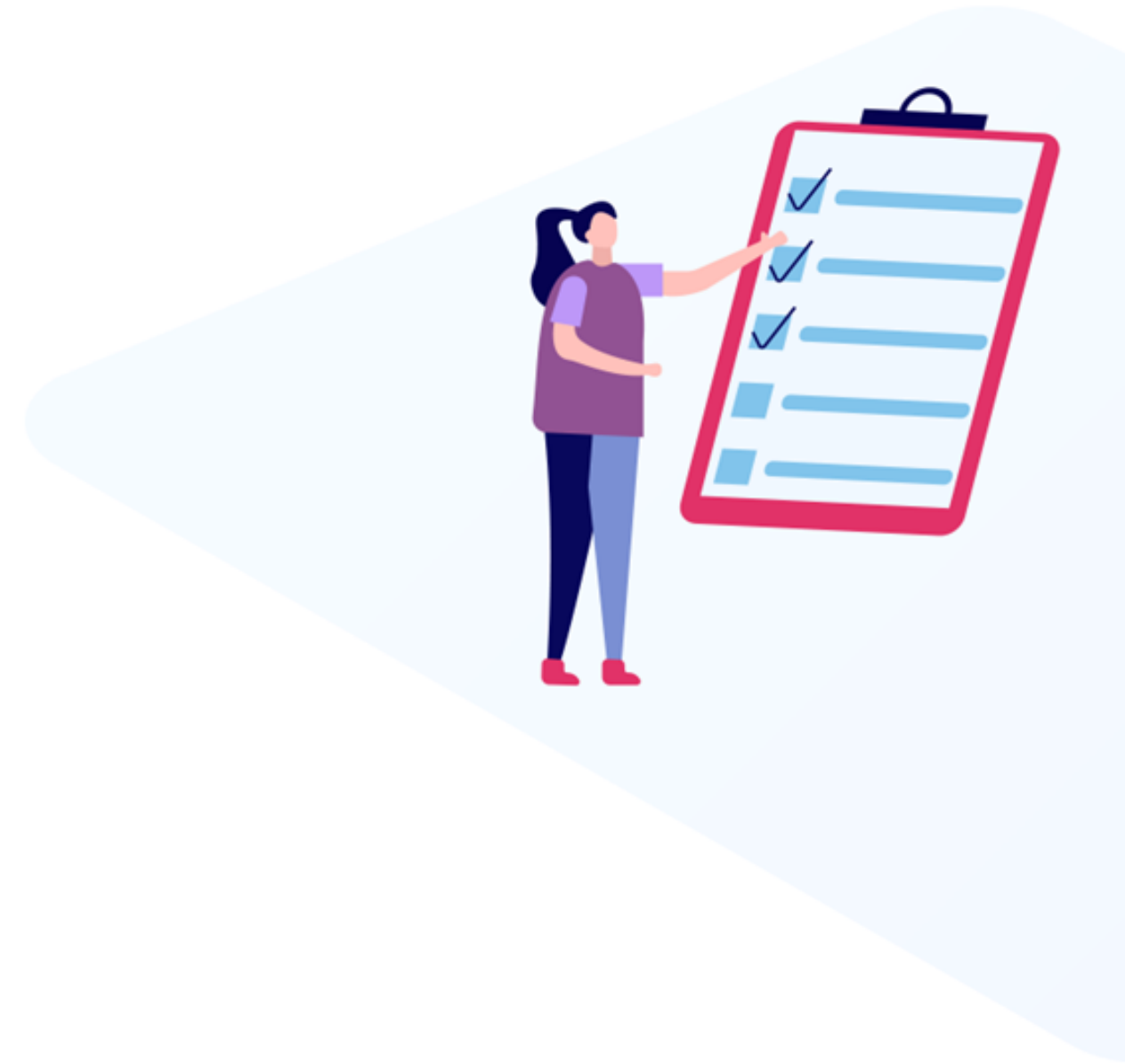# Reinforcement Learning

# Introduction to Reinforcement Learning

# Learning Objectives

By the end of this lesson, you will be able to:

- Summarize basic concepts and terminology in reinforcement learning

- Identify the difference between supervised learning, unsupervised learning, and reinforcement learning

