

Project overview

This project aims to implement the Q-Learning Algorithm and the Deep Q Learning Network (DQN) and compare the learning process and prediction result in the same environment. The implementation and the comparison is done with the Taxi game version 3 under the Toy Text environment provided by the OpenAI Gymnasium library. The Q-learning agent and the DQN agent are built using mainly NumPy and PyTorch libraries.

Approach

Environment

Description In the Taxi game environment, the Taxi agent is randomly spawned into a 5x5 grid world with 4 pick-up/drop-off locations on the Map in Red, Green, Yellow, and Blue colour respectively.

The goal of the game is to let the Taxi agent

1. navigate to the passenger's location
2. pick up the passenger
3. head to the passenger's desired destination (1 of the 4 locations)
4. drop off the passenger at that destination

End of Episode The Taxi game is terminated once the Taxi agent drops off the passenger.

An episode is truncated if the Taxi agent fails to terminate after 200 steps by default.

Game Id

"Taxi-v3"

Action Space

The Taxi agent has totally 6 actions to choose from the range of {0, 1, 2, 3, 4, 5}.

From 0 to 3, each of the number indicates the direction of action.

From 4 to 5, each of the number represents picking up or dropping off the passenger.

- 0 = Head South (Down)
- 1 = Head North (Up)
- 2 = Head East (Right)
- 3 = Head West (Left)

- 4 = Picking up the passenger
- 5 = Dropping off the passenger

Observation Space

In the 5x5 grid world, there are 25 valid position for the Taxi agent to be in.

The passenger can be in 5 unique locations {Red, Greed, Yellow, Blue, Taxi}.

And there are 4 destinations to drop off the passenger {Red, Greed, Yellow, Blue}.

In total, the Taxi game has $(5 \times 5) \times 5 \times 4 = 500$ discrete number of states with 6 possible actions.

Rewards

Incorrect attempts to pick up or drop off the passenger at the wrong location is punished with negative reward of -10 .

Each step also comes with -1 negative reward as living penalty.

Successfully dropping off the passenger at the correct destination is encouraged with positive reward of $+20$.

Choice of model(s)

Q-learning Algorithm

Q-learning in reinforcement learning is essentially a lookup table algorithm. The Q-learning algorithm uses function approximator from a single experience to estimate the state-action and updates the result Q values in a lookup Q value table as reference for the agent to navigate. With the help of the epsilon greedy policy to switch between exploration and exploitation, Q-learning learns the optimal Q-values for every Q state and eventually converge to the optimal policy by taking suboptimal and random actions iteratively.

Deep-Q learning Network

The Deep-Q Network (DQN) is a reinforcement learning algorithm that combines the Q-learning Algorithm and multilayer networks (or neural networks). In essence, the DQN is the same idea as Q-learning in general but replaces the function approximator in the Q-learning with a deep neural network. The DQN takes the representation of the states in something like a one-hot encoded vector to approximate the Q value for output actions along with the weights and bias in the neural network. DQN learns from experience which consists of a state, an action, a reward, and the next state. To prevent learning from sequential experience which usually correlate with each other and lead to overfitting, DQN randomizes the training data before sending to the neural network. DQN does so by utilizing a Replay Memory buffer where a batch of random sample experience is passed on to the multilayer neural network for training only if the batch of experience is filled.

Methods and Purpose of Testing and Experiments

The project focuses on comparing the Q-learning and DQN algorithms in 4 major aspects:

- compare the average reward improvement during the training phase with controlled parameters
- compare prediction performance with controlled parameters
- compare the average reward improvement the training phase with fine-tuned parameters
- compare the prediction performance with fine-tuned parameters

Note:

Controlled parameters refer to using the same controlled value for parameters in common, like learning rate α , and discount rate γ .

Fine-tuned parameters refer to manually fine-tuned and optimized parameters to maximize the reward prediction of the models.

Taxi agent is encouraged with higher reward if the shortest path and correct actions are being taken due to the living penalty, illegal action punishment, and correct action rewards.

Challenges and Trouble Shooting

Difficulty in setting up Stable Baselines for Taxi environment

Initially, the original plan of this project was to do a implementation and comparison between Q-learning, Deep-Q Network (DQN), Advantage Actor Critic (A2C), and Proximal Policy Optimization (PPO). However, after a long struggle, I was not able set the DQN, A2C, PRO models up to perform any decent prediction in the Taxi environment. The training phase of the models often ends abruptly after only a few episodes and the result prediction keeps telling the Taxi agent to run into a wall. I suspect the complex multilayer networks models do not really fit well for the Discrete and relatively small action and observation space of the Taxi problem and, hence, perform significantly worse than the Q-learning algorithm. Therefore, the project is eventually shifted its focus to the implementation and comparison between Q-learning and DQN using the NumPy and PyTorch libraries.

Designing and Implementing Q Learning Agent

Unlike the previous reinforcement learning homework where the series of Agents are already welled designed and implemented for students to only fill in the blanks of the Q-learning algorithm, this project needs to recreate a Q-learning agent in a completely new and different environment. Initially, I tried to mimic the Pacman agent design but soon realized that a lot of the component are just not necessary or do not fit for Taxi game environment, like the `getQvalue()`, `getPolicy()`, `getAction()` functions. The Taxi environment already has built-in solutions, like `env.step(action)`. Therefore, the project leans the essence of the Pacman agent design, that is, the object-oriented class hierarchy where there is first the Agent class, then the ValueEstimationAgent class, the ReinforcementLearningAgent class,

the QLearningAgent class, and finally the DQNAgent class. Based on this Object-Oriented design and the guidance of the [huggingface deep reinforcement learning hands-on tutorial](#), this project adds its own constructors, fields, methods for the agent classes, including fields to instantiate and store the Taxi game environment and to represent Q value table space in NumPy array form for better performance.

Designing and Implementing DQN Agent

The DQN Agent design is heavily influenced by the [PyTorch Reinforcement Learning \(DQN\) Tutorial](#). This is partly because I only have limited knowledge and understanding on how the neural networks works exactly and partly because I have no previous experience in building a neural network in PyTorch from scratch. After some struggling, I realized that the training and optimization functions from the PyTorch tutorial DQN cannot really run on the Taxi environment due to difference in PyTorch version and the Observation space. Unlike the ready-to-use DQN model from Stable Baselines which can be easily adjusted by fiddling the function parameters, the PyTorch DQN design requires manually delve into the nitty-gritty of the model which, unfortunately, is something I am not confident enough to get into at the moment. Eventually, I discovered another DQN tutorial that runs on a Discrete action and observation space of the Frozen Lake, a game environment similar yet different from the Taxi game. Following the tutorial video on YouTube [Deep Q-Learning/Deep Q-Network \(DQN\) Explained | Python PyTorch Deep Reinforcement Learning](#) and the demo code on GitHub, I gradually walk through and modify the DQN PyTorch model to fit for the requirement of the Taxi environment. Though, it was a massive challenge to figure out which part of the code is corresponding to which part of the DQN algorithm, like how to store the Replay Memory, when to batch the experience, how to train on the batch data in the 3 layers neural network, and when to use the optimizer properly.

Result: show the result and interpretation of your experiment. Any iterative improvements summary.

The following is the code implemented for Q-learning agent, DQN agent, and the performance comparison.

```
In [16]: !pip install -U pip
!pip install -U torch
!pip install -U torchvision
!pip install gymnasium
!pip install matplotlib
!pip install imageio
```

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Requirement already satisfied: pip in /opt/anaconda3/lib/python3.12/site-packages (24.2)
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Requirement already satisfied: pillow>=8.3.2 in /opt/anaconda3/lib/python3.12/site-packages (from imageio) (10.3.0)

```
In [17]: import gymnasium as gym
import ale_py
# if using gymnasium
import shimmy

# print(gym.envs.registry.keys())
gym.envs.registration.registry.keys()
```

```
Out[17]: dict_keys(['CartPole-v0', 'CartPole-v1', 'MountainCar-v0', 'MountainCarContinuous-v0', 'Pendulum-v1', 'Acrobot-v1', 'phys2d/CartPole-v0', 'phys2d/CartPole-v1', 'phys2d/Pendulum-v0', 'LunarLander-v3', 'LunarLanderContinuous-v3', 'BipedalWalker-v3', 'BipedalWalkerHardcore-v3', 'CarRacing-v2', 'Blackjack-v1', 'FrozenLake-v1', 'FrozenLake8x8-v1', 'CliffWalking-v0', 'Taxi-v3', 'tabular/Blackjack-v0', 'tabular/CliffWalking-v0', 'Reacher-v2', 'Reacher-v4', 'Reacher-v5', 'Pusher-v2', 'Pusher-v4', 'Pusher-v5', 'InvertedPendulum-v2', 'InvertedPendulum-v4', 'InvertedPendulum-v5', 'InvertedDoublePendulum-v2', 'InvertedDoublePendulum-v4', 'InvertedDoublePendulum-v5', 'HalfCheetah-v2', 'HalfCheetah-v3', 'HalfCheetah-v4', 'HalfCheetah-v5', 'Hopper-v2', 'Hopper-v3', 'Hopper-v4', 'Hopper-v5', 'Swimmer-v2', 'Swimmer-v3', 'Swimmer-v4', 'Swimmer-v5', 'Walker2d-v2', 'Walker2d-v3', 'Walker2d-v4', 'Walker2d-v5', 'Ant-v2', 'Ant-v3', 'Ant-v4', 'Ant-v5', 'Humanoid-v2', 'Humanoid-v3', 'Humanoid-v4', 'Humanoid-v5', 'HumanoidStandup-v2', 'HumanoidStandup-v4', 'HumanoidStandup-v5', 'Adventure-v0', 'AdventureDeterministic-v0', 'AdventureNoFrameskip-v0', 'Adventure-v4', 'AdventureDeterministic-v4', 'AdventureNoFrameskip-v4', 'Adventure-ram-v0', 'Adventure-ramDeterministic-v0', 'Adventure-ramNoFrameskip-v0', 'Adventure-ram-v4', 'Adventure-ramDeterministic-v4', 'Adventure-ramNoFrameskip-v4', 'AirRaid-v0', 'AirRaidDeterministic-v0', 'AirRaidNoFrameskip-v0', 'AirRaid-v4', 'AirRaidDeterministic-v4', 'AirRaidNoFrameskip-v4', 'AirRaid-ram-v0', 'AirRaid-ramDeterministic-v0', 'AirRaid-ramNoFrameskip-v0', 'AirRaid-ram-v4', 'AirRaid-ramDeterministic-v4', 'AirRaid-ramNoFrameskip-v4', 'Alien-v0', 'AlienDeterministic-v0', 'AlienNoFrameskip-v0', 'Alien-v4', 'AlienDeterministic-v4', 'AlienNoFrameskip-v4', 'Alien-ram-v
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tankham-ramNoFrameskip-v4', 'UpNDown-v0', 'UpNDownDeterministic-v0', 'UpNDownNoFrameskip-v0', 'UpNDown-v4', 'UpNDownDeterministic-v4', 'UpNDownNoFrameskip-v4', 'UpNDown-ram-v0', 'UpNDown-ramDeterministic-v0', 'UpNDown-ramNoFrameskip-v0', 'UpNDown-ram-v4', 'UpNDown-ramDeterministic-v4', 'UpNDown-ramNoFrameskip-v4', 'Venture-v0', 'VentureDeterministic-v0', 'VentureNoFrameskip-v0', 'Venture-v4', 'VentureDeterministic-v4', 'VentureNoFrameskip-v4', 'Venture-ram-v0', 'Venture-ramDeterministic-v0', 'Venture-ramNoFrameskip-v0', 'Venture-ram-v4', 'Venture-ramDeterministic-v4', 'Venture-ramNoFrameskip-v4', 'VideoPinball-v0', 'VideoPinballDeterministic-v0', 'VideoPinballNoFrameskip-v0', 'VideoPinball-v4', 'VideoPinballDeterministic-v4', 'VideoPinballNoFrameskip-v4', 'VideoPinball-ram-v0', 'VideoPinball-ramDeterministic-v0', 'VideoPinball-ramNoFrameskip-v0', 'VideoPinball-ram-v4', 'VideoPinball-ramDeterministic-v4', 'VideoPinball-ramNoFrameskip-v4', 'WizardOfWor-v0', 'WizardOfWorDeterministic-v0', 'WizardOfWorNoFrameskip-v0', 'WizardOfWor-v4', 'WizardOfWorDeterministic-v4', 'WizardOfWorNoFrameskip-v4', 'WizardOfWor-ram-v0', 'WizardOfWor-ramDeterministic-v0', 'WizardOfWor-ramNoFrameskip-v0', 'WizardOfWor-ram-v4', 'WizardOfWor-ramDeterministic-v4', 'WizardOfWor-ramNoFrameskip-v4', 'YarsRevenge-v0', 'YarsRevengeDeterministic-v0', 'YarsRevengeNoFrameskip-v0', 'YarsRevenge-v4', 'YarsRevengeDeterministic-v4', 'YarsRevengeNoFrameskip-v4', 'YarsRevenge-ram-v0', 'YarsRevenge-ramDeterministic-v0', 'YarsRevenge-ramNoFrameskip-v0', 'YarsRevenge-ram-v4', 'YarsRevenge-ramDeterministic-v4', 'YarsRevenge-ramNoFrameskip-v4', 'Zaxxon-v0', 'ZaxxonDeterministic-v0', 'ZaxxonNoFrameskip-v0', 'Zaxxon-v4', 'ZaxxonDeterministic-v4', 'ZaxxonNoFrameskip-v4', 'Zaxxon-ram-v0', 'Zaxxon-ramDeterministic-v0', 'Zaxxon-ramNoFrameskip-v0', 'Zaxxon-ram-v4', 'Zaxxon-ramDeterministic-v4', 'Zaxxon-ramNoFrameskip-v4', 'ALE/Adventure-v5', 'ALE/Adventure-ram-v5', 'ALE/AirRaid-v5', 'ALE/AirRaid-ram-v5', 'ALE/Alien-v5', 'ALE/Alien-ram-v5', 'ALE/Amidar-v5', 'ALE/Amidar-ram-v5', 'ALE/Assault-v5', 'ALE/Assault-ram-v5', 'ALE/Asterix-v5', 'ALE/Asterix-ram-v5', 'ALE/Asteroids-v5', 'ALE/Asteroids-ram-v5', 'ALE/Atlantis2-v5', 'ALE/Atlantis2-ram-v5', 'ALE/Atlantis-v5', 'ALE/Atlantis-ram-v5', 'ALE/Backgammon-v5', 'ALE/Backgammon-ram-v5', 'ALE/BankHeist-v5', 'ALE/BankHeist-ram-v5', 'ALE/BasicMath-v5', 'ALE/BasicMath-ram-v5', 'ALE/BattleZone-v5', 'ALE/BattleZone-ram-v5', 'ALE/BeamRider-v5', 'ALE/BeamRider-ram-v5', 'ALE/Berzerk-v5', 'ALE/Berzerk-ram-v5', 'ALE/Blackjack-v5', 'ALE/Blackjack-ram-v5', 'ALE/Bowling-v5', 'ALE/Bowling-ram-v5', 'ALE/Boxing-v5', 'ALE/Boxing-ram-v5', 'ALE/Breakout-v5', 'ALE/Breakout-ram-v5', 'ALE/Carnival-v5', 'ALE/Carnival-ram-v5', 'ALE/Casino-v5', 'ALE/Casino-ram-v5', 'ALE/Centipede-v5', 'ALE/Centipede-ram-v5', 'ALE/ChopperCommand-v5', 'ALE/ChopperCommand-ram-v5', 'ALE/Combat-v5', 'ALE/Combat-ram-v5', 'ALE/CrazyClimber-v5', 'ALE/CrazyClimber-ram-v5', 'ALE/Crossbow-v5', 'ALE/Crossbow-ram-v5', 'ALE/Darkchambers-v5', 'ALE/Darkchambers-ram-v5', 'ALE/Defender-v5', 'ALE/Defender-ram-v5', 'ALE/DemonAttack-v5', 'ALE/DemonAttack-ram-v5', 'ALE/DonkeyKong-v5', 'ALE/DonkeyKong-ram-v5', 'ALE/DoubleDunk-v5', 'ALE/DoubleDunk-ram-v5', 'ALE/Earthworld-v5', 'ALE/Earthworld-ram-v5', 'ALE/ElevatorAction-v5', 'ALE/ElevatorAction-ram-v5', 'ALE/Enduro-v5', 'ALE/Enduro-ram-v5', 'ALE/Entombed-v5', 'ALE/Entombed-ram-v5', 'ALE/Et-v5', 'ALE/Et-ram-v5', 'ALE/FishingDerby-v5', 'ALE/FishingDerby-ram-v5', 'ALE/FlagCapture-v5', 'ALE/FlagCapture-ram-v5', 'ALE/Freeway-v5', 'ALE/Freeway-ram-v5', 'ALE/Frogger-v5', 'ALE/Frogger-ram-v5', 'ALE/Frostbite-v5', 'ALE/Frostbite-ram-v5', 'ALE/Galaxian-v5', 'ALE/Galaxian-ram-v5', 'ALE/Gopher-v5', 'ALE/Gopher-ram-v5', 'ALE/Gravitar-v5', 'ALE/Gravitar-ram-v5', 'ALE/Hangman-v5', 'ALE/Hangman-ram-v5', 'ALE/HauntedHouse-v5', 'ALE/HauntedHouse-ram-v5', 'ALE/Hero-v5', 'ALE/Hero-ram-v5', 'ALE/HumanCannonball-v5', 'ALE/HumanCannonball-ram-v5', 'ALE/IceHockey-v5', 'ALE/IceHockey-ram-v5', 'ALE/Jamesbond-v5', 'ALE/Jamesbond-ram-v5', 'ALE/JourneyEscape-v5', 'ALE/JourneyEscape-

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ram-v5', 'ALE/Joust-v5', 'ALE/Joust-ram-v5', 'ALE/Kaboom-v5', 'ALE/Kaboom-ram-v5', 'ALE/Kangaroo-v5', 'ALE/Kangaroo-ram-v5', 'ALE/KeystoneKapers-v5', 'ALE/KeystoneKapers-ram-v5', 'ALE/KingKong-v5', 'ALE/KingKong-ram-v5', 'ALE/Klax-v5', 'ALE/Klax-ram-v5', 'ALE/Koolaid-v5', 'ALE/Koolaid-ram-v5', 'ALE/Krull-v5', 'ALE/Krull-ram-v5', 'ALE/KungFuMaster-v5', 'ALE/KungFuMaster-ram-v5', 'ALE/LaserGates-v5', 'ALE/LaserGates-ram-v5', 'ALE/LostLuggage-v5', 'ALE/LostLuggage-ram-v5', 'ALE/MarioBros-v5', 'ALE/MarioBros-ram-v5', 'ALE/MazeCraze-v5', 'ALE/MazeCraze-ram-v5', 'ALE/MiniatureGolf-v5', 'ALE/MiniatureGolf-ram-v5', 'ALE/MontezumaRevenge-v5', 'ALE/MontezumaRevenge-ram-v5', 'ALE/MrDo-v5', 'ALE/MrDo-ram-v5', 'ALE/MsPacman-v5', 'ALE/MsPacman-ram-v5', 'ALE/NameThisGame-v5', 'ALE/NameThisGame-ram-v5', 'ALE/Othello-v5', 'ALE/Othello-ram-v5', 'ALE/Pacman-v5', 'ALE/Pacman-ram-v5', 'ALE/Phoenix-v5', 'ALE/Phoenix-ram-v5', 'ALE/Pitfall2-v5', 'ALE/Pitfall2-ram-v5', 'ALE/Pitfall-v5', 'ALE/Pitfall-ram-v5', 'ALE/Pong-v5', 'ALE/Pong-ram-v5', 'ALE/Pooyan-v5', 'ALE/Pooyan-ram-v5', 'ALE/PrivateEye-v5', 'ALE/PrivateEye-ram-v5', 'ALE/Qbert-v5', 'ALE/Qbert-ram-v5', 'ALE/Riverraid-v5', 'ALE/Riverraid-ram-v5', 'ALE/RoadRunner-v5', 'ALE/RoadRunner-ram-v5', 'ALE/Robotank-v5', 'ALE/Robotank-ram-v5', 'ALE/Seaquest-v5', 'ALE/Seaquest-ram-v5', 'ALE/SirLancelot-v5', 'ALE/SirLancelot-ram-v5', 'ALE/Skiing-v5', 'ALE/Skiing-ram-v5', 'ALE/Solaris-v5', 'ALE/Solaris-ram-v5', 'ALE/SpaceInvaders-v5', 'ALE/SpaceInvaders-ram-v5', 'ALE/SpaceWar-v5', 'ALE/SpaceWar-ram-v5', 'ALE/StarGunner-v5', 'ALE/StarGunner-ram-v5', 'ALE/Superman-v5', 'ALE/Superman-ram-v5', 'ALE/Surround-v5', 'ALE/Surround-ram-v5', 'ALE/Tennis-v5', 'ALE/Tennis-ram-v5', 'ALE/Tetris-v5', 'ALE/Tetris-ram-v5', 'ALE/TicTacToe3D-v5', 'ALE/TicTacToe3D-ram-v5', 'ALE/TimePilot-v5', 'ALE/TimePilot-ram-v5', 'ALE/Trondead-v5', 'ALE/Trondead-ram-v5', 'ALE/Turmoil-v5', 'ALE/Turmoil-ram-v5', 'ALE/Tutankham-v5', 'ALE/Tutankham-ram-v5', 'ALE/UpNDown-v5', 'ALE/UpNDown-ram-v5', 'ALE/Venture-v5', 'ALE/Venture-ram-v5', 'ALE/VideoCheckers-v5', 'ALE/VideoCheckers-ram-v5', 'ALE/VideoChess-v5', 'ALE/VideoChess-ram-v5', 'ALE/VideoCube-v5', 'ALE/VideoCube-ram-v5', 'ALE/VideoPinball-v5', 'ALE/VideoPinball-ram-v5', 'ALE/Warlords-v5', 'ALE/Warlords-ram-v5', 'ALE/WizardOfWor-v5', 'ALE/WizardOfWor-ram-v5', 'ALE/WordZapper-v5', 'ALE/WordZapper-ram-v5', 'ALE/YarsRevenge-v5', 'ALE/YarsRevenge-ram-v5', 'ALE/Zaxxon-v5', 'ALE/Zaxxon-ram-v5', 'GymV26Environment-v0', 'GymV21Environment-v0'])

```

```

In [18]: import gymnasium as gym
# import math
import random
import matplotlib
import matplotlib.pyplot as plt
# from collections import namedtuple, deque
# from itertools import count
import numpy as np

import torch
import torch.nn as nn
import torch.optim as optim
import torch.nn.functional as F

# For visualization
import os
import imageio
from PIL import Image, ImageDraw, ImageFont
import matplotlib.pyplot as plt
%matplotlib inline
from IPython import display

```

```

# from IPython.display import Image

import plotly.graph_objects as go
from plotly.subplots import make_subplots

from collections import deque

import json

# env = gym.make("CartPole-v1")
# env = gym.make("Taxi-v3")#, render_mode="rgb_array")
# env = gym.make("ALE/DonkeyKong-v5")

# set up matplotlib
is_ipython = 'inline' in matplotlib.get_backend()
if is_ipython:
    from IPython import display

plt.ion()

# if GPU exist, use GPU
device = torch.device(
    "cuda" if torch.cuda.is_available() else
    "mps" if torch.backends.mps.is_available() else
    "cpu"
)

```

In [19]: `gym.__version__`

Out[19]: `'1.0.0a2'`

Making Agent

```

In [21]: class Agent:
    def __init__(self, game_id, render_mode):
        self.game_id = game_id # game id
        self.render_mode = render_mode
        self.env = gym.make(game_id, render_mode=render_mode)
        # self.state = self.env.reset()
        # self.rewards = []
        # self.steps = []
        # self.poilcy = []

    def select_action(self, state, action):
        return action

    # ===== Display on screen =====
    # Reference: https://stackoverflow.com/questions/40195740/how-to-run-
    def display_state_on_screen(self, episode, step, info=""):
        plt.figure(3)
        plt.clf()
        plt.imshow(self.env.render())
        plt.title("%s | Episode: %d | Step: %d %s" % (self.env.spec.id, e
        plt.axis('off')

```

```

display.clear_output(wait=True)
display.display(plt.gcf())
# ===== Display on screen =====

# ===== to gif =====
# Reference: https://github.com/yuchen071/DQN-for-LunarLander-v2/blob
def add_text_on_img(self, img, score, episode, step):
    img = Image.fromarray(img)
    draw = ImageDraw.Draw(img)
    draw.text((20, 20), f"Score={score: .2f}, Episode={episode}, Step

    return np.array(img)

def save_frames_as_gif(self, frames, filename, path="gifs/"):
    if not os.path.exists(path):
        os.makedirs(path)

    print("Saving gif...", end="")
    imageio.mimsave(path + filename + ".gif", frames, fps=60)

    print("Done!")
# ===== to gif =====

```

```

In [22]: class ValueEstimationAgent(Agent):
def __init__(self, game_id, render_mode, gamma):
    Agent.__init__(self, game_id, render_mode)
    self.gamma = gamma # discount rate

def select_action(self, state, action):
    return action

```

```

In [23]: class ReinforcementLearningAgent(ValueEstimationAgent):
def __init__(self, game_id, render_mode, gamma, alpha):
    ValueEstimationAgent.__init__(self, game_id, render_mode, gamma)
    self.alpha = alpha # alpha learning rate

def select_action(self, state, action):
    return action

```

Making Q Learning Agent

```

In [25]: # Reference: https://huggingface.co/learn/deep-rl-course/unit2/hands-on

class QLearningAgent(ReinforcementLearningAgent):
def __init__(self, game_id, render_mode, gamma, alpha, epsilon, epsilon_min):
    ReinforcementLearningAgent.__init__(self, game_id, render_mode, gamma, alpha)
    #self.game_id
    #self.render_mode
    #self.env=env
    #self.alpha=alpha

```

```

self.gamma=gamma

self.epsilon = epsilon           # epsilon greedy policy
self.epsilon_start = epsilon_start # starting epsilon, usually
self.epsilon_end = epsilon_end    # ending epsilon, usually 0
self.epsilon_decay = epsilon_decay # fixed epsilon decay value
self.max_steps = max_steps        # set max steps for each ep
# replace max_episode_steps of the env with the given max_steps
self.env._max_episode_steps = self.max_steps # TAXI default max

# store the numer of states and actions of the env for easier acc
self.num_states = self.env.observation_space.n
self.num_actions = self.env.action_space.n

# Q value table in numpy array of array form initialize to 0
self.Q_space = np.zeros((self.num_states, self.num_actions)) # s

self.result_model_name = result_model_name

def select_action(self, state, action):
    return action

def train(self, episodes):# , decay_rate):

    # rewards from each episode !
    rewards_per_episode = np.zeros(episodes)

    # record epsilon for display
    epsilon_history = []

    for episode in range(episodes):
        # Reset the environment
        observation = self.env.reset()
        state = observation[0] # state is the 1st elem in the self.

        # acc total reward per episode
        total_reward = 0

        for step in range(self.max_steps):

            # ===== Epsilon Greedy Algorithm Section =====
            # if random number between [0 : 1) > epsilon --> exploita
            if(random.random() > self.epsilon):
                # read argument action with max q value among the 6 a
                action = np.argmax(self.Q_space[state][:])
            # else --> exploration
            else:
                action = self.env.action_space.sample() # pick rando
            # ===== Epsilon Greedy Algorithm Section =====

            # Epsilon decay as we need fewer exploration as time pass
            # Exponential Decay of epsilon
            # refernce: https://medium.com/@CalebMBowyer/strategies-f

```

```

decay_factor = (self.epsilon_end/self.epsilon_start)**(1/
# update self.epsilon
self.epsilon = self.epsilon * decay_factor

# append updated epsilon to the record
epsilon_history.append(self.epsilon)

# https://colab.research.google.com/github/erodola/ML-s2-
# decay_rate = 0.0005 # 1000
# self.epsilon = self.epsilon_end + (self.epsilon_start -

# Take the action (a) and observe the outcome state(s') a
# new_state, reward, done, info = env.step(action)
# observation, reward, terminated, truncated, info

new_state, reward, terminated, truncated, info = self.env

# acc reward to toal_reward to keep track of the total_re
total_reward += reward

# Update Q(s,a):= Q(s,a) + lr_alpha [R(s,a) + gamma * max
# print(state)
# print(action)
#Q_space[state][action] = Q_space[state][action] + learni
#np.max(Q_space[new_state]) -

sample = reward + self.gamma * np.max(self.Q_space[new_st
self.Q_space[state][action] = (1 - self.alpha) * self.Q_s

# if the number of steps elapsed >= max episode steps (20
# If terminated --> finish current episode
if terminated == True or truncated == True:
    break

# update to state to new_state
state = new_state

# store the total reward of each episode for record
rewards_per_episode[episode] = total_reward

# print the progress
i = episode
if (i + 1) % 100 == 0:
    print(f"Episode {i+1}/{episodes}, Avg Reward: {np.mean(re

self.env.close()

# Create new graph
plt.figure(1)

```



```

# Plot average rewards (Y-axis) vs episodes (X-axis)
sum_rewards = np.zeros(episodes)
for x in range(episodes):
    sum_rewards[x] = np.sum(rewards_per_episode[max(0, x-100):(x+1)])
plt.subplot(121) # plot on a 1 row x 2 col grid, at cell 1
plt.plot(sum_rewards)

# Plot epsilon decay (Y-axis) vs episodes (X-axis)
plt.subplot(122) # plot on a 1 row x 2 col grid, at cell 2
plt.plot(epsilon_history)

# Save plots
plt.savefig(self.result_model_name + '.png')

return rewards_per_episode

```

```

def test(self, test_episodes=10, display=False):

```

```

    episode_reward_lst = []

```

```

    frames = []

```

```

    for episode in range(test_episodes): # total_test_episodes == 10
        observation = self.env.reset()
        state = observation[0]

```

```

        total_reward = 0

```

```

        print("=====")
        print("EPISODE ", episode)

```

```

        # added

```

```

        steps_count = 0

```

```

        for step in range(self.max_steps):

```

```

            # Take the action (index) that have the maximum expected
            action = np.argmax(self.Q_space[state][:])

```

```

            # apply selected action

```

```

            new_state, reward, terminated, truncated, info = self.env.step(action)

```

```

            # add up reward for later calculation

```

```

            total_reward += reward

```

```

            # increment step for displaying state on screen

```

```

            steps_count += 1

```

```

        if (display == True):

```

```

            # Display on Screen

```

```

            self.display_state_on_screen(episode, steps_count) #

```

```

        if terminated == True or truncated == True :

```

```

        episode_reward_lst.append(total_reward)
        print ("Score of total rewards:", total_reward)
        break
    state = new_state # Update state to new_state

self.env.close()
# print("Total Steps taken:", steps_count)
print ("Average score over time: " + str(sum(episode_reward_lst)
return episode_reward_lst

# turn test scenario to gif
def test_to_gif(self, filename="q_learning_result", episodes=5):

    frames = []
    for episode in range(episodes):
        observation = self.env.reset()
        state = observation[0]

        score = 0
        for step in range(self.max_steps):
            # store rgb ender to frame
            frame = self.env.render()
            # store the rendered frame to list
            frames.append(self.add_text_on_img(frame, score, episode,

            # selected from the Q value table
            action = np.argmax(self.Q_space[state][:])

            # print current episode, action, state
            print(f"episodes: {episode}, acton: {action}, state: {sta

            # apply selected action
            state, reward, terminated, truncated, info = self.env.ste

            score += reward

            if terminated == True or truncated == True:
                break
        self.env.close()
    # turn frames into gif
    self.save_frames_as_gif(frames, filename=filename)

```

Deep Q Learning (DQN) agent

In [27]: # Defining models
Reference:

```

# https://pytorch.org/tutorials/intermediate/reinforcement_q_learning.htm
# https://colab.research.google.com/github/pytorch/tutorials/blob/gh-page
# https://www.youtube.com/watch?si=fXl8PEnb0TrV9Vwt&v=EURWGTCGzIA&feature

# DQN model
class DQN(nn.Module):
    # 3 layers multi layers learning network
    def __init__(self, in_states, h1_nodes, out_actions):
        super().__init__()
        self.fc1 = nn.Linear(in_states, h1_nodes)      # Input layer = 500
        self.fc2 = nn.Linear(h1_nodes, h1_nodes)      # hidden layer
        self.out = nn.Linear(h1_nodes, out_actions)    # output layer = 6

    def forward(self, x):
        # Rectified Linear Unit (ReLU)
        x = F.relu(self.fc1(x))      # run Input layer
        x = F.relu(self.fc2(x))      # run hidden layer
        x = self.out(x)              # run output layer
        return x

# Define memory for Experience Replay
class ReplayMemory():
    def __init__(self, maxlen):
        self.memory = deque([], maxlen=maxlen)

    def append(self, transition):
        self.memory.append(transition)

    def sample(self, sample_size):
        return random.sample(self.memory, sample_size)

    def __len__(self):
        return len(self.memory)

```

```

In [28]: class DQNAgent(QLearningAgent):
    def __init__(self, game_id, render_mode, gamma, alpha, epsilon, epsilon_start, epsilon_end, epsilon_decay, max_steps, max_episode_steps, num_states, num_actions, Q_table):
        QLearningAgent.__init__(self, game_id, render_mode, gamma, alpha, epsilon, epsilon_start, epsilon_end, epsilon_decay, max_steps, max_episode_steps, num_states, num_actions, Q_table)

        #self.game_id
        #self.render_mode
        #self.env=env
        #self.alpha=alpha
        #self.gamma=gamma

        #self.epsilon = epsilon          # epsilon greedy policy
        #self.epsilon_start = epsilon_start # starting epsilon, usually 1.0
        #self.epsilon_end = epsilon_end    # ending epsilon, usually 0.01
        #self.epsilon_decay = epsilon_decay # fixed epsilon decay value
        #self.max_steps = max_steps        # set max steps for each episode
        ## replace max_episode_steps of the env with the given max_steps
        #self.env._max_episode_steps = self.max_steps # TAXI default max_episode_steps

        ## store the number of states and actions of the env for easier access
        #self.num_states = self.env.observation_space.n
        #self.num_actions = self.env.action_space.n

        ## Q value table in numpy array of array form initialize to 0

```

```

        #self.Q_space = np.zeros((self.num_states, self.num_actions)) #

        #self.result_model_name = result_model_name

# ----- Special Parameters for DQN only -----
network_sync_rate_tau = 10 # after 10 steps, sync policy network and
replay_memory_size = 10000
mini_batch_size = 64

loss_fn = nn.MSELoss() # Mean Squared Error Loss function
optimizer = None # initialize later on

ACTIONS = ['S', 'N', 'E', 'W', 'P', 'D'] # South, North, East, West,
# ----- Special Parameters for DQN only -----

def train(self, episodes):

    # epsilon = 1

    # self.env = gym.make(self.game_id, render_mode=self.render_mode
    # num_states = self.env.observation_space.n
    # num_actions = self.env.action_space.n

    # Epsilon
    # epsilon_start = 1
    # epsilon_end = 0.001

    # set up ReplayMemory obj to store the experience
    memory = ReplayMemory(self.replay_memory_size)

    # need 2 neural networks
    # 1) policy network for training
    # 2) target network makes use of the deep q learning equation
    policy_dqn = DQN(in_states=self.num_states, h1_nodes=128, out_act
    target_dqn = DQN(in_states=self.num_states, h1_nodes=128, out_act

    # copy policy network to target network
    target_dqn.load_state_dict(policy_dqn.state_dict())

    # neural network initially comes with a random set of weights and
    print('Policy (policy network model before training with randomly
    self.print_dqn(policy_dqn)

    # initialize and store Adam optimizer
    self.optimizer = torch.optim.Adam(policy_dqn.parameters(), lr=self

    # rewards from each episode !
    rewards_per_episode = np.zeros(episodes)

    # record epsilon for display
    epsilon_history = []

    # track how many steps has been taken, sync policy network and ta
    step_count = 0

    for episode in range(episodes):

```

```

state, _ = self.env.reset()
total_reward = 0
terminated = False      # True when the taxi drops off the pass
truncated = False       # True when the length of steps in a si

while not terminated and not truncated:

    # ===== Epsilon Greedy Algorithm Section =====
    if random.random() < self.epsilon:
        # Random action
        action = self.env.action_space.sample()
    else:
        # torch.no_grad() tells pytorch not to calculate new
        with torch.no_grad():
            # Use policy network to calculate a set of q valu
            # self.state_to_dqn_input() encodes state to one-
            action = policy_dqn(self.state_to_dqn_input(state)
    # ===== Epsilon Greedy Algorithm Section =====

    # run the action in the env
    new_state, reward, terminated, truncated, _ = self.env.st

    # Memoize the experience, append to the ReplayMemory
    memory.append((state, action, new_state, reward, terminat

    # update state to the new state
    state = new_state

    # increment
    total_reward += reward
    step_count += 1

# store the total reward of each episode for record
rewards_per_episode[episode] = total_reward

# Check if enough experience has been collected for a batch
if len(memory) > self.mini_batch_size:
    mini_batch = memory.sample(self.mini_batch_size)

    # optimize
    self.optimize(mini_batch, policy_dqn, target_dqn)

    # Exponential epsilon decay factor !!!!
    decay_factor = (self.epsilon_end/self.epsilon_start)**(1/
    self.epsilon = self.epsilon * decay_factor

    # https://colab.research.google.com/github/erodola/ML-s2-
    # decay_rate = 0.0005 # 1000
    # episode = i # rename i to episode for the calculation
    # print(self.epsilon, episode)
    # self.epsilon = self.epsilon_end + (self.epsilon_start -

```

```

        # record the epsilon value for later
        epsilon_history.append(self.epsilon)

        # if overstep, load instead of train
        if step_count > self.network_sync_rate_tau:
            target_dqn.load_state_dict(policy_dqn.state_dict())
            step_count = 0

    # print the progress
    if (episode + 1) % 100 == 0:
        print(f"Episode {episode+1}/{episodes}, Avg Reward: {np.m

self.env.close()

torch.save(policy_dqn.state_dict(), self.result_model_name + ".pt

print("!!!!!!!!!!!!!!!!!!!!Trained and Stored the model successfully!

# Display the training progress into png

# Create new graph
plt.figure(1)

# Plot average rewards (Y-axis) vs episodes (X-axis)
sum_rewards = np.zeros(episodes)
for x in range(episodes):
    sum_rewards[x] = np.sum(rewards_per_episode[max(0, x-100):(x+
plt.subplot(121) # plot on a 1 row x 2 col grid, at cell 1
plt.plot(sum_rewards)

# Plot epsilon decay (Y-axis) vs episodes (X-axis)
plt.subplot(122) # plot on a 1 row x 2 col grid, at cell 2
plt.plot(epsilon_history)

# Save plots
plt.savefig(self.result_model_name + '.png') # 'taxi_dql.png')

return rewards_per_episode

def optimize(self, mini_batch, policy_dqn, target_dqn):# , num_states
    current_q_list = []
    target_q_list = []

    for state, action, new_state, reward, terminated in mini_batch:
        if terminated:
            target = torch.FloatTensor([reward])
        else:
            with torch.no_grad():
                target = torch.FloatTensor(
                    reward + self.gamma * target_dqn(self.state_to_dq
                )
            # Q value update

```

```

        current_q = policy_dqn(self.state_to_dqn_input(state))
        target_q = current_q.clone().detach()
        target_q[action] = target

        current_q_list.append(current_q)
        target_q_list.append(target_q)

    loss = self.loss_fn(torch.stack(current_q_list), torch.stack(target_q_list))

    self.optimizer.zero_grad()
    loss.backward()
    self.optimizer.step()

# turn state into one-hot encoding tensor vector
    def state_to_dqn_input(self, state: int) -> torch.Tensor: # , num_states
        input_tensor = torch.zeros(self.num_states)
        input_tensor[state] = 1
        return input_tensor

    def test(self, test_episodes=10, display=False):
        # self.env = gym.make('Taxi-v3', render_mode=self.render_mode) #
        # num_states = self.env.observation_space.n
        # num_actions = self.env.action_space.n

        policy_dqn = DQN(in_states=self.num_states, h1_nodes=128, out_actions=self.num_actions)
        policy_dqn.load_state_dict(torch.load(self.result_model_name + ".pt"))
        policy_dqn.eval()

        print('Policy (trained policy network model from the .pt file):')
        self.print_dqn(policy_dqn)

        episode_reward_lst = list()

        for episode in range(test_episodes):
            state, _ = self.env.reset()
            total_reward = 0
            terminated = False
            truncated = False

            # steps_count for display
            steps_count = 0

            # while not terminated and not truncated:
            for step in range(self.max_steps):

                with torch.no_grad():
                    action = policy_dqn(self.state_to_dqn_input(state)).argmax()

                state, reward, terminated, truncated, _ = self.env.step(action)
                total_reward += reward

                steps_count += 1

```

```

        # only display the Game if being asked to do so
        if (display == True):
            self.display_state_on_screen(episode, steps_count)

        if (terminated == True or truncated == True):
            episode_reward_lst.append(total_reward)
            print(f"Episode {episode+1}: Total Reward = {total_re
            break

        # print(f"Episode {episode+1}: Total Reward = {total_reward}")
        # episode_reward_lst.append(total_reward)

    self.env.close()
    print(f"Average Reward across all Episodes: = {sum(episode_reward

    return episode_reward_lst

# print the initial states and values before the training
def print_dqn(self, dqn): # , num_states):
    for s in range(self.num_states):
        q_values = dqn(self.state_to_dqn_input(s)).tolist()
        q_values_str = ' '.join([f"{q:+.2f}" for q in q_values])
        best_action = self.ACTIONS[dqn(self.state_to_dqn_input(s)).ar
        print(f'State {s:03}, Action {best_action}, Q-values: [{q_val

def test_to_gif(self, filename="dqn_learning_result", episodes=3):
    # capture each frame
    frames = []

    # make DQN for loading policy network
    policy_dqn = DQN(in_states=self.num_states, h1_nodes=128, out_act
    # load and eval the trained policy network
    policy_dqn.load_state_dict(torch.load(self.result_model_name + ".
    policy_dqn.eval()

    print('Policy (trained):')
    self.print_dqn(policy_dqn)

    episode_reward_lst = list()

    for episode in range(episodes):
        # reset env for each episodes == episode
        observation = self.env.reset()
        state = observation[0]

        total_reward = 0
        steps_count = 0

        # for display on the image
        score = 0
        for step in range(self.max_steps):

```



```

        frame = self.env.render()
        frames.append(self.add_text_on_img(frame, score, episode,

# tell torch to not train but to predict
with torch.no_grad():
    # read max action from the trained policy network
    action = policy_dqn(self.state_to_dqn_input(state)).a

print(f"episodes: {episode}, action: {action}, state: {sta

state, reward, terminated, truncated, _ = self.env.step(a

score += reward
total_reward += reward
steps_count += 1

if terminated == True or truncated == True:

    episode_reward_lst.append(total_reward)
    print(f"Episode {episode+1}: Total Reward = {total_re
    break
self.env.close()
self.save_frames_as_gif(frames, filename=filename)
print(f"Average Reward across all Episodes: = {sum(episode_reward

```

Testing and Comparison

Controlled Parameter Training

Q Learning Agent with Controlled Parameters

```

In [32]: my_q_agent_controlled = QLearningAgent(game_id="Taxi-v3", render_mode="rg
        gamma=0.95, alpha=0.5, epsilon=1.0
        epsilon_decay=1000, epsilon_end=0.
        result_model_name="taxi_q_controll

```

```

In [33]: %%time
        my_q_agent_controlled_training_rewards = my_q_agent_controlled.train(1000

```

```

Episode 100/100000, Avg Reward: -474.11, Epsilon: 0.31
Episode 200/100000, Avg Reward: -123.69, Epsilon: 0.17
Episode 300/100000, Avg Reward: -24.75, Epsilon: 0.14
Episode 400/100000, Avg Reward: -6.87, Epsilon: 0.12
Episode 500/100000, Avg Reward: -1.05, Epsilon: 0.11
Episode 600/100000, Avg Reward: 1.15, Epsilon: 0.10
Episode 700/100000, Avg Reward: 1.94, Epsilon: 0.09
Episode 800/100000, Avg Reward: 3.21, Epsilon: 0.08
Episode 900/100000, Avg Reward: 4.17, Epsilon: 0.07
Episode 1000/100000, Avg Reward: 4.72, Epsilon: 0.06
Episode 1100/100000, Avg Reward: 4.62, Epsilon: 0.06
Episode 1200/100000, Avg Reward: 5.67, Epsilon: 0.05
Episode 1300/100000, Avg Reward: 5.20, Epsilon: 0.05
Episode 1400/100000, Avg Reward: 5.30, Epsilon: 0.04

