

# Analysis and Design of an Autonomous Predator-Prey Agent System

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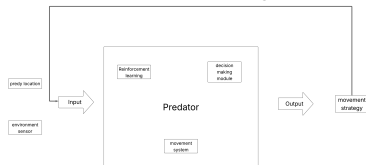
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Workshop 2 - Adaptive Systems

# System Context

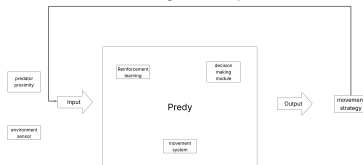
- Simulation of adaptive interactions in discrete 2D environment
- Key components:
  - **Predator**: Adaptive pursuit logic
  - **Prey**: Reactive evasion mechanisms
  - Environment with obstacles and traps

## Predator Loop



Detection → Planning → Action

## Prey Loop



Evasion → Navigation → Survival

## Core Approach

Cybernetic dynamics: Environment feedback-based adaptation

# Sensors and Actuators

## Sensors (5x5 grid radius):

- Predator: Detects prey, walls, traps
- Prey: Detects predator, walls, traps

## Actuators:

- 4-directional movement
- 1 cell per time step

## Reward Function

- Predator: +10 capture reward, -0.1/step
- Prey: +0.1/step survival, -5 capture penalty

# Motion Equations

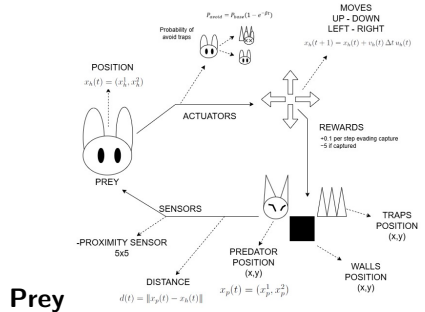
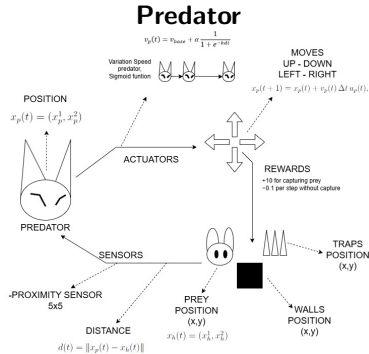
Table: Discrete motion equations

Predator	Prey
$\pi_p(t+1) = \pi_p(t) + \Delta t r_p(t) v_p(t)$	$\pi_h(t+1) = \pi_h(t) + \Delta t r_h(t) u_h(t)$

$$r_p(t) = v_{\max} + \frac{\alpha}{1 + e^{-kd(t)}}$$

Predator's adaptive speed based on distance  $d(t)$

# Phase Diagrams



- Nonlinear behavior sensitive to initial conditions
- Dynamic balance between capture/survival time

# Reinforcement Learning Options

- **Q-Learning**: Discrete state spaces
- **DQN**: High-dimensional inputs (neural networks)
- **SARSA**: On-policy learning, reduced overestimation
- **Actor-Critic**: Continuous action spaces

# References



Sutton, R. S., & Barto, A. G. (2018). *Reinforcement Learning: An Introduction*. MIT Press.



Mnih, V. et al. (2015). Human-level control through deep reinforcement learning. *Nature*.

**Thank you for your attention!**