- Interpret concepts like agents, environments, states, actions, and rewards

- Describe applications and challenges of reinforcement learning
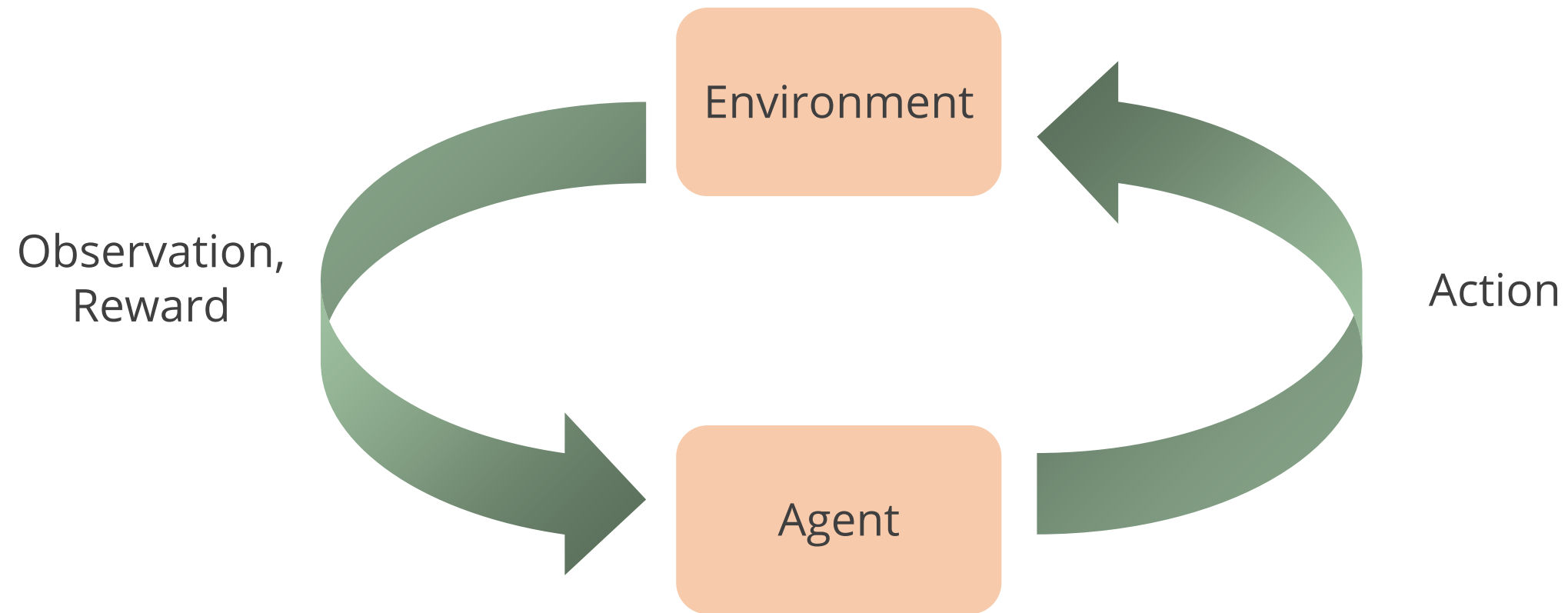
# Overview of Reinforcement Learning

# What Is Reinforcement Learning?

Reinforcement learning is the process of figuring out how to act in various situations to maximize a numerical reward.
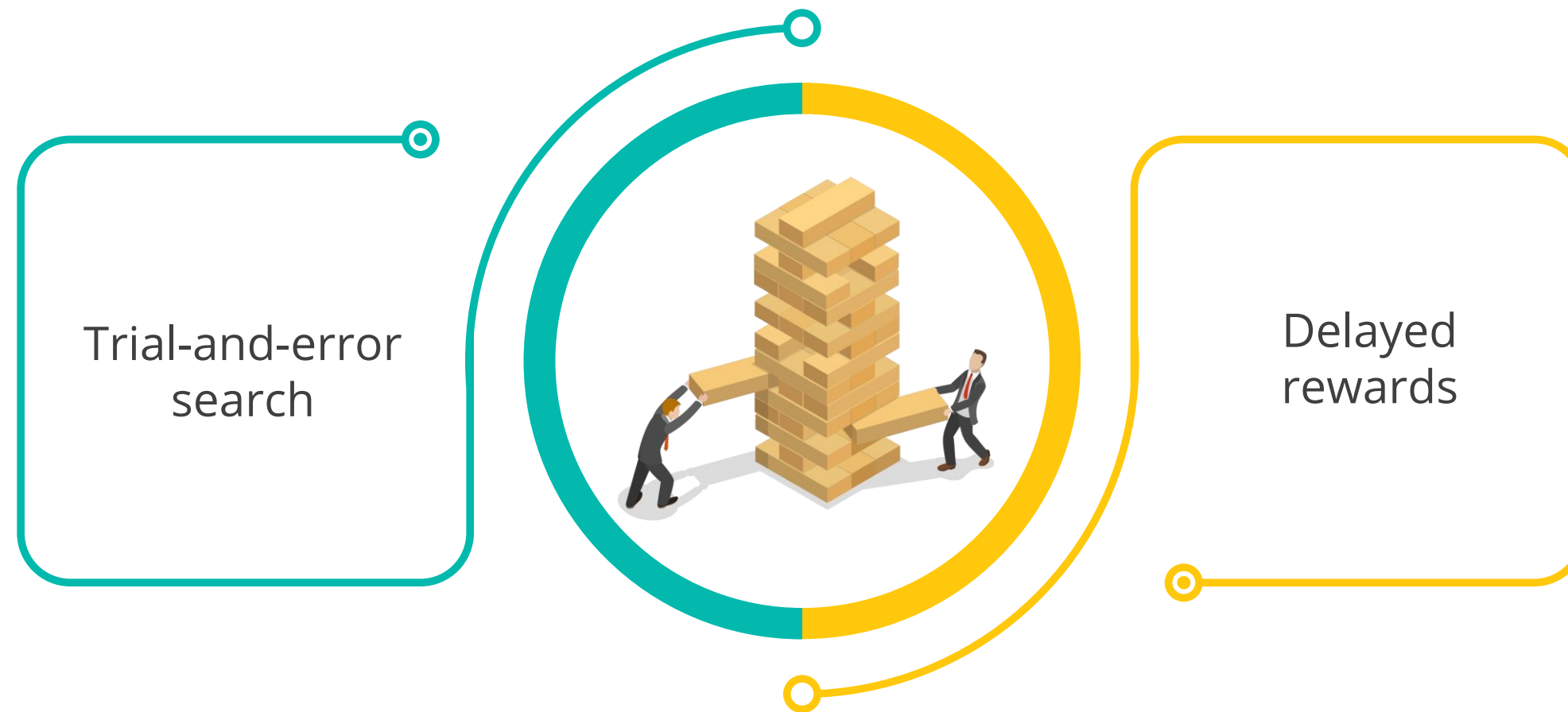