```

Episode	1500/100000	Avg Reward:	5.77	Epsilon:	0.04
Episode	1600/100000	Avg Reward:	5.07	Epsilon:	0.04
Episode	1700/100000	Avg Reward:	5.63	Epsilon:	0.03
Episode	1800/100000	Avg Reward:	6.19	Epsilon:	0.03
Episode	1900/100000	Avg Reward:	6.90	Epsilon:	0.03
Episode	2000/100000	Avg Reward:	6.78	Epsilon:	0.02
Episode	2100/100000	Avg Reward:	6.57	Epsilon:	0.02
Episode	2200/100000	Avg Reward:	6.65	Epsilon:	0.02
Episode	2300/100000	Avg Reward:	6.63	Epsilon:	0.02
Episode	2400/100000	Avg Reward:	6.27	Epsilon:	0.02
Episode	2500/100000	Avg Reward:	6.34	Epsilon:	0.02
Episode	2600/100000	Avg Reward:	7.29	Epsilon:	0.01
Episode	2700/100000	Avg Reward:	7.41	Epsilon:	0.01
Episode	2800/100000	Avg Reward:	7.33	Epsilon:	0.01
Episode	2900/100000	Avg Reward:	7.08	Epsilon:	0.01
Episode	3000/100000	Avg Reward:	7.00	Epsilon:	0.01
Episode	3100/100000	Avg Reward:	7.39	Epsilon:	0.01
Episode	3200/100000	Avg Reward:	7.11	Epsilon:	0.01
Episode	3300/100000	Avg Reward:	7.29	Epsilon:	0.01
Episode	3400/100000	Avg Reward:	7.41	Epsilon:	0.01
Episode	3500/100000	Avg Reward:	7.41	Epsilon:	0.01
Episode	3600/100000	Avg Reward:	7.67	Epsilon:	0.01
Episode	3700/100000	Avg Reward:	7.94	Epsilon:	0.01
Episode	3800/100000	Avg Reward:	7.51	Epsilon:	0.00
Episode	3900/100000	Avg Reward:	8.01	Epsilon:	0.00
Episode	4000/100000	Avg Reward:	7.65	Epsilon:	0.00
Episode	4100/100000	Avg Reward:	7.97	Epsilon:	0.00
Episode	4200/100000	Avg Reward:	7.64	Epsilon:	0.00
Episode	4300/100000	Avg Reward:	7.96	Epsilon:	0.00
Episode	4400/100000	Avg Reward:	7.81	Epsilon:	0.00
Episode	4500/100000	Avg Reward:	8.15	Epsilon:	0.00
Episode	4600/100000	Avg Reward:	7.80	Epsilon:	0.00
Episode	4700/100000	Avg Reward:	7.82	Epsilon:	0.00
Episode	4800/100000	Avg Reward:	7.82	Epsilon:	0.00
Episode	4900/100000	Avg Reward:	7.92	Epsilon:	0.00
Episode	5000/100000	Avg Reward:	7.49	Epsilon:	0.00
Episode	5100/100000	Avg Reward:	8.33	Epsilon:	0.00
Episode	5200/100000	Avg Reward:	7.51	Epsilon:	0.00
Episode	5300/100000	Avg Reward:	7.41	Epsilon:	0.00
Episode	5400/100000	Avg Reward:	8.05	Epsilon:	0.00
Episode	5500/100000	Avg Reward:	8.08	Epsilon:	0.00
Episode	5600/100000	Avg Reward:	7.94	Epsilon:	0.00
Episode	5700/100000	Avg Reward:	8.02	Epsilon:	0.00
Episode	5800/100000	Avg Reward:	7.57	Epsilon:	0.00
Episode	5900/100000	Avg Reward:	7.88	Epsilon:	0.00
Episode	6000/100000	Avg Reward:	7.87	Epsilon:	0.00
Episode	6100/100000	Avg Reward:	8.18	Epsilon:	0.00
Episode	6200/100000	Avg Reward:	7.45	Epsilon:	0.00
Episode	6300/100000	Avg Reward:	8.25	Epsilon:	0.00
Episode	6400/100000	Avg Reward:	7.70	Epsilon:	0.00
Episode	6500/100000	Avg Reward:	7.85	Epsilon:	0.00
Episode	6600/100000	Avg Reward:	7.84	Epsilon:	0.00
Episode	6700/100000	Avg Reward:	7.65	Epsilon:	0.00
Episode	6800/100000	Avg Reward:	7.45	Epsilon:	0.00
Episode	6900/100000	Avg Reward:	7.40	Epsilon:	0.00
Episode	7000/100000	Avg Reward:	7.48	Epsilon:	0.00
Episode	7100/100000	Avg Reward:	7.84	Epsilon:	0.00

Episode 7200/100000, Avg Reward: 7.35, Epsilon: 0.00
Episode 7300/100000, Avg Reward: 7.51, Epsilon: 0.00
Episode 7400/100000, Avg Reward: 7.81, Epsilon: 0.00
Episode 7500/100000, Avg Reward: 7.78, Epsilon: 0.00
Episode 7600/100000, Avg Reward: 7.98, Epsilon: 0.00
Episode 7700/100000, Avg Reward: 7.66, Epsilon: 0.00
Episode 7800/100000, Avg Reward: 7.92, Epsilon: 0.00
Episode 7900/100000, Avg Reward: 8.18, Epsilon: 0.00
Episode 8000/100000, Avg Reward: 8.09, Epsilon: 0.00
Episode 8100/100000, Avg Reward: 7.86, Epsilon: 0.00
Episode 8200/100000, Avg Reward: 7.97, Epsilon: 0.00
Episode 8300/100000, Avg Reward: 7.84, Epsilon: 0.00
Episode 8400/100000, Avg Reward: 7.84, Epsilon: 0.00
Episode 8500/100000, Avg Reward: 7.81, Epsilon: 0.00
Episode 8600/100000, Avg Reward: 7.47, Epsilon: 0.00
Episode 8700/100000, Avg Reward: 7.92, Epsilon: 0.00
Episode 8800/100000, Avg Reward: 7.75, Epsilon: 0.00
Episode 8900/100000, Avg Reward: 7.64, Epsilon: 0.00
Episode 9000/100000, Avg Reward: 7.40, Epsilon: 0.00
Episode 9100/100000, Avg Reward: 8.08, Epsilon: 0.00
Episode 9200/100000, Avg Reward: 8.02, Epsilon: 0.00
Episode 9300/100000, Avg Reward: 7.87, Epsilon: 0.00
Episode 9400/100000, Avg Reward: 7.72, Epsilon: 0.00
Episode 9500/100000, Avg Reward: 7.53, Epsilon: 0.00
Episode 9600/100000, Avg Reward: 7.60, Epsilon: 0.00
Episode 9700/100000, Avg Reward: 7.75, Epsilon: 0.00
Episode 9800/100000, Avg Reward: 7.91, Epsilon: 0.00
Episode 9900/100000, Avg Reward: 7.91, Epsilon: 0.00
Episode 10000/100000, Avg Reward: 7.42, Epsilon: 0.00
Episode 10100/100000, Avg Reward: 7.98, Epsilon: 0.00
Episode 10200/100000, Avg Reward: 7.49, Epsilon: 0.00
Episode 10300/100000, Avg Reward: 7.89, Epsilon: 0.00
Episode 10400/100000, Avg Reward: 7.93, Epsilon: 0.00
Episode 10500/100000, Avg Reward: 7.31, Epsilon: 0.00
Episode 10600/100000, Avg Reward: 7.95, Epsilon: 0.00
Episode 10700/100000, Avg Reward: 8.54, Epsilon: 0.00
Episode 10800/100000, Avg Reward: 7.58, Epsilon: 0.00
Episode 10900/100000, Avg Reward: 8.19, Epsilon: 0.00
Episode 11000/100000, Avg Reward: 8.14, Epsilon: 0.00
Episode 11100/100000, Avg Reward: 7.43, Epsilon: 0.00
Episode 11200/100000, Avg Reward: 7.76, Epsilon: 0.00
Episode 11300/100000, Avg Reward: 7.67, Epsilon: 0.00
Episode 11400/100000, Avg Reward: 7.67, Epsilon: 0.00
Episode 11500/100000, Avg Reward: 8.01, Epsilon: 0.00
Episode 11600/100000, Avg Reward: 7.92, Epsilon: 0.00
Episode 11700/100000, Avg Reward: 7.90, Epsilon: 0.00
Episode 11800/100000, Avg Reward: 8.06, Epsilon: 0.00
Episode 11900/100000, Avg Reward: 7.59, Epsilon: 0.00
Episode 12000/100000, Avg Reward: 7.63, Epsilon: 0.00
Episode 12100/100000, Avg Reward: 7.93, Epsilon: 0.00
Episode 12200/100000, Avg Reward: 7.97, Epsilon: 0.00
Episode 12300/100000, Avg Reward: 7.86, Epsilon: 0.00
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Episode 12600/100000, Avg Reward: 8.00, Epsilon: 0.00
Episode 12700/100000, Avg Reward: 7.48, Epsilon: 0.00
Episode 12800/100000, Avg Reward: 7.69, Epsilon: 0.00

Episode 12900/100000, Avg Reward: 7.29, Epsilon: 0.00
Episode 13000/100000, Avg Reward: 7.82, Epsilon: 0.00
Episode 13100/100000, Avg Reward: 8.24, Epsilon: 0.00
Episode 13200/100000, Avg Reward: 7.53, Epsilon: 0.00
Episode 13300/100000, Avg Reward: 7.99, Epsilon: 0.00
Episode 13400/100000, Avg Reward: 7.55, Epsilon: 0.00
Episode 13500/100000, Avg Reward: 7.63, Epsilon: 0.00
Episode 13600/100000, Avg Reward: 7.97, Epsilon: 0.00
Episode 13700/100000, Avg Reward: 8.06, Epsilon: 0.00
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Episode 14300/100000, Avg Reward: 7.46, Epsilon: 0.00
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Episode 14700/100000, Avg Reward: 8.05, Epsilon: 0.00
Episode 14800/100000, Avg Reward: 7.91, Epsilon: 0.00
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Episode 15700/100000, Avg Reward: 8.12, Epsilon: 0.00
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Episode 17400/100000, Avg Reward: 8.02, Epsilon: 0.00
Episode 17500/100000, Avg Reward: 7.44, Epsilon: 0.00
Episode 17600/100000, Avg Reward: 7.69, Epsilon: 0.00
Episode 17700/100000, Avg Reward: 7.73, Epsilon: 0.00
Episode 17800/100000, Avg Reward: 7.73, Epsilon: 0.00
Episode 17900/100000, Avg Reward: 7.95, Epsilon: 0.00
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Episode 18400/100000, Avg Reward: 8.29, Epsilon: 0.00
Episode 18500/100000, Avg Reward: 7.39, Epsilon: 0.00

Episode 18600/100000, Avg Reward: 7.42, Epsilon: 0.00
Episode 18700/100000, Avg Reward: 7.24, Epsilon: 0.00
Episode 18800/100000, Avg Reward: 8.00, Epsilon: 0.00
Episode 18900/100000, Avg Reward: 7.91, Epsilon: 0.00
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Episode 24400/100000, Avg Reward: 7.84, Epsilon: 0.00
Episode 24500/100000, Avg Reward: 7.65, Epsilon: 0.00
Episode 24600/100000, Avg Reward: 7.82, Epsilon: 0.00
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Episode 24800/100000, Avg Reward: 7.68, Epsilon: 0.00
Episode 24900/100000, Avg Reward: 8.10, Epsilon: 0.00
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Episode 26600/100000, Avg Reward: 7.90, Epsilon: 0.00
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Episode 36400/100000, Avg Reward: 7.79, Epsilon: 0.00
Episode 36500/100000, Avg Reward: 7.73, Epsilon: 0.00
Episode 36600/100000, Avg Reward: 7.74, Epsilon: 0.00
Episode 36700/100000, Avg Reward: 7.73, Epsilon: 0.00
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Episode 38500/100000, Avg Reward: 7.91, Epsilon: 0.00
Episode 38600/100000, Avg Reward: 7.83, Epsilon: 0.00
Episode 38700/100000, Avg Reward: 7.96, Epsilon: 0.00
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Episode 74700/100000, Avg Reward: 7.62, Epsilon: 0.00
Episode 74800/100000, Avg Reward: 7.64, Epsilon: 0.00
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Episode 76300/100000, Avg Reward: 7.52, Epsilon: 0.00
Episode 76400/100000, Avg Reward: 8.08, Epsilon: 0.00
Episode 76500/100000, Avg Reward: 7.91, Epsilon: 0.00
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Episode 76800/100000, Avg Reward: 8.11, Epsilon: 0.00
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Episode 81200/100000, Avg Reward: 7.66, Epsilon: 0.00

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Episode 81400/100000, Avg Reward: 7.66, Epsilon: 0.00
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Episode 81600/100000, Avg Reward: 7.69, Epsilon: 0.00
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Episode 86900/100000, Avg Reward: 8.30, Epsilon: 0.00

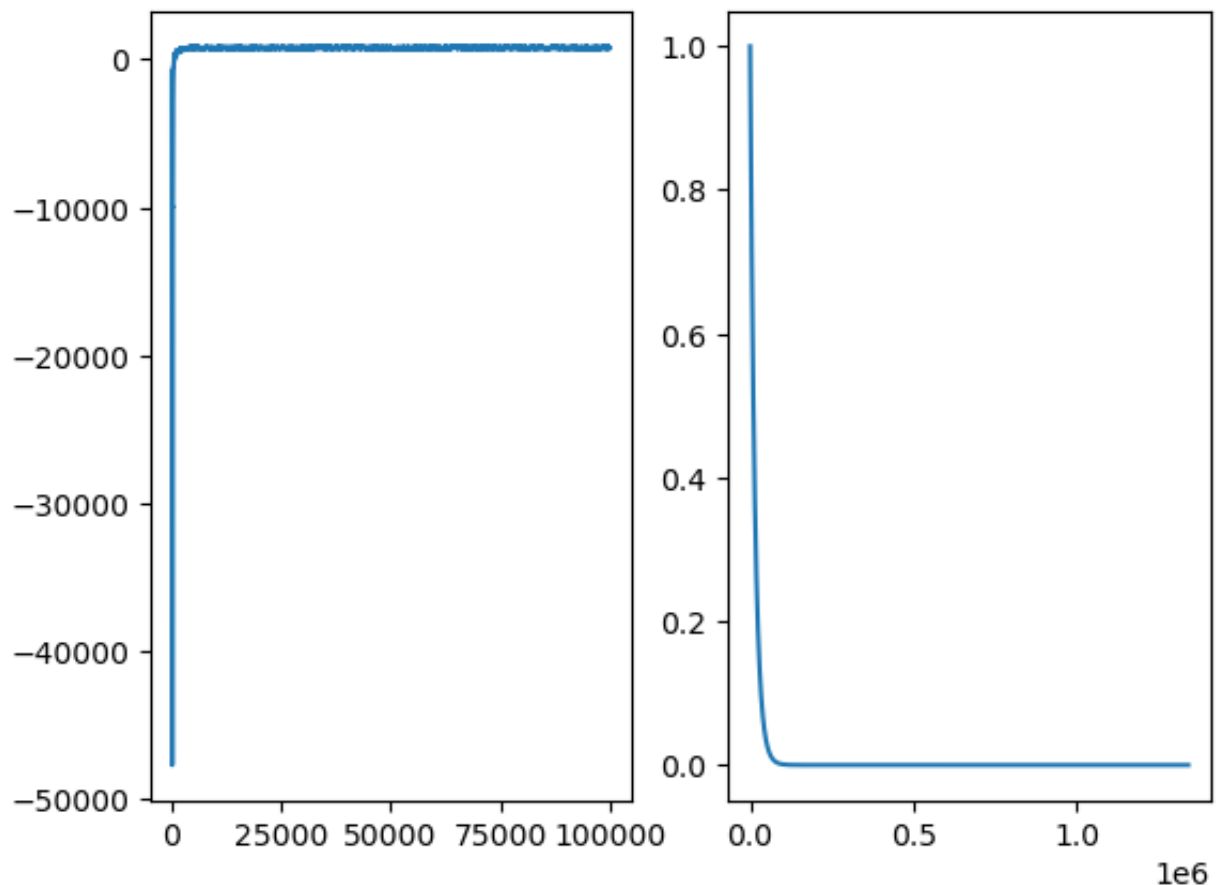
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Episode 95900/100000, Avg Reward: 7.74, Epsilon: 0.00
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```

Episode 98400/100000, Avg Reward: 8.14, Epsilon: 0.00
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Episode 99700/100000, Avg Reward: 8.38, Epsilon: 0.00
Episode 99800/100000, Avg Reward: 7.68, Epsilon: 0.00
Episode 99900/100000, Avg Reward: 8.13, Epsilon: 0.00
Episode 100000/100000, Avg Reward: 7.65, Epsilon: 0.00
CPU times: user 12.7 s, sys: 871 ms, total: 13.6 s
Wall time: 11.9 s

```



```
In [34]: print(my_q_agent_controlled_training_rewards)
```

```
[-767. -812. -785. ...    5.   15.    8.]
```

DQN Agent with Controlled Parameters

```
In [36]: my_dqn_agent_controlled = DQNAgent(game_id="Taxi-v3", gamma=0.95, alpha=0
        epsilon_start=1.0, epsilon_decay=1000,
        max_steps=200, render_mode="rgb_array")
```

```
In [37]: %%time
```

```
my_dqn_agent_controlled_training_rewards = my_dqn_agent_controlled.train(
```

Policy (policy network model before training with randomly initialized values):

