***Autoverse**: Evolving Symbolic Neural Cellular Automata Environments to Train Player Agents*

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Motivation

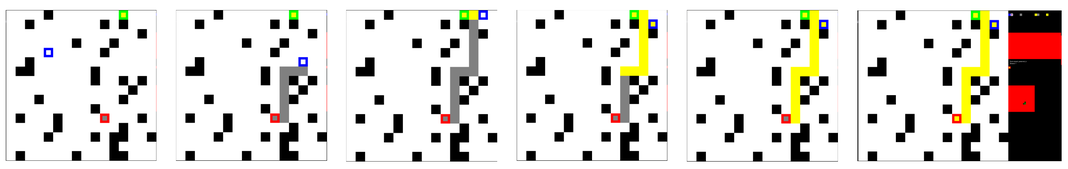
We want to explore Open-Ended Learning (**OEL**)—and Unsupervised Environment Design (UED)—in game environments with **diverse mechanics**

For this, we need a **fast simulator** that can express a wide variety of games and lets us easily **mutate mechanics**.

Methods

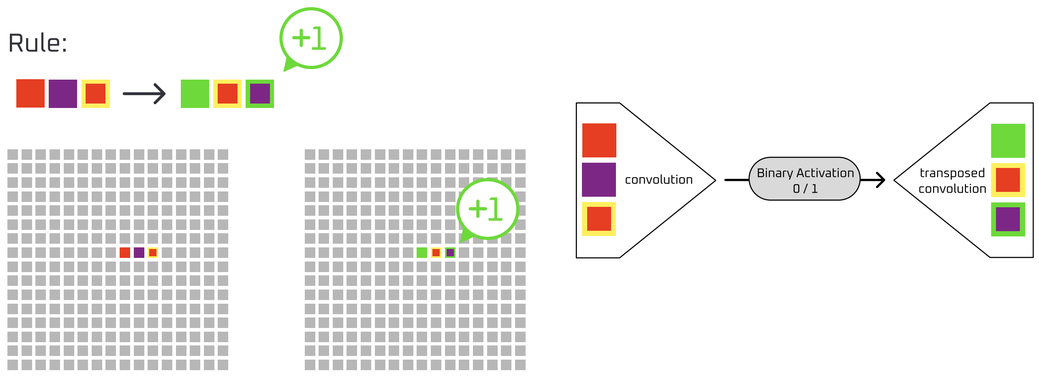
We define a Domain-Specific Language (DSL) of local interactions over grid-worlds, encompassing **mazes**, **dungeons**, **sokoban**-likes, and more.

(In “Power Puzzle”, for example, the player builds electrical circuits.)



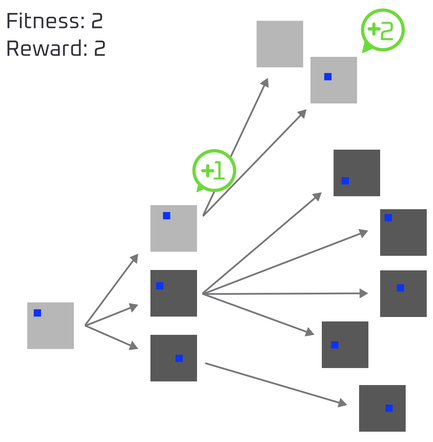
Local rules, global dynamics.

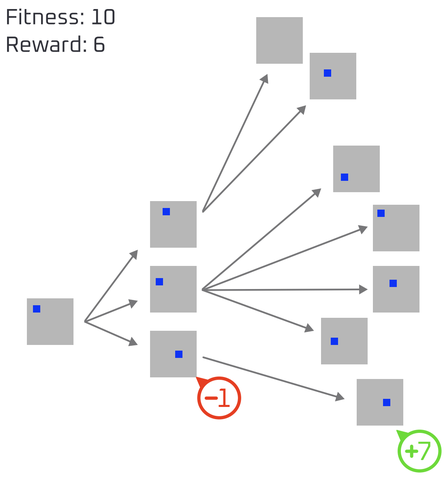
Local pattern **rewrite rules** can be implemented as **convolutions** (we use jax) allowing for parallel execution on the GPU.



Pattern rewrite rules as convolutions.

We mutate rewrite rules, selecting for environments where the best solution takes a long time to find with **greedy search**. (This favors **deceptive** environments.)

