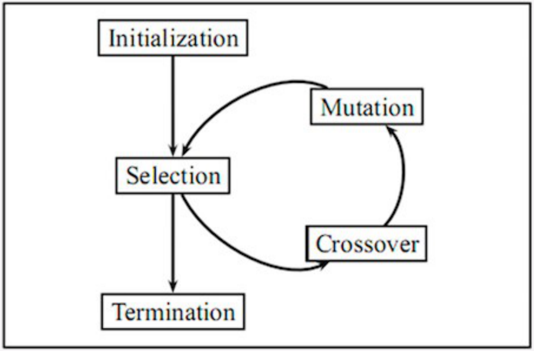

Figure: Evolution Process

- Evolutionary algorithms are known to converge to non-evolving populations rather quickly
- Reliance on fitness function is believed to be the problem
- Questions:
  - Does nature optimize for anything?
  - How to measure novelty?
  - Does natural evolution optimize for novelty?

Novelty Search

- Rewarding with respect to an objective does not improve overall performance
- Difficult to define an appropriate fitness function
- Some goals are unreachable when optimizing for a single or even multiple objectives alone
- Focuses on finding novel behaviours

- Behavioural novelty is described by measuring the distance to the nearest k neighbours
- The nearest neighbours are computed from all the individuals from the current population and from all members from the archive
-

$$\rho(x) = \frac{1}{k} \sum_{i=0}^{k} dist(x, \mu_i),$$

Our approach

- Randomly distributed rewards
- More collected *sugars* = higher the fitness value
- $$\rho(x) = \frac{1}{k}\sum_{i=0}^{k} pick(x, s_i),$$
- Agent is rewarded for exploring the environment

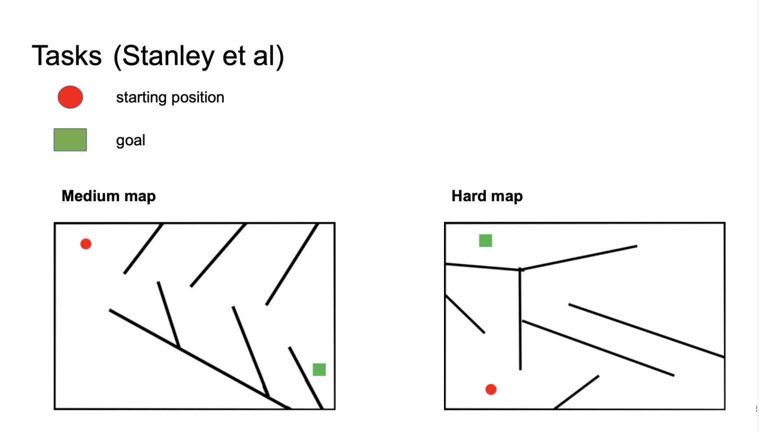

Figure: Maze environments

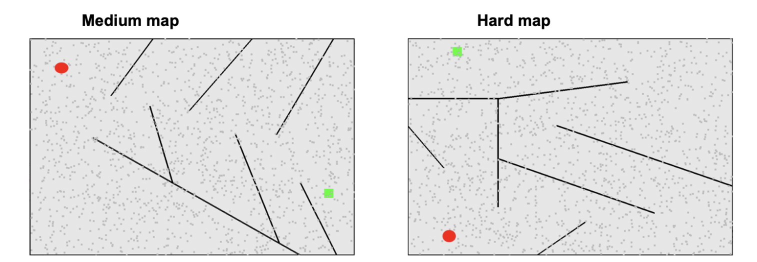

Figure: Maze environments - sugars

- Goal: reach the finish point
- Fitness: distance to the goal
- Novelty: Euclidean distance between k nearest neighbours
- Our approach: number of sugars collected

Table: Results of our implementation

	Medium Map	**Hard Map**
Fitness	17.6	-
Novelty Search	10.4	237.7
Sugar Approach	11.7	86.6

- Average number of generations needed to reach the goal

Benefits of our approach

- Less hyper parameters
- Better results on more complicated mazes
- Less ad-hoc, no need for archive
- Easy implementation - simpler approach

Animations on Google Slides