Assignment 1.1

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Instructions

1. Consider a rational agent. Suppose the performance measure is concerned with just the first T time steps of the environment and ignores everything thereafter. Use real life examples to show that a rational agent's action may depend not just on the state of the environment but also on the time step t ≤ T it has reached. [15 points]

   Hint: Consider any sequential environment in which rewards or goals may take time to arrive.

Answer:

A rational agent is one that tries to maximize its performance measure. When the performance measure is concerned only with the first T time steps of the environment and ignores everything thereafter, the agent's actions can depend not just on the current state of the environment, but also on the specific time step $t \leq T$ that the agent has reached. Here are some examples:

a. **Delivery Drone in a Timed Delivery Task**

   A delivery drone needs to deliver a package to a destination within T minutes, after which the performance measure stops counting. If the drone only considers the current location (environment state), it might take a longer, more scenic route, which could be ideal for energy efficiency but would fail to meet the time-bound delivery. A rational agent (the drone) must consider the time left $t \leq T$ and prioritize a faster route or even riskier paths (e.g., closer to buildings) as t approaches T, to ensure the delivery is completed within the performance window.

b. **Taxi Dispatch System with a Reward for Total Passengers in T Minutes**

A taxi dispatch system aims to maximize passenger pick-ups within a time frame T. If the system only considers current location and passenger requests (state), it might take longer detours or wait for high-fare passengers, which may reduce total pickups within T. To maximize total pickups, the dispatch system adjusts its strategy over time. Early on, it may select passengers based on higher fares. As t approaches T, it might focus on picking up passengers close by, even if the fare is lower, to ensure more rides are completed within the evaluation period.

2. For each of the following, provide a description of the task environment and characteristics as described in section 2.3.2 of the book. Your answers should include descriptions in the following order. Do not mix the order in your answers. [20 points]

Answer:

a. **Fully observable versus partially observable:**

In a **fully observable** environment, an agent's sensors provide complete information about the environment at each step, allowing it to make decisions without needing to infer or guess. With full visibility, the agent can act with confidence, knowing all relevant factors in real time. For example, in **chess**, a chess-playing agent has complete information about the game state because it can "see" the entire board with all positions clearly provided.

In a **partially observable** environment, the agent only has limited information, requiring it to make decisions based on estimations or assumptions about parts of the environment it cannot directly observe. For example, a **self-driving car** has sensors that provide a partial view of the environment, so it may have to estimate the presence of objects around corners or blocked by other vehicles.

b. **Deterministic versus non deterministic/stochastic:**

In a **deterministic** environment, an agent's actions lead to predictable, fixed outcomes. Given a specific action in a specific state, the next state will always be the same, with no randomness involved. For example, in a **chess game**, moving

a piece to a particular square always results in the same outcome, with no chance elements affecting the move's result.

In a **non-deterministic** environment, there is an element of randomness, and actions do not always produce the same results in a given state. In **robot navigation in a crowded area**, even if the robot takes a specific path, the presence and movements of people around it introduce randomness that affects its journey, making the environment non-deterministic.

c. **Episodic vs sequential**

In an **episodic** environment, the agent's actions are divided into distinct episodes, where each action is independent of previous ones. The outcome of one action does not influence the next, so the agent can make decisions based on the current episode without needing to remember past actions. For example, in **image classification**, an AI classifies each image independently without considering previous classifications.

In a **sequential** environment, each action affects future actions and outcomes. The agent considers past actions to make effective decisions, as these have ongoing consequences. For example, in **chess**, each move impacts the possible future moves and strategy, making it a sequential environment where the agent must think ahead and remember past moves.

d. **Static versus dynamic**

In a **static** environment, the environment does not change while the agent is deciding on an action. This stability means the agent doesn't need to account for shifting conditions during its decision-making process. For example, in a **puzzle game** like Sudoku, the puzzle stays the same until the player makes a move, making it a static environment.

In a **dynamic** environment, conditions can change even while the agent is deliberating. For instance, **driving a car** is a dynamic environment where traffic, pedestrians, and signals are constantly changing, requiring the agent to continuously monitor and respond to the environment in real-time.

e. **Discrete versus continuous**

The difference between **discrete** and **continuous** environments can be seen in the state of the environment, the management of time, and the agent's percepts and actions. For example, chess has a limited number of distinct states (not counting the timer), along with discrete percepts and actions. On the other hand, taxi driving presents a continuous-state and continuous-time scenario: the taxi's speed and location, as well as those of other vehicles, vary smoothly over a range of values throughout time. Actions in taxi driving, such as adjusting steering angles, are also continuous. While input from digital cameras is technically discrete, it is usually treated as if it represents continuously varying intensities and locations.

Agent:

- **Single agent versus multi agent**

  The distinction between single-agent and multiagent environments is more complex than it initially appears. In a straightforward case, when an agent solves a crossword puzzle alone, it operates in a **single-agent environment**. In contrast, an agent playing chess interacts with another player, placing it in a **multiagent environment**. However, the comparison raises important questions about what constitutes an agent. For instance, consider agent A, a taxi driver: should it view object B, such as another vehicle, as an agent or merely as an object following physical laws? The key difference lies in whether object B's behavior is aimed at maximizing a performance measure that is influenced by agent A's actions. If B is pursuing its own goals that depend on A's behavior, it qualifies as an agent; if not, it can simply be treated as an inanimate object. This distinction helps clarify the dynamics of interaction in various environments.

Example question:

Playing soccer

Answer: Partially observable, stochastic, sequential, dynamic, continuous, multi agent.

1) Exploring the subsurface oceans of Titan

   Answer: Partially observable, stochastic, sequential, dynamic, continuous, multi-agent

2) Shopping for used AI books on the internet:

   Answer: Partially observable, stochastic, sequential, dynamic, discrete, multi-agent

3) Playing multiple sets (games) in a tennis match

   Answer: Partially observable, stochastic, sequential, dynamic, continuous, multi-agent,

4) Bidding on a single item at an auction 2 out of 2

   Answer: Partially observable, stochastic, sequential, dynamic, discrete, single-agent

3. Consider an agent for a vacuum cleaner environment in which the geography of the environment (extent, boundaries, and obstacles) is unknown as is the initial dirt configuration. The agent can go up and down as well as left and right. Can a simple reflex agent be perfectly rational for this environment? Explain in a few sentences using an example scenario [15 points].

Answer:

In this scenario, a simple reflex agent would struggle to be rational due to the unknown geography and initial dirt configuration. A reflex agent operates based solely on the current percepts, employing condition-action rules without considering the overall environment. For example, if the agent encounters dirt and cleans it but has no awareness of its surroundings, it may inadvertently go back into areas it has already

cleaned. Since the agent cannot remember previous actions or adapt its strategy based on the environment's layout, it cannot optimize its cleaning efficiency or effectively navigate obstacles, rendering it incapable of rational decision-making in this complex and dynamic environment.