```
State 000, Action W, Q-values: [-0.03 -0.00 -0.03 +0.02 -0.05 -0.06]
State 001, Action W, Q-values: [-0.04 -0.00 -0.03 +0.03 -0.05 -0.05]
State 002, Action W, Q-values: [-0.05 -0.00 -0.02 +0.03 -0.06 -0.05]
State 003, Action W, Q-values: [-0.05 -0.00 -0.04 +0.02 -0.06 -0.05]
State 004, Action W, Q-values: [-0.05 +0.00 -0.03 +0.02 -0.06 -0.05]
State 005, Action W, Q-values: [-0.04 -0.00 -0.03 +0.02 -0.06 -0.05]
State 006, Action W, Q-values: [-0.04 -0.00 -0.04 +0.03 -0.06 -0.06]
State 007, Action W, Q-values: [-0.05 -0.00 -0.03 +0.02 -0.06 -0.05]
State 008, Action W, Q-values: [-0.04 -0.00 -0.03 +0.03 -0.06 -0.05]
State 009, Action W, Q-values: [-0.05 -0.00 -0.03 +0.02 -0.06 -0.05]
State 010, Action W, Q-values: [-0.05 -0.00 -0.03 +0.02 -0.06 -0.05]
State 011, Action W, Q-values: [-0.04 -0.00 -0.03 +0.02 -0.06 -0.05]
State 012, Action W, Q-values: [-0.04 +0.00 -0.03 +0.02 -0.06 -0.05]
State 013, Action W, Q-values: [-0.05 -0.01 -0.03 +0.02 -0.06 -0.05]
State 014, Action W, Q-values: [-0.05 -0.01 -0.03 +0.02 -0.06 -0.05]
State 015, Action W, Q-values: [-0.05 -0.00 -0.03 +0.02 -0.06 -0.05]
State 016, Action W, Q-values: [-0.04 +0.01 -0.03 +0.02 -0.05 -0.05]
State 017, Action W, Q-values: [-0.05 -0.01 -0.03 +0.02 -0.06 -0.06]
State 018, Action W, Q-values: [-0.04 -0.00 -0.03 +0.02 -0.06 -0.05]
State 019, Action W, Q-values: [-0.04 -0.00 -0.04 +0.02 -0.06 -0.05]
State 020, Action W, Q-values: [-0.05 +0.00 -0.03 +0.02 -0.06 -0.05]
State 021, Action W, Q-values: [-0.04 -0.00 -0.03 +0.03 -0.05 -0.05]
State 022, Action W, Q-values: [-0.05 -0.00 -0.03 +0.03 -0.05 -0.05]
State 023, Action W, Q-values: [-0.04 -0.00 -0.03 +0.02 -0.06 -0.05]
State 024, Action W, Q-values: [-0.05 -0.00 -0.04 +0.02 -0.05 -0.05]
State 025, Action W, Q-values: [-0.05 -0.00 -0.03 +0.03 -0.06 -0.05]
State 026, Action W, Q-values: [-0.04 +0.00 -0.03 +0.02 -0.05 -0.05]
State 027, Action W, Q-values: [-0.04 -0.01 -0.04 +0.02 -0.06 -0.05]
State 028, Action W, Q-values: [-0.04 -0.00 -0.03 +0.02 -0.06 -0.05]
State 029, Action W, Q-values: [-0.05 +0.00 -0.03 +0.02 -0.05 -0.05]
State 030, Action W, Q-values: [-0.06 -0.00 -0.03 +0.02 -0.06 -0.05]
State 031, Action W, Q-values: [-0.05 -0.01 -0.03 +0.02 -0.06 -0.06]
State 032, Action W, Q-values: [-0.04 -0.01 -0.03 +0.02 -0.06 -0.05]
State 033, Action W, Q-values: [-0.05 -0.00 -0.03 +0.02 -0.06 -0.05]
State 034, Action W, Q-values: [-0.04 +0.01 -0.04 +0.02 -0.06 -0.05]
State 035, Action W, Q-values: [-0.04 -0.00 -0.03 +0.02 -0.06 -0.04]
State 036, Action W, Q-values: [-0.05 -0.01 -0.03 +0.03 -0.05 -0.05]
State 037, Action W, Q-values: [-0.04 -0.00 -0.03 +0.02 -0.06 -0.05]
State 038, Action W, Q-values: [-0.05 -0.00 -0.03 +0.02 -0.06 -0.05]
State 039, Action W, Q-values: [-0.03 +0.00 -0.03 +0.02 -0.06 -0.05]
State 040, Action W, Q-values: [-0.04 +0.00 -0.03 +0.02 -0.05 -0.05]
State 041, Action W, Q-values: [-0.05 -0.00 -0.03 +0.02 -0.06 -0.05]
State 042, Action W, Q-values: [-0.04 +0.00 -0.03 +0.02 -0.06 -0.05]
State 043, Action W, Q-values: [-0.05 -0.00 -0.02 +0.02 -0.06 -0.05]
State 044, Action W, Q-values: [-0.04 -0.00 -0.03 +0.02 -0.05 -0.05]
State 045, Action W, Q-values: [-0.05 +0.00 -0.03 +0.02 -0.05 -0.05]
State 046, Action W, Q-values: [-0.05 -0.00 -0.03 +0.02 -0.05 -0.05]
State 047, Action W, Q-values: [-0.04 -0.00 -0.03 +0.03 -0.06 -0.05]
State 048, Action W, Q-values: [-0.04 -0.00 -0.04 +0.02 -0.06 -0.05]
State 049, Action W, Q-values: [-0.05 -0.00 -0.03 +0.02 -0.06 -0.05]
State 050, Action W, Q-values: [-0.05 -0.00 -0.03 +0.02 -0.06 -0.05]
State 051, Action W, Q-values: [-0.05 -0.00 -0.04 +0.02 -0.06 -0.05]
State 052, Action W, Q-values: [-0.05 -0.00 -0.03 +0.02 -0.06 -0.05]
```

[illegible]

[illegible]

[illegible]

[illegible]

State 281,	Action W,	Q-values:	[-0.05	-0.00	-0.03	+0.02	-0.06	-0.06]
State 282,	Action W,	Q-values:	[-0.04	-0.00	-0.03	+0.02	-0.06	-0.05]
State 283,	Action W,	Q-values:	[-0.05	-0.01	-0.03	+0.02	-0.05	-0.04]
State 284,	Action W,	Q-values:	[-0.04	+0.00	-0.03	+0.02	-0.06	-0.05]
State 285,	Action W,	Q-values:	[-0.05	-0.00	-0.03	+0.02	-0.06	-0.05]
State 286,	Action W,	Q-values:	[-0.05	-0.00	-0.03	+0.02	-0.06	-0.05]
State 287,	Action W,	Q-values:	[-0.04	-0.00	-0.02	+0.02	-0.06	-0.05]
State 288,	Action W,	Q-values:	[-0.05	-0.01	-0.03	+0.02	-0.06	-0.05]
State 289,	Action W,	Q-values:	[-0.05	-0.00	-0.03	+0.02	-0.06	-0.05]
State 290,	Action W,	Q-values:	[-0.05	+0.00	-0.03	+0.03	-0.05	-0.05]
State 291,	Action W,	Q-values:	[-0.05	-0.00	-0.03	+0.02	-0.06	-0.05]
State 292,	Action W,	Q-values:	[-0.04	-0.00	-0.03	+0.02	-0.06	-0.05]
State 293,	Action W,	Q-values:	[-0.05	-0.00	-0.04	+0.02	-0.06	-0.05]
State 294,	Action W,	Q-values:	[-0.04	+0.00	-0.03	+0.02	-0.06	-0.06]
State 295,	Action W,	Q-values:	[-0.05	+0.00	-0.04	+0.03	-0.06	-0.05]
State 296,	Action W,	Q-values:	[-0.04	-0.00	-0.03	+0.02	-0.06	-0.04]
State 297,	Action W,	Q-values:	[-0.04	+0.00	-0.03	+0.02	-0.06	-0.05]
State 298,	Action W,	Q-values:	[-0.05	-0.00	-0.03	+0.02	-0.06	-0.05]
State 299,	Action W,	Q-values:	[-0.04	+0.00	-0.03	+0.02	-0.06	-0.05]
State 300,	Action W,	Q-values:	[-0.05	-0.00	-0.04	+0.02	-0.06	-0.06]
State 301,	Action W,	Q-values:	[-0.04	-0.01	-0.03	+0.02	-0.06	-0.05]
State 302,	Action W,	Q-values:	[-0.04	+0.00	-0.03	+0.03	-0.06	-0.05]
State 303,	Action W,	Q-values:	[-0.04	+0.00	-0.03	+0.03	-0.06	-0.05]
State 304,	Action W,	Q-values:	[-0.04	+0.00	-0.03	+0.02	-0.06	-0.06]
State 305,	Action W,	Q-values:	[-0.04	+0.00	-0.04	+0.03	-0.05	-0.05]
State 306,	Action W,	Q-values:	[-0.04	-0.01	-0.03	+0.02	-0.06	-0.05]
State 307,	Action W,	Q-values:	[-0.04	+0.00	-0.03	+0.02	-0.06	-0.05]
State 308,	Action W,	Q-values:	[-0.04	+0.00	-0.04	+0.02	-0.06	-0.05]
State 309,	Action W,	Q-values:	[-0.04	-0.00	-0.03	+0.03	-0.05	-0.05]
State 310,	Action W,	Q-values:	[-0.04	+0.00	-0.03	+0.02	-0.06	-0.05]
State 311,	Action W,	Q-values:	[-0.04	-0.00	-0.03	+0.02	-0.06	-0.06]
State 312,	Action W,	Q-values:	[-0.05	-0.01	-0.03	+0.03	-0.06	-0.05]
State 313,	Action W,	Q-values:	[-0.05	-0.00	-0.04	+0.02	-0.06	-0.05]
State 314,	Action W,	Q-values:	[-0.05	-0.01	-0.03	+0.02	-0.06	-0.05]
State 315,	Action W,	Q-values:	[-0.05	-0.01	-0.03	+0.03	-0.06	-0.06]
State 316,	Action W,	Q-values:	[-0.04	-0.00	-0.03	+0.02	-0.06	-0.05]
State 317,	Action W,	Q-values:	[-0.05	-0.00	-0.03	+0.03	-0.06	-0.05]
State 318,	Action W,	Q-values:	[-0.04	+0.00	-0.03	+0.02	-0.05	-0.05]
State 319,	Action W,	Q-values:	[-0.05	-0.00	-0.03	+0.02	-0.06	-0.05]
State 320,	Action W,	Q-values:	[-0.05	+0.00	-0.03	+0.02	-0.06	-0.04]
State 321,	Action W,	Q-values:	[-0.05	-0.01	-0.04	+0.02	-0.06	-0.06]
State 322,	Action W,	Q-values:	[-0.04	+0.00	-0.04	+0.02	-0.06	-0.05]
State 323,	Action W,	Q-values:	[-0.04	+0.00	-0.03	+0.02	-0.06	-0.05]
State 324,	Action W,	Q-values:	[-0.05	-0.00	-0.03	+0.03	-0.06	-0.05]
State 325,	Action W,	Q-values:	[-0.03	-0.00	-0.04	+0.02	-0.06	-0.06]
State 326,	Action W,	Q-values:	[-0.04	+0.01	-0.03	+0.02	-0.05	-0.04]
State 327,	Action W,	Q-values:	[-0.05	-0.00	-0.03	+0.02	-0.06	-0.05]
State 328,	Action W,	Q-values:	[-0.05	-0.00	-0.03	+0.02	-0.06	-0.05]
State 329,	Action W,	Q-values:	[-0.05	-0.00	-0.03	+0.02	-0.05	-0.05]
State 330,	Action W,	Q-values:	[-0.04	-0.00	-0.03	+0.02	-0.06	-0.0

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State 452, Action W, Q-values: [-0.05 -0.00 -0.04 +0.02 -0.06 -0.04]
State 453, Action W, Q-values: [-0.04 +0.00 -0.03 +0.02 -0.05 -0.05]
State 454, Action W, Q-values: [-0.04 -0.01 -0.03 +0.02 -0.06 -0.05]
State 455, Action W, Q-values: [-0.05 -0.01 -0.04 +0.02 -0.06 -0.05]
State 456, Action W, Q-values: [-0.04 +0.00 -0.04 +0.02 -0.06 -0.05]
State 457, Action W, Q-values: [-0.05 -0.00 -0.04 +0.02 -0.06 -0.05]
State 458, Action W, Q-values: [-0.04 +0.00 -0.03 +0.02 -0.06 -0.04]
State 459, Action W, Q-values: [-0.04 -0.00 -0.04 +0.03 -0.06 -0.05]
State 460, Action W, Q-values: [-0.05 -0.00 -0.04 +0.02 -0.06 -0.05]
State 461, Action W, Q-values: [-0.05 +0.00 -0.03 +0.02 -0.05 -0.05]
State 462, Action W, Q-values: [-0.05 -0.00 -0.03 +0.02 -0.06 -0.05]
State 463, Action W, Q-values: [-0.05 -0.00 -0.03 +0.02 -0.06 -0.05]
State 464, Action W, Q-values: [-0.04 -0.00 -0.03 +0.02 -0.06 -0.05]
State 465, Action W, Q-values: [-0.05 -0.00 -0.03 +0.02 -0.06 -0.06]
State 466, Action W, Q-values: [-0.04 +0.00 -0.03 +0.02 -0.06 -0.05]
State 467, Action W, Q-values: [-0.05 -0.00 -0.03 +0.02 -0.05 -0.05]
State 468, Action W, Q-values: [-0.04 -0.00 -0.04 +0.02 -0.06 -0.05]
State 469, Action W, Q-values: [-0.04 +0.00 -0.04 +0.02 -0.06 -0.05]
State 470, Action W, Q-values: [-0.04 +0.00 -0.03 +0.03 -0.06 -0.05]
State 471, Action W, Q-values: [-0.05 -0.00 -0.02 +0.02 -0.06 -0.05]
State 472, Action W, Q-values: [-0.04 -0.00 -0.04 +0.02 -0.06 -0.05]
State 473, Action W, Q-values: [-0.04 -0.00 -0.03 +0.02 -0.06 -0.05]
State 474, Action W, Q-values: [-0.05 -0.00 -0.03 +0.02 -0.06 -0.05]
State 475, Action W, Q-values: [-0.05 -0.00 -0.04 +0.01 -0.06 -0.05]
State 476, Action W, Q-values: [-0.05 -0.00 -0.03 +0.02 -0.05 -0.05]
State 477, Action W, Q-values: [-0.04 +0.00 -0.03 +0.03 -0.06 -0.05]
State 478, Action W, Q-values: [-0.04 +0.01 -0.03 +0.02 -0.05 -0.05]
State 479, Action W, Q-values: [-0.05 -0.00 -0.03 +0.02 -0.06 -0.05]
State 480, Action W, Q-values: [-0.04 +0.00 -0.03 +0.02 -0.06 -0.05]
State 481, Action W, Q-values: [-0.04 +0.00 -0.03 +0.02 -0.06 -0.04]
State 482, Action W, Q-values: [-0.05 +0.00 -0.03 +0.02 -0.06 -0.05]
State 483, Action W, Q-values: [-0.04 -0.00 -0.04 +0.02 -0.05 -0.05]
State 484, Action W, Q-values: [-0.05 -0.01 -0.03 +0.02 -0.05 -0.05]
State 485, Action W, Q-values: [-0.04 +0.00 -0.03 +0.02 -0.05 -0.05]
State 486, Action W, Q-values: [-0.04 +0.00 -0.03 +0.03 -0.06 -0.05]
State 487, Action W, Q-values: [-0.05 -0.00 -0.04 +0.02 -0.06 -0.05]
State 488, Action W, Q-values: [-0.05 +0.00 -0.03 +0.02 -0.06 -0.05]
State 489, Action W, Q-values: [-0.05 -0.00 -0.03 +0.02 -0.06 -0.05]
State 490, Action W, Q-values: [-0.05 -0.01 -0.04 +0.02 -0.05 -0.05]
State 491, Action W, Q-values: [-0.05 -0.00 -0.03 +0.02 -0.06 -0.05]
State 492, Action W, Q-values: [-0.05 -0.00 -0.03 +0.02 -0.05 -0.05]
State 493, Action W, Q-values: [-0.05 -0.01 -0.03 +0.02 -0.05 -0.05]
State 494, Action W, Q-values: [-0.05 -0.00 -0.03 +0.03 -0.06 -0.05]
State 495, Action W, Q-values: [-0.05 +0.00 -0.03 +0.02 -0.06 -0.05]
State 496, Action W, Q-values: [-0.04 +0.00 -0.03 +0.03 -0.05 -0.05]
State 497, Action W, Q-values: [-0.05 -0.01 -0.03 +0.03 -0.06 -0.05]
State 498, Action W, Q-values: [-0.05 -0.00 -0.03 +0.02 -0.06 -0.05]
State 499, Action W, Q-values: [-0.04 -0.00 -0.04 +0.02 -0.06 -0.06]
Episode 100/100000, Avg Reward: -780.98, Epsilon: 0.99
Episode 200/100000, Avg Reward: -764.24, Epsilon: 0.99
Episode 300/100000, Avg Reward: -752.45, Epsilon: 0.98
Episode 400/100000, Avg Reward: -760.07, Epsilon: 0.97
Episode 500/100000, Avg Reward: -760.32, Epsilon: 0.97
Episode 600/100000, Avg Reward: -753.85, Epsilon: 0.96
Episode 700/100000, Avg Reward: -747.66, Epsilon: 0.95
Episode 800/100000, Avg Reward: -707.37, Epsilon: 0.95
Episode 900/100000, Avg Reward: -747.86, Epsilon: 0.94
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Episode	1000/100000	Avg Reward:	-743.63	Epsilon:	0.93
Episode	1100/100000	Avg Reward:	-723.94	Epsilon:	0.93
Episode	1200/100000	Avg Reward:	-720.74	Epsilon:	0.92
Episode	1300/100000	Avg Reward:	-727.58	Epsilon:	0.91
Episode	1400/100000	Avg Reward:	-706.80	Epsilon:	0.91
Episode	1500/100000	Avg Reward:	-702.67	Epsilon:	0.90
Episode	1600/100000	Avg Reward:	-712.68	Epsilon:	0.90
Episode	1700/100000	Avg Reward:	-699.46	Epsilon:	0.89
Episode	1800/100000	Avg Reward:	-707.97	Epsilon:	0.88
Episode	1900/100000	Avg Reward:	-707.33	Epsilon:	0.88
Episode	2000/100000	Avg Reward:	-693.54	Epsilon:	0.87
Episode	2100/100000	Avg Reward:	-698.69	Epsilon:	0.86
Episode	2200/100000	Avg Reward:	-690.03	Epsilon:	0.86
Episode	2300/100000	Avg Reward:	-682.40	Epsilon:	0.85
Episode	2400/100000	Avg Reward:	-680.60	Epsilon:	0.85
Episode	2500/100000	Avg Reward:	-671.55	Epsilon:	0.84
Episode	2600/100000	Avg Reward:	-675.95	Epsilon:	0.84
Episode	2700/100000	Avg Reward:	-669.89	Epsilon:	0.83
Episode	2800/100000	Avg Reward:	-676.30	Epsilon:	0.82
Episode	2900/100000	Avg Reward:	-684.47	Epsilon:	0.82
Episode	3000/100000	Avg Reward:	-661.76	Epsilon:	0.81
Episode	3100/100000	Avg Reward:	-664.32	Epsilon:	0.81
Episode	3200/100000	Avg Reward:	-668.93	Epsilon:	0.80
Episode	3300/100000	Avg Reward:	-669.62	Epsilon:	0.80
Episode	3400/100000	Avg Reward:	-652.36	Epsilon:	0.79
Episode	3500/100000	Avg Reward:	-660.19	Epsilon:	0.79
Episode	3600/100000	Avg Reward:	-645.94	Epsilon:	0.78
Episode	3700/100000	Avg Reward:	-631.22	Epsilon:	0.77
Episode	3800/100000	Avg Reward:	-643.36	Epsilon:	0.77
Episode	3900/100000	Avg Reward:	-651.62	Epsilon:	0.76
Episode	4000/100000	Avg Reward:	-632.33	Epsilon:	0.76
Episode	4100/100000	Avg Reward:	-635.98	Epsilon:	0.75
Episode	4200/100000	Avg Reward:	-623.11	Epsilon:	0.75
Episode	4300/100000	Avg Reward:	-618.15	Epsilon:	0.74
Episode	4400/100000	Avg Reward:	-615.42	Epsilon:	0.74
Episode	4500/100000	Avg Reward:	-616.28	Epsilon:	0.73
Episode	4600/100000	Avg Reward:	-632.31	Epsilon:	0.73
Episode	4700/100000	Avg Reward:	-618.54	Epsilon:	0.72
Episode	4800/100000	Avg Reward:	-617.60	Epsilon:	0.72
Episode	4900/100000	Avg Reward:	-618.73	Epsilon:	0.71
Episode	5000/100000	Avg Reward:	-612.98	Epsilon:	0.71
Episode	5100/100000	Avg Reward:	-593.61	Epsilon:	0.70
Episode	5200/100000	Avg Reward:	-587.65	Epsilon:	0.70
Episode	5300/100000	Avg Reward:	-599.15	Epsilon:	0.69
Episode	5400/100000	Avg Reward:	-596.44	Epsilon:	0.69
Episode	5500/100000	Avg Reward:	-595.46	Epsilon:	0.68
Episode	5600/100000	Avg Reward:	-588.88	Epsilon:	0.68
Episode	5700/100000	Avg Reward:	-581.75	Epsilon:	0.67
Episode	5800/100000	Avg Reward:	-576.30	Epsilon:	0.67
Episode	5900/100000	Avg Reward:	-589.02	Epsilon:	0.67
Episode	6000/100000	Avg Reward:	-576.58	Epsilon:	0.66
Episode	6100/100000	Avg Reward:	-580.16	Epsilon:	0.66
Episode	6200/100000	Avg Reward:	-581.76	Epsilon:	0.65
Episode	6300/100000	Avg Reward:	-575.03	Epsilon:	0.65
Episode	6400/100000	Avg Reward:	-568.55	Epsilon:	0.64
Episode	6500/100000	Avg Reward:	-563.57	Epsilon:	0.64
Episode	6600/100000	Avg Reward:	-563.26	Epsilon:	0.63

Episode 6700/100000, Avg Reward: -559.17, Epsilon: 0.63
Episode 6800/100000, Avg Reward: -565.04, Epsilon: 0.63
Episode 6900/100000, Avg Reward: -545.93, Epsilon: 0.62
Episode 7000/100000, Avg Reward: -561.80, Epsilon: 0.62
Episode 7100/100000, Avg Reward: -546.36, Epsilon: 0.61
Episode 7200/100000, Avg Reward: -547.61, Epsilon: 0.61
Episode 7300/100000, Avg Reward: -546.29, Epsilon: 0.60
Episode 7400/100000, Avg Reward: -542.43, Epsilon: 0.60
Episode 7500/100000, Avg Reward: -541.74, Epsilon: 0.60
Episode 7600/100000, Avg Reward: -538.91, Epsilon: 0.59
Episode 7700/100000, Avg Reward: -531.54, Epsilon: 0.59
Episode 7800/100000, Avg Reward: -540.18, Epsilon: 0.58
Episode 7900/100000, Avg Reward: -535.97, Epsilon: 0.58
Episode 8000/100000, Avg Reward: -535.42, Epsilon: 0.58
Episode 8100/100000, Avg Reward: -524.43, Epsilon: 0.57
Episode 8200/100000, Avg Reward: -530.48, Epsilon: 0.57
Episode 8300/100000, Avg Reward: -528.50, Epsilon: 0.56
Episode 8400/100000, Avg Reward: -520.57, Epsilon: 0.56
Episode 8500/100000, Avg Reward: -511.22, Epsilon: 0.56
Episode 8600/100000, Avg Reward: -509.64, Epsilon: 0.55
Episode 8700/100000, Avg Reward: -509.40, Epsilon: 0.55
Episode 8800/100000, Avg Reward: -510.37, Epsilon: 0.54
Episode 8900/100000, Avg Reward: -508.01, Epsilon: 0.54
Episode 9000/100000, Avg Reward: -509.33, Epsilon: 0.54
Episode 9100/100000, Avg Reward: -505.91, Epsilon: 0.53
Episode 9200/100000, Avg Reward: -513.33, Epsilon: 0.53
Episode 9300/100000, Avg Reward: -503.67, Epsilon: 0.53
Episode 9400/100000, Avg Reward: -499.30, Epsilon: 0.52
Episode 9500/100000, Avg Reward: -494.53, Epsilon: 0.52
Episode 9600/100000, Avg Reward: -494.19, Epsilon: 0.52
Episode 9700/100000, Avg Reward: -489.75, Epsilon: 0.51
Episode 9800/100000, Avg Reward: -485.48, Epsilon: 0.51
Episode 9900/100000, Avg Reward: -492.21, Epsilon: 0.50
Episode 10000/100000, Avg Reward: -489.62, Epsilon: 0.50
Episode 10100/100000, Avg Reward: -484.76, Epsilon: 0.50
Episode 10200/100000, Avg Reward: -488.33, Epsilon: 0.49
Episode 10300/100000, Avg Reward: -476.03, Epsilon: 0.49
Episode 10400/100000, Avg Reward: -494.03, Epsilon: 0.49
Episode 10500/100000, Avg Reward: -477.75, Epsilon: 0.48
Episode 10600/100000, Avg Reward: -467.43, Epsilon: 0.48
Episode 10700/100000, Avg Reward: -479.09, Epsilon: 0.48
Episode 10800/100000, Avg Reward: -473.60, Epsilon: 0.47
Episode 10900/100000, Avg Reward: -465.07, Epsilon: 0.47
Episode 11000/100000, Avg Reward: -468.74, Epsilon: 0.47
Episode 11100/100000, Avg Reward: -467.68, Epsilon: 0.46
Episode 11200/100000, Avg Reward: -463.68, Epsilon: 0.46
Episode 11300/100000, Avg Reward: -462.89, Epsilon: 0.46
Episode 11400/100000, Avg Reward: -461.54, Epsilon: 0.45
Episode 11500/100000, Avg Reward: -467.03, Epsilon: 0.45
Episode 11600/100000, Avg Reward: -461.86, Epsilon: 0.45
Episode 11700/100000, Avg Reward: -451.27, Epsilon: 0.45
Episode 11800/100000, Avg Reward: -448.45, Epsilon: 0.44
Episode 11900/100000, Avg Reward: -450.20, Epsilon: 0.44
Episode 12000/100000, Avg Reward: -449.09, Epsilon: 0.44
Episode 12100/100000, Avg Reward: -449.64, Epsilon: 0.43
Episode 12200/100000, Avg Reward: -455.60, Epsilon: 0.43
Episode 12300/100000, Avg Reward: -441.34, Epsilon: 0.43

Episode	12400/100000	Avg Reward:	-453.49	Epsilon:	0.42
Episode	12500/100000	Avg Reward:	-438.59	Epsilon:	0.42
Episode	12600/100000	Avg Reward:	-446.42	Epsilon:	0.42
Episode	12700/100000	Avg Reward:	-438.20	Epsilon:	0.42
Episode	12800/100000	Avg Reward:	-443.54	Epsilon:	0.41
Episode	12900/100000	Avg Reward:	-439.04	Epsilon:	0.41
Episode	13000/100000	Avg Reward:	-436.25	Epsilon:	0.41
Episode	13100/100000	Avg Reward:	-428.60	Epsilon:	0.40
Episode	13200/100000	Avg Reward:	-433.97	Epsilon:	0.40
Episode	13300/100000	Avg Reward:	-426.25	Epsilon:	0.40
Episode	13400/100000	Avg Reward:	-424.55	Epsilon:	0.40
Episode	13500/100000	Avg Reward:	-428.64	Epsilon:	0.39
Episode	13600/100000	Avg Reward:	-419.24	Epsilon:	0.39
Episode	13700/100000	Avg Reward:	-436.19	Epsilon:	0.39
Episode	13800/100000	Avg Reward:	-428.51	Epsilon:	0.39
Episode	13900/100000	Avg Reward:	-420.41	Epsilon:	0.38
Episode	14000/100000	Avg Reward:	-414.29	Epsilon:	0.38
Episode	14100/100000	Avg Reward:	-407.54	Epsilon:	0.38
Episode	14200/100000	Avg Reward:	-406.93	Epsilon:	0.37
Episode	14300/100000	Avg Reward:	-409.61	Epsilon:	0.37
Episode	14400/100000	Avg Reward:	-410.51	Epsilon:	0.37
Episode	14500/100000	Avg Reward:	-413.48	Epsilon:	0.37
Episode	14600/100000	Avg Reward:	-409.70	Epsilon:	0.36
Episode	14700/100000	Avg Reward:	-410.51	Epsilon:	0.36
Episode	14800/100000	Avg Reward:	-397.20	Epsilon:	0.36
Episode	14900/100000	Avg Reward:	-409.52	Epsilon:	0.36
Episode	15000/100000	Avg Reward:	-406.64	Epsilon:	0.35
Episode	15100/100000	Avg Reward:	-404.48	Epsilon:	0.35
Episode	15200/100000	Avg Reward:	-407.98	Epsilon:	0.35
Episode	15300/100000	Avg Reward:	-397.99	Epsilon:	0.35
Episode	15400/100000	Avg Reward:	-400.52	Epsilon:	0.35
Episode	15500/100000	Avg Reward:	-400.43	Epsilon:	0.34
Episode	15600/100000	Avg Reward:	-389.90	Epsilon:	0.34
Episode	15700/100000	Avg Reward:	-394.49	Epsilon:	0.34
Episode	15800/100000	Avg Reward:	-391.07	Epsilon:	0.34
Episode	15900/100000	Avg Reward:	-390.17	Epsilon:	0.33
Episode	16000/100000	Avg Reward:	-396.47	Epsilon:	0.33
Episode	16100/100000	Avg Reward:	-393.32	Epsilon:	0.33
Episode	16200/100000	Avg Reward:	-385.94	Epsilon:	0.33
Episode	16300/100000	Avg Reward:	-390.44	Epsilon:	0.32
Episode	16400/100000	Avg Reward:	-390.53	Epsilon:	0.32
Episode	16500/100000	Avg Reward:	-380.72	Epsilon:	0.32
Episode	16600/100000	Avg Reward:	-379.82	Epsilon:	0.32
Episode	16700/100000	Avg Reward:	-385.13	Epsilon:	0.32
Episode	16800/100000	Avg Reward:	-380.36	Epsilon:	0.31
Episode	16900/100000	Avg Reward:	-383.78	Epsilon:	0.31
Episode	17000/100000	Avg Reward:	-388.28	Epsilon:	0.31
Episode	17100/100000	Avg Reward:	-370.01	Epsilon:	0.31
Episode	17200/100000	Avg Reward:	-374.33	Epsilon:	0.30
Episode	17300/100000	Avg Reward:	-371.09	Epsilon:	0.30
Episode	17400/100000	Avg Reward:	-377.21	Epsilon:	0.30
Episode	17500/100000	Avg Reward:	-362.27	Epsilon:	0.30
Episode	17600/100000	Avg Reward:	-368.12	Epsilon:	0.30
Episode	17700/100000	Avg Reward:	-365.51	Epsilon:	0.29
Episode	17800/100000	Avg Reward:	-367.94	Epsilon:	0.29
Episode	17900/100000	Avg Reward:	-378.11	Epsilon:	0.29
Episode	18000/100000	Avg Reward:	-365.69	Epsilon:	0.29

Episode	18100/100000	Avg Reward:	-364.52	Epsilon:	0.29
Episode	18200/100000	Avg Reward:	-366.23	Epsilon:	0.28
Episode	18300/100000	Avg Reward:	-359.66	Epsilon:	0.28
Episode	18400/100000	Avg Reward:	-359.99	Epsilon:	0.28
Episode	18500/100000	Avg Reward:	-357.05	Epsilon:	0.28
Episode	18600/100000	Avg Reward:	-357.23	Epsilon:	0.28
Episode	18700/100000	Avg Reward:	-360.65	Epsilon:	0.27
Episode	18800/100000	Avg Reward:	-356.33	Epsilon:	0.27
Episode	18900/100000	Avg Reward:	-355.34	Epsilon:	0.27
Episode	19000/100000	Avg Reward:	-359.12	Epsilon:	0.27
Episode	19100/100000	Avg Reward:	-351.56	Epsilon:	0.27
Episode	19200/100000	Avg Reward:	-349.76	Epsilon:	0.27
Episode	19300/100000	Avg Reward:	-350.75	Epsilon:	0.26
Episode	19400/100000	Avg Reward:	-347.33	Epsilon:	0.26
Episode	19500/100000	Avg Reward:	-343.28	Epsilon:	0.26
Episode	19600/100000	Avg Reward:	-343.19	Epsilon:	0.26
Episode	19700/100000	Avg Reward:	-349.76	Epsilon:	0.26
Episode	19800/100000	Avg Reward:	-344.54	Epsilon:	0.25
Episode	19900/100000	Avg Reward:	-344.81	Epsilon:	0.25
Episode	20000/100000	Avg Reward:	-350.48	Epsilon:	0.25
Episode	20100/100000	Avg Reward:	-346.16	Epsilon:	0.25
Episode	20200/100000	Avg Reward:	-336.98	Epsilon:	0.25
Episode	20300/100000	Avg Reward:	-337.70	Epsilon:	0.25
Episode	20400/100000	Avg Reward:	-338.78	Epsilon:	0.24
Episode	20500/100000	Avg Reward:	-341.57	Epsilon:	0.24
Episode	20600/100000	Avg Reward:	-331.94	Epsilon:	0.24
Episode	20700/100000	Avg Reward:	-341.39	Epsilon:	0.24
Episode	20800/100000	Avg Reward:	-341.12	Epsilon:	0.24
Episode	20900/100000	Avg Reward:	-337.61	Epsilon:	0.24
Episode	21000/100000	Avg Reward:	-329.42	Epsilon:	0.23
Episode	21100/100000	Avg Reward:	-336.89	Epsilon:	0.23
Episode	21200/100000	Avg Reward:	-332.84	Epsilon:	0.23
Episode	21300/100000	Avg Reward:	-334.37	Epsilon:	0.23
Episode	21400/100000	Avg Reward:	-325.37	Epsilon:	0.23
Episode	21500/100000	Avg Reward:	-328.88	Epsilon:	0.23
Episode	21600/100000	Avg Reward:	-328.97	Epsilon:	0.22
Episode	21700/100000	Avg Reward:	-326.54	Epsilon:	0.22
Episode	21800/100000	Avg Reward:	-328.43	Epsilon:	0.22
Episode	21900/100000	Avg Reward:	-325.01	Epsilon:	0.22
Episode	22000/100000	Avg Reward:	-325.64	Epsilon:	0.22
Episode	22100/100000	Avg Reward:	-323.33	Epsilon:	0.22
Episode	22200/100000	Avg Reward:	-329.51	Epsilon:	0.22
Episode	22300/100000	Avg Reward:	-321.23	Epsilon:	0.21
Episode	22400/100000	Avg Reward:	-324.65	Epsilon:	0.21
Episode	22500/100000	Avg Reward:	-320.33	Epsilon:	0.21
Episode	22600/100000	Avg Reward:	-319.25	Epsilon:	0.21
Episode	22700/100000	Avg Reward:	-327.26	Epsilon:	0.21
Episode	22800/100000	Avg Reward:	-321.41	Epsilon:	0.21
Episode	22900/100000	Avg Reward:	-318.17	Epsilon:	0.21
Episode	23000/100000	Avg Reward:	-313.94	Epsilon:	0.20
Episode	23100/100000	Avg Reward:	-317.00	Epsilon:	0.20
Episode	23200/100000	Avg Reward:	-312.50	Epsilon:	0.20
Episode	23300/100000	Avg Reward:	-312.86	Epsilon:	0.20
Episode	23400/100000	Avg Reward:	-313.40	Epsilon:	0.20
Episode	23500/100000	Avg Reward:	-317.36	Epsilon:	0.20
Episode	23600/100000	Avg Reward:	-312.32	Epsilon:	0.20
Episode	23700/100000	Avg Reward:	-310.16	Epsilon:	0.19

Episode	23800/100000	Avg Reward:	-312.95	Epsilon:	0.19
Episode	23900/100000	Avg Reward:	-312.23	Epsilon:	0.19
Episode	24000/100000	Avg Reward:	-305.21	Epsilon:	0.19
Episode	24100/100000	Avg Reward:	-309.80	Epsilon:	0.19
Episode	24200/100000	Avg Reward:	-303.86	Epsilon:	0.19
Episode	24300/100000	Avg Reward:	-307.37	Epsilon:	0.19
Episode	24400/100000	Avg Reward:	-309.26	Epsilon:	0.19
Episode	24500/100000	Avg Reward:	-309.53	Epsilon:	0.18
Episode	24600/100000	Avg Reward:	-303.77	Epsilon:	0.18
Episode	24700/100000	Avg Reward:	-301.25	Epsilon:	0.18
Episode	24800/100000	Avg Reward:	-307.55	Epsilon:	0.18
Episode	24900/100000	Avg Reward:	-305.12	Epsilon:	0.18
Episode	25000/100000	Avg Reward:	-304.67	Epsilon:	0.18
Episode	25100/100000	Avg Reward:	-293.15	Epsilon:	0.18
Episode	25200/100000	Avg Reward:	-302.87	Epsilon:	0.18
Episode	25300/100000	Avg Reward:	-302.24	Epsilon:	0.17
Episode	25400/100000	Avg Reward:	-294.50	Epsilon:	0.17
Episode	25500/100000	Avg Reward:	-300.53	Epsilon:	0.17
Episode	25600/100000	Avg Reward:	-299.00	Epsilon:	0.17
Episode	25700/100000	Avg Reward:	-296.48	Epsilon:	0.17
Episode	25800/100000	Avg Reward:	-296.57	Epsilon:	0.17
Episode	25900/100000	Avg Reward:	-292.97	Epsilon:	0.17
Episode	26000/100000	Avg Reward:	-295.31	Epsilon:	0.17
Episode	26100/100000	Avg Reward:	-298.28	Epsilon:	0.16
Episode	26200/100000	Avg Reward:	-294.50	Epsilon:	0.16
Episode	26300/100000	Avg Reward:	-290.36	Epsilon:	0.16
Episode	26400/100000	Avg Reward:	-293.15	Epsilon:	0.16
Episode	26500/100000	Avg Reward:	-290.72	Epsilon:	0.16
Episode	26600/100000	Avg Reward:	-291.80	Epsilon:	0.16
Episode	26700/100000	Avg Reward:	-286.40	Epsilon:	0.16
Episode	26800/100000	Avg Reward:	-286.40	Epsilon:	0.16
Episode	26900/100000	Avg Reward:	-293.06	Epsilon:	0.16
Episode	27000/100000	Avg Reward:	-288.56	Epsilon:	0.15
Episode	27100/100000	Avg Reward:	-288.02	Epsilon:	0.15
Episode	27200/100000	Avg Reward:	-287.57	Epsilon:	0.15
Episode	27300/100000	Avg Reward:	-287.21	Epsilon:	0.15
Episode	27400/100000	Avg Reward:	-287.39	Epsilon:	0.15
Episode	27500/100000	Avg Reward:	-285.41	Epsilon:	0.15
Episode	27600/100000	Avg Reward:	-289.01	Epsilon:	0.15
Episode	27700/100000	Avg Reward:	-286.40	Epsilon:	0.15
Episode	27800/100000	Avg Reward:	-284.24	Epsilon:	0.15
Episode	27900/100000	Avg Reward:	-281.63	Epsilon:	0.15
Episode	28000/100000	Avg Reward:	-282.98	Epsilon:	0.14
Episode	28100/100000	Avg Reward:	-284.60	Epsilon:	0.14
Episode	28200/100000	Avg Reward:	-279.29	Epsilon:	0.14
Episode	28300/100000	Avg Reward:	-283.25	Epsilon:	0.14
Episode	28400/100000	Avg Reward:	-283.52	Epsilon:	0.14
Episode	28500/100000	Avg Reward:	-278.66	Epsilon:	0.14
Episode	28600/100000	Avg Reward:	-279.65	Epsilon:	0.14
Episode	28700/100000	Avg Reward:	-275.96	Epsilon:	0.14
Episode	28800/100000	Avg Reward:	-279.65	Epsilon:	0.14
Episode	28900/100000	Avg Reward:	-276.23	Epsilon:	0.14
Episode	29000/100000	Avg Reward:	-277.58	Epsilon:	0.13
Episode	29100/100000	Avg Reward:	-273.26	Epsilon:	0.13
Episode	29200/100000	Avg Reward:	-273.62	Epsilon:	0.13
Episode	29300/100000	Avg Reward:	-271.91	Epsilon:	0.13
Episode	29400/100000	Avg Reward:	-275.96	Epsilon:	0.13

Episode	29500/100000	Avg Reward:	-275.69	Epsilon:	0.13
Episode	29600/100000	Avg Reward:	-274.43	Epsilon:	0.13
Episode	29700/100000	Avg Reward:	-271.91	Epsilon:	0.13
Episode	29800/100000	Avg Reward:	-271.37	Epsilon:	0.13
Episode	29900/100000	Avg Reward:	-271.73	Epsilon:	0.13
Episode	30000/100000	Avg Reward:	-269.48	Epsilon:	0.13
Episode	30100/100000	Avg Reward:	-268.49	Epsilon:	0.13
Episode	30200/100000	Avg Reward:	-271.19	Epsilon:	0.12
Episode	30300/100000	Avg Reward:	-272.54	Epsilon:	0.12
Episode	30400/100000	Avg Reward:	-266.87	Epsilon:	0.12
Episode	30500/100000	Avg Reward:	-272.54	Epsilon:	0.12
Episode	30600/100000	Avg Reward:	-274.52	Epsilon:	0.12
Episode	30700/100000	Avg Reward:	-274.43	Epsilon:	0.12
Episode	30800/100000	Avg Reward:	-270.02	Epsilon:	0.12
Episode	30900/100000	Avg Reward:	-272.90	Epsilon:	0.12
Episode	31000/100000	Avg Reward:	-265.66	Epsilon:	0.12
Episode	31100/100000	Avg Reward:	-262.01	Epsilon:	0.12
Episode	31200/100000	Avg Reward:	-267.68	Epsilon:	0.12
Episode	31300/100000	Avg Reward:	-266.06	Epsilon:	0.12
Episode	31400/100000	Avg Reward:	-268.49	Epsilon:	0.11
Episode	31500/100000	Avg Reward:	-265.25	Epsilon:	0.11
Episode	31600/100000	Avg Reward:	-271.91	Epsilon:	0.11
Episode	31700/100000	Avg Reward:	-260.84	Epsilon:	0.11
Episode	31800/100000	Avg Reward:	-262.37	Epsilon:	0.11
Episode	31900/100000	Avg Reward:	-263.72	Epsilon:	0.11
Episode	32000/100000	Avg Reward:	-261.83	Epsilon:	0.11
Episode	32100/100000	Avg Reward:	-261.92	Epsilon:	0.11
Episode	32200/100000	Avg Reward:	-258.41	Epsilon:	0.11
Episode	32300/100000	Avg Reward:	-262.19	Epsilon:	0.11
Episode	32400/100000	Avg Reward:	-260.66	Epsilon:	0.11
Episode	32500/100000	Avg Reward:	-258.32	Epsilon:	0.11
Episode	32600/100000	Avg Reward:	-258.23	Epsilon:	0.11
Episode	32700/100000	Avg Reward:	-257.42	Epsilon:	0.10
Episode	32800/100000	Avg Reward:	-255.26	Epsilon:	0.10
Episode	32900/100000	Avg Reward:	-257.78	Epsilon:	0.10
Episode	33000/100000	Avg Reward:	-258.23	Epsilon:	0.10
Episode	33100/100000	Avg Reward:	-262.10	Epsilon:	0.10
Episode	33200/100000	Avg Reward:	-255.71	Epsilon:	0.10
Episode	33300/100000	Avg Reward:	-256.88	Epsilon:	0.10
Episode	33400/100000	Avg Reward:	-255.98	Epsilon:	0.10
Episode	33500/100000	Avg Reward:	-256.34	Epsilon:	0.10
Episode	33600/100000	Avg Reward:	-254.99	Epsilon:	0.10
Episode	33700/100000	Avg Reward:	-255.71	Epsilon:	0.10
Episode	33800/100000	Avg Reward:	-253.55	Epsilon:	0.10
Episode	33900/100000	Avg Reward:	-253.10	Epsilon:	0.10
Episode	34000/100000	Avg Reward:	-255.08	Epsilon:	0.10
Episode	34100/100000	Avg Reward:	-255.89	Epsilon:	0.09
Episode	34200/100000	Avg Reward:	-252.83	Epsilon:	0.09
Episode	34300/100000	Avg Reward:	-255.08	Epsilon:	0.09
Episode	34400/100000	Avg Reward:	-251.57	Epsilon:	0.09
Episode	34500/100000	Avg Reward:	-255.89	Epsilon:	0.09
Episode	34600/100000	Avg Reward:	-250.67	Epsilon:	0.09
Episode	34700/100000	Avg Reward:	-255.17	Epsilon:	0.09
Episode	34800/100000	Avg Reward:	-249.41	Epsilon:	0.09
Episode	34900/100000	Avg Reward:	-251.66	Epsilon:	0.09
Episode	35000/100000	Avg Reward:	-248.96	Epsilon:	0.09
Episode	35100/100000	Avg Reward:	-251.84	Epsilon:	0.09

Episode 35200/100000, Avg Reward: -246.38, Epsilon: 0.09
Episode 35300/100000, Avg Reward: -247.88, Epsilon: 0.09
Episode 35400/100000, Avg Reward: -252.56, Epsilon: 0.09
Episode 35500/100000, Avg Reward: -248.78, Epsilon: 0.09
Episode 35600/100000, Avg Reward: -247.52, Epsilon: 0.09
Episode 35700/100000, Avg Reward: -248.15, Epsilon: 0.08
Episode 35800/100000, Avg Reward: -249.95, Epsilon: 0.08
Episode 35900/100000, Avg Reward: -247.25, Epsilon: 0.08
Episode 36000/100000, Avg Reward: -245.90, Epsilon: 0.08
Episode 36100/100000, Avg Reward: -245.81, Epsilon: 0.08
Episode 36200/100000, Avg Reward: -250.76, Epsilon: 0.08
Episode 36300/100000, Avg Reward: -250.58, Epsilon: 0.08
Episode 36400/100000, Avg Reward: -244.37, Epsilon: 0.08
Episode 36500/100000, Avg Reward: -245.72, Epsilon: 0.08
Episode 36600/100000, Avg Reward: -245.81, Epsilon: 0.08
Episode 36700/100000, Avg Reward: -239.93, Epsilon: 0.08
Episode 36800/100000, Avg Reward: -248.24, Epsilon: 0.08
Episode 36900/100000, Avg Reward: -245.45, Epsilon: 0.08
Episode 37000/100000, Avg Reward: -243.02, Epsilon: 0.08
Episode 37100/100000, Avg Reward: -242.03, Epsilon: 0.08
Episode 37200/100000, Avg Reward: -244.55, Epsilon: 0.08
Episode 37300/100000, Avg Reward: -245.72, Epsilon: 0.08
Episode 37400/100000, Avg Reward: -241.67, Epsilon: 0.08
Episode 37500/100000, Avg Reward: -241.94, Epsilon: 0.07
Episode 37600/100000, Avg Reward: -243.74, Epsilon: 0.07
Episode 37700/100000, Avg Reward: -239.33, Epsilon: 0.07
Episode 37800/100000, Avg Reward: -238.34, Epsilon: 0.07
Episode 37900/100000, Avg Reward: -239.69, Epsilon: 0.07
Episode 38000/100000, Avg Reward: -237.89, Epsilon: 0.07
Episode 38100/100000, Avg Reward: -245.27, Epsilon: 0.07
Episode 38200/100000, Avg Reward: -238.16, Epsilon: 0.07
Episode 38300/100000, Avg Reward: -241.31, Epsilon: 0.07
Episode 38400/100000, Avg Reward: -239.69, Epsilon: 0.07
Episode 38500/100000, Avg Reward: -239.69, Epsilon: 0.07
Episode 38600/100000, Avg Reward: -237.53, Epsilon: 0.07
Episode 38700/100000, Avg Reward: -242.57, Epsilon: 0.07
Episode 38800/100000, Avg Reward: -241.04, Epsilon: 0.07
Episode 38900/100000, Avg Reward: -237.08, Epsilon: 0.07
Episode 39000/100000, Avg Reward: -239.87, Epsilon: 0.07
Episode 39100/100000, Avg Reward: -238.88, Epsilon: 0.07
Episode 39200/100000, Avg Reward: -238.61, Epsilon: 0.07
Episode 39300/100000, Avg Reward: -239.60, Epsilon: 0.07
Episode 39400/100000, Avg Reward: -238.25, Epsilon: 0.07
Episode 39500/100000, Avg Reward: -237.89, Epsilon: 0.07
Episode 39600/100000, Avg Reward: -235.73, Epsilon: 0.06
Episode 39700/100000, Avg Reward: -237.98, Epsilon: 0.06
Episode 39800/100000, Avg Reward: -234.74, Epsilon: 0.06
Episode 39900/100000, Avg Reward: -230.78, Epsilon: 0.06
Episode 40000/100000, Avg Reward: -235.37, Epsilon: 0.06
Episode 40100/100000, Avg Reward: -236.00, Epsilon: 0.06
Episode 40200/100000, Avg Reward: -237.17, Epsilon: 0.06
Episode 40300/100000, Avg Reward: -236.09, Epsilon: 0.06
Episode 40400/100000, Avg Reward: -235.10, Epsilon: 0.06
Episode 40500/100000, Avg Reward: -232.04, Epsilon: 0.06
Episode 40600/100000, Avg Reward: -235.64, Epsilon: 0.06
Episode 40700/100000, Avg Reward: -235.10, Epsilon: 0.06
Episode 40800/100000, Avg Reward: -235.82, Epsilon: 0.06

Episode 40900/100000, Avg Reward: -234.20, Epsilon: 0.06
Episode 41000/100000, Avg Reward: -234.38, Epsilon: 0.06
Episode 41100/100000, Avg Reward: -233.84, Epsilon: 0.06
Episode 41200/100000, Avg Reward: -234.20, Epsilon: 0.06
Episode 41300/100000, Avg Reward: -232.85, Epsilon: 0.06
Episode 41400/100000, Avg Reward: -229.07, Epsilon: 0.06
Episode 41500/100000, Avg Reward: -232.67, Epsilon: 0.06
Episode 41600/100000, Avg Reward: -234.11, Epsilon: 0.06
Episode 41700/100000, Avg Reward: -233.03, Epsilon: 0.06
Episode 41800/100000, Avg Reward: -235.19, Epsilon: 0.06
Episode 41900/100000, Avg Reward: -230.24, Epsilon: 0.06
Episode 42000/100000, Avg Reward: -230.78, Epsilon: 0.05
Episode 42100/100000, Avg Reward: -232.49, Epsilon: 0.05
Episode 42200/100000, Avg Reward: -229.34, Epsilon: 0.05
Episode 42300/100000, Avg Reward: -229.07, Epsilon: 0.05
Episode 42400/100000, Avg Reward: -229.43, Epsilon: 0.05
Episode 42500/100000, Avg Reward: -233.12, Epsilon: 0.05
Episode 42600/100000, Avg Reward: -229.52, Epsilon: 0.05
Episode 42700/100000, Avg Reward: -229.07, Epsilon: 0.05
Episode 42800/100000, Avg Reward: -229.25, Epsilon: 0.05
Episode 42900/100000, Avg Reward: -227.90, Epsilon: 0.05
Episode 43000/100000, Avg Reward: -228.17, Epsilon: 0.05
Episode 43100/100000, Avg Reward: -230.24, Epsilon: 0.05
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Episode 43300/100000, Avg Reward: -227.45, Epsilon: 0.05
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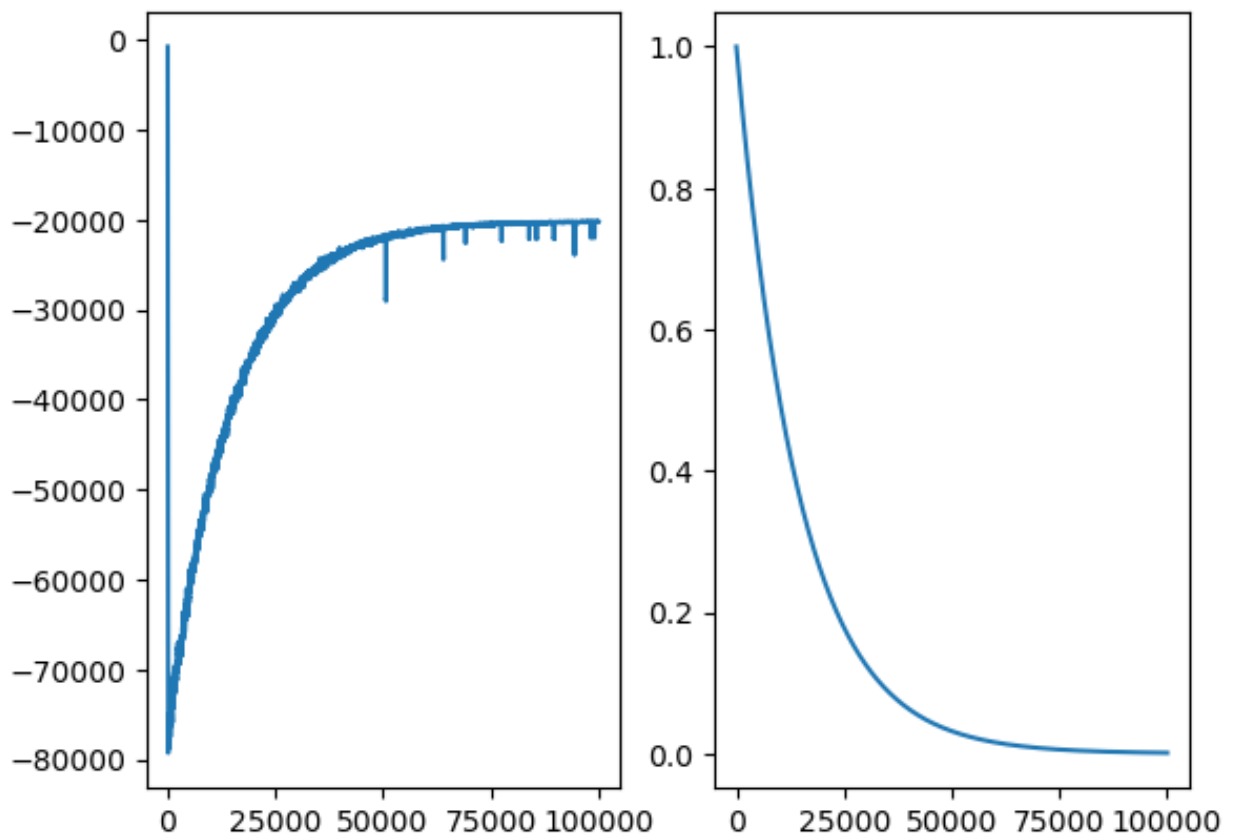
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Episode 97900/100000, Avg Reward: -200.54, Epsilon: 0.00
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Episode 98500/100000, Avg Reward: -200.90, Epsilon: 0.00
Episode 98600/100000, Avg Reward: -200.81, Epsilon: 0.00
Episode 98700/100000, Avg Reward: -200.72, Epsilon: 0.00
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Episode 99700/100000, Avg Reward: -200.81, Epsilon: 0.00
Episode 99800/100000, Avg Reward: -200.54, Epsilon: 0.00
Episode 99900/100000, Avg Reward: -200.72, Epsilon: 0.00
Episode 100000/100000, Avg Reward: -200.18, Epsilon: 0.00
!!!!!!!!!!!!!!!!!!!!Trained and Stored the model successfully!!!!!!!!!!!!!!!!!!!!
CPU times: user 2h 38min 50s, sys: 6min 46s, total: 2h 45min 36s
Wall time: 41min 51s

```



```
In [38]: print(my_dqn_agent_controlled_training_rewards )
```

```
[-785. -758. -776. ... -200. -200. -200.]
```

```
In [39]: controlled_training = {
    "my_q_agent_controlled_training_rewards": list(my_q_agent_controlled_tr
    "my_dqn_agent_controlled_training_rewards": list(my_dqn_agent_controlle
```

```
}
```

```
In [40]: print(type(my_q_agent_controlled_training_rewards))
print(type(my_dqn_agent_controlled_training_rewards))
```

```
<class 'numpy.ndarray'>
<class 'numpy.ndarray'>
```

```
In [41]: with open("controlled_training.json", "w") as f:
        json.dump(controlled_training, f)
```

```
# r = {'is_claimed': 'True', 'rating': 3.5}
# r = json.dumps(controlled_training)
# loaded_r = json.loads(r)
```

```
In [42]: with open("controlled_training.json", "r") as f:
        controlled_training_dict = json.load(f)

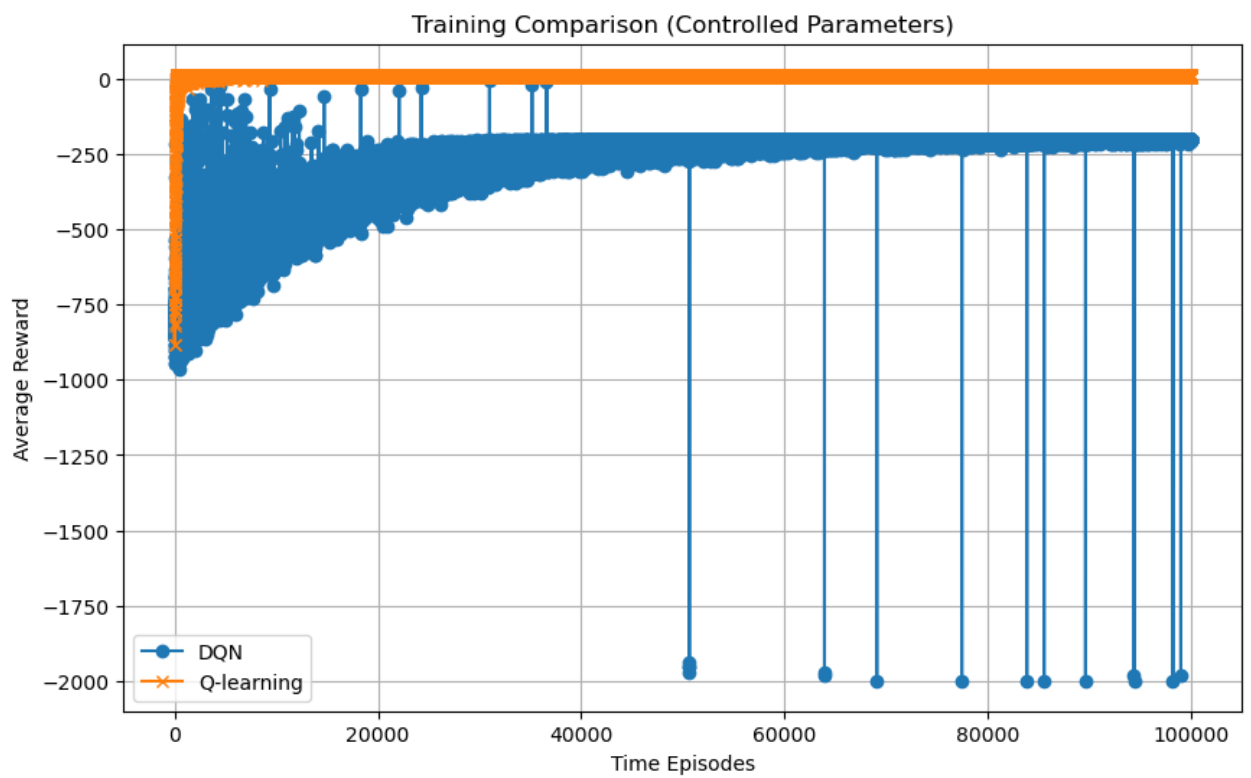
# controlled_training_dict = json.loads(jsonString)
```

Compare the training reward

```
In [44]: x = range(1, 100000 + 1)

plt.figure(figsize=(10, 6))
plt.plot(x, controlled_training_dict["my_dqn_agent_controlled_training_re
plt.plot(x, controlled_training_dict["my_q_agent_controlled_training_rewa

# titles and labels
plt.title('Training Comparison (Controlled Parameters)')
plt.xlabel('Time Episodes')
plt.ylabel('Average Reward')
plt.legend()
# display
plt.grid(True)
plt.show()
```



Prediction with the Controlled models

Q Learning Agent with Controlled Parameters

```
In [47]: my_q_agent_controlled_avg_reward_lst = my_q_agent_controlled.test(test_ep
```

```
=====
EPISODE 0
Score of total rewards: 7
=====
```

```
EPISODE 1
Score of total rewards: 8
=====
```

```
EPISODE 2
Score of total rewards: 9
=====
```

```
EPISODE 3
Score of total rewards: 4
=====
```

```
EPISODE 4
Score of total rewards: 10
=====
```

```
EPISODE 5
Score of total rewards: 4
=====
```

```
EPISODE 6
Score of total rewards: 8
=====
```

```
EPISODE 7
Score of total rewards: 9
=====
```

```
EPISODE 8
Score of total rewards: 7
=====
```


EPISODE 9
Score of total rewards: 9
=====

EPISODE 10
Score of total rewards: 9
=====

EPISODE 11
Score of total rewards: 9
=====

EPISODE 12
Score of total rewards: 4
=====

EPISODE 13
Score of total rewards: 3
=====

EPISODE 14
Score of total rewards: 12
=====

EPISODE 15
Score of total rewards: 3
=====

EPISODE 16
Score of total rewards: 12
=====

EPISODE 17
Score of total rewards: 8
=====

EPISODE 18
Score of total rewards: 6
=====

EPISODE 19
Score of total rewards: 7
=====

EPISODE 20
Score of total rewards: 10
=====

EPISODE 21
Score of total rewards: 7
=====

EPISODE 22
Score of total rewards: 6
=====

EPISODE 23
Score of total rewards: 7
=====

EPISODE 24
Score of total rewards: 9
=====

EPISODE 25
Score of total rewards: 7
=====

EPISODE 26
Score of total rewards: 10
=====

EPISODE 27
Score of total rewards: 10
=====

EPISODE 28
Score of total rewards: 13
=====

EPISODE 29
Score of total rewards: 10
=====

EPISODE 30
Score of total rewards: 8
=====

EPISODE 31
Score of total rewards: 9
=====

EPISODE 32
Score of total rewards: 13
=====

EPISODE 33
Score of total rewards: 8
=====

EPISODE 34
Score of total rewards: 6
=====

EPISODE 35
Score of total rewards: 9
=====

EPISODE 36
Score of total rewards: 6
=====

EPISODE 37
Score of total rewards: 6
=====

EPISODE 38
Score of total rewards: 9
=====

EPISODE 39
Score of total rewards: 6
=====

EPISODE 40
Score of total rewards: 7
=====

EPISODE 41
Score of total rewards: 6
=====

EPISODE 42
Score of total rewards: 10
=====

EPISODE 43
Score of total rewards: 8
=====

EPISODE 44
Score of total rewards: 6
=====

EPISODE 45
Score of total rewards: 10
=====

EPISODE 46
Score of total rewards: 8
=====

EPISODE 47
Score of total rewards: 6
=====

EPISODE 48
Score of total rewards: 9
=====

EPISODE 49
Score of total rewards: 9
=====

EPISODE 50
Score of total rewards: 7
=====

EPISODE 51
Score of total rewards: 7
=====

EPISODE 52
Score of total rewards: 8
=====

EPISODE 53
Score of total rewards: 7
=====

EPISODE 54
Score of total rewards: 9
=====

EPISODE 55
Score of total rewards: 8
=====

EPISODE 56
Score of total rewards: 7
=====

EPISODE 57
Score of total rewards: 6
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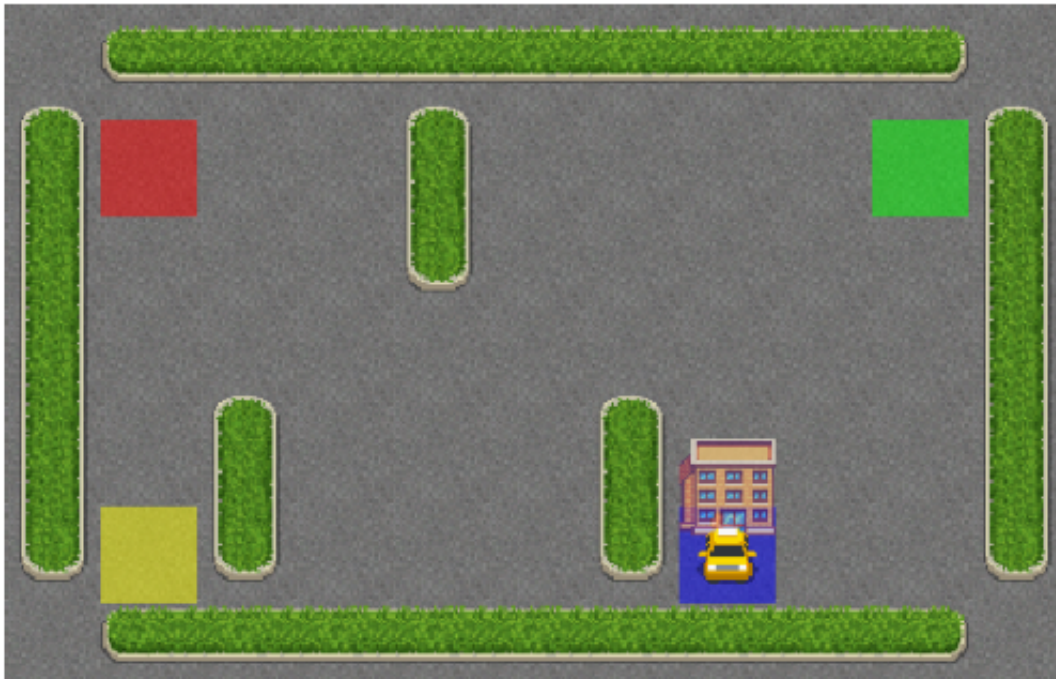
EPISODE 997
Score of total rewards: 8
=====

EPISODE 998
Score of total rewards: 9
=====

EPISODE 999
Score of total rewards: 8
Average score over time: 7.856

```
In [48]: # only to have a look of the test play result  
my_q_agent_controlled.test(test_episodes=5, display=True)
```

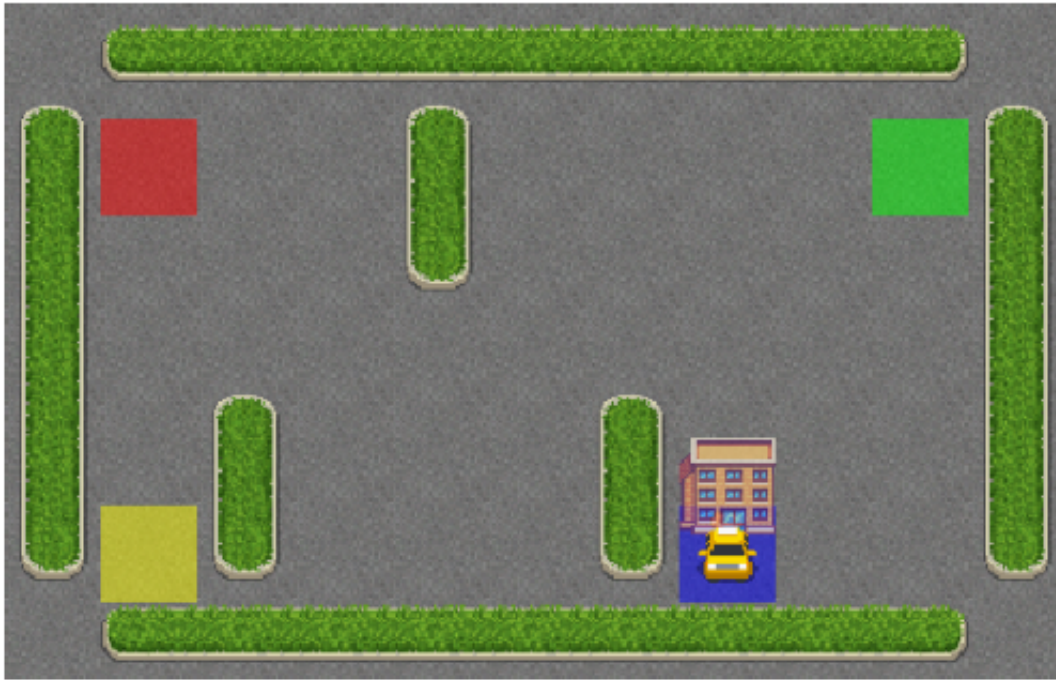
Taxi-v3 | Episode: 4 | Step: 15



Score of total rewards: 6
Average score over time: 8.0

```
Out[48]: [10, 13, 4, 7, 6]
```

Taxi-v3 | Episode: 4 | Step: 15



```
In [49]: # save to GIF
my_q_agent_controlled.test_to_gif(filename="taxi_q_controlled", episodes=5
```