The learner isn't given specific actions but must find the most rewarding ones through trial and error.
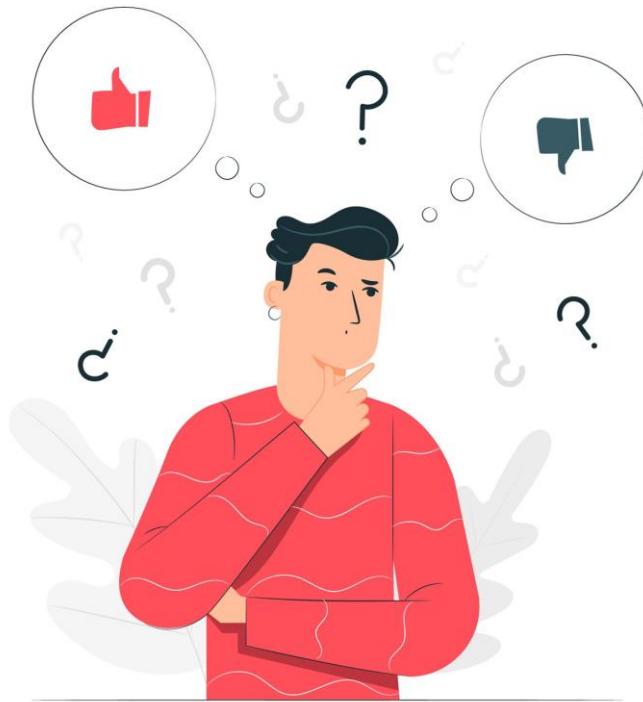
# What Is Reinforcement Learning?

Actions can impact not only immediate rewards but also future situations and subsequent rewards.

The key features that set reinforcement learning apart include:

Trial-and-error search

Delayed rewards

# Do You Agree?

The probability problems involved are formidable... [but] the theory of sequential design will be of the greatest importance to mathematical statistics and science...

– Robins 1952

# History of Reinforcement Learning

Reinforcement Learning (RL) traces its roots back to the 1930s. It originated from the study of animal behaviorism and positive reinforcement conducted by the behavioral psychologist B. F. Skinner.

Positive reinforcement was introduced to increase a behavior.

Negative reinforcement was introduced to decrease a behavior.

# The DeepMind Revolution (2013)

A transformative moment occurred in 2013, led by researchers at DeepMind, a then-emerging startup.

They developed a groundbreaking reinforcement learning algorithm, Deep Q Networks (DQN), capable of mastering a wide array of Atari games from scratch.

Remarkably, this system surpassed human performance in most games without any prior knowledge of their rules.

# The Fusion of Deep Learning With Reinforcement Learning

DeepMind's success story is rooted in the innovative integration of deep learning with reinforcement learning. This fusion resulted in unprecedented advancements in RL.

