

Title

Abandoning Objectiv Abandoning Objectives: Evolution Through
Through the Search for Novelty Alone

Joel Lehman University of Central Florida Kenneth O. Stanley
University of Central Florida

Colin Milhaupt & Greg Jacobus University of New Mexico

Background

► point

The Search for Novelty

- ▶ Objective fitness functions don't reward intermediate stepping stones that lead to the objective
- ▶ Instead, reward instances whose functionality is significantly different from what has been discovered before
- ▶ Seems naive → where is the pressure to adapt?
- ▶ Not necessary → stepping stones are rewarded

Novelty Search Algorithm

- ▶ Key idea: reward divergence from prior behavior
- ▶ Create a spatial mapping of evolved solutions
- ▶ Use k-means to measure sparsity (higher is better)

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

Where x is the point in question and u_i is the i th nearest neighbor of x

Experiment 1: Maze



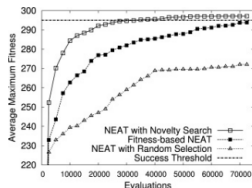
(a) Medium Map



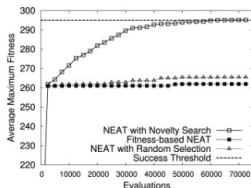
(b) Hard Map

- ▶ Great for deception problems because dead ends that lead close to the goal are local optima
- ▶ Fitness-based NEAT metric is defined as the distance from the robot to the goal at the end of an evaluation
- ▶ Novelty-based NEAT metric rewards the robot for ending in a place where none have ended before; the method of traversal is ignored

Experiment 1: Maze Results



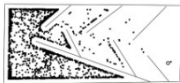
(a) Medium Map



(b) Hard Map

- ▶ Fitness-based NEAT was three times slower (56k evaluations vs 18k)
- ▶ The average genomic complexity of solutions evolved by fitness-based NEAT was almost three times greater than those evolved by Novelty-based NEAT
- ▶ The hard map was solved 3/40 times by fitness-based NEAT and 39/40 times by novelty-based NEAT

Experiment 1: Maze Behaviors



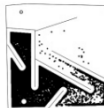
(a) Medium Map Novelty



(b) Hard Map Novelty



(c) Medium Map Fitness



(d) Hard Map Fitness

- ▶ Bounding the Size of the Archive in the Maze Domain
 - ▶ Possible to limit the archive size, and thus additional computational effort, without significantly decreasing the performance of novelty search
- ▶ Removing Walls in the Maze Domain
 - ▶ Fitness fares no better; fitness-based search is not necessarily a viable alternative even when novelty search is not effective

Experiment 1: Maze Behaviors

- ▶ Lengthening the Behavioral Characterization
 - ▶ High-dimensional behavior characterization is not a sufficient basis for predicting that novelty search should fail
- ▶ Reducing the Precision of the Behavioral Characterization
 - ▶ Archive size can be limited without significant loss of performance
- ▶ Characterizing Behavior as the Fitness Measure
 - ▶ This type of conflation can be disruptive to novelty search

Experiment 2

► point