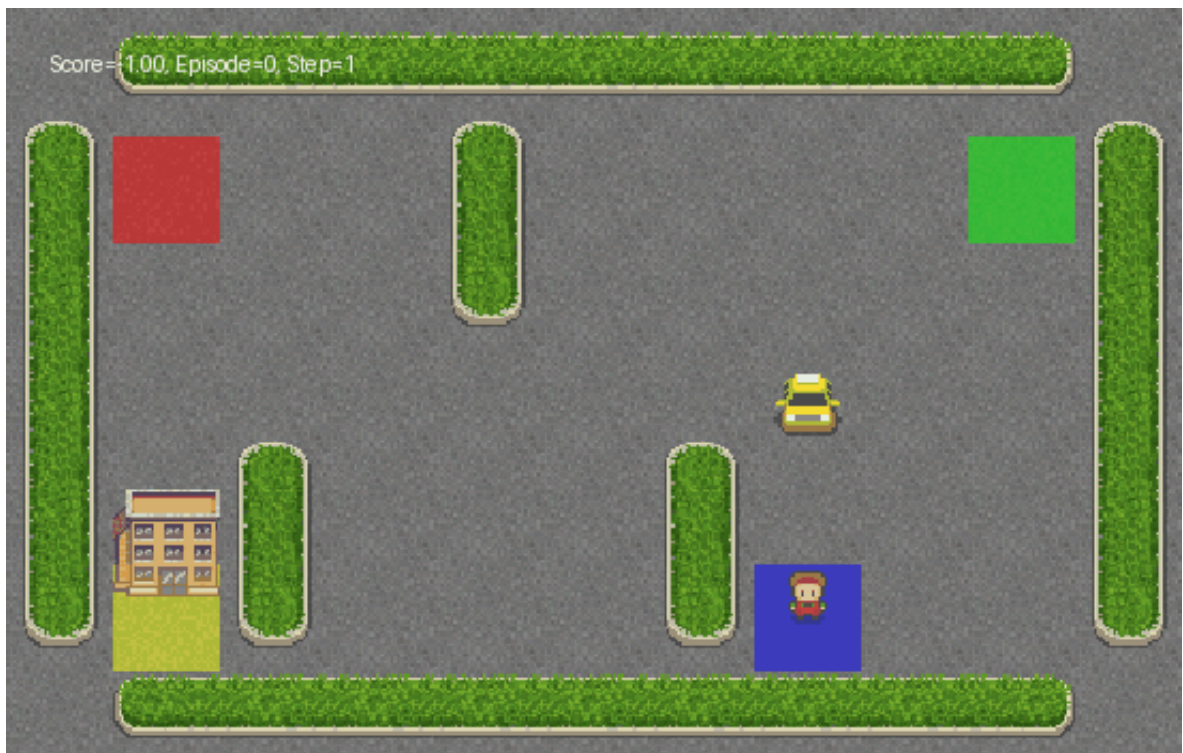
```
episodes: 0, acton: 0, state: 174
episodes: 0, acton: 0, state: 274
episodes: 0, acton: 0, state: 374
episodes: 0, acton: 4, state: 474
episodes: 0, acton: 1, state: 478
episodes: 0, acton: 1, state: 378
episodes: 0, acton: 3, state: 278
episodes: 0, acton: 3, state: 258
episodes: 0, acton: 3, state: 238
episodes: 0, acton: 0, state: 218
episodes: 0, acton: 0, state: 318
episodes: 0, acton: 5, state: 418
episodes: 1, acton: 1, state: 322
episodes: 1, acton: 3, state: 222
episodes: 1, acton: 1, state: 202
episodes: 1, acton: 1, state: 102
episodes: 1, acton: 4, state: 2
episodes: 1, acton: 0, state: 18
episodes: 1, acton: 0, state: 118
episodes: 1, acton: 0, state: 218
episodes: 1, acton: 0, state: 318
episodes: 1, acton: 5, state: 418
episodes: 2, acton: 3, state: 382
episodes: 2, acton: 1, state: 362
episodes: 2, acton: 3, state: 262
episodes: 2, acton: 3, state: 242
episodes: 2, acton: 3, state: 222
episodes: 2, acton: 1, state: 202
episodes: 2, acton: 1, state: 102
episodes: 2, acton: 4, state: 2
episodes: 2, acton: 0, state: 18
episodes: 2, acton: 0, state: 118
```

```
episodes: 2, acton: 0, state: 218
episodes: 2, acton: 0, state: 318
episodes: 2, acton: 5, state: 418
episodes: 3, acton: 3, state: 242
episodes: 3, acton: 3, state: 222
episodes: 3, acton: 1, state: 202
episodes: 3, acton: 1, state: 102
episodes: 3, acton: 4, state: 2
episodes: 3, acton: 0, state: 18
episodes: 3, acton: 0, state: 118
episodes: 3, acton: 0, state: 218
episodes: 3, acton: 0, state: 318
episodes: 3, acton: 5, state: 418
episodes: 4, acton: 3, state: 382
episodes: 4, acton: 1, state: 362
episodes: 4, acton: 3, state: 262
episodes: 4, acton: 3, state: 242
episodes: 4, acton: 3, state: 222
episodes: 4, acton: 1, state: 202
episodes: 4, acton: 1, state: 102
episodes: 4, acton: 4, state: 2
episodes: 4, acton: 0, state: 18
episodes: 4, acton: 0, state: 118
episodes: 4, acton: 0, state: 218
episodes: 4, acton: 0, state: 318
episodes: 4, acton: 5, state: 418
Saving gif...Done!
```

```
In [50]: # display the captured GIF
display.Image(data=open("./gifs/taxi_q_controlled.gif",'rb').read(), format='gif')
# "taxi_q_controlled"
```

```
Out[50]: <IPython.core.display.Image object>
```

If the above display function is not working, here is the previously prepared taxi_q_controlled.gif



DQN Agent with Controlled Parameters

```
In [53]: %%time
my_dqn_agent_controlled_avg_reward_lst = my_dqn_agent_controlled.test(test
```

Policy (trained policy network model from the .pt file):

```
State 000, Action S, Q-values: [-20.00 -20.00 -20.00 -20.00 -29.00 -29.00]
State 001, Action S, Q-values: [-20.00 -20.00 -20.00 -20.00 -29.00 -29.00]
State 002, Action S, Q-values: [-20.00 -20.00 -20.00 -20.00 -29.00 -29.00]
State 003, Action S, Q-values: [-20.00 -20.00 -20.00 -20.00 -29.00 -29.00]
State 004, Action S, Q-values: [-20.00 -20.00 -20.00 -20.00 -29.00 -29.00]
State 005, Action S, Q-values: [-20.00 -20.00 -20.00 -20.00 -29.00 -29.00]
State 006, Action S, Q-values: [-20.00 -20.00 -20.00 -20.00 -29.00 -29.00]
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State 008, Action S, Q-values: [-20.00 -20.00 -20.00 -20.00 -29.00 -29.00]
State 009, Action S, Q-values: [-20.00 -20.00 -20.00 -20.00 -29.00 -29.00]
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State 011, Action S, Q-values: [-20.00 -20.00 -20.00 -20.00 -29.00 -29.00]
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State 028, Action S, Q-values: [-20.00 -20.00 -20.00 -20.00 -29.00 -29.00]
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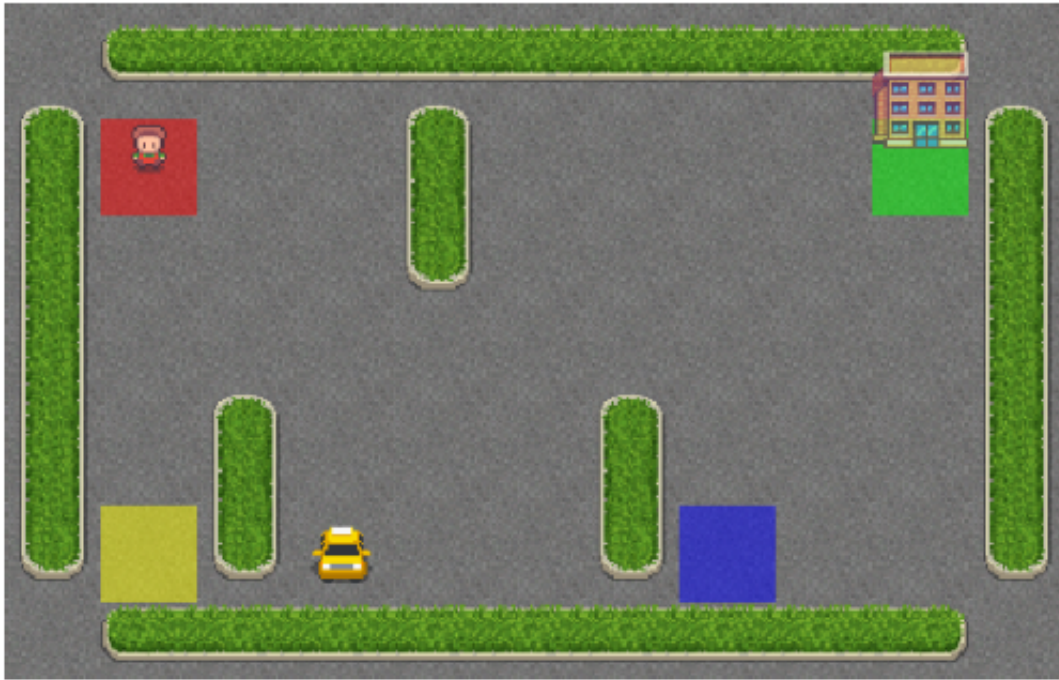
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Episode 1000: Total Reward = -200
Average Reward across all Episodes: = -200.0
CPU times: user 9.4 s, sys: 75.8 ms, total: 9.47 s
Wall time: 8.96 s
```

```
In [54]: # # only to have a look of the test play result
         my_dqn_agent_controlled.test(test_episodes=5, display=True)
```

Taxi-v3 | Episode: 4 | Step: 200

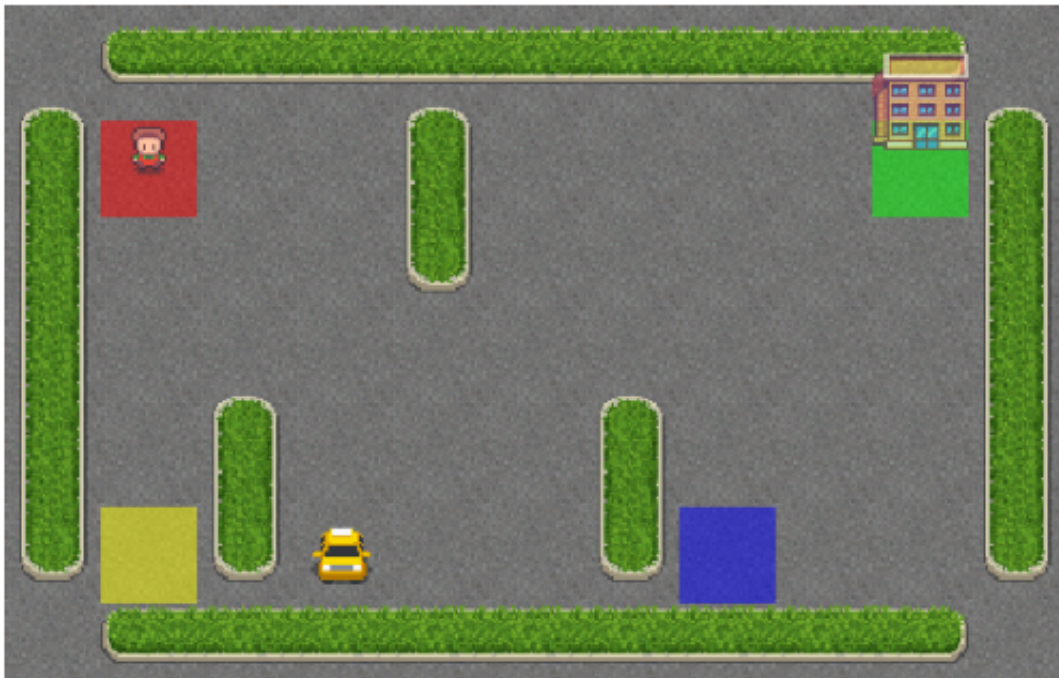


Episode 5: Total Reward = -200

Average Reward across all Episodes: = -200.0

Out[54]: [-200, -200, -200, -200, -200]

Taxi-v3 | Episode: 4 | Step: 200



In [55]: `my_dqn_agent_controlled.test_to_gif(filename="taxi_dqn_controlled", episod`

Policy (trained):

State 000, Action S, Q-values: [-20.00 -20.00 -20.00 -20.00 -29.00 -29.00]

State 001, Action S, Q-values: [-20.00 -20.00 -20.00 -20.00 -29.00 -29.00]

State 002, Action S, Q-values: [-20.00 -20.00 -20.00 -20.00 -29.00 -29.00]

State 003, Action S, Q-values: [-20.00 -20.00 -20.00 -20.00 -29.00 -29.00]

State 004, Action S, Q-values: [-20.00 -20.00 -20.00 -20.00 -29.00 -29.00]

State 005, Action S, Q-values: [-20.00 -20.00 -20.00 -20.00 -29.00 -29.00]

State 006, Action S, Q-values: [-20.00 -20.00 -20.00 -20.00 -29.00 -29.00]

State 007, Action S, Q-values: [-20.00 -20.00 -20.00 -20.00 -29.00 -29.00]

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```

episodes: 4, acton: 0, state: 411
episodes: 4, acton: 0, state: 411
episodes: 4, acton: 0, state: 411
episodes: 4, acton: 0, state: 411
episodes: 4, acton: 0, state: 411
episodes: 4, acton: 0, state: 411
episodes: 4, acton: 0, state: 411
episodes: 4, acton: 0, state: 411
episodes: 4, acton: 0, state: 411
episodes: 4, acton: 0, state: 411
episodes: 4, acton: 0, state: 411
episodes: 4, acton: 0, state: 411
episodes: 4, acton: 0, state: 411
episodes: 4, acton: 0, state: 411
Episode 5: Total Reward = -200
Saving gif...Done!
Average Reward across all Episodes: = -200.0

```

```

In [56]: # display the captured GIF
display.Image(data=open("./gifs/taxi_dqn_controlled.gif", 'rb').read(), fo
# "taxi_q_controlled"

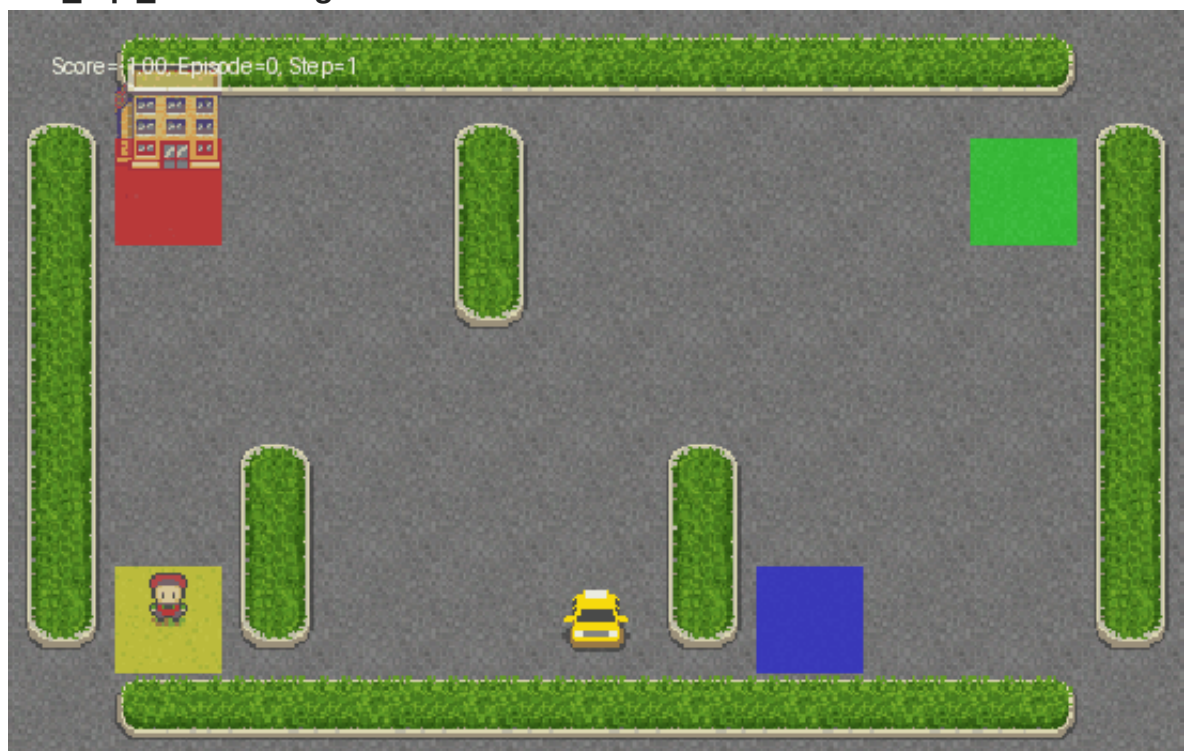
```

```

Out[56]: <IPython.core.display.Image object>

```

If the above display function is not working, here is the previously prepared **taxi_dqn_controlled.gif**



Compare the prediction of controlled models

```

In [59]: #my_q_agent_controlled_avg_reward_lst
#my_dqn_agent_controlled_avg_reward_lst

```

```

In [60]: x = range(1,1000 + 1)

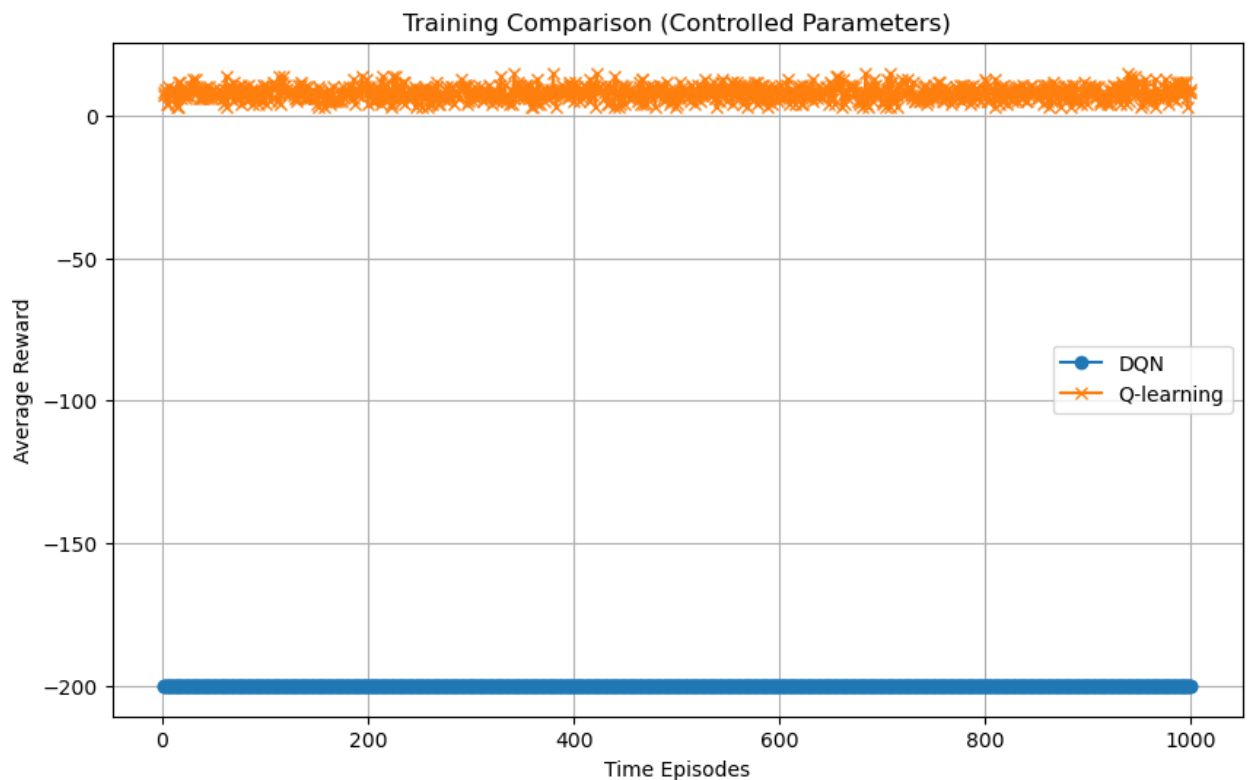
```

```

plt.figure(figsize=(10, 6))
plt.plot(x, my_dqn_agent_controlled_avg_reward_lst, label='DQN', marker='o')
plt.plot(x, my_q_agent_controlled_avg_reward_lst, label='Q-learning', marker='x')

# titles and labels
plt.title('Training Comparison (Controlled Parameters)')
plt.xlabel('Time Episodes')
plt.ylabel('Average Reward')
plt.legend()
# display
plt.grid(True)
plt.show()

```



Fine-tuned Parameter Training

Q Learning Agent with Fine-Tuned Parameters

```

In [63]: my_q_agent_fine_tuned = QLearningAgent(game_id="Taxi-v3", render_mode="rg
        gamma=0.90, alpha=0.5, epsilon=1.0
        epsilon_decay=1000, epsilon_end=0.
        result_model_name="taxi_q_fine_tun

```

```

In [64]: %%time
        my_q_agent_fine_tuned_training_rewards = my_q_agent_fine_tuned.train(1000

```

```

Episode 100/100000, Avg Reward: -468.22, Epsilon: 0.31
Episode 200/100000, Avg Reward: -120.32, Epsilon: 0.17
Episode 300/100000, Avg Reward: -33.64, Epsilon: 0.13
Episode 400/100000, Avg Reward: -6.38, Epsilon: 0.12
Episode 500/100000, Avg Reward: -2.02, Epsilon: 0.10
Episode 600/100000, Avg Reward: -0.13, Epsilon: 0.09
Episode 700/100000, Avg Reward: 2.09, Epsilon: 0.08
Episode 800/100000, Avg Reward: 3.39, Epsilon: 0.07

```

Episode 900/100000, Avg Reward: 2.37, Epsilon: 0.07
Episode 1000/100000, Avg Reward: 3.33, Epsilon: 0.06
Episode 1100/100000, Avg Reward: 4.28, Epsilon: 0.06
Episode 1200/100000, Avg Reward: 4.99, Epsilon: 0.05
Episode 1300/100000, Avg Reward: 5.48, Epsilon: 0.05
Episode 1400/100000, Avg Reward: 5.18, Epsilon: 0.04
Episode 1500/100000, Avg Reward: 5.26, Epsilon: 0.04
Episode 1600/100000, Avg Reward: 6.67, Epsilon: 0.03
Episode 1700/100000, Avg Reward: 6.59, Epsilon: 0.03
Episode 1800/100000, Avg Reward: 6.32, Epsilon: 0.03
Episode 1900/100000, Avg Reward: 7.16, Epsilon: 0.03
Episode 2000/100000, Avg Reward: 6.24, Epsilon: 0.02
Episode 2100/100000, Avg Reward: 6.13, Epsilon: 0.02
Episode 2200/100000, Avg Reward: 7.08, Epsilon: 0.02
Episode 2300/100000, Avg Reward: 7.27, Epsilon: 0.02
Episode 2400/100000, Avg Reward: 6.37, Epsilon: 0.02
Episode 2500/100000, Avg Reward: 7.21, Epsilon: 0.01
Episode 2600/100000, Avg Reward: 7.76, Epsilon: 0.01
Episode 2700/100000, Avg Reward: 7.24, Epsilon: 0.01
Episode 2800/100000, Avg Reward: 7.75, Epsilon: 0.01
Episode 2900/100000, Avg Reward: 7.61, Epsilon: 0.01
Episode 3000/100000, Avg Reward: 7.34, Epsilon: 0.01
Episode 3100/100000, Avg Reward: 7.77, Epsilon: 0.01
Episode 3200/100000, Avg Reward: 7.38, Epsilon: 0.01
Episode 3300/100000, Avg Reward: 8.01, Epsilon: 0.01
Episode 3400/100000, Avg Reward: 7.38, Epsilon: 0.01
Episode 3500/100000, Avg Reward: 7.95, Epsilon: 0.01
Episode 3600/100000, Avg Reward: 7.37, Epsilon: 0.01
Episode 3700/100000, Avg Reward: 8.10, Epsilon: 0.01
Episode 3800/100000, Avg Reward: 7.08, Epsilon: 0.00
Episode 3900/100000, Avg Reward: 6.87, Epsilon: 0.00
Episode 4000/100000, Avg Reward: 8.23, Epsilon: 0.00
Episode 4100/100000, Avg Reward: 7.43, Epsilon: 0.00
Episode 4200/100000, Avg Reward: 7.20, Epsilon: 0.00
Episode 4300/100000, Avg Reward: 7.70, Epsilon: 0.00
Episode 4400/100000, Avg Reward: 7.85, Epsilon: 0.00
Episode 4500/100000, Avg Reward: 7.77, Epsilon: 0.00
Episode 4600/100000, Avg Reward: 7.30, Epsilon: 0.00
Episode 4700/100000, Avg Reward: 7.22, Epsilon: 0.00
Episode 4800/100000, Avg Reward: 7.97, Epsilon: 0.00
Episode 4900/100000, Avg Reward: 7.63, Epsilon: 0.00
Episode 5000/100000, Avg Reward: 8.02, Epsilon: 0.00
Episode 5100/100000, Avg Reward: 8.27, Epsilon: 0.00
Episode 5200/100000, Avg Reward: 8.07, Epsilon: 0.00
Episode 5300/100000, Avg Reward: 8.19, Epsilon: 0.00
Episode 5400/100000, Avg Reward: 7.60, Epsilon: 0.00
Episode 5500/100000, Avg Reward: 7.92, Epsilon: 0.00
Episode 5600/100000, Avg Reward: 7.89, Epsilon: 0.00
Episode 5700/100000, Avg Reward: 7.82, Epsilon: 0.00
Episode 5800/100000, Avg Reward: 7.88, Epsilon: 0.00
Episode 5900/100000, Avg Reward: 7.76, Epsilon: 0.00
Episode 6000/100000, Avg Reward: 7.50, Epsilon: 0.00
Episode 6100/100000, Avg Reward: 7.96, Epsilon: 0.00
Episode 6200/100000, Avg Reward: 7.81, Epsilon: 0.00
Episode 6300/100000, Avg Reward: 8.03, Epsilon: 0.00
Episode 6400/100000, Avg Reward: 8.11, Epsilon: 0.00
Episode 6500/100000, Avg Reward: 8.36, Epsilon: 0.00

Episode 6600/100000, Avg Reward: 7.61, Epsilon: 0.00
Episode 6700/100000, Avg Reward: 7.71, Epsilon: 0.00
Episode 6800/100000, Avg Reward: 7.77, Epsilon: 0.00
Episode 6900/100000, Avg Reward: 7.88, Epsilon: 0.00
Episode 7000/100000, Avg Reward: 7.84, Epsilon: 0.00
Episode 7100/100000, Avg Reward: 7.69, Epsilon: 0.00
Episode 7200/100000, Avg Reward: 8.02, Epsilon: 0.00
Episode 7300/100000, Avg Reward: 7.38, Epsilon: 0.00
Episode 7400/100000, Avg Reward: 8.00, Epsilon: 0.00
Episode 7500/100000, Avg Reward: 7.71, Epsilon: 0.00
Episode 7600/100000, Avg Reward: 7.64, Epsilon: 0.00
Episode 7700/100000, Avg Reward: 7.99, Epsilon: 0.00
Episode 7800/100000, Avg Reward: 7.19, Epsilon: 0.00
Episode 7900/100000, Avg Reward: 8.10, Epsilon: 0.00
Episode 8000/100000, Avg Reward: 7.68, Epsilon: 0.00
Episode 8100/100000, Avg Reward: 8.07, Epsilon: 0.00
Episode 8200/100000, Avg Reward: 7.73, Epsilon: 0.00
Episode 8300/100000, Avg Reward: 7.96, Epsilon: 0.00
Episode 8400/100000, Avg Reward: 8.04, Epsilon: 0.00
Episode 8500/100000, Avg Reward: 7.88, Epsilon: 0.00
Episode 8600/100000, Avg Reward: 7.49, Epsilon: 0.00
Episode 8700/100000, Avg Reward: 7.80, Epsilon: 0.00
Episode 8800/100000, Avg Reward: 7.66, Epsilon: 0.00
Episode 8900/100000, Avg Reward: 7.86, Epsilon: 0.00
Episode 9000/100000, Avg Reward: 7.47, Epsilon: 0.00
Episode 9100/100000, Avg Reward: 8.11, Epsilon: 0.00
Episode 9200/100000, Avg Reward: 8.31, Epsilon: 0.00
Episode 9300/100000, Avg Reward: 7.38, Epsilon: 0.00
Episode 9400/100000, Avg Reward: 7.95, Epsilon: 0.00
Episode 9500/100000, Avg Reward: 8.21, Epsilon: 0.00
Episode 9600/100000, Avg Reward: 7.33, Epsilon: 0.00
Episode 9700/100000, Avg Reward: 7.60, Epsilon: 0.00
Episode 9800/100000, Avg Reward: 8.04, Epsilon: 0.00
Episode 9900/100000, Avg Reward: 7.78, Epsilon: 0.00
Episode 10000/100000, Avg Reward: 7.63, Epsilon: 0.00
Episode 10100/100000, Avg Reward: 7.75, Epsilon: 0.00
Episode 10200/100000, Avg Reward: 7.36, Epsilon: 0.00
Episode 10300/100000, Avg Reward: 7.53, Epsilon: 0.00
Episode 10400/100000, Avg Reward: 7.66, Epsilon: 0.00
Episode 10500/100000, Avg Reward: 7.59, Epsilon: 0.00
Episode 10600/100000, Avg Reward: 7.72, Epsilon: 0.00
Episode 10700/100000, Avg Reward: 8.02, Epsilon: 0.00
Episode 10800/100000, Avg Reward: 7.48, Epsilon: 0.00
Episode 10900/100000, Avg Reward: 7.89, Epsilon: 0.00
Episode 11000/100000, Avg Reward: 8.05, Epsilon: 0.00
Episode 11100/100000, Avg Reward: 7.77, Epsilon: 0.00
Episode 11200/100000, Avg Reward: 7.83, Epsilon: 0.00
Episode 11300/100000, Avg Reward: 7.81, Epsilon: 0.00
Episode 11400/100000, Avg Reward: 7.88, Epsilon: 0.00
Episode 11500/100000, Avg Reward: 8.12, Epsilon: 0.00
Episode 11600/100000, Avg Reward: 8.01, Epsilon: 0.00
Episode 11700/100000, Avg Reward: 7.57, Epsilon: 0.00
Episode 11800/100000, Avg Reward: 7.83, Epsilon: 0.00
Episode 11900/100000, Avg Reward: 8.05, Epsilon: 0.00
Episode 12000/100000, Avg Reward: 7.93, Epsilon: 0.00
Episode 12100/100000, Avg Reward: 7.29, Epsilon: 0.00
Episode 12200/100000, Avg Reward: 8.13, Epsilon: 0.00

Episode 12300/100000, Avg Reward: 8.09, Epsilon: 0.00
Episode 12400/100000, Avg Reward: 7.94, Epsilon: 0.00
Episode 12500/100000, Avg Reward: 7.67, Epsilon: 0.00
Episode 12600/100000, Avg Reward: 7.86, Epsilon: 0.00
Episode 12700/100000, Avg Reward: 7.84, Epsilon: 0.00
Episode 12800/100000, Avg Reward: 7.74, Epsilon: 0.00
Episode 12900/100000, Avg Reward: 7.61, Epsilon: 0.00
Episode 13000/100000, Avg Reward: 8.07, Epsilon: 0.00
Episode 13100/100000, Avg Reward: 8.31, Epsilon: 0.00
Episode 13200/100000, Avg Reward: 7.74, Epsilon: 0.00
Episode 13300/100000, Avg Reward: 7.95, Epsilon: 0.00
Episode 13400/100000, Avg Reward: 7.92, Epsilon: 0.00
Episode 13500/100000, Avg Reward: 7.89, Epsilon: 0.00
Episode 13600/100000, Avg Reward: 7.36, Epsilon: 0.00
Episode 13700/100000, Avg Reward: 7.74, Epsilon: 0.00
Episode 13800/100000, Avg Reward: 7.77, Epsilon: 0.00
Episode 13900/100000, Avg Reward: 8.40, Epsilon: 0.00
Episode 14000/100000, Avg Reward: 7.54, Epsilon: 0.00
Episode 14100/100000, Avg Reward: 7.67, Epsilon: 0.00
Episode 14200/100000, Avg Reward: 7.55, Epsilon: 0.00
Episode 14300/100000, Avg Reward: 7.12, Epsilon: 0.00
Episode 14400/100000, Avg Reward: 7.55, Epsilon: 0.00
Episode 14500/100000, Avg Reward: 7.47, Epsilon: 0.00
Episode 14600/100000, Avg Reward: 8.00, Epsilon: 0.00
Episode 14700/100000, Avg Reward: 7.82, Epsilon: 0.00
Episode 14800/100000, Avg Reward: 7.94, Epsilon: 0.00
Episode 14900/100000, Avg Reward: 7.89, Epsilon: 0.00
Episode 15000/100000, Avg Reward: 7.70, Epsilon: 0.00
Episode 15100/100000, Avg Reward: 7.93, Epsilon: 0.00
Episode 15200/100000, Avg Reward: 7.74, Epsilon: 0.00
Episode 15300/100000, Avg Reward: 8.25, Epsilon: 0.00
Episode 15400/100000, Avg Reward: 7.89, Epsilon: 0.00
Episode 15500/100000, Avg Reward: 7.92, Epsilon: 0.00
Episode 15600/100000, Avg Reward: 7.60, Epsilon: 0.00
Episode 15700/100000, Avg Reward: 8.05, Epsilon: 0.00
Episode 15800/100000, Avg Reward: 7.29, Epsilon: 0.00
Episode 15900/100000, Avg Reward: 7.88, Epsilon: 0.00
Episode 16000/100000, Avg Reward: 7.56, Epsilon: 0.00
Episode 16100/100000, Avg Reward: 7.80, Epsilon: 0.00
Episode 16200/100000, Avg Reward: 7.88, Epsilon: 0.00
Episode 16300/100000, Avg Reward: 7.96, Epsilon: 0.00
Episode 16400/100000, Avg Reward: 7.60, Epsilon: 0.00
Episode 16500/100000, Avg Reward: 8.24, Epsilon: 0.00
Episode 16600/100000, Avg Reward: 7.77, Epsilon: 0.00
Episode 16700/100000, Avg Reward: 8.22, Epsilon: 0.00
Episode 16800/100000, Avg Reward: 7.69, Epsilon: 0.00
Episode 16900/100000, Avg Reward: 8.01, Epsilon: 0.00
Episode 17000/100000, Avg Reward: 7.77, Epsilon: 0.00
Episode 17100/100000, Avg Reward: 7.91, Epsilon: 0.00
Episode 17200/100000, Avg Reward: 7.85, Epsilon: 0.00
Episode 17300/100000, Avg Reward: 7.99, Epsilon: 0.00
Episode 17400/100000, Avg Reward: 8.05, Epsilon: 0.00
Episode 17500/100000, Avg Reward: 8.08, Epsilon: 0.00
Episode 17600/100000, Avg Reward: 7.60, Epsilon: 0.00
Episode 17700/100000, Avg Reward: 7.89, Epsilon: 0.00
Episode 17800/100000, Avg Reward: 7.79, Epsilon: 0.00
Episode 17900/100000, Avg Reward: 7.65, Epsilon: 0.00

Episode	18000/100000	Avg Reward:	7.58	Epsilon:	0.00
Episode	18100/100000	Avg Reward:	8.07	Epsilon:	0.00
Episode	18200/100000	Avg Reward:	7.84	Epsilon:	0.00
Episode	18300/100000	Avg Reward:	7.81	Epsilon:	0.00
Episode	18400/100000	Avg Reward:	7.47	Epsilon:	0.00
Episode	18500/100000	Avg Reward:	7.46	Epsilon:	0.00
Episode	18600/100000	Avg Reward:	8.01	Epsilon:	0.00
Episode	18700/100000	Avg Reward:	7.73	Epsilon:	0.00
Episode	18800/100000	Avg Reward:	7.75	Epsilon:	0.00
Episode	18900/100000	Avg Reward:	7.40	Epsilon:	0.00
Episode	19000/100000	Avg Reward:	8.16	Epsilon:	0.00
Episode	19100/100000	Avg Reward:	7.91	Epsilon:	0.00
Episode	19200/100000	Avg Reward:	7.72	Epsilon:	0.00
Episode	19300/100000	Avg Reward:	7.84	Epsilon:	0.00
Episode	19400/100000	Avg Reward:	7.87	Epsilon:	0.00
Episode	19500/100000	Avg Reward:	7.85	Epsilon:	0.00
Episode	19600/100000	Avg Reward:	7.99	Epsilon:	0.00
Episode	19700/100000	Avg Reward:	7.83	Epsilon:	0.00
Episode	19800/100000	Avg Reward:	7.77	Epsilon:	0.00
Episode	19900/100000	Avg Reward:	7.82	Epsilon:	0.00
Episode	20000/100000	Avg Reward:	7.59	Epsilon:	0.00
Episode	20100/100000	Avg Reward:	7.84	Epsilon:	0.00
Episode	20200/100000	Avg Reward:	8.43	Epsilon:	0.00
Episode	20300/100000	Avg Reward:	7.52	Epsilon:	0.00
Episode	20400/100000	Avg Reward:	7.79	Epsilon:	0.00
Episode	20500/100000	Avg Reward:	8.17	Epsilon:	0.00
Episode	20600/100000	Avg Reward:	7.87	Epsilon:	0.00
Episode	20700/100000	Avg Reward:	7.98	Epsilon:	0.00
Episode	20800/100000	Avg Reward:	7.65	Epsilon:	0.00
Episode	20900/100000	Avg Reward:	8.04	Epsilon:	0.00
Episode	21000/100000	Avg Reward:	7.87	Epsilon:	0.00
Episode	21100/100000	Avg Reward:	8.27	Epsilon:	0.00
Episode	21200/100000	Avg Reward:	7.87	Epsilon:	0.00
Episode	21300/100000	Avg Reward:	7.72	Epsilon:	0.00
Episode	21400/100000	Avg Reward:	7.81	Epsilon:	0.00
Episode	21500/100000	Avg Reward:	7.89	Epsilon:	0.00
Episode	21600/100000	Avg Reward:	7.64	Epsilon:	0.00
Episode	21700/100000	Avg Reward:	7.92	Epsilon:	0.00
Episode	21800/100000	Avg Reward:	8.12	Epsilon:	0.00
Episode	21900/100000	Avg Reward:	7.99	Epsilon:	0.00
Episode	22000/100000	Avg Reward:	7.94	Epsilon:	0.00
Episode	22100/100000	Avg Reward:	7.89	Epsilon:	0.00
Episode	22200/100000	Avg Reward:	7.77	Epsilon:	0.00
Episode	22300/100000	Avg Reward:	7.63	Epsilon:	0.00
Episode	22400/100000	Avg Reward:	8.18	Epsilon:	0.00
Episode	22500/100000	Avg Reward:	8.12	Epsilon:	0.00
Episode	22600/100000	Avg Reward:	8.19	Epsilon:	0.00
Episode	22700/100000	Avg Reward:	7.95	Epsilon:	0.00
Episode	22800/100000	Avg Reward:	7.84	Epsilon:	0.00
Episode	22900/100000	Avg Reward:	7.75	Epsilon:	0.00
Episode	23000/100000	Avg Reward:	7.90	Epsilon:	0.00
Episode	23100/100000	Avg Reward:	7.89	Epsilon:	0.00
Episode	23200/100000	Avg Reward:	7.93	Epsilon:	0.00
Episode	23300/100000	Avg Reward:	8.08	Epsilon:	0.00
Episode	23400/100000	Avg Reward:	7.70	Epsilon:	0.00
Episode	23500/100000	Avg Reward:	7.65	Epsilon:	0.00
Episode	23600/100000	Avg Reward:	7.82	Epsilon:	0.00

Episode 23700/100000, Avg Reward: 7.91, Epsilon: 0.00
Episode 23800/100000, Avg Reward: 8.07, Epsilon: 0.00
Episode 23900/100000, Avg Reward: 8.08, Epsilon: 0.00
Episode 24000/100000, Avg Reward: 7.86, Epsilon: 0.00
Episode 24100/100000, Avg Reward: 7.60, Epsilon: 0.00
Episode 24200/100000, Avg Reward: 8.24, Epsilon: 0.00
Episode 24300/100000, Avg Reward: 8.33, Epsilon: 0.00
Episode 24400/100000, Avg Reward: 8.01, Epsilon: 0.00
Episode 24500/100000, Avg Reward: 7.88, Epsilon: 0.00
Episode 24600/100000, Avg Reward: 8.41, Epsilon: 0.00
Episode 24700/100000, Avg Reward: 8.26, Epsilon: 0.00
Episode 24800/100000, Avg Reward: 7.85, Epsilon: 0.00
Episode 24900/100000, Avg Reward: 7.62, Epsilon: 0.00
Episode 25000/100000, Avg Reward: 8.18, Epsilon: 0.00
Episode 25100/100000, Avg Reward: 7.83, Epsilon: 0.00
Episode 25200/100000, Avg Reward: 7.76, Epsilon: 0.00
Episode 25300/100000, Avg Reward: 8.01, Epsilon: 0.00
Episode 25400/100000, Avg Reward: 8.22, Epsilon: 0.00
Episode 25500/100000, Avg Reward: 7.95, Epsilon: 0.00
Episode 25600/100000, Avg Reward: 7.84, Epsilon: 0.00
Episode 25700/100000, Avg Reward: 7.74, Epsilon: 0.00
Episode 25800/100000, Avg Reward: 7.56, Epsilon: 0.00
Episode 25900/100000, Avg Reward: 8.18, Epsilon: 0.00
Episode 26000/100000, Avg Reward: 8.13, Epsilon: 0.00
Episode 26100/100000, Avg Reward: 7.75, Epsilon: 0.00
Episode 26200/100000, Avg Reward: 7.98, Epsilon: 0.00
Episode 26300/100000, Avg Reward: 7.84, Epsilon: 0.00
Episode 26400/100000, Avg Reward: 7.86, Epsilon: 0.00
Episode 26500/100000, Avg Reward: 7.94, Epsilon: 0.00
Episode 26600/100000, Avg Reward: 7.66, Epsilon: 0.00
Episode 26700/100000, Avg Reward: 8.14, Epsilon: 0.00
Episode 26800/100000, Avg Reward: 7.78, Epsilon: 0.00
Episode 26900/100000, Avg Reward: 7.75, Epsilon: 0.00
Episode 27000/100000, Avg Reward: 7.78, Epsilon: 0.00
Episode 27100/100000, Avg Reward: 7.58, Epsilon: 0.00
Episode 27200/100000, Avg Reward: 7.67, Epsilon: 0.00
Episode 27300/100000, Avg Reward: 7.92, Epsilon: 0.00
Episode 27400/100000, Avg Reward: 7.76, Epsilon: 0.00
Episode 27500/100000, Avg Reward: 7.44, Epsilon: 0.00
Episode 27600/100000, Avg Reward: 7.75, Epsilon: 0.00
Episode 27700/100000, Avg Reward: 7.72, Epsilon: 0.00
Episode 27800/100000, Avg Reward: 7.65, Epsilon: 0.00
Episode 27900/100000, Avg Reward: 7.59, Epsilon: 0.00
Episode 28000/100000, Avg Reward: 7.88, Epsilon: 0.00
Episode 28100/100000, Avg Reward: 7.83, Epsilon: 0.00
Episode 28200/100000, Avg Reward: 8.08, Epsilon: 0.00
Episode 28300/100000, Avg Reward: 7.75, Epsilon: 0.00
Episode 28400/100000, Avg Reward: 7.60, Epsilon: 0.00
Episode 28500/100000, Avg Reward: 8.08, Epsilon: 0.00
Episode 28600/100000, Avg Reward: 7.78, Epsilon: 0.00
Episode 28700/100000, Avg Reward: 7.88, Epsilon: 0.00
Episode 28800/100000, Avg Reward: 8.04, Epsilon: 0.00
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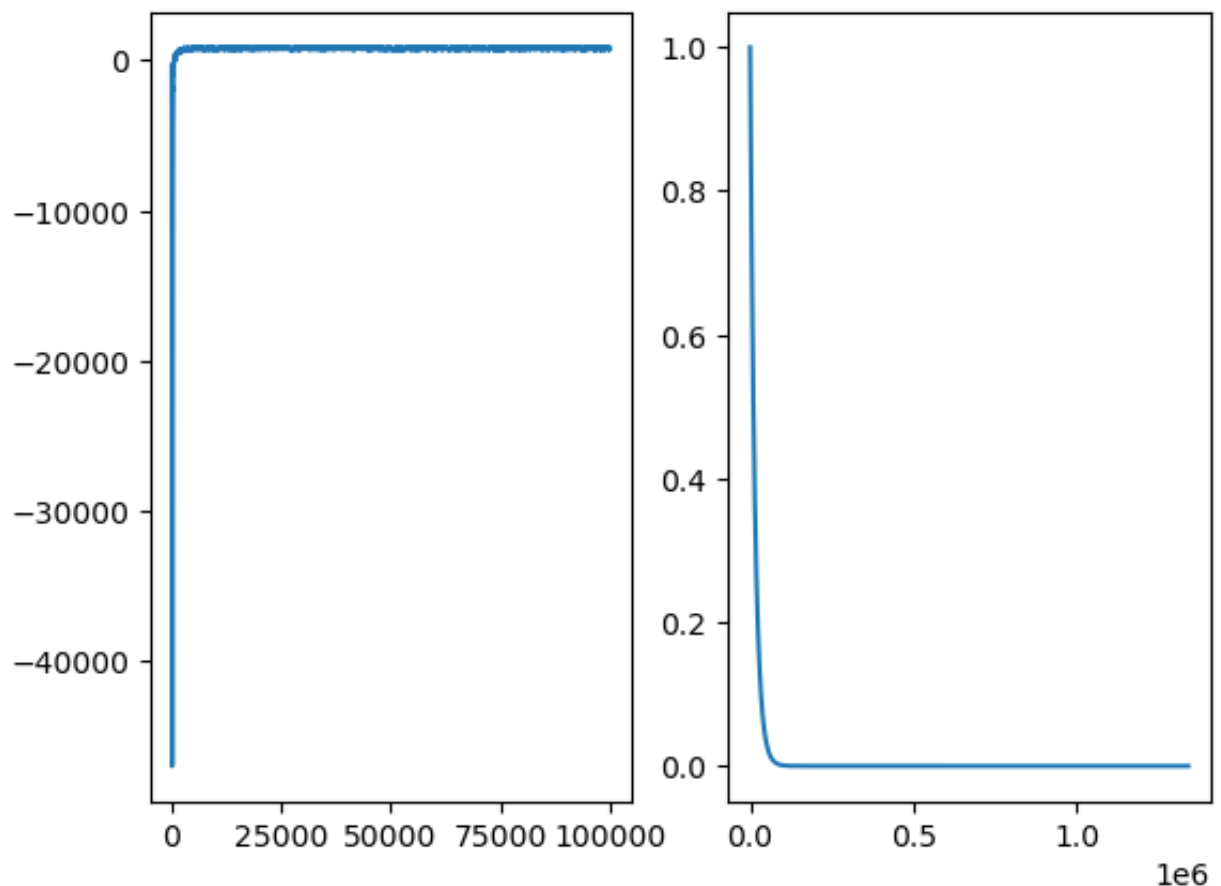
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Episode 95200/100000, Avg Reward: 8.06, Epsilon: 0.00
Episode 95300/100000, Avg Reward: 7.83, Epsilon: 0.00
Episode 95400/100000, Avg Reward: 7.90, Epsilon: 0.00
Episode 95500/100000, Avg Reward: 8.13, Epsilon: 0.00
Episode 95600/100000, Avg Reward: 8.16, Epsilon: 0.00
Episode 95700/100000, Avg Reward: 8.13, Epsilon: 0.00
Episode 95800/100000, Avg Reward: 7.73, Epsilon: 0.00
Episode 95900/100000, Avg Reward: 7.94, Epsilon: 0.00
Episode 96000/100000, Avg Reward: 8.09, Epsilon: 0.00
Episode 96100/100000, Avg Reward: 7.48, Epsilon: 0.00
Episode 96200/100000, Avg Reward: 8.27, Epsilon: 0.00
Episode 96300/100000, Avg Reward: 7.62, Epsilon: 0.00
Episode 96400/100000, Avg Reward: 8.62, Epsilon: 0.00
Episode 96500/100000, Avg Reward: 7.81, Epsilon: 0.00
Episode 96600/100000, Avg Reward: 7.83, Epsilon: 0.00
Episode 96700/100000, Avg Reward: 7.37, Epsilon: 0.00
Episode 96800/100000, Avg Reward: 7.74, Epsilon: 0.00
Episode 96900/100000, Avg Reward: 7.71, Epsilon: 0.00
Episode 97000/100000, Avg Reward: 8.18, Epsilon: 0.00
Episode 97100/100000, Avg Reward: 8.13, Epsilon: 0.00
Episode 97200/100000, Avg Reward: 8.03, Epsilon: 0.00
Episode 97300/100000, Avg Reward: 7.72, Epsilon: 0.00
Episode 97400/100000, Avg Reward: 8.07, Epsilon: 0.00
Episode 97500/100000, Avg Reward: 7.37, Epsilon: 0.00
Episode 97600/100000, Avg Reward: 7.95, Epsilon: 0.00
Episode 97700/100000, Avg Reward: 7.50, Epsilon: 0.00