**Deep learning**

**Reinforcement learning**
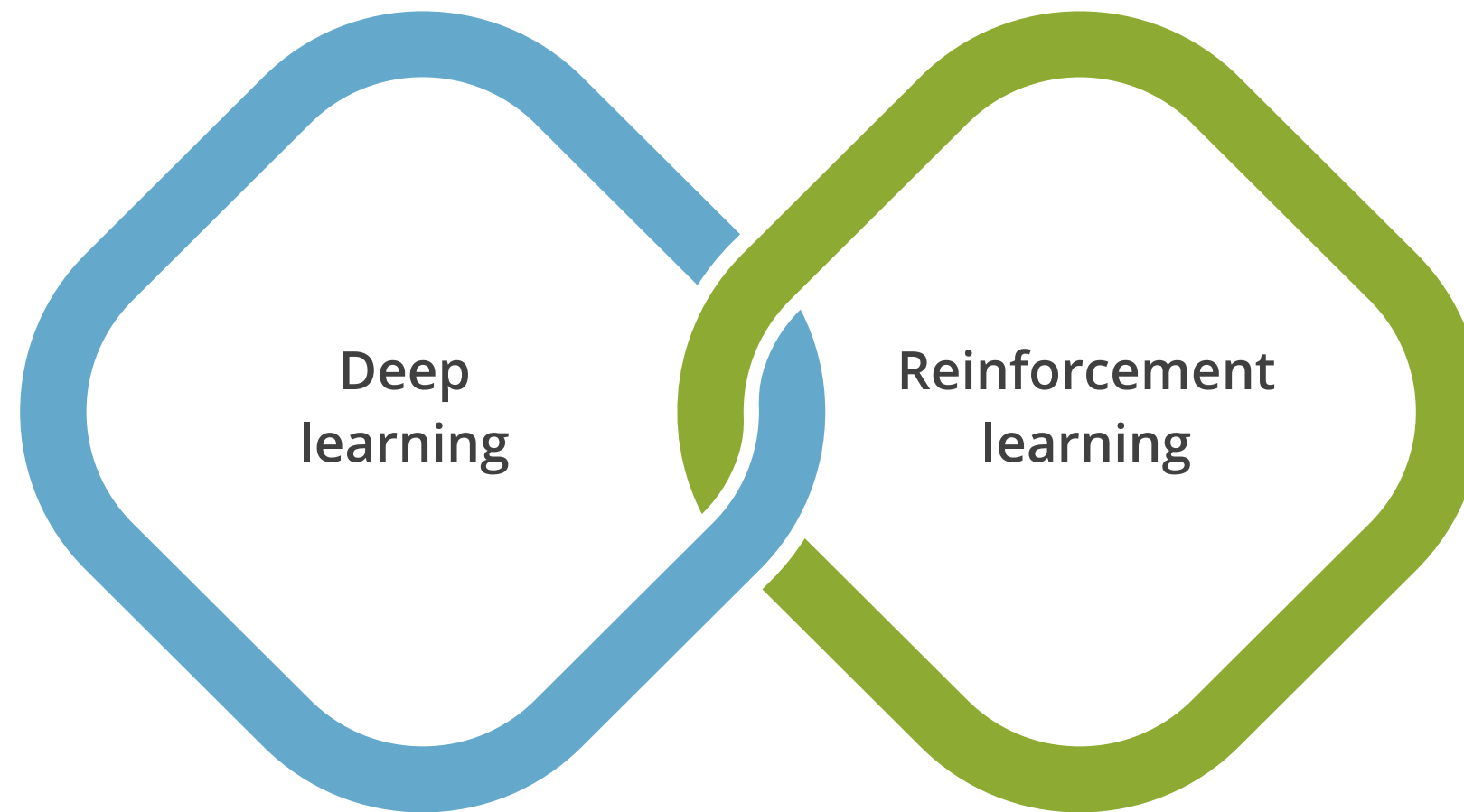
