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

The goal of the agent in this case is to balance the pole vertically on a moving cart for as long as possible, gaining a reward for every timestep.

* + What are the various state values?

The various state values are the cart position, pole angle, cart velocity, and pole angular velocity.

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

The possible actions that can be performed are moving the cart left or right to keep the pole upright for as long as possible.

* + What reinforcement algorithm is used for this problem?

The reinforcement algorithm used for this problem is a deep Q-learning algorithm (DQN).

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

Experience replay works in this algorithm because it uses minibatches and stores the agent’s experiences that include state, action, reward, and next state. The Q-values are calculated for each state/action pair, if this pair continues the game play the Q-value will be positive, if this pair ends the game the Q-value will be negative.

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

A discount factor, commonly referred to as GAMMA, that approaches 1 incentivizes the agent to prioritize long-term advantageous strategies and future rewards, thereby enabling more informed and strategic decision-making.

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

The neural network architecture that is used in the cartpole problem has an input layer that includes the state of the environment (pole angle, pole angular velocity, cart position, and cart velocity). This connects the hidden layers with Relu activation function that pulls out features and learns the representations of the input state. These layers connect to the output layer that has 2 outcomes for each action (Balawedjer, 2021).

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

The neural network makes the Q-learning algorithm more efficient by allowing it to run faster by estimated Q values. These Q-values represent the rewards for each state/action pair which allows the agent to play more efficiently.

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

The values that I adjusted: GAMMA from 0.95 to 0.99, learning rate from 0.001 to 0.005, Exploration MIN from 0.01 to 0.005, and the Exploration Decay from 0.995 to 0.95. The base code output was solved in 129 runs, 229 total runs. After adjusting the value listed above, the output is solved in 45 runs, 145 total runs. Demonstrating that the agent was able to solve the problem faster with the averages very close in both examples, although the max value was higher in the base code.

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