```

Episode 97800/100000, Avg Reward: 7.54, Epsilon: 0.00
Episode 97900/100000, Avg Reward: 7.79, Epsilon: 0.00
Episode 98000/100000, Avg Reward: 7.85, Epsilon: 0.00
Episode 98100/100000, Avg Reward: 8.25, Epsilon: 0.00
Episode 98200/100000, Avg Reward: 7.37, Epsilon: 0.00
Episode 98300/100000, Avg Reward: 7.65, Epsilon: 0.00
Episode 98400/100000, Avg Reward: 7.84, Epsilon: 0.00
Episode 98500/100000, Avg Reward: 7.90, Epsilon: 0.00
Episode 98600/100000, Avg Reward: 7.99, Epsilon: 0.00
Episode 98700/100000, Avg Reward: 7.65, Epsilon: 0.00
Episode 98800/100000, Avg Reward: 7.44, Epsilon: 0.00
Episode 98900/100000, Avg Reward: 7.64, Epsilon: 0.00
Episode 99000/100000, Avg Reward: 7.96, Epsilon: 0.00
Episode 99100/100000, Avg Reward: 7.78, Epsilon: 0.00
Episode 99200/100000, Avg Reward: 7.83, Epsilon: 0.00
Episode 99300/100000, Avg Reward: 8.33, Epsilon: 0.00
Episode 99400/100000, Avg Reward: 7.68, Epsilon: 0.00
Episode 99500/100000, Avg Reward: 8.15, Epsilon: 0.00
Episode 99600/100000, Avg Reward: 7.79, Epsilon: 0.00
Episode 99700/100000, Avg Reward: 8.07, Epsilon: 0.00
Episode 99800/100000, Avg Reward: 7.32, Epsilon: 0.00
Episode 99900/100000, Avg Reward: 7.67, Epsilon: 0.00
Episode 100000/100000, Avg Reward: 8.16, Epsilon: 0.00
CPU times: user 12.4 s, sys: 649 ms, total: 13.1 s
Wall time: 12.1 s

```



```
In [65]: print(my_q_agent_fine_tuned_training_rewards)
```

```
[-287. -731. -704. ...    7.   11.    9.]
```

DQN Agent with Fine-Tuned Parameters

```
In [67]: my_dqn_agent_fine_tuned = DQNAgent(game_id="Taxi-v3", gamma=0.90, alpha=0
epsilon_start=1.0, epsilon_decay=1000,
max_steps=200, render_mode="rgb_array")
```