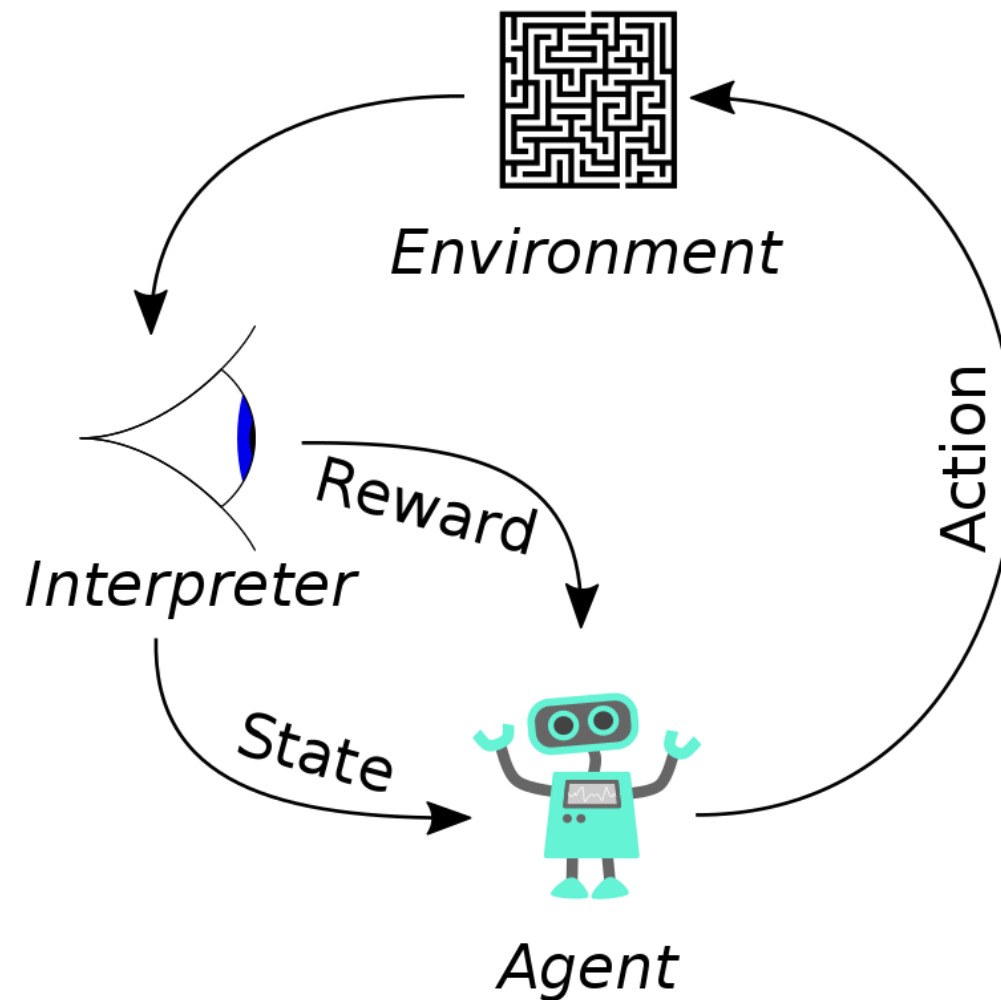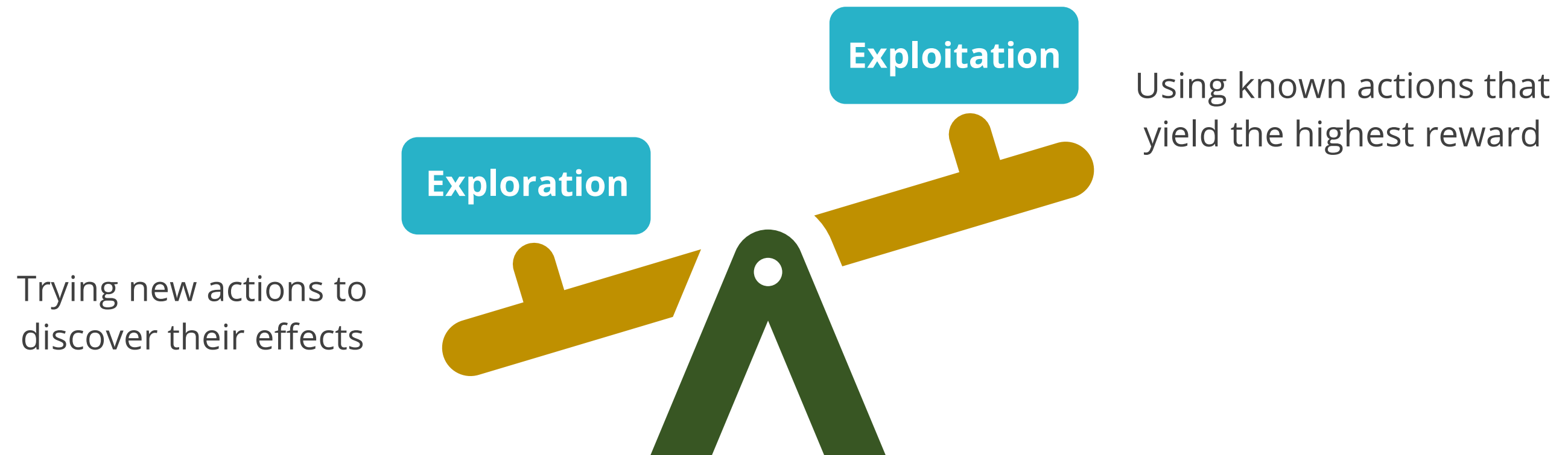# Key Concepts of Reinforcement Learning

