* **Explain how reinforcement learning concepts apply to the cartpole problem.**
  + What is the goal of the agent in this case?

In the problem, the agent that maneuvers in the environment, must determine how to move the cart to maintain the pole’s balance. According to Surma, “The goal is to keep the cartpole balanced by applying appropriate forces to a pivot point.” (Surma, 2021, para 1). When the runs are complete, a number is outputted that will be used for future references to enable better results for machine learning.

* + What are the various state values?

The states are the variables that identify the current position of the agent. The various state values are the exploration factor and learning rate.

* + What are the possible actions that can be performed?

Possible actions on the cart are moving it left or right, which can cause the pole to be balanced or topple over. The exploration maximum, minimum, and decay are the determining factor of the possible actions that can be performed.

* + What reinforcement algorithm is used for this problem?

The reinforcement algorithm used for this problem is the deep Q-learning technique, which combines Q-learning with neural networks to understand optimal actions better.

* **Analyze how experience replay is applied to the cartpole problem.**
  + How does experience replay work in this algorithm?

The experience replay work in the algorithm Is the process that samples each action and updates the connected Q-value. According to Kerner, “Q-learning is a machine learning approach that enables a model to iteratively learn and improve over time by taking the correct action.” (Karner, n.d., para 1). Since the Q-values measure the quality of the movement, they can determine the best action for the given algorithms.

* + What is the effect of introducing a discount factor for calculating the future rewards?

John states, “The discount factor influences the rat’s preference for short-term or long-term rewards. The discount factor in reinforcement learning plays a crucial role in balancing the importance of immediate rewards versus future rewards.” (John, 2021, para 13). The effect of introducing a discount factor for calculating the future rewards is that if discount factors are set to higher values that are closer to one, there are long-term rewards. However, when the factors are closer to zero, the agents will focus on short-term gains.

* **Analyze how neural networks are used in deep Q-learning.**
  + Explain the neural network architecture that is used in the cartpole problem.

Depending on the states that are passed on the neural networks, the neural networks can estimate each Q-value per action. Neural networks architecture has interconnected layers that translate data into meaningful representations. In the cartpole problem, the neural networks are used to determine what is the largest Q-value for the best current known action for the state.

* + How does the neural network make the Q-learning algorithm more efficient?

Neural networks make Q-learning algorithms more efficient because of their approximation with the Q-value function. When the state is taken as the input, all possible actions are generated as outputs within the Q-learning algorithm. Neural networks also do not affect the distribution of states, actions, and rewards because Q-learning uses experience replay to learn in small batches.

* + What difference do you see in the algorithm performance when you increase or decrease the learning rate?

When the learning rate is increased, the algorithms performance becomes less accurate.

**References**

John, I. (2023, August 12). Deep Reinforcement Learning: building intelligent agents. *Medium*. <https://medium.com/@irisjohn/deep-reinforcement-learning-building-intelligent-agents-cb87e0240a71>

Kerner, S. M. (2023, May 22). *Q-learning*. Enterprise AI. <https://www.techtarget.com/searchenterpriseai/definition/Q-learning>

Surma, G. (2021, October 13). Cartpole - Introduction to Reinforcement Learning (DQN - Deep Q-Learning). *Medium*. <https://gsurma.medium.com/cartpole-introduction-to-reinforcement-learning-ed0eb5b58288>