```
In [68]: %%time
my_dqn_agent_fine_tuned_training_rewards = my_dqn_agent_fine_tuned.train(
```

Policy (policy network model before training with randomly initialized values):

State 000, Action P, Q-values:	[-0.00 +0.01 -0.06 -0.04 +0.07 +0.05]
State 001, Action P, Q-values:	[+0.00 +0.01 -0.06 -0.03 +0.07 +0.05]
State 002, Action P, Q-values:	[-0.01 +0.01 -0.07 -0.04 +0.07 +0.04]
State 003, Action P, Q-values:	[+0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 004, Action P, Q-values:	[+0.00 +0.01 -0.07 -0.04 +0.08 +0.06]
State 005, Action P, Q-values:	[+0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 006, Action P, Q-values:	[+0.01 +0.00 -0.05 -0.03 +0.07 +0.05]
State 007, Action P, Q-values:	[-0.00 +0.02 -0.07 -0.04 +0.08 +0.05]
State 008, Action P, Q-values:	[+0.00 +0.01 -0.07 -0.04 +0.07 +0.04]
State 009, Action P, Q-values:	[+0.00 +0.00 -0.07 -0.03 +0.07 +0.05]
State 010, Action P, Q-values:	[-0.01 +0.01 -0.07 -0.03 +0.07 +0.05]
State 011, Action P, Q-values:	[-0.00 +0.01 -0.06 -0.03 +0.07 +0.04]
State 012, Action P, Q-values:	[+0.01 +0.01 -0.07 -0.03 +0.07 +0.05]
State 013, Action P, Q-values:	[+0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 014, Action P, Q-values:	[+0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 015, Action P, Q-values:	[+0.00 +0.00 -0.07 -0.03 +0.07 +0.05]
State 016, Action P, Q-values:	[+0.01 +0.01 -0.07 -0.03 +0.07 +0.05]
State 017, Action P, Q-values:	[+0.00 +0.01 -0.07 -0.04 +0.07 +0.04]
State 018, Action P, Q-values:	[-0.00 +0.01 -0.07 -0.03 +0.06 +0.05]
State 019, Action P, Q-values:	[+0.00 +0.01 -0.06 -0.03 +0.08 +0.04]
State 020, Action P, Q-values:	[-0.00 +0.00 -0.06 -0.03 +0.06 +0.05]
State 021, Action P, Q-values:	[-0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 022, Action P, Q-values:	[-0.01 +0.01 -0.07 -0.03 +0.07 +0.05]
State 023, Action P, Q-values:	[+0.00 +0.00 -0.06 -0.03 +0.07 +0.04]
State 024, Action P, Q-values:	[+0.00 -0.00 -0.07 -0.03 +0.06 +0.04]
State 025, Action P, Q-values:	[-0.00 +0.01 -0.06 -0.04 +0.08 +0.04]
State 026, Action P, Q-values:	[-0.00 +0.01 -0.07 -0.03 +0.08 +0.05]
State 027, Action P, Q-values:	[+0.00 +0.01 -0.08 -0.03 +0.07 +0.04]
State 028, Action P, Q-values:	[+0.00 +0.01 -0.07 -0.03 +0.07 +0.04]
State 029, Action P, Q-values:	[+0.01 +0.00 -0.06 -0.03 +0.07 +0.04]
State 030, Action P, Q-values:	[-0.00 +0.00 -0.07 -0.04 +0.07 +0.05]
State 031, Action P, Q-values:	[-0.00 +0.01 -0.07 -0.03 +0.08 +0.05]
State 032, Action P, Q-values:	[-0.01 +0.00 -0.07 -0.03 +0.06 +0.04]
State 033, Action P, Q-values:	[+0.01 +0.00 -0.06 -0.03 +0.07 +0.05]
State 034, Action P, Q-values:	[-0.00 +0.01 -0.06 -0.03 +0.07 +0.05]
State 035, Action P, Q-values:	[+0.00 +0.00 -0.06 -0.03 +0.07 +0.05]
State 036, Action P, Q-values:	[+0.01 +0.02 -0.06 -0.03 +0.08 +0.05]
State 037, Action P, Q-values:	[+0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 038, Action P, Q-values:	[-0.00 +0.01 -0.07 -0.03 +0.07 +0.04]
State 039, Action P, Q-values:	[+0.00 +0.01 -0.06 -0.03 +0.07 +0.04]
State 040, Action P, Q-values:	[+0.00 +0.01 -0.07 -0.03 +0.07 +0.04]
State 041, Action P, Q-values:	[+0.00 +0.01 -0.06 -0.03 +0.07 +0.05]
State 042, Action P, Q-values:	[-0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 043, Action P, Q-values:	[+0.00 +0.00 -0.06 -0.02 +0.07 +0.04]
State 044, Action P, Q-values:	[+0.00 +0.01 -0.06 -0.04 +0.07 +0.05]
State 045, Action P, Q-values:	[+0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 046, Action P, Q-values:	[+0.01 +0.01 -0.06 -0.03 +0.07 +0.05]
State 047, Action P, Q-values:	[-0.00 +0.01 -0.07 -0.03 +0.07 +0.04]

State 048,	Action P,	Q-values:	[+0.00	-0.00	-0.07	-0.03	+0.08	+0.05]
State 049,	Action P,	Q-values:	[+0.00	+0.01	-0.06	-0.03	+0.07	+0.05]
State 050,	Action P,	Q-values:	[+0.00	+0.01	-0.07	-0.03	+0.07	+0.04]
State 051,	Action P,	Q-values:	[-0.00	+0.01	-0.07	-0.03	+0.06	+0.04]
State 052,	Action P,	Q-values:	[+0.00	+0.00	-0.07	-0.03	+0.07	+0.05]
State 053,	Action P,	Q-values:	[+0.00	+0.01	-0.06	-0.03	+0.07	+0.06]
State 054,	Action P,	Q-values:	[-0.00	+0.01	-0.07	-0.04	+0.07	+0.05]
State 055,	Action P,	Q-values:	[+0.00	+0.01	-0.07	-0.04	+0.07	+0.04]
State 056,	Action P,	Q-values:	[-0.01	+0.00	-0.07	-0.03	+0.07	+0.04]
State 057,	Action P,	Q-values:	[+0.00	+0.01	-0.06	-0.03	+0.07	+0.05]
State 058,	Action P,	Q-values:	[-0.00	+0.00	-0.06	-0.03	+0.07	+0.04]
State 059,	Action P,	Q-values:	[-0.00	+0.00	-0.07	-0.03	+0.07	+0.05]
State 060,	Action P,	Q-values:	[-0.01	+0.01	-0.07	-0.03	+0.07	+0.04]
State 061,	Action P,	Q-values:	[-0.00	+0.01	-0.07	-0.04	+0.07	+0.05]
State 062,	Action P,	Q-values:	[+0.00	+0.01	-0.07	-0.03	+0.07	+0.04]
State 063,	Action P,	Q-values:	[-0.00	+0.01	-0.06	-0.03	+0.07	+0.04]
State 064,	Action P,	Q-values:	[-0.00	+0.00	-0.07	-0.03	+0.07	+0.04]
State 065,	Action P,	Q-values:	[-0.00	+0.01	-0.07	-0.03	+0.08	+0.05]
State 066,	Action P,	Q-values:	[-0.00	+0.01	-0.07	-0.03	+0.07	+0.05]
State 067,	Action P,	Q-values:	[+0.00	+0.01	-0.06	-0.04	+0.07	+0.06]
State 068,	Action P,	Q-values:	[-0.01	+0.01	-0.07	-0.03	+0.07	+0.05]
State 069,	Action P,	Q-values:	[-0.00	+0.01	-0.06	-0.04	+0.07	+0.04]
State 070,	Action P,	Q-values:	[-0.00	+0.01	-0.07	-0.02	+0.07	+0.04]
State 071,	Action P,	Q-values:	[-0.00	+0.01	-0.07	-0.04	+0.07	+0.04]
State 072,	Action P,	Q-values:	[-0.00	+0.02	-0.07	-0.03	+0.08	+0.05]
State 073,	Action P,	Q-values:	[+0.00	+0.01	-0.06	-0.04	+0.08	+0.05]
State 074,	Action P,	Q-values:	[-0.00	+0.00	-0.07	-0.03	+0.07	+0.04]
State 075,	Action P,	Q-values:	[+0.00	+0.01	-0.07	-0.03	+0.07	+0.04]
State 076,	Action P,	Q-values:	[-0.00	+0.01	-0.07	-0.03	+0.07	+0.05]
State 077,	Action P,	Q-values:	[-0.00	+0.01	-0.07	-0.03	+0.07	+0.05]
State 078,	Action P,	Q-values:	[+0.00	+0.01	-0.06	-0.03	+0.07	+0.04]
State 079,	Action P,	Q-values:	[-0.00	+0.01	-0.07	-0.03	+0.07	+0.05]
State 080,	Action P,	Q-values:	[+0.01	+0.01	-0.07	-0.03	+0.07	+0.05]
State 081,	Action P,	Q-values:	[-0.00	+0.01	-0.07	-0.04	+0.07	+0.04]
State 082,	Action P,	Q-values:	[+0.00	+0.01	-0.06	-0.03	+0.07	+0.05]
State 083,	Action P,	Q-values:	[-0.00	+0.01	-0.06	-0.03	+0.07	+0.04]
State 084,	Action P,	Q-values:	[+0.00	+0.00	-0.06	-0.03	+0.07	+0.05]
State 085,	Action P,	Q-values:	[-0.01	+0.01	-0.07	-0.03	+0.07	+0.04]
State 086,	Action P,	Q-values:	[+0.00	+0.00	-0.06	-0.04	+0.07	+0.05]
State 087,	Action P,	Q-values:	[-0.00	+0.01	-0.07	-0.03	+0.07	+0.04]
State 088,	Action P,	Q-values:	[-0.00	+0.01	-0.07	-0.04	+0.07	+0.04]
State 089,	Action P,	Q-values:	[-0.00	+0.01	-0.07	-0.03	+0.07	+0.05]
State 090,	Action P,	Q-values:	[+0.01	+0.01	-0.07	-0.03	+0.06	+0.05]
State 091,	Action P,	Q-values:	[+0.01	+0.00	-0.07	-0.03	+0.07	+0.04]
State 092,	Action P,	Q-values:	[+0.01	+0.02	-0.07	-0.02	+0.07	+0.05]
State 093,	Action P,	Q-values:	[-0.00	+0.01	-0.06	-0.03	+0.07	+0.05]
State 094,	Action P,	Q-values:	[-0.00	+0.01	-0.06	-0.03	+0.07	+0.04]
State 095,	Action P,	Q-values:	[+0.00	+0.01	-0.06	-0.03	+0.07	+0.04]
State 096,	Action P,	Q-values:	[-0.00	+0.01	-0.07	-0.03	+0.07	+0.04]
State 097,	Action P,	Q-values:	[+0.01	+0.02	-0.06	-0.03	+0.08	+0.0

State 105, Action P, Q-values: [+0.00 +0.01 -0.07 -0.04 +0.08 +0.05]
State 106, Action P, Q-values: [+0.00 +0.01 -0.06 -0.03 +0.07 +0.05]
State 107, Action P, Q-values: [+0.00 +0.00 -0.07 -0.04 +0.07 +0.05]
State 108, Action P, Q-values: [-0.01 +0.01 -0.07 -0.03 +0.07 +0.05]
State 109, Action P, Q-values: [+0.00 +0.01 -0.06 -0.03 +0.07 +0.05]
State 110, Action P, Q-values: [+0.00 +0.00 -0.07 -0.03 +0.07 +0.04]
State 111, Action P, Q-values: [-0.00 +0.00 -0.07 -0.04 +0.07 +0.05]
State 112, Action P, Q-values: [+0.00 +0.01 -0.06 -0.04 +0.07 +0.04]
State 113, Action P, Q-values: [+0.01 +0.00 -0.06 -0.03 +0.07 +0.05]
State 114, Action P, Q-values: [-0.01 +0.01 -0.07 -0.04 +0.07 +0.04]
State 115, Action P, Q-values: [+0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 116, Action P, Q-values: [+0.00 +0.01 -0.06 -0.03 +0.07 +0.05]
State 117, Action P, Q-values: [-0.01 -0.00 -0.07 -0.03 +0.07 +0.05]
State 118, Action P, Q-values: [+0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 119, Action P, Q-values: [+0.00 +0.01 -0.07 -0.03 +0.07 +0.04]
State 120, Action P, Q-values: [-0.00 +0.01 -0.06 -0.03 +0.07 +0.04]
State 121, Action P, Q-values: [+0.00 +0.02 -0.07 -0.03 +0.07 +0.05]
State 122, Action P, Q-values: [+0.00 +0.01 -0.07 -0.04 +0.07 +0.05]
State 123, Action P, Q-values: [-0.00 +0.01 -0.06 -0.03 +0.07 +0.04]
State 124, Action P, Q-values: [-0.01 +0.01 -0.07 -0.03 +0.08 +0.04]
State 125, Action P, Q-values: [+0.00 +0.01 -0.07 -0.03 +0.07 +0.04]
State 126, Action P, Q-values: [+0.00 +0.00 -0.07 -0.03 +0.07 +0.05]
State 127, Action P, Q-values: [+0.00 +0.01 -0.06 -0.03 +0.07 +0.05]
State 128, Action P, Q-values: [-0.00 +0.01 -0.06 -0.03 +0.07 +0.05]
State 129, Action P, Q-values: [+0.00 +0.01 -0.07 -0.02 +0.07 +0.05]
State 130, Action P, Q-values: [+0.00 +0.00 -0.07 -0.04 +0.07 +0.05]
State 131, Action P, Q-values: [-0.00 -0.00 -0.06 -0.03 +0.08 +0.05]
State 132, Action P, Q-values: [+0.01 +0.01 -0.06 -0.03 +0.07 +0.05]
State 133, Action P, Q-values: [+0.01 +0.01 -0.06 -0.03 +0.07 +0.05]
State 134, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.08 +0.05]
State 135, Action P, Q-values: [+0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 136, Action P, Q-values: [-0.00 -0.00 -0.07 -0.03 +0.07 +0.04]
State 137, Action P, Q-values: [-0.00 +0.01 -0.06 -0.04 +0.07 +0.05]
State 138, Action P, Q-values: [+0.00 +0.01 -0.06 -0.04 +0.07 +0.05]
State 139, Action P, Q-values: [-0.01 +0.01 -0.07 -0.04 +0.07 +0.05]
State 140, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.07 +0.04]
State 141, Action P, Q-values: [+0.00 +0.02 -0.07 -0.03 +0.07 +0.05]
State 142, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 143, Action P, Q-values: [-0.01 +0.01 -0.07 -0.03 +0.07 +0.05]
State 144, Action P, Q-values: [+0.01 +0.02 -0.07 -0.04 +0.07 +0.04]
State 145, Action P, Q-values: [+0.01 +0.01 -0.07 -0.03 +0.07 +0.05]
State 146, Action P, Q-values: [+0.00 -0.00 -0.07 -0.04 +0.07 +0.05]
State 147, Action P, Q-values: [-0.00 +0.02 -0.07 -0.03 +0.07 +0.05]
State 148, Action P, Q-values: [-0.01 +0.02 -0.07 -0.03 +0.07 +0.05]
State 149, Action P, Q-values: [+0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 150, Action P, Q-values: [+0.00 +0.00 -0.08 -0.03 +0.07 +0.05]
State 151, Action P, Q-values: [+0.01 +0.01 -0.06 -0.03 +0.07 +0.05]
State 152, Action P, Q-values: [+0.01 +0.02 -0.07 -0.03 +0.07 +0.04]
State 153, Action P, Q-values: [-0.00 +0.01 -0.06 -0.03 +0.07 +0.04]
State 154, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 155, Action P, Q-values: [-0.01 +0.00 -0.07 -0.03 +0.08 +0.05]
State 156, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.07 +0.04]
State 157, Action P, Q-values: [-0.00 +0.00 -0.06 -0.04 +0.07 +0.05]
State 158, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 159, Action P, Q-values: [+0.00 +0.01 -0.06 -0.04 +0.07 +0.05]
State 160, Action P, Q-values: [-0.00 +0.01 -0.07 -0.04 +0.07 +0.03]
State 161, Action P, Q-values: [+0.01 +0.00 -0.06 -0.04 +0.07 +0.05]

State 162, Action P, Q-values: [+0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 163, Action P, Q-values: [-0.00 +0.01 -0.07 -0.04 +0.07 +0.05]
State 164, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.07 +0.04]
State 165, Action P, Q-values: [+0.01 +0.01 -0.07 -0.04 +0.07 +0.05]
State 166, Action P, Q-values: [+0.00 +0.01 -0.06 -0.03 +0.07 +0.05]
State 167, Action P, Q-values: [+0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 168, Action P, Q-values: [+0.00 +0.01 -0.06 -0.03 +0.07 +0.04]
State 169, Action P, Q-values: [-0.00 +0.01 -0.06 -0.03 +0.08 +0.05]
State 170, Action P, Q-values: [+0.00 +0.01 -0.06 -0.04 +0.07 +0.05]
State 171, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.07 +0.04]
State 172, Action P, Q-values: [+0.00 +0.01 -0.06 -0.03 +0.07 +0.05]
State 173, Action P, Q-values: [-0.00 +0.01 -0.06 -0.04 +0.08 +0.05]
State 174, Action P, Q-values: [+0.00 +0.01 -0.07 -0.04 +0.07 +0.05]
State 175, Action P, Q-values: [+0.00 +0.01 -0.06 -0.04 +0.08 +0.04]
State 176, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 177, Action P, Q-values: [+0.00 +0.00 -0.07 -0.03 +0.06 +0.04]
State 178, Action P, Q-values: [+0.00 -0.00 -0.07 -0.03 +0.07 +0.04]
State 179, Action P, Q-values: [+0.01 -0.00 -0.06 -0.04 +0.07 +0.05]
State 180, Action P, Q-values: [+0.00 +0.00 -0.06 -0.03 +0.08 +0.05]
State 181, Action P, Q-values: [+0.00 +0.01 -0.07 -0.03 +0.08 +0.05]
State 182, Action P, Q-values: [-0.00 +0.01 -0.07 -0.04 +0.07 +0.04]
State 183, Action P, Q-values: [+0.01 +0.02 -0.07 -0.03 +0.07 +0.05]
State 184, Action P, Q-values: [+0.00 +0.00 -0.07 -0.03 +0.07 +0.05]
State 185, Action P, Q-values: [+0.00 +0.00 -0.07 -0.04 +0.07 +0.05]
State 186, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.07 +0.04]
State 187, Action P, Q-values: [-0.00 +0.00 -0.07 -0.03 +0.07 +0.05]
State 188, Action P, Q-values: [-0.00 +0.00 -0.07 -0.03 +0.07 +0.05]
State 189, Action P, Q-values: [-0.00 +0.01 -0.07 -0.04 +0.07 +0.04]
State 190, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.08 +0.05]
State 191, Action P, Q-values: [+0.00 +0.01 -0.07 -0.04 +0.07 +0.05]
State 192, Action P, Q-values: [+0.00 +0.01 -0.06 -0.03 +0.07 +0.04]
State 193, Action P, Q-values: [-0.00 +0.00 -0.06 -0.03 +0.07 +0.04]
State 194, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 195, Action P, Q-values: [-0.00 +0.00 -0.07 -0.03 +0.07 +0.04]
State 196, Action P, Q-values: [-0.00 +0.01 -0.06 -0.04 +0.07 +0.05]
State 197, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.06 +0.05]
State 198, Action P, Q-values: [-0.00 +0.00 -0.07 -0.03 +0.07 +0.04]
State 199, Action P, Q-values: [-0.00 +0.01 -0.06 -0.03 +0.07 +0.05]
State 200, Action P, Q-values: [-0.00 +0.02 -0.06 -0.03 +0.07 +0.05]
State 201, Action P, Q-values: [+0.00 +0.01 -0.07 -0.03 +0.08 +0.05]
State 202, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 203, Action P, Q-values: [-0.00 +0.01 -0.07 -0.04 +0.07 +0.04]
State 204, Action P, Q-values: [-0.00 +0.00 -0.07 -0.03 +0.07 +0.05]
State 205, Action P, Q-values: [+0.00 +0.02 -0.07 -0.03 +0.07 +0.04]
State 206, Action P, Q-values: [-0.00 +0.00 -0.07 -0.03 +0.07 +0.05]
State 207, Action P, Q-values: [+0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 208, Action P, Q-values: [+0.00 +0.00 -0.07 -0.04 +0.07 +0.05]
State 209, Action P, Q-values: [-0.00 +0.01 -0.07 -0.04 +0.07 +0.04]
State 210, Action P, Q-values: [+0.01 +0.00 -0.06 -0.03 +0.06 +0.05]
State 211, Action P, Q-values: [-0.01 +0.01 -0.07 -0.04 +0.08 +0.05]
State 212, Action P, Q-values: [-0.00 +0.01 -0.07 -0.02 +0.07 +0.04]
State 213, Action P, Q-values: [+0.00 +0.02 -0.07 -0.03 +0.08 +0.05]
State 214, Action P, Q-values: [+0.01 +0.01 -0.06 -0.03 +0.08 +0.05]
State 215, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.06 +0.04]
State 216, Action P, Q-values: [-0.00 +0.00 -0.07 -0.03 +0.07 +0.04]
State 217, Action P, Q-values: [+0.00 +0.02 -0.07 -0.03 +0.07 +0.05]
State 218, Action P, Q-values: [+0.00 +0.01 -0.07 -0.03 +0.07 +0.05]

State 219, Action P, Q-values: [-0.00 +0.01 -0.06 -0.03 +0.07 +0.04]
State 220, Action P, Q-values: [+0.01 +0.00 -0.06 -0.03 +0.07 +0.05]
State 221, Action P, Q-values: [+0.00 +0.00 -0.07 -0.03 +0.08 +0.05]
State 222, Action P, Q-values: [+0.00 +0.02 -0.06 -0.03 +0.07 +0.05]
State 223, Action P, Q-values: [+0.01 +0.01 -0.06 -0.03 +0.07 +0.05]
State 224, Action P, Q-values: [-0.00 +0.02 -0.07 -0.04 +0.07 +0.06]
State 225, Action P, Q-values: [+0.00 +0.01 -0.06 -0.03 +0.07 +0.05]
State 226, Action P, Q-values: [+0.00 +0.00 -0.07 -0.03 +0.07 +0.04]
State 227, Action P, Q-values: [-0.01 +0.01 -0.07 -0.02 +0.07 +0.04]
State 228, Action P, Q-values: [+0.00 +0.00 -0.07 -0.03 +0.07 +0.05]
State 229, Action P, Q-values: [-0.00 +0.01 -0.06 -0.03 +0.07 +0.05]
State 230, Action P, Q-values: [+0.00 +0.00 -0.06 -0.03 +0.07 +0.04]
State 231, Action P, Q-values: [+0.00 +0.02 -0.07 -0.03 +0.07 +0.04]
State 232, Action P, Q-values: [-0.00 +0.00 -0.06 -0.03 +0.07 +0.04]
State 233, Action P, Q-values: [+0.00 +0.01 -0.07 -0.03 +0.06 +0.05]
State 234, Action P, Q-values: [+0.00 +0.02 -0.06 -0.03 +0.07 +0.06]
State 235, Action P, Q-values: [+0.00 +0.00 -0.06 -0.03 +0.07 +0.04]
State 236, Action P, Q-values: [+0.01 +0.00 -0.06 -0.03 +0.07 +0.05]
State 237, Action P, Q-values: [-0.01 +0.01 -0.07 -0.03 +0.07 +0.05]
State 238, Action P, Q-values: [-0.01 +0.01 -0.07 -0.03 +0.07 +0.05]
State 239, Action P, Q-values: [-0.01 +0.01 -0.07 -0.04 +0.07 +0.04]
State 240, Action P, Q-values: [-0.00 -0.00 -0.06 -0.03 +0.07 +0.05]
State 241, Action P, Q-values: [+0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 242, Action P, Q-values: [-0.01 +0.01 -0.06 -0.04 +0.07 +0.04]
State 243, Action P, Q-values: [-0.01 +0.01 -0.07 -0.03 +0.07 +0.04]
State 244, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 245, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.07 +0.04]
State 246, Action P, Q-values: [+0.00 +0.01 -0.07 -0.03 +0.07 +0.04]
State 247, Action P, Q-values: [+0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 248, Action P, Q-values: [+0.00 +0.00 -0.07 -0.04 +0.07 +0.05]
State 249, Action P, Q-values: [+0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 250, Action P, Q-values: [-0.00 +0.00 -0.06 -0.03 +0.07 +0.05]
State 251, Action P, Q-values: [+0.00 +0.02 -0.07 -0.03 +0.07 +0.05]
State 252, Action P, Q-values: [+0.00 +0.00 -0.06 -0.04 +0.07 +0.05]
State 253, Action P, Q-values: [+0.00 +0.01 -0.07 -0.03 +0.07 +0.04]
State 254, Action P, Q-values: [-0.00 +0.01 -0.07 -0.04 +0.08 +0.05]
State 255, Action P, Q-values: [-0.00 +0.02 -0.07 -0.03 +0.07 +0.05]
State 256, Action P, Q-values: [+0.01 +0.01 -0.07 -0.03 +0.07 +0.05]
State 257, Action P, Q-values: [+0.01 +0.01 -0.06 -0.03 +0.07 +0.05]
State 258, Action P, Q-values: [+0.00 +0.01 -0.07 -0.04 +0.07 +0.04]
State 259, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.08 +0.05]
State 260, Action P, Q-values: [+0.00 +0.00 -0.07 -0.03 +0.07 +0.04]
State 261, Action P, Q-values: [+0.00 +0.01 -0.06 -0.04 +0.07 +0.04]
State 262, Action P, Q-values: [+0.00 +0.01 -0.06 -0.03 +0.06 +0.04]
State 263, Action P, Q-values: [+0.00 +0.01 -0.06 -0.03 +0.07 +0.05]
State 264, Action P, Q-values: [+0.01 +0.01 -0.07 -0.04 +0.07 +0.05]
State 265, Action P, Q-values: [-0.01 +0.01 -0.07 -0.03 +0.07 +0.05]
State 266, Action P, Q-values: [+0.01 +0.01 -0.07 -0.02 +0.07 +0.05]
State 267, Action P, Q-values: [-0.00 +0.00 -0.07 -0.03 +0.08 +0.05]
State 268, Action P, Q-values: [+0.00 +0.00 -0.08 -0.03 +0.07 +0.05]
State 269, Action P, Q-values: [-0.00 +0.01 -0.06 -0.03 +0.07 +0.04]
State 270, Action P, Q-values: [+0.00 +0.01 -0.06 -0.04 +0.07 +0.05]
State 271, Action P, Q-values: [+0.00 +0.01 -0.06 -0.03 +0.08 +0.05]
State 272, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.07 +0.04]
State 273, Action P, Q-values: [+0.01 +0.00 -0.06 -0.03 +0.07 +0.05]
State 274, Action P, Q-values: [+0.00 +0.01 -0.06 -0.04 +0.07 +0.05]
State 275, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.08 +0.04]

State 276,	Action P,	Q-values:	[-0.01	+0.01	-0.06	-0.03	+0.07	+0.04]
State 277,	Action P,	Q-values:	[+0.00	+0.01	-0.06	-0.03	+0.07	+0.04]
State 278,	Action P,	Q-values:	[-0.00	+0.01	-0.07	-0.03	+0.07	+0.05]
State 279,	Action P,	Q-values:	[-0.00	+0.01	-0.07	-0.03	+0.07	+0.05]
State 280,	Action P,	Q-values:	[-0.00	+0.00	-0.07	-0.03	+0.08	+0.04]
State 281,	Action P,	Q-values:	[-0.00	+0.01	-0.07	-0.03	+0.07	+0.04]
State 282,	Action P,	Q-values:	[+0.00	+0.01	-0.06	-0.04	+0.07	+0.05]
State 283,	Action P,	Q-values:	[-0.00	+0.00	-0.07	-0.03	+0.07	+0.04]
State 284,	Action P,	Q-values:	[-0.00	+0.01	-0.07	-0.03	+0.07	+0.05]
State 285,	Action P,	Q-values:	[+0.01	+0.02	-0.07	-0.02	+0.07	+0.05]
State 286,	Action P,	Q-values:	[+0.00	+0.02	-0.07	-0.03	+0.07	+0.05]
State 287,	Action P,	Q-values:	[+0.01	+0.00	-0.06	-0.03	+0.07	+0.05]
State 288,	Action P,	Q-values:	[+0.00	+0.01	-0.06	-0.03	+0.07	+0.04]
State 289,	Action P,	Q-values:	[-0.00	+0.01	-0.06	-0.04	+0.07	+0.05]
State 290,	Action P,	Q-values:	[+0.00	+0.01	-0.07	-0.03	+0.08	+0.05]
State 291,	Action P,	Q-values:	[+0.00	+0.01	-0.07	-0.03	+0.07	+0.05]
State 292,	Action P,	Q-values:	[+0.00	+0.01	-0.06	-0.03	+0.07	+0.05]
State 293,	Action P,	Q-values:	[+0.00	+0.01	-0.07	-0.03	+0.07	+0.05]
State 294,	Action P,	Q-values:	[+0.00	+0.01	-0.06	-0.04	+0.07	+0.05]
State 295,	Action P,	Q-values:	[+0.00	+0.01	-0.07	-0.03	+0.07	+0.04]
State 296,	Action P,	Q-values:	[-0.00	+0.01	-0.07	-0.02	+0.07	+0.05]
State 297,	Action P,	Q-values:	[+0.00	+0.01	-0.07	-0.03	+0.08	+0.05]
State 298,	Action P,	Q-values:	[-0.00	+0.01	-0.07	-0.03	+0.07	+0.04]
State 299,	Action P,	Q-values:	[-0.00	+0.01	-0.07	-0.04	+0.07	+0.05]
State 300,	Action P,	Q-values:	[-0.00	+0.01	-0.07	-0.03	+0.07	+0.04]
State 301,	Action P,	Q-values:	[+0.01	+0.01	-0.07	-0.03	+0.07	+0.05]
State 302,	Action P,	Q-values:	[+0.00	+0.01	-0.07	-0.03	+0.07	+0.05]
State 303,	Action P,	Q-values:	[-0.01	+0.01	-0.07	-0.03	+0.07	+0.05]
State 304,	Action P,	Q-values:	[+0.00	+0.01	-0.06	-0.03	+0.07	+0.04]
State 305,	Action P,	Q-values:	[+0.01	+0.02	-0.08	-0.03	+0.07	+0.05]
State 306,	Action P,	Q-values:	[+0.00	+0.01	-0.06	-0.03	+0.07	+0.05]
State 307,	Action P,	Q-values:	[+0.00	+0.00	-0.06	-0.03	+0.07	+0.05]
State 308,	Action P,	Q-values:	[-0.00	+0.01	-0.06	-0.04	+0.07	+0.05]
State 309,	Action P,	Q-values:	[-0.00	+0.01	-0.07	-0.03	+0.07	+0.04]
State 310,	Action P,	Q-values:	[-0.00	+0.01	-0.06	-0.03	+0.07	+0.05]
State 311,	Action P,	Q-values:	[-0.00	+0.00	-0.06	-0.03	+0.07	+0.05]
State 312,	Action P,	Q-values:	[-0.00	+0.01	-0.07	-0.03	+0.07	+0.05]
State 313,	Action P,	Q-values:	[+0.01	+0.00	-0.07	-0.03	+0.07	+0.04]
State 314,	Action P,	Q-values:	[+0.00	+0.01	-0.06	-0.03	+0.07	+0.04]
State 315,	Action P,	Q-values:	[-0.01	+0.01	-0.07	-0.03	+0.07	+0.04]
State 316,	Action P,	Q-values:	[+0.00	+0.01	-0.06	-0.03	+0.07	+0.04]
State 317,	Action P,	Q-values:	[-0.00	+0.01	-0.06	-0.04	+0.07	+0.05]
State 318,	Action P,	Q-values:	[+0.00	+0.01	-0.07	-0.03	+0.07	+0.05]
State 319,	Action P,	Q-values:	[-0.01	+0.01	-0.07	-0.04	+0.07	+0.04]
State 320,	Action P,	Q-values:	[+0.01	+0.01	-0.07	-0.03	+0.07	+0.04]
State 321,	Action P,	Q-values:	[+0.00	+0.01	-0.07	-0.03	+0.06	+0.04]
State 322,	Action P,	Q-values:	[+0.00	+0.01	-0.06	-0.03	+0.07	+0.05]
State 323,	Action P,	Q-values:	[-0.00	+0.01	-0.06	-0.03	+0.07	+0.05]
State 324,	Action P,	Q-values:	[-0.00	+0.01	-0.06	-0.03	+0.07	+0.05]
State 325,	Action P,	Q-values:	[-0.00	+0.01	-0.06	-0.04	+0.07	+0.0

State 333, Action P, Q-values: [-0.00 +0.00 -0.07 -0.03 +0.07 +0.05]
State 334, Action P, Q-values: [-0.00 +0.01 -0.06 -0.03 +0.07 +0.04]
State 335, Action P, Q-values: [+0.01 +0.01 -0.06 -0.04 +0.07 +0.04]
State 336, Action P, Q-values: [+0.01 +0.00 -0.06 -0.03 +0.06 +0.04]
State 337, Action P, Q-values: [-0.00 +0.02 -0.07 -0.03 +0.07 +0.04]
State 338, Action P, Q-values: [+0.00 +0.00 -0.07 -0.03 +0.07 +0.05]
State 339, Action P, Q-values: [-0.01 +0.01 -0.07 -0.03 +0.07 +0.04]
State 340, Action P, Q-values: [+0.00 +0.01 -0.06 -0.04 +0.07 +0.05]
State 341, Action P, Q-values: [+0.00 +0.00 -0.07 -0.03 +0.07 +0.05]
State 342, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.08 +0.05]
State 343, Action P, Q-values: [+0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 344, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 345, Action P, Q-values: [-0.00 +0.00 -0.07 -0.03 +0.08 +0.04]
State 346, Action P, Q-values: [+0.00 +0.01 -0.06 -0.03 +0.06 +0.04]
State 347, Action P, Q-values: [+0.00 +0.01 -0.06 -0.04 +0.08 +0.04]
State 348, Action P, Q-values: [-0.01 +0.01 -0.07 -0.04 +0.07 +0.05]
State 349, Action P, Q-values: [+0.01 +0.00 -0.07 -0.04 +0.07 +0.05]
State 350, Action P, Q-values: [-0.00 +0.00 -0.07 -0.03 +0.07 +0.04]
State 351, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 352, Action P, Q-values: [+0.00 +0.01 -0.06 -0.03 +0.06 +0.04]
State 353, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 354, Action P, Q-values: [+0.01 +0.00 -0.06 -0.03 +0.07 +0.05]
State 355, Action P, Q-values: [+0.00 +0.00 -0.07 -0.04 +0.07 +0.04]
State 356, Action P, Q-values: [-0.00 -0.00 -0.07 -0.03 +0.07 +0.04]
State 357, Action P, Q-values: [-0.00 +0.01 -0.06 -0.03 +0.07 +0.05]
State 358, Action P, Q-values: [-0.01 +0.01 -0.07 -0.03 +0.07 +0.05]
State 359, Action P, Q-values: [-0.01 +0.00 -0.07 -0.03 +0.07 +0.04]
State 360, Action P, Q-values: [-0.01 +0.01 -0.07 -0.02 +0.07 +0.05]
State 361, Action P, Q-values: [+0.00 +0.01 -0.06 -0.03 +0.08 +0.05]
State 362, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.06 +0.04]
State 363, Action P, Q-values: [-0.00 +0.01 -0.07 -0.04 +0.07 +0.04]
State 364, Action P, Q-values: [-0.00 +0.01 -0.07 -0.04 +0.08 +0.05]
State 365, Action P, Q-values: [-0.00 +0.01 -0.06 -0.03 +0.07 +0.04]
State 366, Action P, Q-values: [+0.00 +0.01 -0.07 -0.03 +0.06 +0.05]
State 367, Action P, Q-values: [+0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 368, Action P, Q-values: [+0.01 +0.02 -0.06 -0.03 +0.07 +0.05]
State 369, Action P, Q-values: [-0.00 +0.02 -0.07 -0.03 +0.07 +0.05]
State 370, Action P, Q-values: [-0.00 +0.01 -0.06 -0.04 +0.07 +0.04]
State 371, Action P, Q-values: [+0.00 +0.01 -0.06 -0.03 +0.07 +0.05]
State 372, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 373, Action P, Q-values: [-0.00 +0.02 -0.07 -0.03 +0.07 +0.05]
State 374, Action P, Q-values: [-0.01 +0.01 -0.07 -0.03 +0.07 +0.05]
State 375, Action P, Q-values: [-0.01 +0.01 -0.06 -0.03 +0.07 +0.05]
State 376, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 377, Action P, Q-values: [+0.00 +0.00 -0.07 -0.03 +0.07 +0.04]
State 378, Action P, Q-values: [+0.00 +0.02 -0.07 -0.02 +0.06 +0.05]
State 379, Action P, Q-values: [+0.00 +0.00 -0.06 -0.03 +0.07 +0.05]
State 380, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.08 +0.04]
State 381, Action P, Q-values: [+0.00 +0.01 -0.07 -0.03 +0.08 +0.05]
State 382, Action P, Q-values: [+0.01 +0.01 -0.07 -0.03 +0.07 +0.05]
State 383, Action P, Q-values: [-0.00 +0.01 -0.07 -0.04 +0.08 +0.05]
State 384, Action P, Q-values: [-0.00 +0.00 -0.06 -0.04 +0.07 +0.05]
State 385, Action P, Q-values: [-0.01 +0.01 -0.07 -0.03 +0.07 +0.05]
State 386, Action P, Q-values: [+0.00 +0.00 -0.07 -0.03 +0.07 +0.05]
State 387, Action P, Q-values: [+0.00 +0.01 -0.07 -0.03 +0.07 +0.04]
State 388, Action P, Q-values: [+0.01 +0.01 -0.06 -0.03 +0.07 +0.05]
State 389, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.07 +0.05]

State 390, Action P, Q-values: [+0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 391, Action P, Q-values: [-0.00 +0.01 -0.07 -0.04 +0.07 +0.04]
State 392, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 393, Action P, Q-values: [+0.00 +0.02 -0.07 -0.04 +0.07 +0.05]
State 394, Action P, Q-values: [-0.00 +0.00 -0.06 -0.03 +0.07 +0.04]
State 395, Action P, Q-values: [+0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 396, Action P, Q-values: [-0.01 +0.01 -0.07 -0.03 +0.07 +0.04]
State 397, Action P, Q-values: [+0.00 +0.01 -0.06 -0.03 +0.07 +0.05]
State 398, Action P, Q-values: [-0.00 +0.00 -0.07 -0.03 +0.07 +0.05]
State 399, Action P, Q-values: [-0.00 +0.00 -0.07 -0.03 +0.07 +0.05]
State 400, Action P, Q-values: [+0.00 +0.01 -0.06 -0.03 +0.07 +0.05]
State 401, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 402, Action P, Q-values: [+0.00 +0.02 -0.06 -0.03 +0.07 +0.05]
State 403, Action P, Q-values: [+0.00 +0.00 -0.06 -0.04 +0.07 +0.05]
State 404, Action P, Q-values: [-0.01 +0.02 -0.07 -0.04 +0.07 +0.05]
State 405, Action P, Q-values: [+0.00 +0.01 -0.06 -0.03 +0.07 +0.05]
State 406, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 407, Action P, Q-values: [+0.01 +0.00 -0.06 -0.03 +0.07 +0.04]
State 408, Action P, Q-values: [+0.00 +0.01 -0.06 -0.02 +0.07 +0.05]
State 409, Action P, Q-values: [-0.00 +0.01 -0.07 -0.04 +0.07 +0.05]
State 410, Action P, Q-values: [+0.00 +0.01 -0.07 -0.03 +0.08 +0.05]
State 411, Action P, Q-values: [-0.00 +0.01 -0.07 -0.04 +0.07 +0.04]
State 412, Action P, Q-values: [-0.00 +0.01 -0.08 -0.03 +0.07 +0.05]
State 413, Action P, Q-values: [+0.00 +0.00 -0.07 -0.03 +0.07 +0.05]
State 414, Action P, Q-values: [-0.00 +0.01 -0.06 -0.03 +0.07 +0.04]
State 415, Action P, Q-values: [-0.01 +0.00 -0.06 -0.03 +0.08 +0.04]
State 416, Action P, Q-values: [+0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 417, Action P, Q-values: [-0.01 +0.01 -0.07 -0.03 +0.07 +0.05]
State 418, Action P, Q-values: [+0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 419, Action P, Q-values: [+0.00 +0.00 -0.06 -0.03 +0.07 +0.05]
State 420, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 421, Action P, Q-values: [+0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 422, Action P, Q-values: [+0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 423, Action P, Q-values: [+0.01 +0.01 -0.07 -0.03 +0.07 +0.05]
State 424, Action P, Q-values: [-0.00 +0.01 -0.06 -0.03 +0.07 +0.04]
State 425, Action P, Q-values: [-0.00 +0.00 -0.06 -0.03 +0.07 +0.04]
State 426, Action P, Q-values: [+0.00 +0.01 -0.06 -0.04 +0.07 +0.05]
State 427, Action P, Q-values: [+0.00 +0.02 -0.07 -0.03 +0.06 +0.05]
State 428, Action P, Q-values: [+0.00 +0.00 -0.07 -0.03 +0.07 +0.05]
State 429, Action P, Q-values: [+0.00 +0.01 -0.06 -0.04 +0.07 +0.04]
State 430, Action P, Q-values: [+0.00 +0.00 -0.06 -0.03 +0.07 +0.04]
State 431, Action P, Q-values: [-0.00 +0.00 -0.07 -0.04 +0.07 +0.04]
State 432, Action P, Q-values: [+0.00 +0.00 -0.07 -0.03 +0.07 +0.04]
State 433, Action P, Q-values: [-0.00 +0.01 -0.06 -0.03 +0.07 +0.05]
State 434, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.08 +0.05]
State 435, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.07 +0.04]
State 436, Action P, Q-values: [-0.00 +0.00 -0.06 -0.02 +0.06 +0.05]
State 437, Action P, Q-values: [+0.01 +0.00 -0.07 -0.03 +0.07 +0.04]
State 438, Action P, Q-values: [+0.01 +0.01 -0.06 -0.04 +0.07 +0.06]
State 439, Action P, Q-values: [+0.01 +0.00 -0.06 -0.03 +0.08 +0.05]
State 440, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 441, Action P, Q-values: [-0.00 +0.02 -0.07 -0.03 +0.06 +0.04]
State 442, Action P, Q-values: [+0.00 +0.00 -0.06 -0.03 +0.06 +0.04]
State 443, Action P, Q-values: [-0.00 +0.01 -0.06 -0.02 +0.07 +0.04]
State 444, Action P, Q-values: [-0.00 +0.02 -0.07 -0.04 +0.07 +0.05]
State 445, Action P, Q-values: [-0.00 +0.01 -0.05 -0.03 +0.06 +0.05]
State 446, Action P, Q-values: [-0.01 +0.01 -0.07 -0.04 +0.07 +0.05]

State 447, Action P, Q-values: [-0.00 +0.00 -0.07 -0.03 +0.07 +0.05]
State 448, Action P, Q-values: [+0.00 +0.01 -0.07 -0.03 +0.07 +0.04]
State 449, Action P, Q-values: [+0.00 +0.00 -0.06 -0.03 +0.07 +0.05]
State 450, Action P, Q-values: [-0.00 +0.01 -0.07 -0.04 +0.07 +0.05]
State 451, Action P, Q-values: [-0.00 +0.00 -0.06 -0.04 +0.07 +0.04]
State 452, Action P, Q-values: [-0.00 +0.00 -0.07 -0.03 +0.07 +0.05]
State 453, Action P, Q-values: [-0.00 +0.00 -0.06 -0.03 +0.07 +0.05]
State 454, Action P, Q-values: [+0.00 +0.01 -0.07 -0.03 +0.07 +0.04]
State 455, Action P, Q-values: [+0.00 +0.00 -0.07 -0.04 +0.07 +0.05]
State 456, Action P, Q-values: [+0.00 +0.01 -0.07 -0.04 +0.07 +0.04]
State 457, Action P, Q-values: [+0.00 +0.00 -0.06 -0.04 +0.07 +0.05]
State 458, Action P, Q-values: [-0.00 +0.01 -0.06 -0.03 +0.07 +0.04]
State 459, Action P, Q-values: [-0.00 +0.01 -0.06 -0.03 +0.08 +0.05]
State 460, Action P, Q-values: [-0.01 +0.01 -0.07 -0.03 +0.07 +0.05]
State 461, Action P, Q-values: [-0.00 +0.00 -0.07 -0.03 +0.07 +0.05]
State 462, Action P, Q-values: [+0.00 +0.01 -0.07 -0.04 +0.07 +0.05]
State 463, Action P, Q-values: [+0.00 +0.01 -0.07 -0.02 +0.07 +0.04]
State 464, Action P, Q-values: [-0.01 +0.01 -0.06 -0.03 +0.07 +0.05]
State 465, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 466, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 467, Action P, Q-values: [+0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 468, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.07 +0.04]
State 469, Action P, Q-values: [+0.00 +0.00 -0.06 -0.03 +0.07 +0.05]
State 470, Action P, Q-values: [+0.01 +0.01 -0.07 -0.03 +0.07 +0.05]
State 471, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 472, Action P, Q-values: [+0.01 +0.01 -0.06 -0.04 +0.07 +0.05]
State 473, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 474, Action P, Q-values: [-0.00 +0.02 -0.07 -0.04 +0.07 +0.05]
State 475, Action P, Q-values: [-0.00 +0.00 -0.07 -0.04 +0.07 +0.04]
State 476, Action P, Q-values: [+0.01 +0.02 -0.07 -0.03 +0.07 +0.05]
State 477, Action P, Q-values: [+0.00 +0.01 -0.06 -0.03 +0.07 +0.05]
State 478, Action P, Q-values: [+0.01 +0.00 -0.06 -0.03 +0.07 +0.05]
State 479, Action P, Q-values: [-0.00 +0.01 -0.06 -0.04 +0.08 +0.04]
State 480, Action P, Q-values: [-0.00 +0.01 -0.06 -0.03 +0.06 +0.04]
State 481, Action P, Q-values: [-0.00 +0.01 -0.06 -0.03 +0.07 +0.05]
State 482, Action P, Q-values: [-0.00 +0.01 -0.07 -0.02 +0.08 +0.05]
State 483, Action P, Q-values: [-0.00 +0.01 -0.07 -0.04 +0.07 +0.05]
State 484, Action P, Q-values: [-0.00 +0.02 -0.07 -0.04 +0.07 +0.05]
State 485, Action P, Q-values: [-0.00 +0.01 -0.07 -0.04 +0.07 +0.04]
State 486, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.06 +0.05]
State 487, Action P, Q-values: [+0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 488, Action P, Q-values: [-0.00 +0.01 -0.07 -0.04 +0.07 +0.05]
State 489, Action P, Q-values: [+0.00 +0.01 -0.07 -0.03 +0.07 +0.04]
State 490, Action P, Q-values: [+0.00 +0.01 -0.06 -0.03 +0.07 +0.05]
State 491, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.07 +0.04]
State 492, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 493, Action P, Q-values: [-0.00 +0.00 -0.06 -0.04 +0.07 +0.04]
State 494, Action P, Q-values: [+0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
State 495, Action P, Q-values: [-0.01 +0.01 -0.06 -0.03 +0.07 +0.05]
State 496, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.07 +0.04]
State 497, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.07 +0.04]
State 498, Action P, Q-values: [+0.01 +0.01 -0.07 -0.03 +0.07 +0.05]
State 499, Action P, Q-values: [-0.00 +0.01 -0.07 -0.03 +0.07 +0.05]
Episode 100/100000, Avg Reward: -754.91, Epsilon: 0.99
Episode 200/100000, Avg Reward: -769.25, Epsilon: 0.99
Episode 300/100000, Avg Reward: -754.88, Epsilon: 0.98
Episode 400/100000, Avg Reward: -770.70, Epsilon: 0.97

Episode 500/100000, Avg Reward: -742.45, Epsilon: 0.97
Episode 600/100000, Avg Reward: -761.26, Epsilon: 0.96
Episode 700/100000, Avg Reward: -747.82, Epsilon: 0.95
Episode 800/100000, Avg Reward: -744.88, Epsilon: 0.95
Episode 900/100000, Avg Reward: -750.46, Epsilon: 0.94
Episode 1000/100000, Avg Reward: -727.18, Epsilon: 0.93
Episode 1100/100000, Avg Reward: -715.02, Epsilon: 0.93
Episode 1200/100000, Avg Reward: -732.32, Epsilon: 0.92
Episode 1300/100000, Avg Reward: -743.16, Epsilon: 0.91
Episode 1400/100000, Avg Reward: -723.38, Epsilon: 0.91
Episode 1500/100000, Avg Reward: -707.97, Epsilon: 0.90
Episode 1600/100000, Avg Reward: -719.01, Epsilon: 0.90
Episode 1700/100000, Avg Reward: -715.62, Epsilon: 0.89
Episode 1800/100000, Avg Reward: -718.00, Epsilon: 0.88
Episode 1900/100000, Avg Reward: -715.55, Epsilon: 0.88
Episode 2000/100000, Avg Reward: -703.45, Epsilon: 0.87
Episode 2100/100000, Avg Reward: -700.58, Epsilon: 0.86
Episode 2200/100000, Avg Reward: -683.69, Epsilon: 0.86
Episode 2300/100000, Avg Reward: -693.17, Epsilon: 0.85
Episode 2400/100000, Avg Reward: -675.50, Epsilon: 0.85
Episode 2500/100000, Avg Reward: -682.36, Epsilon: 0.84
Episode 2600/100000, Avg Reward: -674.52, Epsilon: 0.84
Episode 2700/100000, Avg Reward: -658.16, Epsilon: 0.83
Episode 2800/100000, Avg Reward: -663.08, Epsilon: 0.82
Episode 2900/100000, Avg Reward: -636.75, Epsilon: 0.82
Episode 3000/100000, Avg Reward: -665.21, Epsilon: 0.81
Episode 3100/100000, Avg Reward: -641.46, Epsilon: 0.81
Episode 3200/100000, Avg Reward: -641.36, Epsilon: 0.80
Episode 3300/100000, Avg Reward: -641.10, Epsilon: 0.80
Episode 3400/100000, Avg Reward: -628.31, Epsilon: 0.79
Episode 3500/100000, Avg Reward: -637.81, Epsilon: 0.79
Episode 3600/100000, Avg Reward: -600.53, Epsilon: 0.78
Episode 3700/100000, Avg Reward: -591.41, Epsilon: 0.77
Episode 3800/100000, Avg Reward: -618.54, Epsilon: 0.77
Episode 3900/100000, Avg Reward: -597.41, Epsilon: 0.76
Episode 4000/100000, Avg Reward: -597.00, Epsilon: 0.76
Episode 4100/100000, Avg Reward: -588.97, Epsilon: 0.75
Episode 4200/100000, Avg Reward: -609.53, Epsilon: 0.75
Episode 4300/100000, Avg Reward: -627.33, Epsilon: 0.74
Episode 4400/100000, Avg Reward: -589.01, Epsilon: 0.74
Episode 4500/100000, Avg Reward: -577.46, Epsilon: 0.73
Episode 4600/100000, Avg Reward: -554.37, Epsilon: 0.73
Episode 4700/100000, Avg Reward: -579.74, Epsilon: 0.72
Episode 4800/100000, Avg Reward: -569.12, Epsilon: 0.72
Episode 4900/100000, Avg Reward: -588.64, Epsilon: 0.71
Episode 5000/100000, Avg Reward: -573.27, Epsilon: 0.71
Episode 5100/100000, Avg Reward: -552.60, Epsilon: 0.70
Episode 5200/100000, Avg Reward: -566.66, Epsilon: 0.70
Episode 5300/100000, Avg Reward: -526.36, Epsilon: 0.69
Episode 5400/100000, Avg Reward: -507.24, Epsilon: 0.69
Episode 5500/100000, Avg Reward: -467.25, Epsilon: 0.68
Episode 5600/100000, Avg Reward: -469.11, Epsilon: 0.68
Episode 5700/100000, Avg Reward: -465.81, Epsilon: 0.67
Episode 5800/100000, Avg Reward: -450.74, Epsilon: 0.67
Episode 5900/100000, Avg Reward: -431.26, Epsilon: 0.67
Episode 6000/100000, Avg Reward: -433.27, Epsilon: 0.66
Episode 6100/100000, Avg Reward: -388.56, Epsilon: 0.66

Episode 6200/100000, Avg Reward: -364.87, Epsilon: 0.65
Episode 6300/100000, Avg Reward: -322.37, Epsilon: 0.65
Episode 6400/100000, Avg Reward: -302.63, Epsilon: 0.64
Episode 6500/100000, Avg Reward: -190.28, Epsilon: 0.64
Episode 6600/100000, Avg Reward: -121.60, Epsilon: 0.63
Episode 6700/100000, Avg Reward: -133.53, Epsilon: 0.63
Episode 6800/100000, Avg Reward: -110.62, Epsilon: 0.63
Episode 6900/100000, Avg Reward: -97.02, Epsilon: 0.62
Episode 7000/100000, Avg Reward: -89.19, Epsilon: 0.62
Episode 7100/100000, Avg Reward: -86.45, Epsilon: 0.61
Episode 7200/100000, Avg Reward: -86.25, Epsilon: 0.61
Episode 7300/100000, Avg Reward: -77.92, Epsilon: 0.60
Episode 7400/100000, Avg Reward: -79.51, Epsilon: 0.60
Episode 7500/100000, Avg Reward: -64.22, Epsilon: 0.60
Episode 7600/100000, Avg Reward: -70.94, Epsilon: 0.59
Episode 7700/100000, Avg Reward: -70.53, Epsilon: 0.59
Episode 7800/100000, Avg Reward: -75.60, Epsilon: 0.58
Episode 7900/100000, Avg Reward: -67.94, Epsilon: 0.58
Episode 8000/100000, Avg Reward: -59.76, Epsilon: 0.58
Episode 8100/100000, Avg Reward: -64.81, Epsilon: 0.57
Episode 8200/100000, Avg Reward: -70.64, Epsilon: 0.57
Episode 8300/100000, Avg Reward: -60.57, Epsilon: 0.56
Episode 8400/100000, Avg Reward: -60.85, Epsilon: 0.56
Episode 8500/100000, Avg Reward: -56.71, Epsilon: 0.56
Episode 8600/100000, Avg Reward: -63.61, Epsilon: 0.55
Episode 8700/100000, Avg Reward: -68.48, Epsilon: 0.55
Episode 8800/100000, Avg Reward: -61.22, Epsilon: 0.54
Episode 8900/100000, Avg Reward: -55.55, Epsilon: 0.54
Episode 9000/100000, Avg Reward: -53.55, Epsilon: 0.54
Episode 9100/100000, Avg Reward: -54.07, Epsilon: 0.53
Episode 9200/100000, Avg Reward: -52.90, Epsilon: 0.53
Episode 9300/100000, Avg Reward: -55.73, Epsilon: 0.53
Episode 9400/100000, Avg Reward: -54.07, Epsilon: 0.52
Episode 9500/100000, Avg Reward: -56.66, Epsilon: 0.52
Episode 9600/100000, Avg Reward: -48.10, Epsilon: 0.52
Episode 9700/100000, Avg Reward: -44.66, Epsilon: 0.51
Episode 9800/100000, Avg Reward: -54.52, Epsilon: 0.51
Episode 9900/100000, Avg Reward: -40.43, Epsilon: 0.50
Episode 10000/100000, Avg Reward: -45.21, Epsilon: 0.50
Episode 10100/100000, Avg Reward: -44.88, Epsilon: 0.50
Episode 10200/100000, Avg Reward: -47.04, Epsilon: 0.49
Episode 10300/100000, Avg Reward: -47.21, Epsilon: 0.49
Episode 10400/100000, Avg Reward: -48.18, Epsilon: 0.49
Episode 10500/100000, Avg Reward: -43.88, Epsilon: 0.48
Episode 10600/100000, Avg Reward: -48.13, Epsilon: 0.48
Episode 10700/100000, Avg Reward: -41.42, Epsilon: 0.48
Episode 10800/100000, Avg Reward: -44.91, Epsilon: 0.47
Episode 10900/100000, Avg Reward: -39.33, Epsilon: 0.47
Episode 11000/100000, Avg Reward: -40.75, Epsilon: 0.47
Episode 11100/100000, Avg Reward: -38.17, Epsilon: 0.46
Episode 11200/100000, Avg Reward: -39.45, Epsilon: 0.46
Episode 11300/100000, Avg Reward: -41.15, Epsilon: 0.46
Episode 11400/100000, Avg Reward: -39.60, Epsilon: 0.45
Episode 11500/100000, Avg Reward: -40.35, Epsilon: 0.45
Episode 11600/100000, Avg Reward: -36.56, Epsilon: 0.45
Episode 11700/100000, Avg Reward: -37.50, Epsilon: 0.45
Episode 11800/100000, Avg Reward: -34.81, Epsilon: 0.44

Episode	11900/100000	Avg Reward:	-31.24	Epsilon:	0.44
Episode	12000/100000	Avg Reward:	-34.87	Epsilon:	0.44
Episode	12100/100000	Avg Reward:	-32.57	Epsilon:	0.43
Episode	12200/100000	Avg Reward:	-31.36	Epsilon:	0.43
Episode	12300/100000	Avg Reward:	-28.91	Epsilon:	0.43
Episode	12400/100000	Avg Reward:	-34.04	Epsilon:	0.42
Episode	12500/100000	Avg Reward:	-29.47	Epsilon:	0.42
Episode	12600/100000	Avg Reward:	-28.21	Epsilon:	0.42
Episode	12700/100000	Avg Reward:	-30.54	Epsilon:	0.42
Episode	12800/100000	Avg Reward:	-28.90	Epsilon:	0.41
Episode	12900/100000	Avg Reward:	-33.08	Epsilon:	0.41
Episode	13000/100000	Avg Reward:	-31.77	Epsilon:	0.41
Episode	13100/100000	Avg Reward:	-26.00	Epsilon:	0.40
Episode	13200/100000	Avg Reward:	-28.48	Epsilon:	0.40
Episode	13300/100000	Avg Reward:	-29.52	Epsilon:	0.40
Episode	13400/100000	Avg Reward:	-24.67	Epsilon:	0.40
Episode	13500/100000	Avg Reward:	-33.81	Epsilon:	0.39
Episode	13600/100000	Avg Reward:	-25.99	Epsilon:	0.39
Episode	13700/100000	Avg Reward:	-23.93	Epsilon:	0.39
Episode	13800/100000	Avg Reward:	-22.60	Epsilon:	0.39
Episode	13900/100000	Avg Reward:	-27.07	Epsilon:	0.38
Episode	14000/100000	Avg Reward:	-29.50	Epsilon:	0.38
Episode	14100/100000	Avg Reward:	-28.73	Epsilon:	0.38
Episode	14200/100000	Avg Reward:	-22.88	Epsilon:	0.37
Episode	14300/100000	Avg Reward:	-21.71	Epsilon:	0.37
Episode	14400/100000	Avg Reward:	-22.28	Epsilon:	0.37
Episode	14500/100000	Avg Reward:	-23.79	Epsilon:	0.37
Episode	14600/100000	Avg Reward:	-20.28	Epsilon:	0.36
Episode	14700/100000	Avg Reward:	-18.05	Epsilon:	0.36
Episode	14800/100000	Avg Reward:	-17.26	Epsilon:	0.36
Episode	14900/100000	Avg Reward:	-23.83	Epsilon:	0.36
Episode	15000/100000	Avg Reward:	-23.72	Epsilon:	0.35
Episode	15100/100000	Avg Reward:	-19.74	Epsilon:	0.35
Episode	15200/100000	Avg Reward:	-16.42	Epsilon:	0.35
Episode	15300/100000	Avg Reward:	-19.49	Epsilon:	0.35
Episode	15400/100000	Avg Reward:	-24.35	Epsilon:	0.35
Episode	15500/100000	Avg Reward:	-21.78	Epsilon:	0.34
Episode	15600/100000	Avg Reward:	-18.42	Epsilon:	0.34
Episode	15700/100000	Avg Reward:	-16.72	Epsilon:	0.34
Episode	15800/100000	Avg Reward:	-18.66	Epsilon:	0.34
Episode	15900/100000	Avg Reward:	-23.78	Epsilon:	0.33
Episode	16000/100000	Avg Reward:	-17.71	Epsilon:	0.33
Episode	16100/100000	Avg Reward:	-20.04	Epsilon:	0.33
Episode	16200/100000	Avg Reward:	-15.23	Epsilon:	0.33
Episode	16300/100000	Avg Reward:	-25.41	Epsilon:	0.32
Episode	16400/100000	Avg Reward:	-20.02	Epsilon:	0.32
Episode	16500/100000	Avg Reward:	-18.82	Epsilon:	0.32
Episode	16600/100000	Avg Reward:	-13.90	Epsilon:	0.32
Episode	16700/100000	Avg Reward:	-12.72	Epsilon:	0.32
Episode	16800/100000	Avg Reward:	-17.14	Epsilon:	0.31
Episode	16900/100000	Avg Reward:	-16.51	Epsilon:	0.31
Episode	17000/100000	Avg Reward:	-14.42	Epsilon:	0.31
Episode	17100/100000	Avg Reward:	-15.74	Epsilon:	0.31
Episode	17200/100000	Avg Reward:	-15.85	Epsilon:	0.30
Episode	17300/100000	Avg Reward:	-17.42	Epsilon:	0.30
Episode	17400/100000	Avg Reward:	-15.68	Epsilon:	0.30
Episode	17500/100000	Avg Reward:	-14.06	Epsilon:	0.30

Episode 17600/100000, Avg Reward: -14.46, Epsilon: 0.30
Episode 17700/100000, Avg Reward: -13.43, Epsilon: 0.29
Episode 17800/100000, Avg Reward: -13.42, Epsilon: 0.29
Episode 17900/100000, Avg Reward: -12.77, Epsilon: 0.29
Episode 18000/100000, Avg Reward: -12.88, Epsilon: 0.29
Episode 18100/100000, Avg Reward: -10.34, Epsilon: 0.29
Episode 18200/100000, Avg Reward: -14.55, Epsilon: 0.28
Episode 18300/100000, Avg Reward: -11.44, Epsilon: 0.28
Episode 18400/100000, Avg Reward: -14.85, Epsilon: 0.28
Episode 18500/100000, Avg Reward: -10.11, Epsilon: 0.28
Episode 18600/100000, Avg Reward: -14.41, Epsilon: 0.28
Episode 18700/100000, Avg Reward: -14.75, Epsilon: 0.27
Episode 18800/100000, Avg Reward: -11.13, Epsilon: 0.27
Episode 18900/100000, Avg Reward: -10.12, Epsilon: 0.27
Episode 19000/100000, Avg Reward: -10.50, Epsilon: 0.27
Episode 19100/100000, Avg Reward: -11.14, Epsilon: 0.27
Episode 19200/100000, Avg Reward: -12.73, Epsilon: 0.27
Episode 19300/100000, Avg Reward: -8.83, Epsilon: 0.26
Episode 19400/100000, Avg Reward: -8.85, Epsilon: 0.26
Episode 19500/100000, Avg Reward: -6.98, Epsilon: 0.26
Episode 19600/100000, Avg Reward: -9.67, Epsilon: 0.26
Episode 19700/100000, Avg Reward: -13.06, Epsilon: 0.26
Episode 19800/100000, Avg Reward: -9.40, Epsilon: 0.25
Episode 19900/100000, Avg Reward: -10.17, Epsilon: 0.25
Episode 20000/100000, Avg Reward: -13.23, Epsilon: 0.25
Episode 20100/100000, Avg Reward: -7.80, Epsilon: 0.25
Episode 20200/100000, Avg Reward: -10.41, Epsilon: 0.25
Episode 20300/100000, Avg Reward: -10.62, Epsilon: 0.25
Episode 20400/100000, Avg Reward: -9.41, Epsilon: 0.24
Episode 20500/100000, Avg Reward: -8.59, Epsilon: 0.24
Episode 20600/100000, Avg Reward: -6.72, Epsilon: 0.24
Episode 20700/100000, Avg Reward: -9.04, Epsilon: 0.24
Episode 20800/100000, Avg Reward: -5.65, Epsilon: 0.24
Episode 20900/100000, Avg Reward: -8.32, Epsilon: 0.24
Episode 21000/100000, Avg Reward: -7.73, Epsilon: 0.23
Episode 21100/100000, Avg Reward: -4.40, Epsilon: 0.23
Episode 21200/100000, Avg Reward: -10.36, Epsilon: 0.23
Episode 21300/100000, Avg Reward: -6.99, Epsilon: 0.23
Episode 21400/100000, Avg Reward: -6.82, Epsilon: 0.23
Episode 21500/100000, Avg Reward: -6.94, Epsilon: 0.23
Episode 21600/100000, Avg Reward: -5.82, Epsilon: 0.22
Episode 21700/100000, Avg Reward: -8.58, Epsilon: 0.22
Episode 21800/100000, Avg Reward: -7.46, Epsilon: 0.22
Episode 21900/100000, Avg Reward: -5.89, Epsilon: 0.22
Episode 22000/100000, Avg Reward: -6.14, Epsilon: 0.22
Episode 22100/100000, Avg Reward: -6.89, Epsilon: 0.22
Episode 22200/100000, Avg Reward: -6.54, Epsilon: 0.22
Episode 22300/100000, Avg Reward: -8.71, Epsilon: 0.21
Episode 22400/100000, Avg Reward: -7.71, Epsilon: 0.21
Episode 22500/100000, Avg Reward: -9.14, Epsilon: 0.21
Episode 22600/100000, Avg Reward: -8.00, Epsilon: 0.21
Episode 22700/100000, Avg Reward: -5.22, Epsilon: 0.21
Episode 22800/100000, Avg Reward: -5.29, Epsilon: 0.21
Episode 22900/100000, Avg Reward: -7.66, Epsilon: 0.21
Episode 23000/100000, Avg Reward: -4.57, Epsilon: 0.20
Episode 23100/100000, Avg Reward: -5.87, Epsilon: 0.20
Episode 23200/100000, Avg Reward: -5.74, Epsilon: 0.20

Episode 23300/100000, Avg Reward: -4.60, Epsilon: 0.20
Episode 23400/100000, Avg Reward: -4.17, Epsilon: 0.20
Episode 23500/100000, Avg Reward: -4.42, Epsilon: 0.20
Episode 23600/100000, Avg Reward: -4.26, Epsilon: 0.20
Episode 23700/100000, Avg Reward: -5.14, Epsilon: 0.19
Episode 23800/100000, Avg Reward: -5.44, Epsilon: 0.19
Episode 23900/100000, Avg Reward: -5.64, Epsilon: 0.19
Episode 24000/100000, Avg Reward: -5.00, Epsilon: 0.19
Episode 24100/100000, Avg Reward: -4.52, Epsilon: 0.19
Episode 24200/100000, Avg Reward: -3.80, Epsilon: 0.19
Episode 24300/100000, Avg Reward: -5.74, Epsilon: 0.19
Episode 24400/100000, Avg Reward: -4.54, Epsilon: 0.19
Episode 24500/100000, Avg Reward: -6.15, Epsilon: 0.18
Episode 24600/100000, Avg Reward: -3.31, Epsilon: 0.18
Episode 24700/100000, Avg Reward: -2.86, Epsilon: 0.18
Episode 24800/100000, Avg Reward: -3.58, Epsilon: 0.18
Episode 24900/100000, Avg Reward: -1.73, Epsilon: 0.18
Episode 25000/100000, Avg Reward: -6.93, Epsilon: 0.18
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Episode 25200/100000, Avg Reward: -2.37, Epsilon: 0.18
Episode 25300/100000, Avg Reward: -4.80, Epsilon: 0.17
Episode 25400/100000, Avg Reward: -2.72, Epsilon: 0.17
Episode 25500/100000, Avg Reward: -2.59, Epsilon: 0.17
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Episode 25700/100000, Avg Reward: -3.54, Epsilon: 0.17
Episode 25800/100000, Avg Reward: -2.52, Epsilon: 0.17
Episode 25900/100000, Avg Reward: -1.38, Epsilon: 0.17
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Episode 26100/100000, Avg Reward: -0.68, Epsilon: 0.16
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Episode 26300/100000, Avg Reward: -0.17, Epsilon: 0.16
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Episode 26500/100000, Avg Reward: -2.45, Epsilon: 0.16
Episode 26600/100000, Avg Reward: -1.08, Epsilon: 0.16
Episode 26700/100000, Avg Reward: -0.94, Epsilon: 0.16
Episode 26800/100000, Avg Reward: -2.69, Epsilon: 0.16
Episode 26900/100000, Avg Reward: -2.29, Epsilon: 0.16
Episode 27000/100000, Avg Reward: -1.59, Epsilon: 0.15
Episode 27100/100000, Avg Reward: -1.80, Epsilon: 0.15
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Episode 27900/100000, Avg Reward: -1.52, Epsilon: 0.15
Episode 28000/100000, Avg Reward: -0.24, Epsilon: 0.14
Episode 28100/100000, Avg Reward: -1.33, Epsilon: 0.14
Episode 28200/100000, Avg Reward: -1.59, Epsilon: 0.14
Episode 28300/100000, Avg Reward: -1.12, Epsilon: 0.14
Episode 28400/100000, Avg Reward: 1.55, Epsilon: 0.14
Episode 28500/100000, Avg Reward: -2.52, Epsilon: 0.14
Episode 28600/100000, Avg Reward: 0.70, Epsilon: 0.14
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Episode 28800/100000, Avg Reward: 0.31, Epsilon: 0.14
Episode 28900/100000, Avg Reward: -1.13, Epsilon: 0.14

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Episode 29300/100000, Avg Reward: 0.11, Epsilon: 0.13
Episode 29400/100000, Avg Reward: -0.88, Epsilon: 0.13
Episode 29500/100000, Avg Reward: 0.22, Epsilon: 0.13
Episode 29600/100000, Avg Reward: -0.05, Epsilon: 0.13
Episode 29700/100000, Avg Reward: 0.56, Epsilon: 0.13
Episode 29800/100000, Avg Reward: -0.36, Epsilon: 0.13
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Episode 30400/100000, Avg Reward: -0.26, Epsilon: 0.12
Episode 30500/100000, Avg Reward: 0.24, Epsilon: 0.12
Episode 30600/100000, Avg Reward: 1.55, Epsilon: 0.12
Episode 30700/100000, Avg Reward: 0.39, Epsilon: 0.12
Episode 30800/100000, Avg Reward: 0.96, Epsilon: 0.12
Episode 30900/100000, Avg Reward: -0.68, Epsilon: 0.12
Episode 31000/100000, Avg Reward: 1.23, Epsilon: 0.12
Episode 31100/100000, Avg Reward: -1.06, Epsilon: 0.12
Episode 31200/100000, Avg Reward: 0.36, Epsilon: 0.12
Episode 31300/100000, Avg Reward: 2.58, Epsilon: 0.12
Episode 31400/100000, Avg Reward: 0.88, Epsilon: 0.11
Episode 31500/100000, Avg Reward: 1.16, Epsilon: 0.11
Episode 31600/100000, Avg Reward: 1.13, Epsilon: 0.11
Episode 31700/100000, Avg Reward: 1.99, Epsilon: 0.11
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Episode 31900/100000, Avg Reward: 2.24, Epsilon: 0.11
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Episode 32200/100000, Avg Reward: 1.87, Epsilon: 0.11
Episode 32300/100000, Avg Reward: 1.11, Epsilon: 0.11
Episode 32400/100000, Avg Reward: 0.58, Epsilon: 0.11
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Episode 32600/100000, Avg Reward: 2.21, Epsilon: 0.11
Episode 32700/100000, Avg Reward: 1.33, Epsilon: 0.10
Episode 32800/100000, Avg Reward: 2.35, Epsilon: 0.10
Episode 32900/100000, Avg Reward: 1.86, Epsilon: 0.10
Episode 33000/100000, Avg Reward: 1.41, Epsilon: 0.10
Episode 33100/100000, Avg Reward: 4.77, Epsilon: 0.10
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Episode 33300/100000, Avg Reward: 2.26, Epsilon: 0.10
Episode 33400/100000, Avg Reward: 0.72, Epsilon: 0.10
Episode 33500/100000, Avg Reward: 1.56, Epsilon: 0.10
Episode 33600/100000, Avg Reward: 1.51, Epsilon: 0.10
Episode 33700/100000, Avg Reward: 4.01, Epsilon: 0.10
Episode 33800/100000, Avg Reward: 3.95, Epsilon: 0.10
Episode 33900/100000, Avg Reward: 1.74, Epsilon: 0.10
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Episode 34100/100000, Avg Reward: 2.80, Epsilon: 0.09
Episode 34200/100000, Avg Reward: 2.83, Epsilon: 0.09
Episode 34300/100000, Avg Reward: 3.50, Epsilon: 0.09
Episode 34400/100000, Avg Reward: 2.51, Epsilon: 0.09
Episode 34500/100000, Avg Reward: 3.34, Epsilon: 0.09
Episode 34600/100000, Avg Reward: 2.14, Epsilon: 0.09

Episode 34700/100000, Avg Reward: 1.60, Epsilon: 0.09
Episode 34800/100000, Avg Reward: 3.88, Epsilon: 0.09
Episode 34900/100000, Avg Reward: 1.09, Epsilon: 0.09
Episode 35000/100000, Avg Reward: 4.13, Epsilon: 0.09
Episode 35100/100000, Avg Reward: 0.88, Epsilon: 0.09
Episode 35200/100000, Avg Reward: 1.23, Epsilon: 0.09
Episode 35300/100000, Avg Reward: 1.92, Epsilon: 0.09
Episode 35400/100000, Avg Reward: 2.76, Epsilon: 0.09
Episode 35500/100000, Avg Reward: 3.89, Epsilon: 0.09
Episode 35600/100000, Avg Reward: 2.09, Epsilon: 0.09
Episode 35700/100000, Avg Reward: 4.98, Epsilon: 0.08
Episode 35800/100000, Avg Reward: 3.33, Epsilon: 0.08
Episode 35900/100000, Avg Reward: 3.26, Epsilon: 0.08
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Episode 36100/100000, Avg Reward: 3.77, Epsilon: 0.08
Episode 36200/100000, Avg Reward: 2.78, Epsilon: 0.08
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Episode 36400/100000, Avg Reward: 4.07, Epsilon: 0.08
Episode 36500/100000, Avg Reward: 2.58, Epsilon: 0.08
Episode 36600/100000, Avg Reward: 4.71, Epsilon: 0.08
Episode 36700/100000, Avg Reward: 2.86, Epsilon: 0.08
Episode 36800/100000, Avg Reward: 3.92, Epsilon: 0.08
Episode 36900/100000, Avg Reward: 2.93, Epsilon: 0.08
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Episode 37100/100000, Avg Reward: 2.77, Epsilon: 0.08
Episode 37200/100000, Avg Reward: 3.06, Epsilon: 0.08
Episode 37300/100000, Avg Reward: 3.61, Epsilon: 0.08
Episode 37400/100000, Avg Reward: 4.06, Epsilon: 0.08
Episode 37500/100000, Avg Reward: 3.69, Epsilon: 0.07
Episode 37600/100000, Avg Reward: 4.25, Epsilon: 0.07
Episode 37700/100000, Avg Reward: 4.06, Epsilon: 0.07
Episode 37800/100000, Avg Reward: 3.87, Epsilon: 0.07
Episode 37900/100000, Avg Reward: 4.86, Epsilon: 0.07
Episode 38000/100000, Avg Reward: 2.96, Epsilon: 0.07
Episode 38100/100000, Avg Reward: 1.06, Epsilon: 0.07
Episode 38200/100000, Avg Reward: 4.87, Epsilon: 0.07
Episode 38300/100000, Avg Reward: 3.57, Epsilon: 0.07
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Episode 38500/100000, Avg Reward: 4.88, Epsilon: 0.07
Episode 38600/100000, Avg Reward: 5.26, Epsilon: 0.07
Episode 38700/100000, Avg Reward: 5.05, Epsilon: 0.07
Episode 38800/100000, Avg Reward: 1.50, Epsilon: 0.07
Episode 38900/100000, Avg Reward: 5.06, Epsilon: 0.07
Episode 39000/100000, Avg Reward: 4.86, Epsilon: 0.07
Episode 39100/100000, Avg Reward: 3.28, Epsilon: 0.07
Episode 39200/100000, Avg Reward: 3.36, Epsilon: 0.07
Episode 39300/100000, Avg Reward: 3.57, Epsilon: 0.07
Episode 39400/100000, Avg Reward: 3.06, Epsilon: 0.07
Episode 39500/100000, Avg Reward: 3.29, Epsilon: 0.07
Episode 39600/100000, Avg Reward: 4.26, Epsilon: 0.06
Episode 39700/100000, Avg Reward: 5.09, Epsilon: 0.06
Episode 39800/100000, Avg Reward: 5.51, Epsilon: 0.06
Episode 39900/100000, Avg Reward: 3.59, Epsilon: 0.06
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Episode 40100/100000, Avg Reward: 4.75, Epsilon: 0.06
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Episode 40300/100000, Avg Reward: 5.20, Epsilon: 0.06

Episode 40400/100000, Avg Reward: 4.84, Epsilon: 0.06
Episode 40500/100000, Avg Reward: 3.69, Epsilon: 0.06
Episode 40600/100000, Avg Reward: 4.98, Epsilon: 0.06
Episode 40700/100000, Avg Reward: 3.73, Epsilon: 0.06
Episode 40800/100000, Avg Reward: 4.32, Epsilon: 0.06
Episode 40900/100000, Avg Reward: 4.05, Epsilon: 0.06
Episode 41000/100000, Avg Reward: 4.55, Epsilon: 0.06
Episode 41100/100000, Avg Reward: 4.73, Epsilon: 0.06
Episode 41200/100000, Avg Reward: 4.76, Epsilon: 0.06
Episode 41300/100000, Avg Reward: 5.22, Epsilon: 0.06
Episode 41400/100000, Avg Reward: 3.62, Epsilon: 0.06
Episode 41500/100000, Avg Reward: 5.12, Epsilon: 0.06
Episode 41600/100000, Avg Reward: 5.66, Epsilon: 0.06
Episode 41700/100000, Avg Reward: 5.70, Epsilon: 0.06
Episode 41800/100000, Avg Reward: 4.38, Epsilon: 0.06
Episode 41900/100000, Avg Reward: 4.72, Epsilon: 0.06
Episode 42000/100000, Avg Reward: 4.84, Epsilon: 0.05
Episode 42100/100000, Avg Reward: 4.87, Epsilon: 0.05
Episode 42200/100000, Avg Reward: 5.79, Epsilon: 0.05
Episode 42300/100000, Avg Reward: 3.76, Epsilon: 0.05
Episode 42400/100000, Avg Reward: 3.20, Epsilon: 0.05
Episode 42500/100000, Avg Reward: 5.24, Epsilon: 0.05
Episode 42600/100000, Avg Reward: 5.67, Epsilon: 0.05
Episode 42700/100000, Avg Reward: 2.36, Epsilon: 0.05
Episode 42800/100000, Avg Reward: 4.00, Epsilon: 0.05
Episode 42900/100000, Avg Reward: 5.00, Epsilon: 0.05
Episode 43000/100000, Avg Reward: 5.85, Epsilon: 0.05
Episode 43100/100000, Avg Reward: 4.86, Epsilon: 0.05
Episode 43200/100000, Avg Reward: 5.17, Epsilon: 0.05
Episode 43300/100000, Avg Reward: 5.25, Epsilon: 0.05
Episode 43400/100000, Avg Reward: 4.78, Epsilon: 0.05
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Episode 43600/100000, Avg Reward: 5.41, Epsilon: 0.05
Episode 43700/100000, Avg Reward: 6.02, Epsilon: 0.05
Episode 43800/100000, Avg Reward: 5.87, Epsilon: 0.05
Episode 43900/100000, Avg Reward: 4.03, Epsilon: 0.05
Episode 44000/100000, Avg Reward: 4.84, Epsilon: 0.05
Episode 44100/100000, Avg Reward: 5.86, Epsilon: 0.05
Episode 44200/100000, Avg Reward: 5.63, Epsilon: 0.05
Episode 44300/100000, Avg Reward: 4.99, Epsilon: 0.05
Episode 44400/100000, Avg Reward: 3.26, Epsilon: 0.05
Episode 44500/100000, Avg Reward: 3.10, Epsilon: 0.05
Episode 44600/100000, Avg Reward: 5.56, Epsilon: 0.05
Episode 44700/100000, Avg Reward: 5.65, Epsilon: 0.05
Episode 44800/100000, Avg Reward: 5.07, Epsilon: 0.05
Episode 44900/100000, Avg Reward: 4.37, Epsilon: 0.04
Episode 45000/100000, Avg Reward: 4.72, Epsilon: 0.04
Episode 45100/100000, Avg Reward: 5.97, Epsilon: 0.04
Episode 45200/100000, Avg Reward: 5.86, Epsilon: 0.04
Episode 45300/100000, Avg Reward: 5.59, Epsilon: 0.04
Episode 45400/100000, Avg Reward: 5.73, Epsilon: 0.04
Episode 45500/100000, Avg Reward: 5.72, Epsilon: 0.04
Episode 45600/100000, Avg Reward: 5.48, Epsilon: 0.04
Episode 45700/100000, Avg Reward: 5.54, Epsilon: 0.04
Episode 45800/100000, Avg Reward: 6.13, Epsilon: 0.04
Episode 45900/100000, Avg Reward: 6.15, Epsilon: 0.04
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Episode 46100/100000, Avg Reward: 6.54, Epsilon: 0.04
Episode 46200/100000, Avg Reward: 4.53, Epsilon: 0.04
Episode 46300/100000, Avg Reward: 5.90, Epsilon: 0.04
Episode 46400/100000, Avg Reward: 5.88, Epsilon: 0.04
Episode 46500/100000, Avg Reward: 5.96, Epsilon: 0.04
Episode 46600/100000, Avg Reward: 5.50, Epsilon: 0.04
Episode 46700/100000, Avg Reward: 5.50, Epsilon: 0.04
Episode 46800/100000, Avg Reward: 5.74, Epsilon: 0.04
Episode 46900/100000, Avg Reward: 5.90, Epsilon: 0.04
Episode 47000/100000, Avg Reward: 6.12, Epsilon: 0.04
Episode 47100/100000, Avg Reward: 6.24, Epsilon: 0.04
Episode 47200/100000, Avg Reward: 6.08, Epsilon: 0.04
Episode 47300/100000, Avg Reward: 5.62, Epsilon: 0.04
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Episode 47500/100000, Avg Reward: 5.10, Epsilon: 0.04
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Episode 80800/100000, Avg Reward: 7.84, Epsilon: 0.00
Episode 80900/100000, Avg Reward: 7.66, Epsilon: 0.00
Episode 81000/100000, Avg Reward: 7.62, Epsilon: 0.00
Episode 81100/100000, Avg Reward: 7.77, Epsilon: 0.00
Episode 81200/100000, Avg Reward: 7.55, Epsilon: 0.00
Episode 81300/100000, Avg Reward: 7.65, Epsilon: 0.00
Episode 81400/100000, Avg Reward: 3.60, Epsilon: 0.00
Episode 81500/100000, Avg Reward: 7.84, Epsilon: 0.00
Episode 81600/100000, Avg Reward: 0.50, Epsilon: 0.00
Episode 81700/100000, Avg Reward: 7.56, Epsilon: 0.00
Episode 81800/100000, Avg Reward: 8.30, Epsilon: 0.00
Episode 81900/100000, Avg Reward: 7.64, Epsilon: 0.00
Episode 82000/100000, Avg Reward: 7.84, Epsilon: 0.00
Episode 82100/100000, Avg Reward: 8.07, Epsilon: 0.00
Episode 82200/100000, Avg Reward: 7.61, Epsilon: 0.00
Episode 82300/100000, Avg Reward: 7.56, Epsilon: 0.00
Episode 82400/100000, Avg Reward: 7.71, Epsilon: 0.00
Episode 82500/100000, Avg Reward: 7.94, Epsilon: 0.00
Episode 82600/100000, Avg Reward: 7.55, Epsilon: 0.00
Episode 82700/100000, Avg Reward: 8.20, Epsilon: 0.00
Episode 82800/100000, Avg Reward: 5.64, Epsilon: 0.00
Episode 82900/100000, Avg Reward: 7.55, Epsilon: 0.00
Episode 83000/100000, Avg Reward: 5.71, Epsilon: 0.00
Episode 83100/100000, Avg Reward: 8.00, Epsilon: 0.00
Episode 83200/100000, Avg Reward: 7.87, Epsilon: 0.00
Episode 83300/100000, Avg Reward: 7.73, Epsilon: 0.00
Episode 83400/100000, Avg Reward: 5.60, Epsilon: 0.00
Episode 83500/100000, Avg Reward: 7.86, Epsilon: 0.00
Episode 83600/100000, Avg Reward: 5.50, Epsilon: 0.00
Episode 83700/100000, Avg Reward: 7.82, Epsilon: 0.00
Episode 83800/100000, Avg Reward: 8.34, Epsilon: 0.00
Episode 83900/100000, Avg Reward: 7.63, Epsilon: 0.00
Episode 84000/100000, Avg Reward: 7.43, Epsilon: 0.00
Episode 84100/100000, Avg Reward: 7.83, Epsilon: 0.00
Episode 84200/100000, Avg Reward: 7.95, Epsilon: 0.00
Episode 84300/100000, Avg Reward: 7.87, Epsilon: 0.00
Episode 84400/100000, Avg Reward: 8.09, Epsilon: 0.00
Episode 84500/100000, Avg Reward: 7.91, Epsilon: 0.00
Episode 84600/100000, Avg Reward: 7.53, Epsilon: 0.00
Episode 84700/100000, Avg Reward: 7.94, Epsilon: 0.00
Episode 84800/100000, Avg Reward: 7.44, Epsilon: 0.00
Episode 84900/100000, Avg Reward: 8.29, Epsilon: 0.00
Episode 85000/100000, Avg Reward: 8.06, Epsilon: 0.00
Episode 85100/100000, Avg Reward: 6.08, Epsilon: 0.00
Episode 85200/100000, Avg Reward: 7.76, Epsilon: 0.00
Episode 85300/100000, Avg Reward: 7.85, Epsilon: 0.00
Episode 85400/100000, Avg Reward: 7.58, Epsilon: 0.00
Episode 85500/100000, Avg Reward: 7.54, Epsilon: 0.00
Episode 85600/100000, Avg Reward: 7.84, Epsilon: 0.00
Episode 85700/100000, Avg Reward: 7.62, Epsilon: 0.00
Episode 85800/100000, Avg Reward: 7.28, Epsilon: 0.00
Episode 85900/100000, Avg Reward: 5.53, Epsilon: 0.00

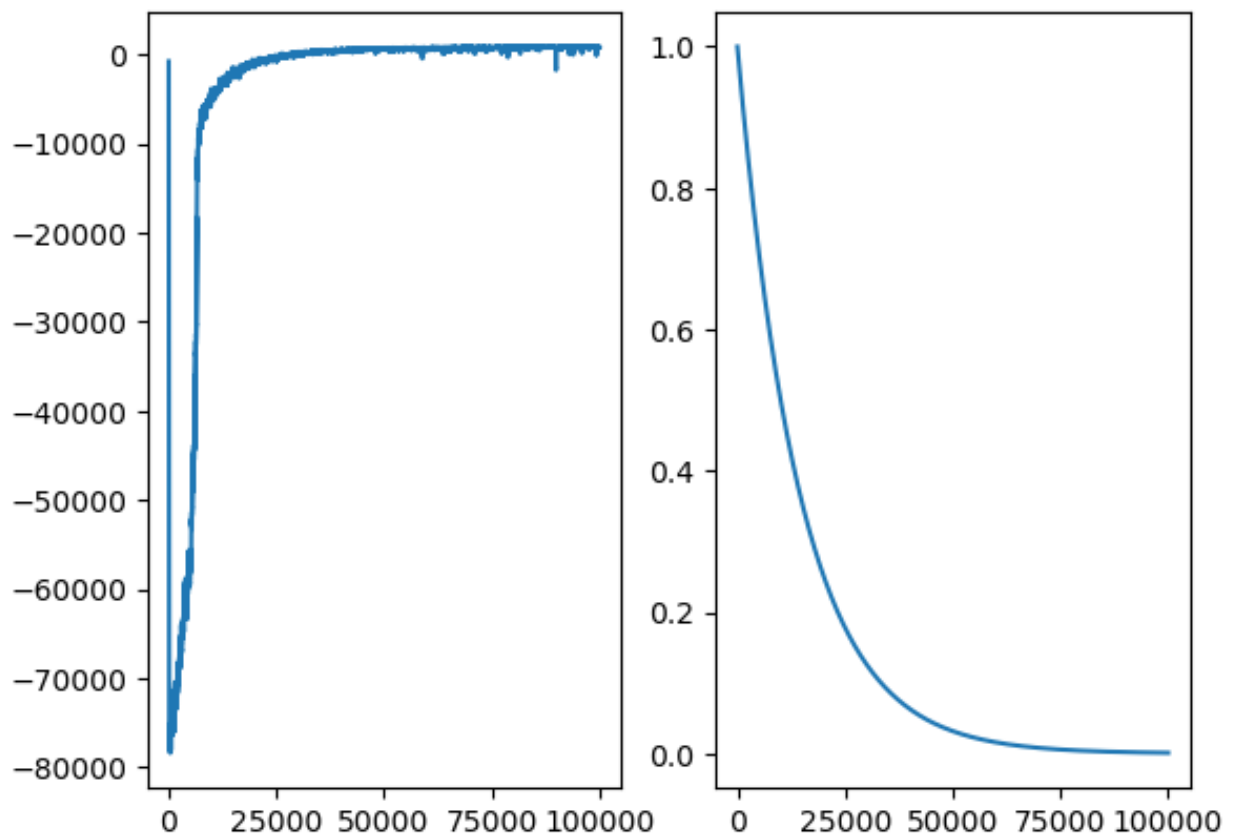
Episode 86000/100000, Avg Reward: 5.71, Epsilon: 0.00
Episode 86100/100000, Avg Reward: 7.76, Epsilon: 0.00
Episode 86200/100000, Avg Reward: 7.91, Epsilon: 0.00
Episode 86300/100000, Avg Reward: 7.87, Epsilon: 0.00
Episode 86400/100000, Avg Reward: 7.97, Epsilon: 0.00
Episode 86500/100000, Avg Reward: 7.04, Epsilon: 0.00
Episode 86600/100000, Avg Reward: 7.68, Epsilon: 0.00
Episode 86700/100000, Avg Reward: 7.73, Epsilon: 0.00
Episode 86800/100000, Avg Reward: 7.73, Epsilon: 0.00
Episode 86900/100000, Avg Reward: 7.77, Epsilon: 0.00
Episode 87000/100000, Avg Reward: 8.20, Epsilon: 0.00
Episode 87100/100000, Avg Reward: 8.01, Epsilon: 0.00
Episode 87200/100000, Avg Reward: 7.91, Epsilon: 0.00
Episode 87300/100000, Avg Reward: 7.32, Epsilon: 0.00
Episode 87400/100000, Avg Reward: 7.27, Epsilon: 0.00
Episode 87500/100000, Avg Reward: 7.69, Epsilon: 0.00
Episode 87600/100000, Avg Reward: 7.70, Epsilon: 0.00
Episode 87700/100000, Avg Reward: 7.88, Epsilon: 0.00
Episode 87800/100000, Avg Reward: 7.48, Epsilon: 0.00
Episode 87900/100000, Avg Reward: 7.69, Epsilon: 0.00
Episode 88000/100000, Avg Reward: 7.39, Epsilon: 0.00
Episode 88100/100000, Avg Reward: 7.80, Epsilon: 0.00
Episode 88200/100000, Avg Reward: 7.85, Epsilon: 0.00
Episode 88300/100000, Avg Reward: 7.66, Epsilon: 0.00
Episode 88400/100000, Avg Reward: 8.06, Epsilon: 0.00
Episode 88500/100000, Avg Reward: 7.35, Epsilon: 0.00
Episode 88600/100000, Avg Reward: 8.09, Epsilon: 0.00
Episode 88700/100000, Avg Reward: 8.24, Epsilon: 0.00
Episode 88800/100000, Avg Reward: 8.51, Epsilon: 0.00
Episode 88900/100000, Avg Reward: 7.25, Epsilon: 0.00
Episode 89000/100000, Avg Reward: 7.91, Epsilon: 0.00
Episode 89100/100000, Avg Reward: 8.37, Epsilon: 0.00
Episode 89200/100000, Avg Reward: 7.75, Epsilon: 0.00
Episode 89300/100000, Avg Reward: 7.53, Epsilon: 0.00
Episode 89400/100000, Avg Reward: 7.53, Epsilon: 0.00
Episode 89500/100000, Avg Reward: 7.97, Epsilon: 0.00
Episode 89600/100000, Avg Reward: 7.95, Epsilon: 0.00
Episode 89700/100000, Avg Reward: 7.45, Epsilon: 0.00
Episode 89800/100000, Avg Reward: 8.11, Epsilon: 0.00
Episode 89900/100000, Avg Reward: -17.73, Epsilon: 0.00
Episode 90000/100000, Avg Reward: 7.57, Epsilon: 0.00
Episode 90100/100000, Avg Reward: 7.35, Epsilon: 0.00
Episode 90200/100000, Avg Reward: 7.31, Epsilon: 0.00
Episode 90300/100000, Avg Reward: 7.75, Epsilon: 0.00
Episode 90400/100000, Avg Reward: 8.32, Epsilon: 0.00
Episode 90500/100000, Avg Reward: 5.70, Epsilon: 0.00
Episode 90600/100000, Avg Reward: 5.40, Epsilon: 0.00
Episode 90700/100000, Avg Reward: 8.20, Epsilon: 0.00
Episode 90800/100000, Avg Reward: 8.07, Epsilon: 0.00
Episode 90900/100000, Avg Reward: 8.26, Epsilon: 0.00
Episode 91000/100000, Avg Reward: 5.75, Epsilon: 0.00
Episode 91100/100000, Avg Reward: 6.02, Epsilon: 0.00
Episode 91200/100000, Avg Reward: 7.54, Epsilon: 0.00
Episode 91300/100000, Avg Reward: 7.75, Epsilon: 0.00
Episode 91400/100000, Avg Reward: 7.48, Epsilon: 0.00
Episode 91500/100000, Avg Reward: 7.43, Epsilon: 0.00
Episode 91600/100000, Avg Reward: 7.99, Epsilon: 0.00

Episode 91700/100000, Avg Reward: 7.95, Epsilon: 0.00
Episode 91800/100000, Avg Reward: 7.95, Epsilon: 0.00
Episode 91900/100000, Avg Reward: 7.93, Epsilon: 0.00
Episode 92000/100000, Avg Reward: 8.08, Epsilon: 0.00
Episode 92100/100000, Avg Reward: 8.26, Epsilon: 0.00
Episode 92200/100000, Avg Reward: 7.69, Epsilon: 0.00
Episode 92300/100000, Avg Reward: 7.81, Epsilon: 0.00
Episode 92400/100000, Avg Reward: 7.70, Epsilon: 0.00
Episode 92500/100000, Avg Reward: 8.02, Epsilon: 0.00
Episode 92600/100000, Avg Reward: 7.53, Epsilon: 0.00
Episode 92700/100000, Avg Reward: 7.72, Epsilon: 0.00
Episode 92800/100000, Avg Reward: 7.47, Epsilon: 0.00
Episode 92900/100000, Avg Reward: 3.67, Epsilon: 0.00
Episode 93000/100000, Avg Reward: 1.97, Epsilon: 0.00
Episode 93100/100000, Avg Reward: 5.92, Epsilon: 0.00
Episode 93200/100000, Avg Reward: 7.86, Epsilon: 0.00
Episode 93300/100000, Avg Reward: 7.99, Epsilon: 0.00
Episode 93400/100000, Avg Reward: 7.81, Epsilon: 0.00
Episode 93500/100000, Avg Reward: 8.06, Epsilon: 0.00
Episode 93600/100000, Avg Reward: 7.80, Epsilon: 0.00
Episode 93700/100000, Avg Reward: 7.70, Epsilon: 0.00
Episode 93800/100000, Avg Reward: 4.00, Epsilon: 0.00
Episode 93900/100000, Avg Reward: 3.57, Epsilon: 0.00
Episode 94000/100000, Avg Reward: 5.82, Epsilon: 0.00
Episode 94100/100000, Avg Reward: 7.88, Epsilon: 0.00
Episode 94200/100000, Avg Reward: 8.14, Epsilon: 0.00
Episode 94300/100000, Avg Reward: 7.84, Epsilon: 0.00
Episode 94400/100000, Avg Reward: 7.57, Epsilon: 0.00
Episode 94500/100000, Avg Reward: 7.97, Epsilon: 0.00
Episode 94600/100000, Avg Reward: 7.79, Epsilon: 0.00
Episode 94700/100000, Avg Reward: 7.84, Epsilon: 0.00
Episode 94800/100000, Avg Reward: 8.31, Epsilon: 0.00
Episode 94900/100000, Avg Reward: 7.61, Epsilon: 0.00
Episode 95000/100000, Avg Reward: 7.31, Epsilon: 0.00
Episode 95100/100000, Avg Reward: 7.59, Epsilon: 0.00
Episode 95200/100000, Avg Reward: 7.66, Epsilon: 0.00
Episode 95300/100000, Avg Reward: 7.71, Epsilon: 0.00
Episode 95400/100000, Avg Reward: 5.54, Epsilon: 0.00
Episode 95500/100000, Avg Reward: 8.25, Epsilon: 0.00
Episode 95600/100000, Avg Reward: 5.65, Epsilon: 0.00
Episode 95700/100000, Avg Reward: 7.86, Epsilon: 0.00
Episode 95800/100000, Avg Reward: 8.05, Epsilon: 0.00
Episode 95900/100000, Avg Reward: 5.79, Epsilon: 0.00
Episode 96000/100000, Avg Reward: 3.72, Epsilon: 0.00
Episode 96100/100000, Avg Reward: 7.62, Epsilon: 0.00
Episode 96200/100000, Avg Reward: 8.03, Epsilon: 0.00
Episode 96300/100000, Avg Reward: 8.02, Epsilon: 0.00
Episode 96400/100000, Avg Reward: 5.44, Epsilon: 0.00
Episode 96500/100000, Avg Reward: 8.02, Epsilon: 0.00
Episode 96600/100000, Avg Reward: 8.35, Epsilon: 0.00
Episode 96700/100000, Avg Reward: 7.70, Epsilon: 0.00
Episode 96800/100000, Avg Reward: 7.87, Epsilon: 0.00
Episode 96900/100000, Avg Reward: 7.67, Epsilon: 0.00
Episode 97000/100000, Avg Reward: 8.36, Epsilon: 0.00
Episode 97100/100000, Avg Reward: 7.66, Epsilon: 0.00
Episode 97200/100000, Avg Reward: 7.47, Epsilon: 0.00
Episode 97300/100000, Avg Reward: 8.33, Epsilon: 0.00

