

Lenia-Ammonia: Lenia with a Dynamic Physical Environment

This is a modification of Bert Chan's Lenia (using `Lenia_Ammonia.py`) that moves beyond simple mathematical rules and places Lenia organisms into a **simulated physical environment**.

The standard Lenia simulation is "disembodied"—organisms' rules don't depend on a physical world. This modification simulates a **liquid ammonia (NH₃) environment**, complete with thermodynamics, chemistry, and fluid dynamics.

The most important feature is a new agent-environment feedback loop:

1. Organisms' metabolism generates heat.
2. This heat creates temperature gradients in the liquid ammonia.
3. These gradients cause thermal convection currents
4. The convection currents physically move the organisms through the world.

This allows organisms to "evolve propulsion" by weaponizing physics. Asymmetric shapes create asymmetric thrust, allowing them to "swim" by creating their own currents.

🧪 Demos
coming soon!

✨ Key Features

Ammonia Environment: Simulation parameters are tuned for a liquid ammonia environment, featuring lower temperature, faster time scaling (`AMMONIA_T = 18`), and wider diffusion kernels (`AMMONIA_RING`) to simulate lower viscosity.

Thermal Dynamics: Organisms generate metabolic heat (`HEAT_GENERATION`). This heat diffuses (`THERMAL_DIFFUSION`) and radiates to a configurable ambient temperature (`AMBIENT_TEMP`).

Convection Propulsion: A new `apply_convection` function calculates temperature gradients (`np.gradient(self.temperature)`) and applies a physical shift (`scipy.ndimage.shift`) to the organisms, nutrients, and waste fields.

Metabolic Cycle: Organisms consume `self.nutrients` (using Monod kinetics) and produce toxic `self.waste`, which inhibits growth. This creates local ecological pressures.

Environmental Features: The world can be initialized with "hydrothermal" vents (`nutrient_sources`) and "ice patches" (`cold_zones`) to create a more complex landscape.

🛠 Requirements

This script requires several Python libraries. You can install them using `pip`:

```
```bash
```

```
pip install numpy scipy scikit-image pillow
```

```
pip install pyopencl reikna # For GPU acceleration (optional but recommended)
```