# The Process of Reinforcement Learning

The agent acts in the environment and learns by trial and error to maximize its rewards.

# Finding a Fine Balance

A fundamental aspect of RL is the balance between exploration and exploitation.

**Exploitation**

**Exploration**

Using known actions that yield the highest reward

Trying new actions to discover their effects

# Example 1: Automated Thermostat System

Let's consider an example of an automated thermostat system using reinforcement learning.



- Applying reinforcement learning to automated thermostat system makes it capable of dynamically adjusting to changing conditions.

- It helps optimizing energy usage and providing a comfortable environment for occupants.

**Let's explore the example step by step in next few slides**

# Example 1: Automated Thermostat System

Let's consider an example of an automated thermostat system using reinforcement learning.

| Agent | Environment | Action | Reward |
|-------|-------------|--------|--------|



The agent is a smart thermostat system installed in a home or office.

# Example 1: Automated Thermostat System

Let's consider an example of an automated thermostat system using reinforcement learning.

| Agent | **Environment** | Action | Reward |



The environment includes the interior of the building, external weather conditions, and the preferences of the inhabitants.

Let's consider an example of an automated thermostat system using reinforcement learning.

| Agent | Environment | **Action** | Reward |
|-------|-------------|------------|--------|



The actions involve adjusting the heating or cooling settings to maintain a comfortable temperature.

# Example 1: Automated Thermostat System

Let's consider an example of an automated thermostat system using reinforcement learning.

| Agent | Environment | Action | **Reward** |
|-------|-------------|--------|------------|



The reward is calculated based on the energy efficiency achieved and the comfort level maintained.

# Example 1: Automated Thermostat System

Let's consider an example of an automated thermostat system using reinforcement learning.

**Positive rewards**

These are given for maintaining the desired temperature with minimal energy use.

**Negative rewards**

These are given when the system uses excessive energy or fails to keep the temperature within comfortable limits.

# Example 2: Autonomous Underwater Vehicle (AUV)

Let's consider another example of autonomous underwater vehicle (AUV) using reinforcement learning.



Reinforcement learning enables AUVs to:

- Learn from their experiences,

- Make informed decisions, and

- Adapt to unforeseen circumstances.

Ultimately improving their overall performance and efficiency.

**Let's explore the example step by step in next few slides**

Let's consider another example of autonomous underwater vehicle (AUV) using reinforcement learning.

| **Agent** | Environment | Action | Reward |
|---|---|---|---|



The agent is an AUV designed for underwater exploration and data collection.

Let's consider another example of autonomous underwater vehicle (AUV) using reinforcement learning.

| Agent | Environment | Action | Reward |
|-------|-------------|--------|--------|



The environment is the underwater landscape, including varying depths, water currents, marine life, and obstacles like rocks or man-made structures.

Let's consider another example of autonomous underwater vehicle (AUV) using reinforcement learning.

| Agent | Environment | **Action** | Reward |
|-------|-------------|------------|--------|



Actions include navigating through the water, avoiding obstacles, and collecting data using onboard sensors.

Let's consider another example of autonomous underwater vehicle (AUV) using reinforcement learning.

| Agent | Environment | Action | **Reward** |



The reward system might be based on the quantity and quality of data collected.

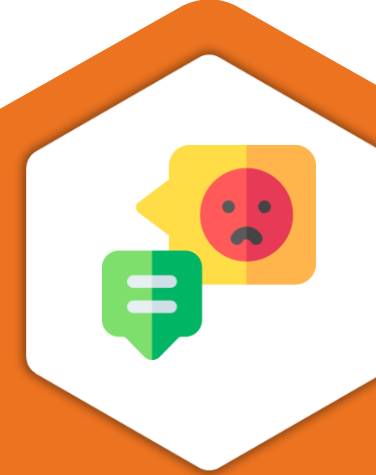# Example 2: Autonomous Underwater Vehicle (AUV)

Let's consider another example of autonomous underwater vehicle (AUV) using reinforcement learning.

## Positive rewards

These are given for successful data acquisition

## Negative rewards

These are given for collisions or inefficient routes.

