Introduction to Reinforcement Learning

DEPARTMENT OF COMPUTER SCIENCE
ST. FRANCIS XAVIER UNIVERSITY

CSCI-531 - Reinforcement Learning

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We said that we want to maximize a reward, but **what is a reward?**

What is a Reward?

Activity

Try to explain what a reward is.

Key Characteristics

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Strategy with No Knowledge

Activity

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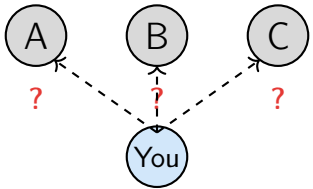

A Simple Example: Learning to Navigate

Scenario

Imagine you're in a new city trying to find the best coffee shop.

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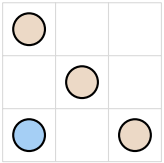

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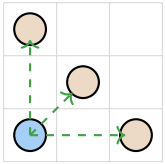

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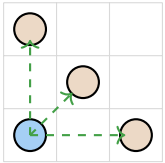

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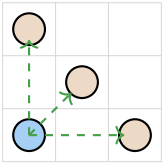

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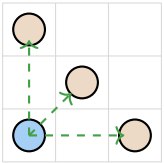

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Coffee Shop Strategies

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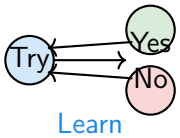
Exploit	Explore	Balance
Safe but limited	Risky but learning	Optimal strategy

Key Concepts - The Basics

Reinforcement learning has two main characteristics:

- **Trial-and-error search:** Learning by trying things and seeing what works



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- **Delayed rewards:** Actions now may have consequences much later

Why these matter:

- **Trial-and-error** means no teacher provides "correct" answers - you learn by experience
- **Delayed rewards** means you must connect actions to outcomes that happen later

Important Distinction

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You need to understand the distinction.

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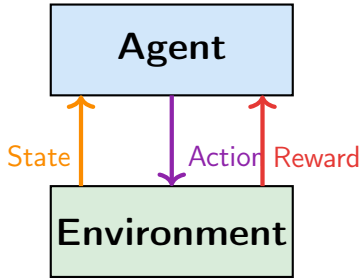

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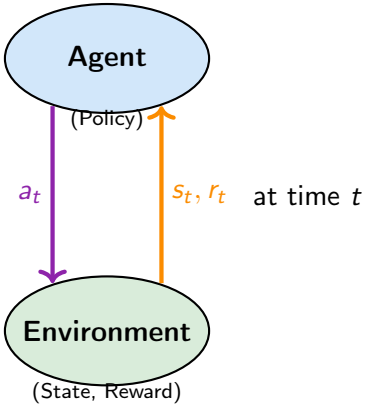

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- **Autonomous Systems:** Self-driving cars make split-second decisions in complex environments
- **Finance & Trading:** Systems optimize investment decisions over time under uncertainty

What Makes These Problems Special?

Why Traditional AI Approaches Fail

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You might wonder: why couldn't traditional machine learning solve these problems? Understanding what RL is requires understanding what it's not.

What Reinforcement Learning is NOT?

Understanding RL is easier when we compare it to other learning paradigms:

Learning Type	Data Required	Feedback Type	Goal
Supervised	Labeled examples	Immediate correct answers	Predict/classify
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- **No feedback:** You can't improve without knowing if you're doing well

Learning Paradigms

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2. What would unsupervised learning find in a chess game, and why isn't that sufficient?
3. Give an example of a problem where you'd need each type of learning.

The Challenges of Reinforcement Learning

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The Exploration-Exploitation Trade-off

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This is the fundamental challenge in RL

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Understanding these challenges prepares us to examine what makes RL systems work. Every RL agent relies on the same core building blocks.

The Four Core Elements

Element	Purpose	Think of it as...	Required?
Policy	Decision maker	The brain that chooses actions	Essential
Reward Function	Goal definition	The scoring system	Essential
Value Function	Long-term predictor	The strategic advisor	Essential
Model	Environment simulator	The crystal ball	Optional

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These four elements work together like a team - each has a specific role, but their real power comes from how they interact in the learning process.

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Definition: Policy

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What it does:

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Examples:

- **Chess:** "If opponent threatens my queen, move it to safety"
- **Trading:** "If price drops 5%, sell 20% of holdings"

$s_1 \rightarrow a_2$
$s_2 \rightarrow a_1$
$s_3 \rightarrow a_3$

2. Reward Function - The Goal Definition

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Examples:

- **Game:** +10 for winning, -1 for losing, 0 for draw
- **Robot:** +1 for forward movement, -10 for collision
- **Trading:** +profit for good trades, -loss for bad ones

3. Value Function - The Strategic Advisor

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Key insight: We seek actions that lead to states with higher **value**, not higher immediate **reward**.

Activity: Reward vs Value

Interactive Activity

Reward vs Value - Which would you choose?

- State A: immediate reward = 100, long-term value = 3
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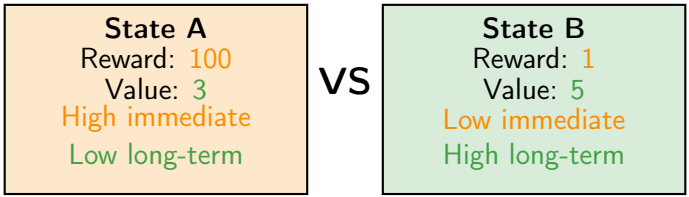

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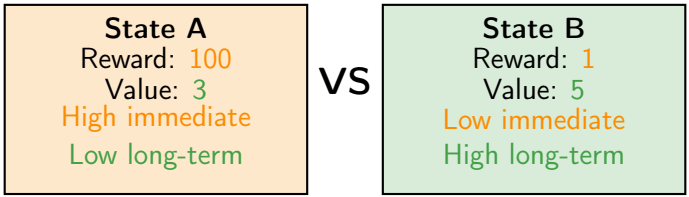

Question: Why might State B be better despite lower immediate reward?

Value vs Reward Examples

Examples of choosing value over immediate reward:

- **Chess:** Sacrificing a piece (negative reward) to gain better position (higher value)

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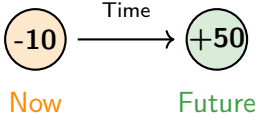
Strategic Thinking



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Type	Model?	Characteristics	Examples
Model-based	Yes	Can plan ahead, simulate scenarios	Chess engines
Model-free	No	Learn directly from experience	Most game AI

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Up Next: Multi-Armed Bandits

Current Limitations & Assumptions

RL is powerful but has important limitations to keep in mind:

Challenge	Description	Impact
State Design	How to represent the current situation	Learning speed
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- **Design matters:** How you frame the problem affects what the agent can learn

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Interactive Activity

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