```

Episode 97400/100000, Avg Reward: 7.50, Epsilon: 0.00
Episode 97500/100000, Avg Reward: 8.17, Epsilon: 0.00
Episode 97600/100000, Avg Reward: 5.73, Epsilon: 0.00
Episode 97700/100000, Avg Reward: 8.33, Epsilon: 0.00
Episode 97800/100000, Avg Reward: 8.00, Epsilon: 0.00
Episode 97900/100000, Avg Reward: 7.92, Epsilon: 0.00
Episode 98000/100000, Avg Reward: 7.97, Epsilon: 0.00
Episode 98100/100000, Avg Reward: 7.93, Epsilon: 0.00
Episode 98200/100000, Avg Reward: 8.04, Epsilon: 0.00
Episode 98300/100000, Avg Reward: 7.96, Epsilon: 0.00
Episode 98400/100000, Avg Reward: 7.66, Epsilon: 0.00
Episode 98500/100000, Avg Reward: 7.93, Epsilon: 0.00
Episode 98600/100000, Avg Reward: 8.12, Epsilon: 0.00
Episode 98700/100000, Avg Reward: 8.12, Epsilon: 0.00
Episode 98800/100000, Avg Reward: 7.60, Epsilon: 0.00
Episode 98900/100000, Avg Reward: 7.92, Epsilon: 0.00
Episode 99000/100000, Avg Reward: 5.80, Epsilon: 0.00
Episode 99100/100000, Avg Reward: 5.75, Epsilon: 0.00
Episode 99200/100000, Avg Reward: 5.62, Epsilon: 0.00
Episode 99300/100000, Avg Reward: -0.55, Epsilon: 0.00
Episode 99400/100000, Avg Reward: 7.44, Epsilon: 0.00
Episode 99500/100000, Avg Reward: 7.71, Epsilon: 0.00
Episode 99600/100000, Avg Reward: 7.91, Epsilon: 0.00
Episode 99700/100000, Avg Reward: 7.94, Epsilon: 0.00
Episode 99800/100000, Avg Reward: 7.97, Epsilon: 0.00
Episode 99900/100000, Avg Reward: 8.01, Epsilon: 0.00
Episode 100000/100000, Avg Reward: 8.02, Epsilon: 0.00
!!!!!!!!!!!!!!!!!!!!Trained and Stored the model successfully!!!!!!!!!!!!!!!!!!!!
CPU times: user 1h 41min 49s, sys: 3min 58s, total: 1h 45min 47s
Wall time: 33min 29s

```



```
In [69]: print(my_dqn_agent_fine_tuned_training_rewards)
```

```
[-785. -785. -758. ...    7.    7.   13.]
```

```
In [70]: fine_tuned_training = {  
    "my_q_agent_fine_tuned_training_rewards": list(my_q_agent_fine_tuned_tr  
    "my_dqn_agent_fine_tuned_training_rewards": list(my_dqn_agent_fine_tune  
    }
```

```
In [71]: print(type(my_q_agent_fine_tuned_training_rewards))  
print(type(my_dqn_agent_fine_tuned_training_rewards))
```

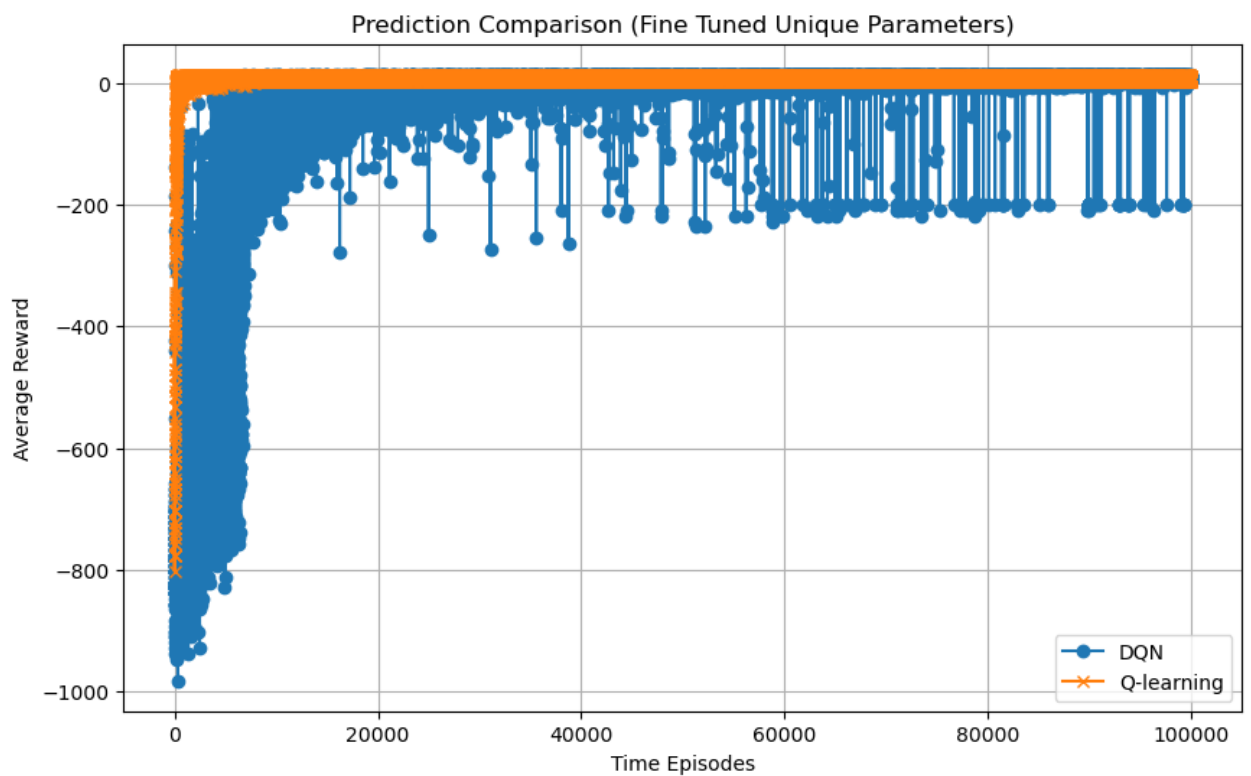
```
<class 'numpy.ndarray'>  
<class 'numpy.ndarray'>
```

```
In [72]: with open("fine_tuned_training.json", "w") as f:  
    json.dump(fine_tuned_training , f)
```

```
In [73]: with open("fine_tuned_training.json", "r") as f:  
    fine_tuned_training_dict = json.load(f)
```

Compare the training reward

```
In [75]: x = range(1,100000 + 1)  
  
plt.figure(figsize=(10, 6))  
plt.plot(x, fine_tuned_training_dict["my_dqn_agent_fine_tuned_training_re  
plt.plot(x, fine_tuned_training_dict["my_q_agent_fine_tuned_training_rewa  
  
# titles and labels  
plt.title('Prediction Comparison (Fine Tuned Unique Parameters)')  
plt.xlabel('Time Episodes')  
plt.ylabel('Average Reward')  
plt.legend()  
# display  
plt.grid(True)  
plt.show()
```



Prediction with the Fine-tuned models

Q Learning Agent with Fine Tuned Parameters

```
In [78]: my_q_agent_fine_tuned_avg_reward_lst = my_q_agent_fine_tuned.test(test_ep
```

```
=====
EPISODE 0
Score of total rewards: 11
=====
```

```
EPISODE 1
Score of total rewards: 7
=====
```

```
EPISODE 2
Score of total rewards: 5
=====
```

```
EPISODE 3
Score of total rewards: 6
=====
```

```
EPISODE 4
Score of total rewards: 8
=====
```

```
EPISODE 5
Score of total rewards: 12
=====
```

```
EPISODE 6
Score of total rewards: 6
=====
```

```
EPISODE 7
Score of total rewards: 10
=====
```

```
EPISODE 8
Score of total rewards: 6
=====
```

EPISODE 9
Score of total rewards: 5
=====

EPISODE 10
Score of total rewards: 3
=====

EPISODE 11
Score of total rewards: 12
=====

EPISODE 12
Score of total rewards: 7
=====

EPISODE 13
Score of total rewards: 6
=====

EPISODE 14
Score of total rewards: 9
=====

EPISODE 15
Score of total rewards: 11
=====

EPISODE 16
Score of total rewards: 5
=====

EPISODE 17
Score of total rewards: 10
=====

EPISODE 18
Score of total rewards: 7
=====

EPISODE 19
Score of total rewards: 5
=====

EPISODE 20
Score of total rewards: 9
=====

EPISODE 21
Score of total rewards: 10
=====

EPISODE 22
Score of total rewards: 12
=====

EPISODE 23
Score of total rewards: 11
=====

EPISODE 24
Score of total rewards: 6
=====

EPISODE 25
Score of total rewards: 7
=====

EPISODE 26
Score of total rewards: 4
=====

EPISODE 27
Score of total rewards: 8
=====

EPISODE 28
Score of total rewards: 8
=====

EPISODE 29
Score of total rewards: 5
=====

EPISODE 30
Score of total rewards: 9
=====

EPISODE 31
Score of total rewards: 12
=====

EPISODE 32
Score of total rewards: 5
=====

EPISODE 33
Score of total rewards: 13
=====

EPISODE 34
Score of total rewards: 9
=====

EPISODE 35
Score of total rewards: 4
=====

EPISODE 36
Score of total rewards: 9
=====

EPISODE 37
Score of total rewards: 8
=====

EPISODE 38
Score of total rewards: 7
=====

EPISODE 39
Score of total rewards: 6
=====

EPISODE 40
Score of total rewards: 9
=====

EPISODE 41
Score of total rewards: 6
=====

EPISODE 42
Score of total rewards: 8
=====

EPISODE 43
Score of total rewards: 10
=====

EPISODE 44
Score of total rewards: 12
=====

EPISODE 45
Score of total rewards: 7
=====

EPISODE 46
Score of total rewards: 12
=====

EPISODE 47
Score of total rewards: 9
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EPISODE 48
Score of total rewards: 6
=====

EPISODE 49
Score of total rewards: 10
=====

EPISODE 50
Score of total rewards: 4
=====

EPISODE 51
Score of total rewards: 4
=====

EPISODE 52
Score of total rewards: 6
=====

EPISODE 53
Score of total rewards: 12
=====

EPISODE 54
Score of total rewards: 5
=====

EPISODE 55
Score of total rewards: 10
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EPISODE 56
Score of total rewards: 7
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EPISODE 57
Score of total rewards: 10
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EPISODE 58
Score of total rewards: 9
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EPISODE 59
Score of total rewards: 8
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EPISODE 60
Score of total rewards: 8
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EPISODE 61
Score of total rewards: 14
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EPISODE 62
Score of total rewards: 4
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EPISODE 63
Score of total rewards: 13
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EPISODE 64
Score of total rewards: 9
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EPISODE 65
Score of total rewards: 5
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EPISODE 66
Score of total rewards: 10
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EPISODE 67
Score of total rewards: 4
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EPISODE 68
Score of total rewards: 11
=====

EPISODE 69
Score of total rewards: 8
=====

EPISODE 70
Score of total rewards: 10
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EPISODE 71
Score of total rewards: 9
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EPISODE 72
Score of total rewards: 9
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EPISODE 73
Score of total rewards: 8
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EPISODE 74
Score of total rewards: 8
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EPISODE 75
Score of total rewards: 13
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EPISODE 76
Score of total rewards: 7
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EPISODE 77
Score of total rewards: 8
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EPISODE 78
Score of total rewards: 11
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EPISODE 79
Score of total rewards: 9
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EPISODE 80
Score of total rewards: 13
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EPISODE 81
Score of total rewards: 4
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EPISODE 82
Score of total rewards: 8
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EPISODE 83
Score of total rewards: 10
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EPISODE 84
Score of total rewards: 6
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EPISODE 85
Score of total rewards: 6
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EPISODE 86
Score of total rewards: 5
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EPISODE 87
Score of total rewards: 8
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EPISODE 88
Score of total rewards: 7
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EPISODE 89
Score of total rewards: 7
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EPISODE 90
Score of total rewards: 6
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EPISODE 91
Score of total rewards: 4
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EPISODE 92
Score of total rewards: 6
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EPISODE 93
Score of total rewards: 6
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EPISODE 94
Score of total rewards: 6
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EPISODE 95
Score of total rewards: 5
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EPISODE 96
Score of total rewards: 8
=====

EPISODE 97
Score of total rewards: 7
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EPISODE 98
Score of total rewards: 6
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EPISODE 99
Score of total rewards: 3
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EPISODE 100
Score of total rewards: 7
=====

EPISODE 101
Score of total rewards: 8
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EPISODE 102
Score of total rewards: 7
=====

EPISODE 103
Score of total rewards: 6
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EPISODE 104
Score of total rewards: 9
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EPISODE 105
Score of total rewards: 10
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EPISODE 106
Score of total rewards: 7
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EPISODE 107
Score of total rewards: 8
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EPISODE 108
Score of total rewards: 15
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EPISODE 109
Score of total rewards: 11
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EPISODE 110
Score of total rewards: 9
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EPISODE 111
Score of total rewards: 7
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EPISODE 112
Score of total rewards: 8
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EPISODE 113
Score of total rewards: 6
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EPISODE 114
Score of total rewards: 5
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EPISODE 115
Score of total rewards: 8
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EPISODE 116
Score of total rewards: 6
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EPISODE 117
Score of total rewards: 7
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EPISODE 118
Score of total rewards: 7
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EPISODE 119
Score of total rewards: 11
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EPISODE 120
Score of total rewards: 4
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EPISODE 121
Score of total rewards: 6
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EPISODE 122
Score of total rewards: 8
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EPISODE 123
Score of total rewards: 7
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EPISODE 124
Score of total rewards: 13
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EPISODE 125
Score of total rewards: 11
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EPISODE 126
Score of total rewards: 8
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EPISODE 127
Score of total rewards: 5
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EPISODE 128
Score of total rewards: 3
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EPISODE 129
Score of total rewards: 8
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EPISODE 130
Score of total rewards: 8
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EPISODE 131
Score of total rewards: 6
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EPISODE 132
Score of total rewards: 8
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EPISODE 133
Score of total rewards: 3
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EPISODE 134
Score of total rewards: 13
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EPISODE 135
Score of total rewards: 5
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EPISODE 136
Score of total rewards: 11
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EPISODE 137
Score of total rewards: 10
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EPISODE 138
Score of total rewards: 11
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EPISODE 139
Score of total rewards: 10
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EPISODE 140
Score of total rewards: 6
=====

EPISODE 141
Score of total rewards: 11
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EPISODE 142
Score of total rewards: 6
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EPISODE 143
Score of total rewards: 7
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EPISODE 144
Score of total rewards: 7
=====

EPISODE 145
Score of total rewards: 6
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EPISODE 146
Score of total rewards: 8
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EPISODE 147
Score of total rewards: 8
=====

EPISODE 148
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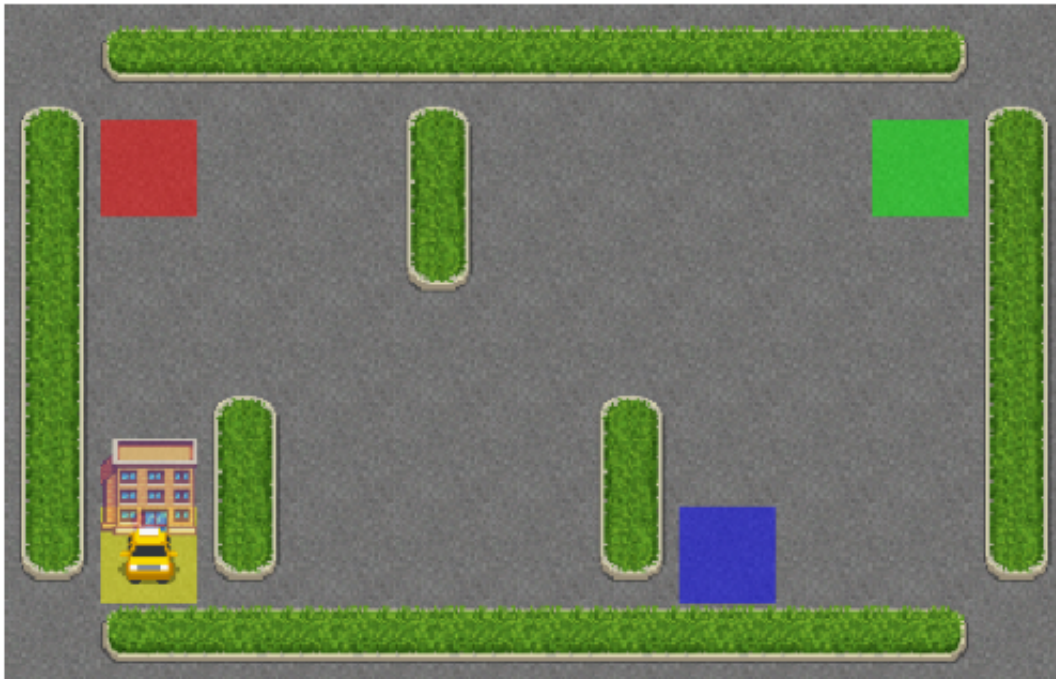
EPISODE 998
Score of total rewards: 6

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EPISODE 999
Score of total rewards: 7
Average score over time: 7.949

```
In [79]: # only to have a look of the test play result  
my_q_agent_fine_tuned.test(test_episodes=5, display=True)
```

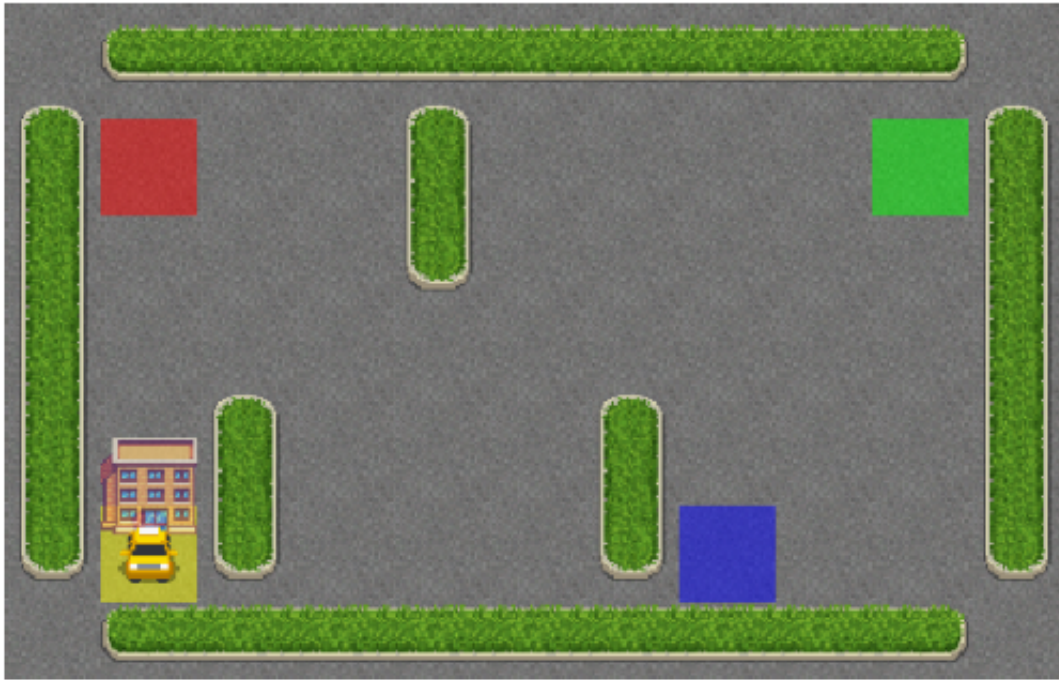
Taxi-v3 | Episode: 4 | Step: 17



Score of total rewards: 4
Average score over time: 7.8

Out[79]: [13, 3, 11, 8, 4]

Taxi-v3 | Episode: 4 | Step: 17



```
In [80]: # save to GIF
         my_q_agent_fine_tuned.test_to_gif(filename="taxi_q_fine_tuned", episodes=5
```

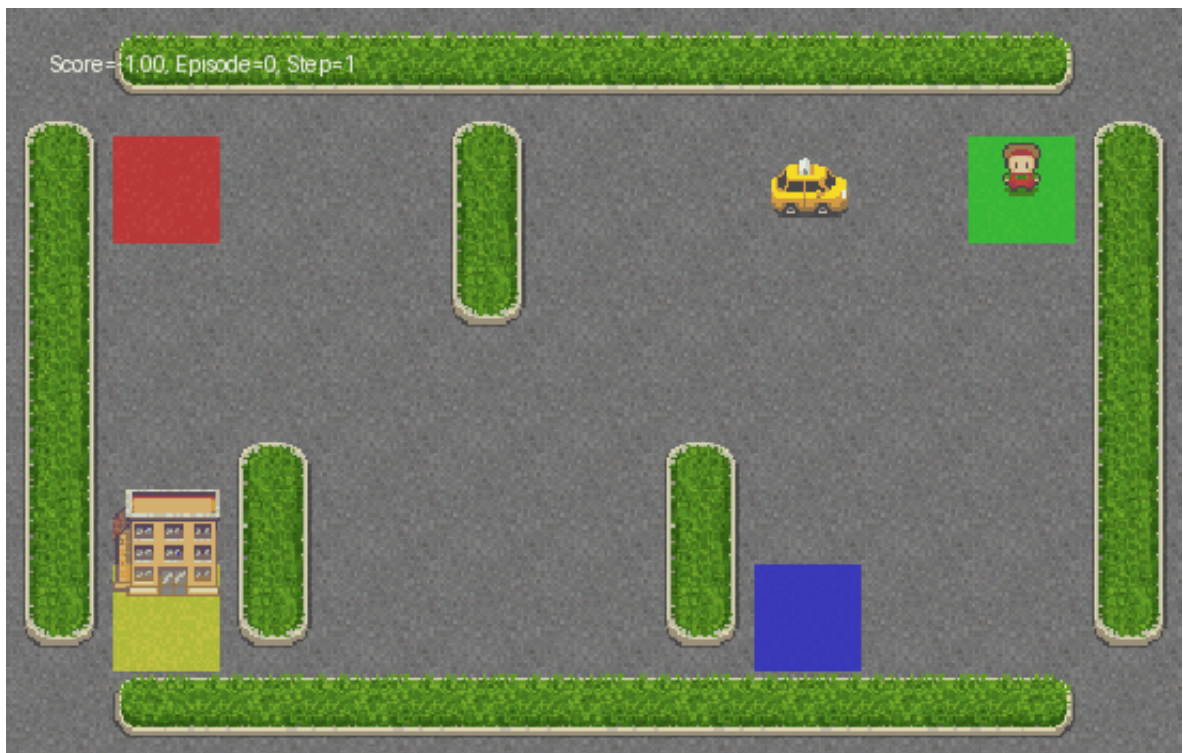
```
episodes: 0, acton: 2, state: 46
episodes: 0, acton: 2, state: 66
episodes: 0, acton: 4, state: 86
episodes: 0, acton: 3, state: 98
episodes: 0, acton: 3, state: 78
episodes: 0, acton: 0, state: 58
episodes: 0, acton: 0, state: 158
episodes: 0, acton: 3, state: 258
episodes: 0, acton: 3, state: 238
episodes: 0, acton: 0, state: 218
episodes: 0, acton: 0, state: 318
episodes: 0, acton: 5, state: 418
episodes: 1, acton: 3, state: 243
episodes: 1, acton: 3, state: 223
episodes: 1, acton: 1, state: 203
episodes: 1, acton: 1, state: 103
episodes: 1, acton: 4, state: 3
episodes: 1, acton: 0, state: 19
episodes: 1, acton: 0, state: 119
episodes: 1, acton: 2, state: 219
episodes: 1, acton: 2, state: 239
episodes: 1, acton: 2, state: 259
episodes: 1, acton: 0, state: 279
episodes: 1, acton: 0, state: 379
episodes: 1, acton: 5, state: 479
episodes: 2, acton: 0, state: 9
episodes: 2, acton: 0, state: 109
episodes: 2, acton: 0, state: 209
episodes: 2, acton: 0, state: 309
episodes: 2, acton: 4, state: 409
episodes: 2, acton: 1, state: 417
episodes: 2, acton: 1, state: 317
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episodes: 2, acton: 2, state: 217
episodes: 2, acton: 2, state: 237
episodes: 2, acton: 1, state: 257
episodes: 2, acton: 1, state: 157
episodes: 2, acton: 2, state: 57
episodes: 2, acton: 2, state: 77
episodes: 2, acton: 5, state: 97
episodes: 3, acton: 2, state: 212
episodes: 3, acton: 2, state: 232
episodes: 3, acton: 2, state: 252
episodes: 3, acton: 0, state: 272
episodes: 3, acton: 0, state: 372
episodes: 3, acton: 4, state: 472
episodes: 3, acton: 1, state: 476
episodes: 3, acton: 1, state: 376
episodes: 3, acton: 3, state: 276
episodes: 3, acton: 3, state: 256
episodes: 3, acton: 3, state: 236
episodes: 3, acton: 1, state: 216
episodes: 3, acton: 1, state: 116
episodes: 3, acton: 5, state: 16
episodes: 4, acton: 2, state: 207
episodes: 4, acton: 2, state: 227
episodes: 4, acton: 1, state: 247
episodes: 4, acton: 1, state: 147
episodes: 4, acton: 2, state: 47
episodes: 4, acton: 2, state: 67
episodes: 4, acton: 4, state: 87
episodes: 4, acton: 0, state: 99
episodes: 4, acton: 0, state: 199
episodes: 4, acton: 3, state: 299
episodes: 4, acton: 0, state: 279
episodes: 4, acton: 0, state: 379
episodes: 4, acton: 5, state: 479
Saving gif...Done!
```

```
In [81]: # display the captured GIF
display.Image(data=open("./gifs/taxi_q_fine_tuned.gif",'rb').read(), format='gif')
# taxi_q_fine_tuned
```

```
Out[81]: <IPython.core.display.Image object>
```

If the above display function is not working, here is the previously prepared taxi_q_fine_tuned.gif



DQN Agent with Fine Tuned Parameters

```
In [84]: %%time
my_dqn_agent_fine_tuned_avg_reward_lst = my_dqn_agent_fine_tuned.test(test
```

