Homework 3 AI Algorithm
Markov Decision Process

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1 Vaccination Strategies

In the context of a pandemic like COVID-19, this method can be applied to design vaccination strategies for a population at various scales. For example, a country could be divided into regions or departments, and different parameters could be analyzed to optimize the number of deaths or infections.

States

- **Proportion of vaccinated population:** This is a key parameter as it determines the effectiveness of the actions taken. Additional factors, such as the availability of multiple doses or the demographic group being vaccinated (adults, children, etc.), could also be considered.
- **Infection rate:** Serves as an indicator and can be segmented by population groups.
- **Vaccine dose availability:** Indicates distribution limits and could be influenced by constraints such as storage capacity, delivery schedules, and locations.

Actions

- Distribute doses across regions based on parameters like vulnerable populations or regional infection rates.
- Prioritize high-risk groups.

Rewards

- **Infection reduction:** A reward can be given for each infection prevented, with higher weights for regions with high propagation risks.
- **Logistics cost minimization:** Includes financial costs related to distribution, storage, etc., by optimizing routes and reducing travel distances.

2 Irrigation Planning for Fields and Crops

Smart irrigation management can significantly enhance agricultural productivity, especially in areas where water resources are limited. Using an MDP-based approach, it is possible to optimize water usage to maximize yields while minimizing waste.

States

- **Current soil moisture:** Directly reflects the water needs of crops. Additional factors like soil type, which influences water retention, and crop-specific requirements could also be considered.
- **Weather forecasts:** Helps anticipate not only precipitation but also conditions such as high temperatures or strong winds that increase evaporation.
- **Available water levels:** Includes the amount of stored water and the constraints or delays in delivering it through local infrastructure.

Actions

- Activate irrigation: Decide the optimal time to water crops, avoiding unnecessary actions, such as watering before expected rainfall.
- Adjust water volume: Modulate the amount of water used based on precise crop needs, avoiding overwatering and waste.
- Wait for precipitation: In some cases, doing nothing and relying on predicted rainfall may be the most efficient action.

Rewards

- **Maximizing crop yields:** Increased productivity directly translates into measurable rewards, such as economic gains for farmers.
- **Minimizing water consumption:** Rewards could reflect long-term savings in water resources and reduced environmental impact, critical for sustainable management.

3 Artificial Intelligence in Video Games

AI in video games plays a key role in creating engaging and immersive experiences. The MDP approach helps model complex decisions so the AI can adapt in real time to the player's actions, making the gameplay dynamic and captivating. For instance, in battle royale games (multiplayer games with many players on the same map), AI-controlled bots are often used to fill matches quickly and allow players to showcase their skills against varying levels of competition.

States

- **Current AI position:** Influences interactions with the environment, such as hiding behind obstacles or moving to a strategic vantage point.
- **Enemy and resource status:** Includes not only enemy positions but also their alertness levels or weaknesses, offering opportunities for targeted attacks.
- **Player progression:** Beyond storyline advancement, this state could include indicators of difficulty, such as failure frequency or collected items, allowing the AI to adjust its strategy to match the player's observed capabilities.

Actions

- Move: Tactical choices like taking an advantageous position or escaping high-risk areas.
- Attack: Decide not only when to strike but also what weapon or skill to use to maximize success.
- Defend: Includes dodging, using shields, or seeking temporary shelter.
- Collect items: Gather critical resources like ammunition or health kits to ensure survival and progress.

Rewards

- **Points scored:** Eliminating enemies or achieving objectives increases the player's score, providing immediate feedback.
- **Prolonged survival:** Keeping the AI or the player alive for a certain period can measure success.
- **Achieving game objectives:** Completing missions, such as defeating a boss or solving a puzzle, is a significant reward.

Extending the MDP Framework

MDPs can also model less tangible aspects, such as the player's emotional experience. For example, if the player shows signs of frustration (detected through inactivity or repeated errors), the AI could adapt the difficulty to prevent abandonment. Similarly, scenarios, scenes, or dialogues could be tailored based on the player's choices or actions in the game. Those potential parameters demonstrate how we can stretch the development of the MDP into some complex subjects such as video games.