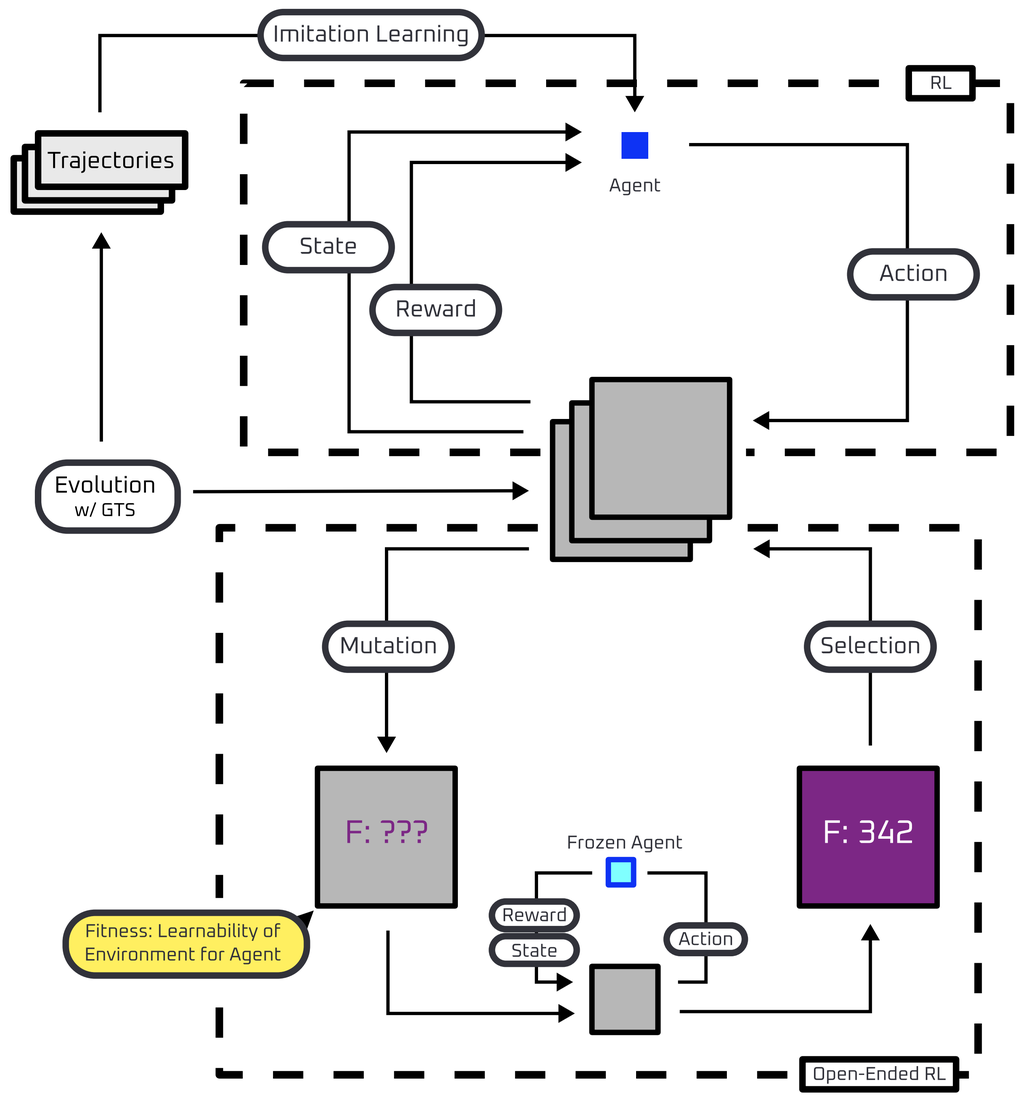




Evolve environments to maximize complexity.

We Imitation Learn on player trajectories from search, then continue to Reinforcement Learn in evolved environments.

Use search to jump-start Reinforcement Learning.



Continue evolving environments to maximize surprise.

During RL, we continue evolving environments to maximize value function error of the player agent.

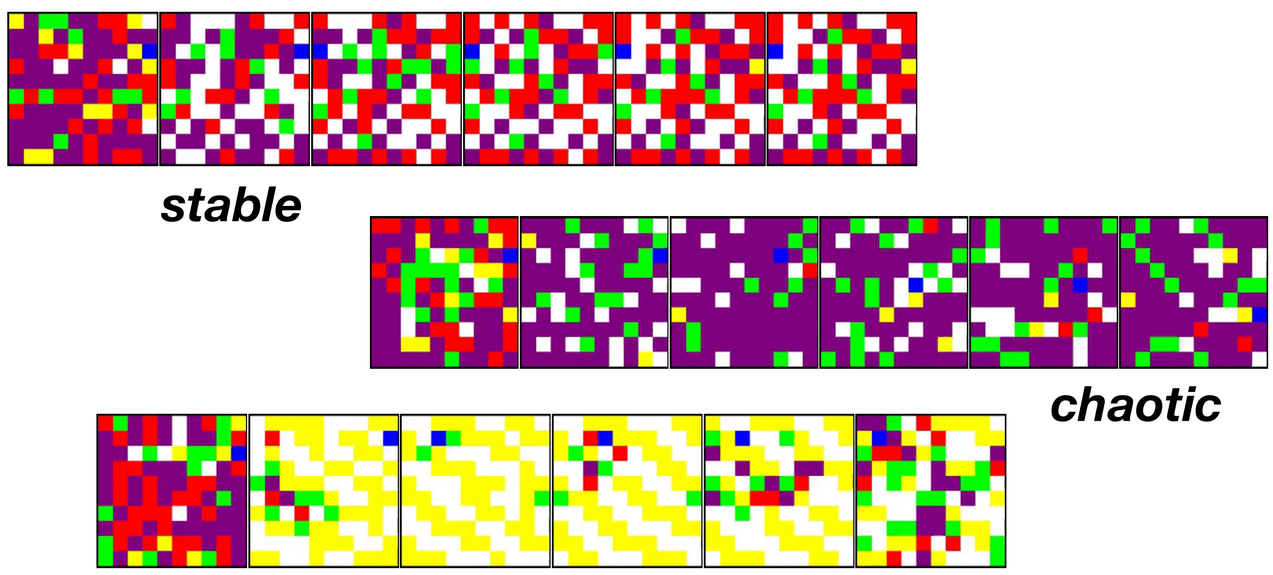
Results

Running evolution (for search-based complexity) for longer, to generate a set of training environments, leads to better generalization (w.r.t. performance on environments from a separate evolutionary run).

More evolved environments, better generalization.

	train mean	val. mean	test mean
load gen			
0	130.88 ± 3.73	51.38 ± 1.24	90.79 ± 6.79
10	$\mathbf{174.32 \pm 29.53}$	67.03 ± 3.61	123.92 ± 6.51
20	121.71 ± 1.07	$\mathbf{71.18 \pm 0.25}$	$\mathbf{133.71 \pm 9.60}$

Many flavors (entropically speaking)…



stable

chaotic

and balanced!