

# Predator-Prey Reinforcement Learning Simulation

A 2D simulation of predator-prey dynamics with reinforcement learning agents. Prey gain energy by staying still, while predators gain energy by consuming prey. Both species can reproduce when they accumulate enough energy.

## Features

- Real-time 2D simulation with Pygame visualization
- Camera controls for panning and zooming
- Agent movement with energy dynamics
- Reinforcement learning using Proximal Policy Optimization (PPO)
- Live charts showing population and energy statistics
- Simulation state saving/loading using HDF5
- Replay mode for visualizing saved simulations
- CSV export of simulation statistics

## Requirements

- Python 3.11+
- PyTorch 2.x (with CUDA 12 for GPU acceleration)
- NumPy
- Pygame
- Matplotlib
- h5py
- pandas

## Installation

1. Clone the repository:

```
bash
```

```
git clone https://github.com/yourusername/predator-prey-sim.git
cd predator-prey-sim
```

2. Create and activate a virtual environment (optional but recommended):

```
bash
```

```
python -m venv venv
```

```
source venv/bin/activate # On Windows: venv\Scripts\activate
```

3. Install dependencies:

```
bash
```

```
pip install torch numpy pygame matplotlib h5py pandas
```

## Running the Simulation

### Basic Usage

```
bash
```

```
python main.py
```

This will start the simulation with default parameters.

### Command Line Options

- `--width` - Width of the world (default: 500)
- `--height` - Height of the world (default: 500)
- `--prey` - Initial number of prey agents (default: 500)
- `--predators` - Initial number of predator agents (default: 50)
- `--train` - Enable reinforcement learning training
- `--replay`