# Applications and Challenges in Reinforcement Learning
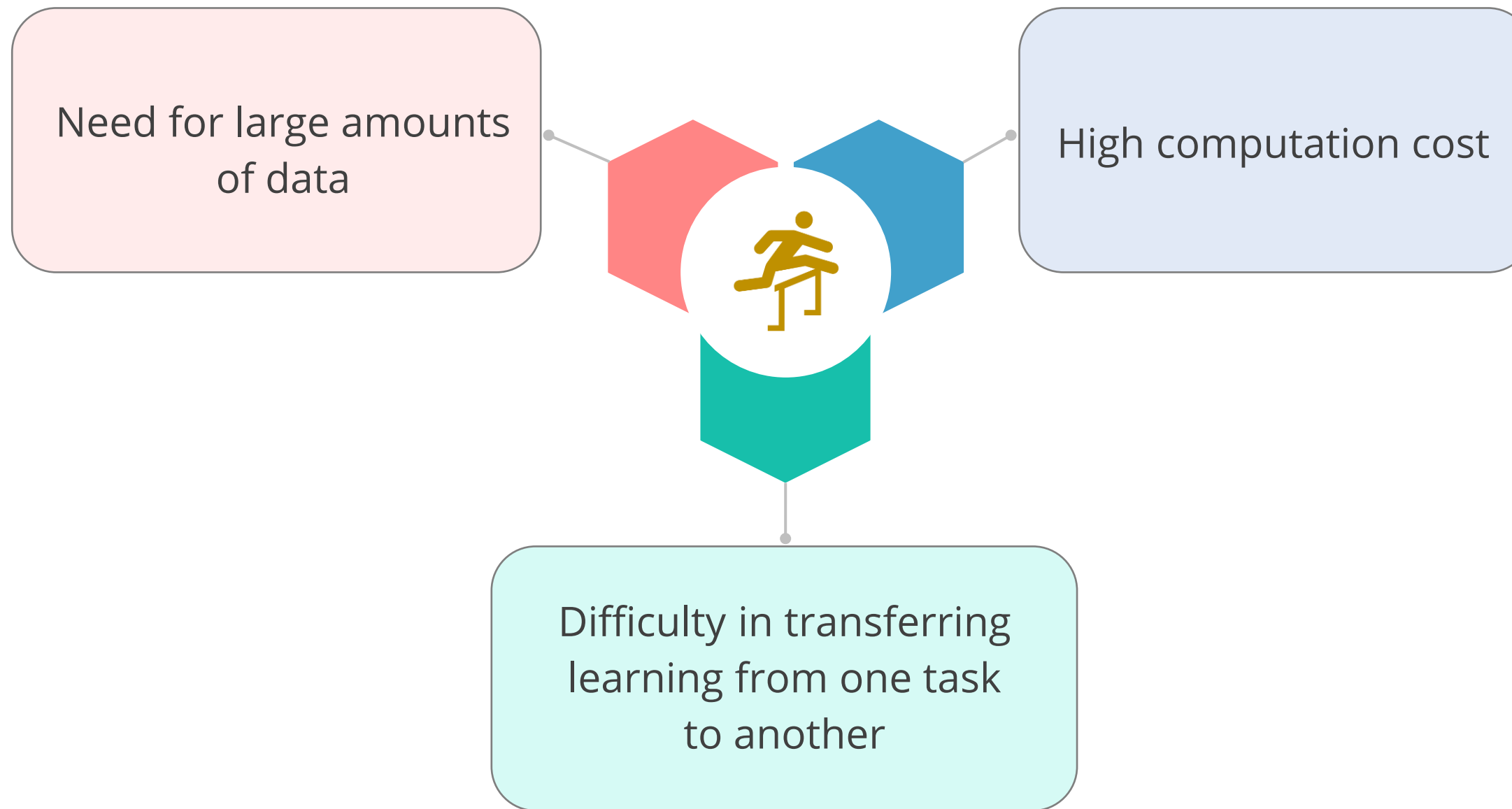
# Applications of Reinforcement Learning

Reinforcement learning has been applied to a diverse range of fields including but not limited to:



Gaming

Autonomous vehicles

Marketing

Finance

Industry automation

Healthcare
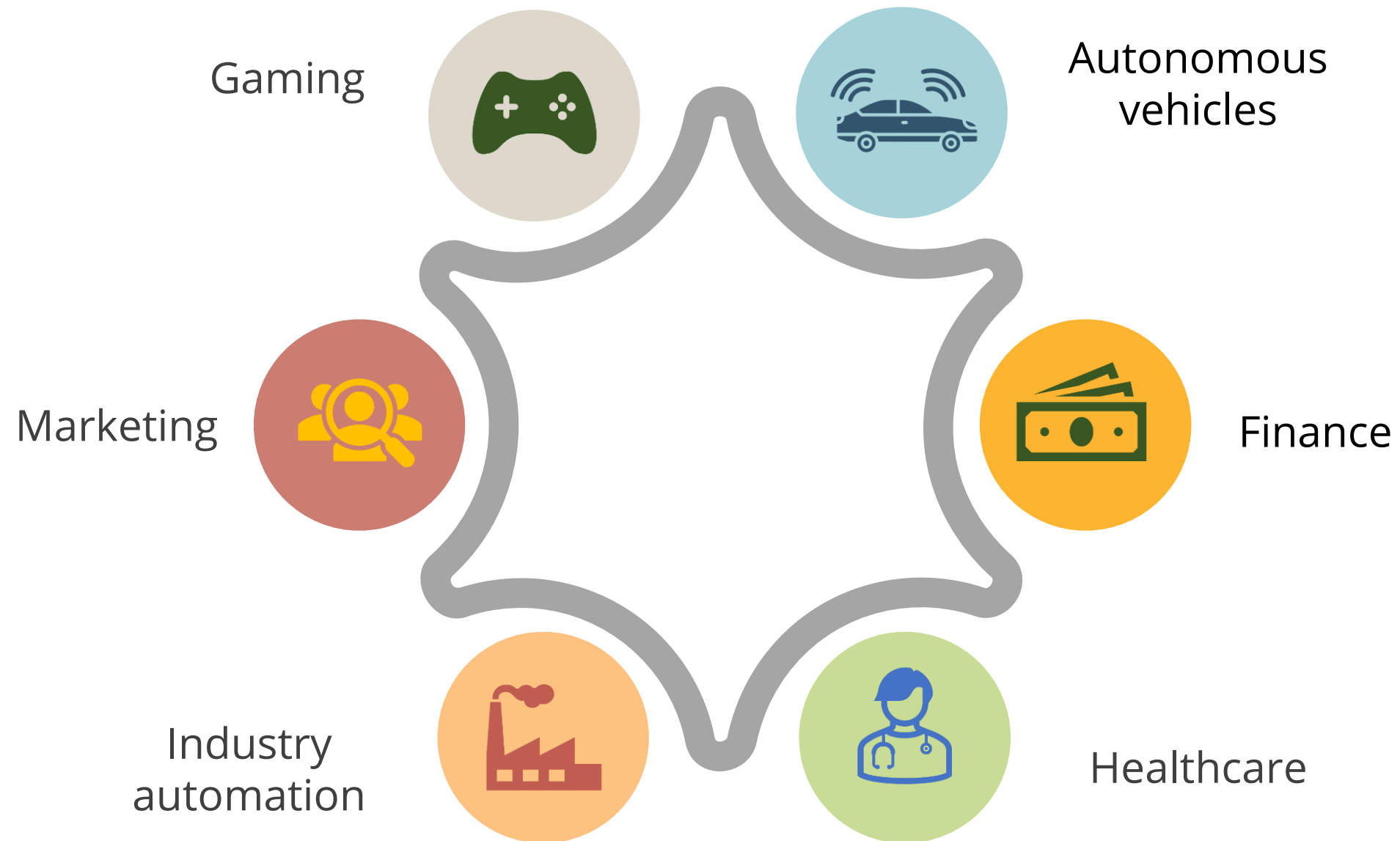
# Challenges of Reinforcement Learning

While reinforcement learning has shown remarkable results, it faces the following challenges



Need for large amounts of data

High computation cost

Difficulty in transferring learning from one task to another

# Key Takeaways

- Reinforcement learning is a ML paradigm where an agent learns to make decisions through interaction with an environment.

- The agent acts in the environment and learns by trial and error to maximize its rewards.

- A fundamental aspect of RL is the balance between exploration and exploitation.

**Knowledge Check**

**What is reinforcement learning?**

A.    A supervised learning technique

B.    A type of unsupervised learning

C.    A machine learning paradigm where an agent learns to make decisions through interaction with an environment

D.    A form of deep learning

## What is reinforcement learning?

A.     A supervised learning technique

B.     A type of unsupervised learning

C.     A machine learning paradigm where an agent learns to make decisions through interaction with an environment

D.     A form of deep learning

The correct answer is **C**

**A machine learning paradigm where an agent learns to make decisions through interaction with an environment.**

**What is the primary goal of an agent in reinforcement learning?**

A.   To memorize the training dataset

B.   To minimize the prediction error

C.   To maximize the cumulative reward over time

D.   To achieve 100% accuracy in decision-making

**What is the primary goal of an agent in reinforcement learning?**

A.    To memorize the training dataset

B.    To minimize the prediction error

C.    To maximize the cumulative reward over time

D.    To achieve 100% accuracy in decision-making

The correct answer is **C**

**The primary goal of an agent is to maximize the cumulative reward over time**

**In reinforcement learning, what is an agent?**

A. The part of the environment the agent interacts with

B. The neural network used for training

C. The learning algorithm

D. The entity that makes decisions and takes actions in an environment

**In reinforcement learning, what is an agent?**

A.   The part of the environment the agent interacts with

B.   The neural network used for training

C.   The learning algorithm

D.   The entity that makes decisions and takes actions in an environment

The correct answer is **D**

**An agent is the entity that makes decisions and takes actions in an environment.**

# Thank You