```
Policy (trained policy network model from the .pt file):
State 000, Action S, Q-values: [+3.28 +2.97 +2.57 +3.14 -6.41 -4.24]
State 001, Action P, Q-values: [-0.06 +0.25 -0.07 +0.56 +1.62 -7.34]
State 002, Action P, Q-values: [+4.88 +5.60 +3.82 +5.23 +7.83 -2.38]
State 003, Action P, Q-values: [+0.83 +1.55 +0.80 +1.53 +2.93 -6.61]
State 004, Action S, Q-values: [-4.90 -5.50 -5.24 -5.03 -20.64 -16.31]
State 005, Action S, Q-values: [+3.30 +3.01 +2.70 +3.12 -6.39 -4.10]
State 006, Action S, Q-values: [-4.91 -5.56 -5.04 -4.93 -20.70 -15.53]
State 007, Action E, Q-values: [-3.11 -3.47 -3.08 -3.16 -12.66 -12.61]
State 008, Action S, Q-values: [+1.50 +0.41 -0.06 +0.83 -10.00 -10.78]
State 009, Action S, Q-values: [-2.36 -3.56 -3.31 -3.10 -14.26 -13.08]
State 010, Action S, Q-values: [+3.26 +2.81 +2.52 +3.06 -6.52 -4.19]
State 011, Action S, Q-values: [-1.47 -2.78 -2.56 -2.35 -12.11 -12.46]
State 012, Action S, Q-values: [-3.60 -4.53 -4.08 -4.12 -16.06 -13.86]
State 013, Action S, Q-values: [-2.23 -3.08 -2.39 -3.00 -12.47 -11.94]
State 014, Action S, Q-values: [-3.75 -4.26 -3.83 -4.30 -16.79 -13.16]
State 015, Action S, Q-values: [+3.17 +2.82 +2.56 +3.01 -6.71 -4.35]
State 016, Action D, Q-values: [+14.84 +16.31 +14.28 +15.92 +6.97 +20.00]
State 017, Action S, Q-values: [+2.93 +1.86 +2.87 +2.03 -7.93 -3.28]
State 018, Action S, Q-values: [+9.71 +7.32 +6.03 +7.68 -2.44 +1.72]
State 019, Action S, Q-values: [+4.43 +2.97 +4.42 +3.40 -6.99 -2.36]
State 020, Action S, Q-values: [+3.22 +2.85 +2.48 +3.01 -6.76 -4.35]
State 021, Action W, Q-values: [-1.03 -0.72 -0.06 +0.44 -9.34 -10.39]
State 022, Action W, Q-values: [+3.76 +4.76 +5.00 +5.98 -3.84 -3.49]
State 023, Action W, Q-values: [-0.09 +1.06 +1.00 +1.65 -6.93 -9.67]
State 024, Action S, Q-values: [-4.40 -4.88 -4.79 -4.75 -18.36 -15.41]
State 025, Action S, Q-values: [+3.47 +2.99 +2.87 +3.23 -6.43 -4.25]
State 026, Action S, Q-values: [-4.35 -5.17 -5.01 -4.92 -19.51 -15.92]
State 027, Action S, Q-values: [-2.31 -3.37 -2.71 -3.01 -13.71 -12.42]
State 028, Action S, Q-values: [+0.30 -0.57 -0.64 +0.24 -10.21 -11.01]
```


State 029, Action S, Q-values: [-3.09 -3.64 -3.62 -3.56 -13.99 -13.10]
State 030, Action S, Q-values: [+3.27 +2.78 +2.51 +3.03 -6.59 -4.37]
State 031, Action S, Q-values: [-2.31 -4.09 -3.06 -2.71 -13.42 -12.33]
State 032, Action S, Q-values: [-3.05 -3.98 -3.42 -3.97 -15.86 -13.81]
State 033, Action S, Q-values: [-1.47 -2.32 -2.20 -2.04 -12.00 -12.50]
State 034, Action S, Q-values: [-3.08 -4.10 -3.60 -3.51 -13.81 -13.16]
State 035, Action S, Q-values: [+3.32 +3.08 +2.67 +3.20 -6.81 -4.15]
State 036, Action W, Q-values: [+14.31 +14.31 +15.02 +17.04 +3.69 +6.29]
State 037, Action S, Q-values: [+4.47 +2.76 +3.00 +2.45 -6.66 -4.86]
State 038, Action S, Q-values: [+7.35 +5.38 +5.41 +6.56 -4.70 -1.64]
State 039, Action S, Q-values: [+6.02 +3.99 +4.28 +3.09 -5.51 -4.88]
State 040, Action S, Q-values: [+3.25 +2.79 +2.64 +3.08 -6.21 -4.29]
State 041, Action S, Q-values: [-3.71 -4.37 -4.46 -4.10 -16.32 -13.92]
State 042, Action S, Q-values: [-0.75 -1.57 -2.01 -1.25 -11.01 -11.77]
State 043, Action S, Q-values: [-3.06 -3.81 -3.87 -3.43 -15.18 -13.57]
State 044, Action E, Q-values: [-1.43 -1.28 -0.56 -0.99 -11.63 -10.91]
State 045, Action S, Q-values: [+2.91 +2.51 +2.35 +2.71 -6.89 -4.53]
State 046, Action E, Q-values: [-1.55 -1.91 -0.57 -1.49 -12.44 -11.90]
State 047, Action E, Q-values: [+1.53 +1.80 +2.93 +1.89 -7.58 -7.07]
State 048, Action S, Q-values: [-0.60 -1.79 -1.99 -1.13 -11.51 -11.94]
State 049, Action S, Q-values: [-3.76 -4.34 -4.05 -4.08 -15.88 -13.16]
State 050, Action S, Q-values: [+3.22 +2.76 +2.43 +2.97 -6.35 -4.15]
State 051, Action S, Q-values: [-3.08 -3.80 -3.73 -3.60 -14.66 -13.32]
State 052, Action S, Q-values: [-2.34 -3.17 -2.64 -2.78 -13.39 -12.51]
State 053, Action E, Q-values: [-0.98 -1.56 -0.74 -1.37 -11.60 -11.64]
State 054, Action S, Q-values: [-2.35 -3.51 -3.00 -3.25 -12.66 -12.63]
State 055, Action S, Q-values: [+3.06 +2.69 +2.45 +2.93 -6.80 -4.29]
State 056, Action S, Q-values: [+6.00 +4.55 +3.25 +4.93 -5.04 -3.23]
State 057, Action E, Q-values: [+10.77 +12.61 +14.33 +12.15 +2.30 +3.75]
State 058, Action S, Q-values: [+6.02 +3.97 +3.27 +4.09 -5.28 -5.14]
State 059, Action S, Q-values: [+7.24 +5.30 +6.04 +6.12 -4.94 -2.05]
State 060, Action S, Q-values: [+3.21 +2.92 +2.60 +3.01 -6.56 -4.18]
State 061, Action W, Q-values: [-4.36 -5.23 -5.10 -4.36 -17.92 -15.38]
State 062, Action S, Q-values: [-1.63 -2.18 -2.42 -1.73 -12.10 -11.74]
State 063, Action W, Q-values: [-3.75 -4.17 -4.42 -3.74 -16.24 -14.30]
State 064, Action E, Q-values: [-0.61 -0.65 +0.47 -1.01 -9.32 -9.21]
State 065, Action S, Q-values: [+3.23 +3.08 +2.71 +3.12 -6.40 -4.01]
State 066, Action E, Q-values: [-0.37 -0.98 +0.45 -0.52 -9.25 -8.79]
State 067, Action E, Q-values: [+2.33 +3.10 +4.39 +2.32 -3.71 -5.76]
State 068, Action S, Q-values: [-1.52 -2.42 -3.07 -1.95 -10.98 -12.01]
State 069, Action W, Q-values: [-4.38 -4.87 -4.83 -4.36 -18.00 -14.76]
State 070, Action S, Q-values: [+3.12 +2.52 +2.40 +2.87 -6.66 -4.36]
State 071, Action S, Q-values: [-3.75 -4.63 -4.76 -3.82 -16.93 -14.56]
State 072, Action S, Q-values: [-1.52 -2.39 -2.55 -2.39 -12.45 -12.44]
State 073, Action S, Q-values: [+0.48 -0.80 -0.77 -1.05 -10.67 -11.38]
State 074, Action S, Q-values: [-1.50 -2.41 -2.71 -2.11 -12.56 -12.60]
State 075, Action S, Q-values: [+3.32 +2.95 +2.70 +3.08 -6.39 -4.11]
State 076, Action W, Q-values: [+4.38 +2.93 +2.29 +4.38 -6.86 -5.45]
State 077, Action E, Q-values: [+11.91 +14.38 +17.02 +13.46 +2.02 +2.86]
State 078, Action S, Q-values: [+4.38 +2.61 +2.19 +4.36 -5.76 -5.82]
State 079, Action S, Q-values: [+9.75 +7.13 +6.53 +6.24 -0.80 -0.70]
State 080, Action S, Q-values: [+3.22 +2.87 +2.59 +3.06 -6.32 -4.25]
State 081, Action W, Q-values: [-4.87 -5.45 -5.12 -4.86 -20.10 -15.52]
State 082, Action W, Q-values: [-2.47 -3.00 -2.63 -2.37 -13.82 -12.61]
State 083, Action W, Q-values: [-4.40 -4.89 -4.69 -4.32 -17.96 -14.42]
State 084, Action P, Q-values: [-0.10 +0.38 +0.20 +0.59 +1.62 -7.31]
State 085, Action S, Q-values: [+3.23 +2.99 +2.68 +3.13 -6.48 -4.03]

State 086, Action P, Q-values: [-0.11 +0.45 +0.17 +0.52 +1.63 -7.40]
State 087, Action P, Q-values: [+3.70 +3.99 +3.56 +3.65 +6.03 -3.29]
State 088, Action S, Q-values: [-2.37 -3.00 -2.69 -2.39 -12.23 -11.67]
State 089, Action S, Q-values: [-4.93 -5.45 -5.27 -4.94 -20.98 -16.05]
State 090, Action S, Q-values: [+3.45 +3.05 +2.83 +3.23 -6.38 -4.01]
State 091, Action W, Q-values: [-4.41 -5.04 -4.95 -4.37 -18.80 -15.04]
State 092, Action W, Q-values: [-2.35 -3.09 -3.02 -2.31 -12.91 -12.67]
State 093, Action S, Q-values: [-0.53 -1.72 -1.38 -0.90 -11.77 -12.03]
State 094, Action S, Q-values: [-2.41 -2.98 -2.69 -2.45 -13.69 -12.37]
State 095, Action S, Q-values: [+3.19 +2.82 +2.65 +3.02 -6.58 -4.27]
State 096, Action S, Q-values: [+2.94 +1.94 +1.73 +2.93 -8.86 -2.00]
State 097, Action D, Q-values: [+14.26 +15.56 +15.42 +14.72 +7.18 +20.00]
State 098, Action S, Q-values: [+2.91 +1.61 +1.71 +2.90 -9.06 -2.11]
State 099, Action S, Q-values: [+7.81 +6.31 +6.30 +7.76 -3.15 +2.51]
State 100, Action S, Q-values: [+3.22 +2.98 +2.77 +3.15 -6.67 -4.24]
State 101, Action N, Q-values: [-0.72 +0.46 -1.23 -0.34 -10.31 -10.44]
State 102, Action N, Q-values: [+3.43 +6.00 +4.66 +4.63 -3.80 -4.64]
State 103, Action N, Q-values: [+0.32 +1.45 +0.16 +0.99 -8.88 -7.90]
State 104, Action S, Q-values: [-4.35 -5.24 -4.54 -4.71 -19.09 -14.91]
State 105, Action S, Q-values: [+3.26 +2.86 +2.73 +3.05 -6.36 -4.10]
State 106, Action E, Q-values: [-4.43 -4.75 -4.40 -4.53 -18.70 -14.71]
State 107, Action S, Q-values: [-2.37 -3.50 -2.59 -2.72 -13.49 -11.99]
State 108, Action S, Q-values: [+2.91 +0.10 +1.31 +0.98 -9.12 -8.98]
State 109, Action S, Q-values: [-1.54 -2.99 -2.83 -2.08 -12.07 -12.33]
State 110, Action S, Q-values: [+3.40 +2.96 +2.71 +3.16 -6.58 -4.03]
State 111, Action S, Q-values: [-0.54 -2.57 -2.09 -1.51 -11.42 -12.13]
State 112, Action S, Q-values: [-2.99 -4.01 -3.07 -3.49 -13.79 -12.17]
State 113, Action S, Q-values: [-1.45 -2.72 -1.68 -1.87 -11.96 -11.81]
State 114, Action S, Q-values: [-3.03 -4.24 -3.48 -3.45 -13.60 -12.63]
State 115, Action S, Q-values: [+3.22 +2.92 +2.57 +3.15 -6.54 -4.17]
State 116, Action N, Q-values: [+12.08 +17.03 +13.22 +14.35 +2.41 +4.76]
State 117, Action S, Q-values: [+4.38 +1.61 +4.31 +3.51 -5.37 -5.63]
State 118, Action S, Q-values: [+11.91 +7.63 +8.14 +9.07 +1.23 +1.08]
State 119, Action S, Q-values: [+6.03 +2.92 +5.86 +4.86 -5.05 -3.94]
State 120, Action S, Q-values: [+3.08 +2.80 +2.53 +3.01 -6.44 -4.43]
State 121, Action N, Q-values: [-1.55 -0.46 -1.48 -0.50 -10.38 -10.07]
State 122, Action N, Q-values: [+2.04 +4.33 +3.41 +4.30 -6.68 -6.18]
State 123, Action W, Q-values: [-1.19 +0.51 -0.08 +0.57 -9.29 -10.20]
State 124, Action S, Q-values: [-3.80 -4.48 -4.24 -3.98 -15.94 -13.72]
State 125, Action S, Q-values: [+3.22 +2.84 +2.46 +3.11 -6.39 -4.44]
State 126, Action S, Q-values: [-3.73 -4.31 -4.11 -4.21 -15.83 -13.54]
State 127, Action S, Q-values: [-1.56 -2.66 -2.01 -2.09 -10.41 -11.45]
State 128, Action S, Q-values: [+1.63 -0.48 +0.63 +1.52 -7.86 -10.17]
State 129, Action S, Q-values: [-2.37 -3.75 -2.96 -2.41 -12.64 -12.16]
State 130, Action S, Q-values: [+3.62 +3.22 +2.88 +3.40 -6.20 -4.00]
State 131, Action W, Q-values: [-1.52 -2.85 -2.10 -1.51 -11.99 -12.15]
State 132, Action S, Q-values: [-2.37 -3.25 -2.97 -2.94 -13.21 -12.19]
State 133, Action S, Q-values: [-0.50 -1.93 -1.01 -1.19 -10.55 -11.24]
State 134, Action S, Q-values: [-2.32 -3.43 -3.27 -3.61 -12.80 -13.04]
State 135, Action S, Q-values: [+3.33 +2.99 +2.82 +3.20 -6.69 -4.08]
State 136, Action N, Q-values: [+10.16 +14.33 +12.36 +13.13 +2.43 +3.02]
State 137, Action S, Q-values: [+5.96 +3.16 +4.03 +3.31 -3.19 -3.17]
State 138, Action S, Q-values: [+9.12 +6.73 +7.52 +9.04 -2.12 +0.64]
State 139, Action S, Q-values: [+7.82 +4.92 +5.82 +5.33 -2.52 -1.48]
State 140, Action S, Q-values: [+3.08 +2.72 +2.50 +2.93 -6.57 -4.36]
State 141, Action S, Q-values: [-3.03 -4.24 -4.16 -3.60 -14.86 -13.36]
State 142, Action S, Q-values: [+0.45 -1.40 -1.34 -0.11 -8.68 -10.35]

State 143, Action S, Q-values: [-2.29 -3.28 -3.08 -2.91 -12.30 -12.07]
State 144, Action E, Q-values: [-2.54 -1.50 -1.45 -2.22 -11.78 -11.65]
State 145, Action S, Q-values: [+3.15 +2.78 +2.66 +3.02 -6.58 -4.44]
State 146, Action N, Q-values: [-2.64 -1.51 -1.55 -1.98 -11.82 -11.71]
State 147, Action E, Q-values: [-0.61 +1.62 +1.66 -0.23 -8.41 -9.93]
State 148, Action S, Q-values: [+0.44 -1.46 -1.16 -0.15 -9.89 -10.85]
State 149, Action S, Q-values: [-3.06 -3.98 -3.70 -3.43 -14.03 -12.82]
State 150, Action S, Q-values: [+3.26 +2.83 +2.63 +3.10 -6.90 -4.26]
State 151, Action S, Q-values: [-2.34 -3.53 -3.60 -3.03 -13.27 -12.53]
State 152, Action S, Q-values: [-1.47 -3.12 -1.83 -2.43 -11.55 -11.35]
State 153, Action E, Q-values: [+0.50 -1.65 +0.52 -0.31 -10.68 -11.82]
State 154, Action S, Q-values: [-1.50 -2.58 -1.59 -2.01 -11.48 -11.50]
State 155, Action S, Q-values: [+3.21 +3.04 +2.64 +3.09 -6.11 -4.22]
State 156, Action S, Q-values: [+7.77 +4.99 +4.97 +6.23 -1.81 -0.84]
State 157, Action E, Q-values: [+8.00 +11.88 +11.88 +9.72 +1.04 +0.84]
State 158, Action S, Q-values: [+7.74 +4.66 +5.19 +6.12 -2.11 -1.19]
State 159, Action E, Q-values: [+8.26 +6.36 +8.95 +7.16 -2.64 -0.96]
State 160, Action S, Q-values: [+3.04 +2.67 +2.42 +2.90 -6.45 -4.48]
State 161, Action S, Q-values: [-3.75 -4.28 -4.08 -3.75 -15.38 -13.29]
State 162, Action S, Q-values: [-0.56 -2.25 -2.02 -0.58 -10.39 -11.22]
State 163, Action S, Q-values: [-3.08 -4.21 -4.16 -3.08 -14.55 -13.28]
State 164, Action E, Q-values: [-1.77 -0.68 -0.58 -1.93 -10.68 -11.44]
State 165, Action S, Q-values: [+3.24 +2.81 +2.59 +3.03 -6.52 -4.26]
State 166, Action E, Q-values: [-1.74 -0.62 -0.59 -1.34 -11.20 -10.63]
State 167, Action E, Q-values: [+0.86 +2.91 +2.93 +1.01 -8.26 -7.61]
State 168, Action S, Q-values: [-0.58 -2.02 -2.03 -0.59 -11.12 -11.94]
State 169, Action S, Q-values: [-3.70 -4.57 -4.33 -3.92 -16.59 -13.81]
State 170, Action S, Q-values: [+3.36 +3.10 +2.78 +3.19 -6.31 -4.23]
State 171, Action S, Q-values: [-3.07 -3.66 -3.27 -3.07 -13.18 -12.37]
State 172, Action S, Q-values: [-0.57 -2.22 -2.26 -1.22 -10.66 -12.00]
State 173, Action S, Q-values: [+1.65 -0.38 -0.26 +0.03 -10.72 -9.21]
State 174, Action S, Q-values: [-0.46 -2.23 -2.05 -1.65 -11.45 -11.96]
State 175, Action S, Q-values: [+3.03 +2.66 +2.36 +2.82 -6.54 -4.65]
State 176, Action S, Q-values: [+6.01 +3.13 +3.50 +5.94 -5.16 -3.48]
State 177, Action N, Q-values: [+9.94 +14.34 +14.31 +11.29 +1.75 +2.46]
State 178, Action W, Q-values: [+5.78 +3.67 +4.21 +6.00 -4.07 -2.35]
State 179, Action S, Q-values: [+11.94 +8.32 +8.05 +8.40 +0.07 +1.96]
State 180, Action S, Q-values: [+3.35 +3.00 +2.70 +3.14 -6.24 -4.11]
State 181, Action W, Q-values: [-4.36 -5.65 -4.71 -4.32 -18.42 -15.15]
State 182, Action W, Q-values: [-1.67 -2.67 -2.21 -1.50 -12.02 -11.33]
State 183, Action S, Q-values: [-3.73 -4.45 -4.25 -3.77 -15.92 -13.91]
State 184, Action N, Q-values: [-0.63 +0.42 -0.27 -0.59 -9.45 -9.13]
State 185, Action S, Q-values: [+3.42 +3.02 +2.67 +3.16 -6.69 -4.04]
State 186, Action N, Q-values: [-0.80 +0.40 -0.83 -0.42 -9.88 -10.10]
State 187, Action N, Q-values: [+2.00 +4.38 +3.92 +1.70 -5.07 -6.43]
State 188, Action W, Q-values: [-1.57 -3.11 -2.26 -1.54 -12.80 -11.30]
State 189, Action S, Q-values: [-4.33 -5.05 -4.79 -4.39 -18.57 -15.01]
State 190, Action S, Q-values: [+3.09 +2.72 +2.41 +2.93 -6.23 -4.23]
State 191, Action W, Q-values: [-3.79 -4.68 -4.05 -3.72 -16.09 -13.79]
State 192, Action S, Q-values: [-1.46 -2.79 -1.81 -1.69 -12.84 -11.67]
State 193, Action S, Q-values: [+0.49 -1.32 -0.37 +0.19 -9.96 -10.98]
State 194, Action S, Q-values: [-1.49 -2.86 -2.06 -1.96 -12.67 -12.20]
State 195, Action W, Q-values: [+3.02 +2.86 +2.81 +3.07 -6.81 -4.41]
State 196, Action W, Q-values: [+4.35 +2.12 +3.46 +4.39 -5.95 -5.06]
State 197, Action N, Q-values: [+12.09 +17.04 +14.77 +13.66 +3.54 +4.25]
State 198, Action W, Q-values: [+4.34 +1.95 +3.17 +4.37 -6.84 -5.70]
State 199, Action S, Q-values: [+9.77 +5.95 +7.59 +8.80 -0.07 -0.87]

State 200, Action S, Q-values: [+3.22 +2.84 +2.62 +3.16 -6.61 -4.45]
State 201, Action N, Q-values: [-1.73 -0.55 -2.10 -1.21 -11.05 -11.63]
State 202, Action N, Q-values: [+2.53 +4.39 +2.38 +3.10 -6.29 -5.59]
State 203, Action N, Q-values: [-0.81 +0.43 -1.52 -0.46 -10.94 -11.24]
State 204, Action E, Q-values: [-4.21 -4.79 -3.73 -4.30 -17.53 -13.83]
State 205, Action S, Q-values: [+3.33 +3.07 +2.67 +3.20 -6.40 -4.04]
State 206, Action E, Q-values: [-4.39 -4.25 -3.73 -3.96 -16.61 -14.09]
State 207, Action E, Q-values: [-2.05 -2.98 -1.54 -1.96 -12.39 -11.93]
State 208, Action S, Q-values: [+4.34 +1.21 +2.19 +2.98 -6.44 -6.99]
State 209, Action S, Q-values: [-0.57 -2.34 -1.76 -1.47 -10.68 -11.30]
State 210, Action S, Q-values: [+3.14 +3.00 +2.60 +3.09 -6.58 -4.27]
State 211, Action S, Q-values: [+0.39 -1.64 -1.00 -0.21 -10.08 -9.94]
State 212, Action E, Q-values: [-3.08 -3.12 -2.43 -2.66 -11.56 -12.10]
State 213, Action E, Q-values: [-1.64 -2.03 -0.48 -1.39 -12.78 -11.92]
State 214, Action E, Q-values: [-3.21 -3.48 -2.32 -2.82 -12.63 -12.90]
State 215, Action S, Q-values: [+3.03 +2.79 +2.54 +2.99 -6.58 -4.31]
State 216, Action N, Q-values: [+10.17 +14.31 +10.87 +12.06 +2.10 +2.60]
State 217, Action E, Q-values: [+3.68 +4.15 +5.97 +3.94 -4.03 -4.72]
State 218, Action S, Q-values: [+14.33 +9.62 +10.12 +11.79 +1.35 +3.58]
State 219, Action E, Q-values: [+4.64 +5.25 +7.82 +5.80 -3.34 -2.93]
State 220, Action S, Q-values: [+3.33 +3.00 +2.66 +3.20 -6.45 -4.04]
State 221, Action W, Q-values: [-2.59 -1.45 -3.16 -1.43 -11.76 -12.96]
State 222, Action N, Q-values: [+1.02 +2.90 +0.94 +2.88 -7.88 -7.45]
State 223, Action W, Q-values: [-1.93 -0.56 -2.14 -0.55 -11.95 -11.60]
State 224, Action E, Q-values: [-3.89 -3.64 -3.05 -3.75 -15.41 -13.37]
State 225, Action S, Q-values: [+3.33 +2.84 +2.67 +3.14 -6.66 -4.18]
State 226, Action E, Q-values: [-3.41 -3.57 -3.04 -3.63 -14.11 -12.69]
State 227, Action E, Q-values: [-1.56 -2.39 -0.58 -2.68 -11.61 -12.01]
State 228, Action W, Q-values: [+1.62 +0.43 +1.41 +2.90 -8.45 -7.36]
State 229, Action W, Q-values: [-1.99 -2.42 -2.38 -1.42 -11.05 -12.55]
State 230, Action S, Q-values: [+3.27 +2.89 +2.53 +3.08 -6.07 -4.28]
State 231, Action W, Q-values: [-1.51 -1.92 -1.95 -0.59 -11.01 -11.30]
State 232, Action E, Q-values: [-2.55 -2.54 -1.59 -2.54 -12.26 -11.86]
State 233, Action E, Q-values: [-0.57 -1.23 +0.48 -1.24 -11.37 -10.07]
State 234, Action E, Q-values: [-2.39 -2.86 -1.53 -2.49 -12.48 -12.15]
State 235, Action S, Q-values: [+3.29 +2.82 +2.59 +3.08 -6.83 -4.29]
State 236, Action N, Q-values: [+8.34 +11.89 +8.84 +11.88 -0.05 +0.71]
State 237, Action E, Q-values: [+4.45 +6.33 +7.73 +4.63 -2.22 -3.60]
State 238, Action W, Q-values: [+9.22 +8.71 +9.10 +11.92 +1.30 +0.81]
State 239, Action E, Q-values: [+6.92 +7.78 +9.75 +7.02 +0.03 +0.58]
State 240, Action S, Q-values: [+3.18 +2.85 +2.50 +2.92 -6.59 -4.20]
State 241, Action W, Q-values: [-2.77 -3.04 -3.30 -2.28 -12.28 -12.52]
State 242, Action W, Q-values: [-0.28 +0.31 +0.09 +1.62 -7.80 -9.42]
State 243, Action W, Q-values: [-2.42 -2.50 -2.71 -1.46 -11.27 -11.76]
State 244, Action E, Q-values: [-3.30 -2.32 -2.29 -3.19 -13.10 -12.10]
State 245, Action S, Q-values: [+3.22 +2.94 +2.68 +3.15 -6.29 -4.15]
State 246, Action E, Q-values: [-3.52 -2.39 -2.35 -3.22 -13.06 -12.73]
State 247, Action E, Q-values: [-1.56 +0.32 +0.42 -1.34 -9.95 -10.87]
State 248, Action W, Q-values: [+0.92 -0.55 +0.18 +1.63 -10.23 -9.62]
State 249, Action W, Q-values: [-2.90 -3.88 -3.84 -2.27 -12.76 -13.18]
State 250, Action S, Q-values: [+3.21 +2.77 +2.55 +3.01 -6.92 -4.23]
State 251, Action W, Q-values: [-2.30 -2.85 -2.93 -1.48 -12.42 -12.62]
State 252, Action E, Q-values: [-1.48 -2.04 -0.56 -1.68 -11.41 -11.41]
State 253, Action E, Q-values: [+0.94 -0.23 +1.54 +0.32 -8.40 -7.37]
State 254, Action E, Q-values: [-1.44 -1.91 -0.58 -1.76 -10.31 -10.46]
State 255, Action S, Q-values: [+3.26 +2.66 +2.55 +3.00 -6.82 -4.21]
State 256, Action W, Q-values: [+7.53 +7.24 +7.12 +9.75 -0.84 -0.15]

State 257, Action N, Q-values: [+6.28 +9.70 +9.67 +6.27 -1.55 -1.89]
State 258, Action W, Q-values: [+7.92 +6.64 +6.93 +9.71 -0.80 +0.63]
State 259, Action E, Q-values: [+8.03 +9.53 +11.91 +8.68 +0.51 -0.06]
State 260, Action S, Q-values: [+3.21 +2.78 +2.46 +3.01 -6.41 -4.40]
State 261, Action W, Q-values: [-3.59 -3.67 -3.96 -3.04 -14.51 -13.43]
State 262, Action W, Q-values: [-1.38 -0.46 -1.09 +0.43 -9.76 -11.34]
State 263, Action W, Q-values: [-2.96 -3.28 -3.42 -2.32 -12.93 -12.78]
State 264, Action E, Q-values: [-2.44 -1.46 -1.44 -2.29 -11.57 -11.47]
State 265, Action S, Q-values: [+3.40 +3.01 +2.70 +3.19 -6.22 -4.03]
State 266, Action E, Q-values: [-2.58 -1.52 -1.49 -2.11 -11.66 -11.07]
State 267, Action E, Q-values: [-0.22 +1.61 +1.63 -0.05 -9.67 -8.77]
State 268, Action W, Q-values: [-0.51 -1.34 -1.44 +0.45 -10.74 -11.50]
State 269, Action W, Q-values: [-3.85 -3.99 -3.92 -3.05 -15.34 -13.82]
State 270, Action S, Q-values: [+3.26 +2.83 +2.44 +3.07 -6.71 -4.30]
State 271, Action W, Q-values: [-3.34 -3.53 -3.37 -2.37 -12.94 -13.15]
State 272, Action S, Q-values: [+0.47 -1.76 -1.06 -1.35 -9.52 -11.17]
State 273, Action S, Q-values: [+2.90 +0.41 +1.76 +1.89 -7.49 -6.31]
State 274, Action S, Q-values: [+0.41 -1.57 -1.38 -1.20 -10.80 -11.00]
State 275, Action S, Q-values: [+3.17 +2.98 +2.62 +3.02 -6.52 -4.17]
State 276, Action W, Q-values: [+5.08 +6.13 +4.87 +7.82 -2.97 -2.69]
State 277, Action N, Q-values: [+7.82 +11.87 +11.82 +8.40 +0.53 +0.00]
State 278, Action W, Q-values: [+5.98 +4.88 +5.30 +7.72 -2.16 -1.77]
State 279, Action S, Q-values: [+14.28 +9.54 +9.94 +10.85 +0.94 +3.50]
State 280, Action S, Q-values: [+3.15 +2.76 +2.56 +2.99 -6.38 -4.47]
State 281, Action W, Q-values: [-4.58 -4.75 -4.50 -3.69 -17.85 -14.76]
State 282, Action W, Q-values: [-1.43 -1.93 -1.58 -0.51 -11.12 -11.23]
State 283, Action W, Q-values: [-3.50 -4.06 -3.69 -3.04 -14.23 -13.18]
State 284, Action N, Q-values: [-1.75 -0.49 -1.58 -1.51 -11.77 -11.68]
State 285, Action S, Q-values: [+3.05 +2.68 +2.44 +2.89 -6.67 -4.27]
State 286, Action N, Q-values: [-2.08 -0.62 -1.55 -1.57 -11.72 -11.86]
State 287, Action N, Q-values: [+0.93 +2.92 +2.25 +1.41 -7.84 -7.77]
State 288, Action W, Q-values: [-1.38 -2.14 -1.40 -0.58 -11.71 -12.24]
State 289, Action W, Q-values: [-4.27 -5.24 -4.40 -3.71 -17.45 -14.65]
State 290, Action S, Q-values: [+3.24 +2.95 +2.67 +3.16 -6.37 -4.27]
State 291, Action W, Q-values: [-3.83 -3.88 -3.50 -2.97 -14.99 -13.06]
State 292, Action S, Q-values: [-0.54 -2.03 -1.33 -0.82 -10.82 -11.48]
State 293, Action W, Q-values: [+1.46 -0.09 +0.81 +1.66 -7.78 -10.14]
State 294, Action S, Q-values: [-0.53 -1.84 -1.28 -0.57 -11.05 -11.39]
State 295, Action S, Q-values: [+3.04 +2.45 +2.37 +2.82 -6.53 -4.52]
State 296, Action W, Q-values: [+3.65 +4.15 +4.70 +6.01 -4.11 -4.27]
State 297, Action N, Q-values: [+9.97 +14.34 +12.32 +10.96 +2.05 +2.21]
State 298, Action W, Q-values: [+3.55 +4.14 +5.04 +5.97 -4.40 -4.39]
State 299, Action W, Q-values: [+11.91 +8.49 +9.64 +11.95 +0.66 +2.36]
State 300, Action S, Q-values: [+3.23 +2.99 +2.61 +3.09 -6.19 -4.22]
State 301, Action N, Q-values: [-2.47 -1.45 -2.07 -1.96 -12.74 -12.14]
State 302, Action N, Q-values: [+0.97 +2.89 +2.17 +2.11 -9.07 -8.12]
State 303, Action N, Q-values: [-1.71 -0.57 -1.83 -1.34 -12.03 -11.65]
State 304, Action N, Q-values: [-5.25 -4.44 -5.12 -4.87 -19.67 -15.34]
State 305, Action S, Q-values: [+3.19 +2.67 +2.31 +2.83 -6.50 -4.19]
State 306, Action N, Q-values: [-5.19 -4.39 -4.96 -4.74 -19.75 -14.97]
State 307, Action N, Q-values: [-3.00 -2.39 -3.07 -2.77 -11.39 -11.49]
State 308, Action S, Q-values: [+5.95 +2.03 +4.14 +4.28 -4.81 -4.97]
State 309, Action S, Q-values: [+0.44 -1.65 -0.32 -0.19 -7.55 -8.97]
State 310, Action S, Q-values: [+3.18 +2.98 +2.70 +3.10 -6.66 -4.19]
State 311, Action S, Q-values: [+1.54 -0.48 +0.87 +0.53 -7.59 -8.26]
State 312, Action N, Q-values: [-3.88 -3.11 -3.62 -3.45 -13.98 -12.41]
State 313, Action N, Q-values: [-2.39 -1.50 -1.76 -2.30 -13.00 -11.76]

State 314, Action N, Q-values: [-3.89 -3.14 -3.68 -3.52 -14.43 -13.15]
State 315, Action S, Q-values: [+3.45 +3.05 +2.72 +3.25 -6.54 -3.94]
State 316, Action N, Q-values: [+7.98 +11.90 +9.46 +9.97 +1.26 +0.50]
State 317, Action N, Q-values: [+1.69 +4.37 +4.07 +2.75 -6.30 -7.45]
State 318, Action S, Q-values: [+16.99 +11.45 +13.68 +14.33 +3.18 +5.48]
State 319, Action N, Q-values: [+3.20 +6.04 +5.07 +4.70 -4.66 -4.87]
State 320, Action S, Q-values: [+3.25 +2.90 +2.57 +3.09 -6.54 -4.31]
State 321, Action N, Q-values: [-3.12 -2.33 -3.80 -3.02 -11.99 -12.96]
State 322, Action N, Q-values: [-0.50 +1.63 +0.25 +0.65 -7.89 -10.68]
State 323, Action N, Q-values: [-2.55 -1.51 -2.78 -2.13 -12.47 -12.02]
State 324, Action N, Q-values: [-4.52 -3.80 -4.31 -4.06 -17.71 -13.77]
State 325, Action S, Q-values: [+3.01 +2.75 +2.57 +2.90 -6.54 -4.51]
State 326, Action N, Q-values: [-4.49 -3.77 -4.16 -4.16 -17.54 -13.38]
State 327, Action E, Q-values: [-2.41 -1.64 -1.52 -1.84 -12.54 -12.11]
State 328, Action N, Q-values: [+0.31 +1.60 -0.01 +0.73 -9.83 -9.84]
State 329, Action N, Q-values: [-2.99 -2.32 -2.76 -2.89 -12.66 -11.86]
State 330, Action S, Q-values: [+3.20 +3.01 +2.55 +3.10 -6.48 -4.17]
State 331, Action N, Q-values: [-2.75 -1.50 -2.60 -1.67 -12.48 -12.32]
State 332, Action N, Q-values: [-3.23 -2.48 -2.85 -2.73 -11.71 -11.69]
State 333, Action E, Q-values: [-1.98 -0.73 -0.60 -1.52 -11.73 -11.36]
State 334, Action N, Q-values: [-3.27 -2.44 -2.81 -2.90 -13.11 -12.27]
State 335, Action S, Q-values: [+3.35 +3.00 +2.84 +3.16 -6.32 -4.00]
State 336, Action N, Q-values: [+6.19 +8.55 +5.79 +7.19 -3.18 -1.56]
State 337, Action E, Q-values: [+2.99 +5.41 +5.70 +4.71 -5.86 -4.99]
State 338, Action N, Q-values: [+6.54 +9.16 +6.55 +7.65 -2.03 -0.84]
State 339, Action N, Q-values: [+4.57 +7.36 +6.81 +5.97 -3.99 -3.11]
State 340, Action S, Q-values: [+3.26 +2.94 +2.77 +3.13 -6.72 -4.36]
State 341, Action N, Q-values: [-3.79 -3.13 -3.76 -3.41 -14.13 -13.17]
State 342, Action N, Q-values: [-0.88 +0.43 -0.68 +0.26 -10.86 -10.34]
State 343, Action N, Q-values: [-3.13 -2.31 -3.25 -2.39 -12.63 -12.21]
State 344, Action N, Q-values: [-3.66 -3.07 -3.53 -3.73 -13.96 -12.65]
State 345, Action S, Q-values: [+3.15 +2.92 +2.54 +3.08 -6.71 -4.11]
State 346, Action N, Q-values: [-3.82 -3.12 -3.44 -4.08 -14.74 -13.12]
State 347, Action N, Q-values: [-1.55 -0.55 -0.82 -1.40 -12.10 -10.94]
State 348, Action N, Q-values: [-1.01 +0.42 -1.00 +0.32 -11.20 -10.87]
State 349, Action N, Q-values: [-3.82 -3.07 -3.73 -3.08 -14.77 -13.02]
State 350, Action S, Q-values: [+3.15 +2.82 +2.55 +3.05 -6.84 -4.30]
State 351, Action W, Q-values: [-3.09 -2.35 -2.94 -2.33 -12.49 -11.71]
State 352, Action N, Q-values: [-2.62 -1.56 -1.73 -2.36 -13.59 -12.61]
State 353, Action N, Q-values: [-0.84 +0.37 -0.67 -0.61 -10.80 -10.86]
State 354, Action N, Q-values: [-1.99 -1.57 -1.81 -1.77 -12.61 -12.04]
State 355, Action S, Q-values: [+3.16 +3.01 +2.55 +3.10 -6.88 -4.31]
State 356, Action N, Q-values: [+4.39 +6.66 +5.19 +6.24 -4.81 -3.16]
State 357, Action N, Q-values: [+4.87 +7.44 +6.53 +4.73 -3.10 -3.15]
State 358, Action N, Q-values: [+4.78 +7.31 +5.45 +6.83 -3.87 -2.54]
State 359, Action N, Q-values: [+6.20 +9.07 +7.33 +6.49 -2.10 -2.31]
State 360, Action S, Q-values: [+3.30 +2.89 +2.73 +3.17 -6.57 -4.22]
State 361, Action N, Q-values: [-4.29 -3.77 -4.55 -4.14 -17.35 -13.85]
State 362, Action N, Q-values: [-1.57 -0.51 -1.51 -1.20 -10.89 -10.80]
State 363, Action N, Q-values: [-3.74 -3.09 -3.82 -3.39 -13.99 -12.33]
State 364, Action E, Q-values: [-3.15 -2.45 -2.24 -3.00 -13.60 -12.37]
State 365, Action S, Q-values: [+3.32 +3.11 +2.69 +3.21 -6.66 -4.07]
State 366, Action N, Q-values: [-3.32 -2.36 -2.69 -2.90 -12.74 -12.61]
State 367, Action N, Q-values: [-1.50 +0.46 +0.32 -0.55 -11.04 -11.15]
State 368, Action N, Q-values: [-1.73 -0.60 -2.08 -1.22 -10.66 -11.00]
State 369, Action N, Q-values: [-4.32 -3.79 -4.50 -4.13 -16.68 -13.58]
State 370, Action S, Q-values: [+3.22 +2.85 +2.66 +3.08 -6.65 -4.38]

State 371, Action N, Q-values: [-3.81 -3.09 -3.99 -3.51 -14.58 -12.84]
State 372, Action S, Q-values: [+1.61 -0.66 -0.05 +0.25 -7.52 -9.27]
State 373, Action S, Q-values: [+4.36 +1.90 +2.24 +3.81 -6.85 -5.18]
State 374, Action S, Q-values: [+1.59 -0.53 +0.00 +0.14 -7.42 -9.08]
State 375, Action S, Q-values: [+3.22 +2.80 +2.65 +3.10 -6.50 -4.46]
State 376, Action N, Q-values: [+3.31 +6.01 +4.75 +4.77 -3.60 -4.76]
State 377, Action N, Q-values: [+6.23 +9.69 +9.66 +7.77 +0.27 -0.99]
State 378, Action N, Q-values: [+3.35 +5.98 +4.26 +5.13 -3.33 -5.02]
State 379, Action S, Q-values: [+16.97 +11.25 +12.15 +14.09 +3.31 +4.75]
State 380, Action S, Q-values: [+3.14 +2.89 +2.61 +2.96 -6.35 -4.57]
State 381, Action N, Q-values: [-4.94 -4.30 -5.09 -4.38 -19.75 -14.84]
State 382, Action N, Q-values: [-2.48 -1.50 -1.90 -1.94 -13.20 -12.25]
State 383, Action W, Q-values: [-4.55 -3.75 -4.45 -3.73 -16.32 -13.93]
State 384, Action N, Q-values: [-2.42 -1.41 -1.54 -2.49 -13.55 -12.76]
State 385, Action S, Q-values: [+3.18 +2.76 +2.48 +3.00 -6.62 -4.32]
State 386, Action N, Q-values: [-2.51 -1.55 -2.04 -2.27 -12.99 -12.44]
State 387, Action N, Q-values: [-0.71 +1.57 +0.98 -0.10 -8.42 -11.52]
State 388, Action N, Q-values: [-2.48 -1.54 -2.02 -1.89 -11.93 -11.56]
State 389, Action N, Q-values: [-5.13 -4.38 -5.17 -4.43 -19.11 -14.85]
State 390, Action S, Q-values: [+3.32 +2.98 +2.77 +3.27 -6.56 -4.18]
State 391, Action W, Q-values: [-4.33 -3.80 -4.53 -3.79 -16.01 -13.20]
State 392, Action W, Q-values: [+0.38 -1.47 -0.48 +0.47 -9.09 -10.24]
State 393, Action S, Q-values: [+3.01 +1.06 +2.18 +2.89 -8.13 -6.83]
State 394, Action W, Q-values: [+0.42 -1.21 -0.69 +0.50 -9.86 -10.96]
State 395, Action S, Q-values: [+3.16 +2.93 +2.69 +3.12 -6.42 -4.23]
State 396, Action N, Q-values: [+2.11 +4.25 +3.39 +3.88 -7.32 -6.46]
State 397, Action N, Q-values: [+7.87 +11.89 +9.43 +8.46 +0.78 -0.44]
State 398, Action N, Q-values: [+2.62 +4.32 +3.28 +4.17 -7.11 -5.56]
State 399, Action S, Q-values: [+14.32 +9.97 +11.51 +12.87 +2.04 +4.34]
State 400, Action S, Q-values: [+3.27 +2.97 +2.66 +3.08 -6.66 -4.17]
State 401, Action N, Q-values: [-2.93 -2.31 -2.79 -3.11 -13.12 -12.63]
State 402, Action N, Q-values: [+1.01 +1.81 +0.09 +1.47 -9.49 -10.35]
State 403, Action N, Q-values: [-2.10 -1.30 -2.02 -1.95 -12.81 -12.15]
State 404, Action N, Q-values: [-5.82 -5.01 -5.82 -5.29 -21.82 -16.63]
State 405, Action S, Q-values: [+3.16 +2.89 +2.61 +2.99 -6.23 -4.30]
State 406, Action N, Q-values: [-5.31 -4.93 -5.38 -5.17 -21.07 -16.10]
State 407, Action N, Q-values: [-3.64 -3.12 -3.79 -3.60 -14.92 -13.26]
State 408, Action P, Q-values: [+5.41 +4.27 +3.76 +5.09 +7.83 -2.40]
State 409, Action P, Q-values: [+0.39 +0.44 +0.62 +0.88 +1.61 -7.36]
State 410, Action S, Q-values: [+3.01 +2.81 +2.44 +2.91 -6.48 -4.51]
State 411, Action P, Q-values: [+1.13 +0.29 +1.44 +1.54 +2.88 -6.69]
State 412, Action N, Q-values: [-4.30 -3.73 -4.36 -4.01 -17.07 -13.29]
State 413, Action N, Q-values: [-2.99 -2.35 -2.84 -3.02 -14.10 -12.54]
State 414, Action N, Q-values: [-4.42 -3.76 -4.42 -4.21 -17.46 -14.15]
State 415, Action S, Q-values: [+2.98 +2.80 +2.60 +2.91 -6.65 -4.71]
State 416, Action N, Q-values: [+7.57 +9.77 +6.80 +8.32 -1.94 +2.09]
State 417, Action N, Q-values: [+1.95 +2.93 +1.35 +1.84 -8.76 -2.48]
State 418, Action D, Q-values: [+16.82 +14.52 +16.75 +16.17 +7.40 +19.98]
State 419, Action N, Q-values: [+2.95 +4.46 +3.07 +3.28 -5.96 -1.56]
State 420, Action S, Q-values: [+3.16 +2.71 +2.47 +2.93 -6.48 -4.28]
State 421, Action N, Q-values: [-3.47 -3.11 -3.92 -3.46 -13.84 -12.91]
State 422, Action N, Q-values: [-0.57 +0.48 -0.97 -0.30 -10.33 -10.35]
State 423, Action N, Q-values: [-2.95 -2.33 -3.24 -3.16 -14.13 -13.02]
State 424, Action N, Q-values: [-4.45 -4.26 -4.43 -4.49 -18.11 -14.31]
State 425, Action S, Q-values: [+3.06 +2.68 +2.33 +2.94 -6.85 -4.48]
State 426, Action N, Q-values: [-5.02 -4.40 -5.10 -4.87 -20.21 -15.40]
State 427, Action N, Q-values: [-2.96 -2.30 -2.70 -3.05 -13.58 -12.95]

State 428, Action N, Q-values: [+0.18 +0.48 -1.10 +0.18 -9.09 -10.40]
State 429, Action N, Q-values: [-3.59 -3.07 -3.71 -3.51 -14.46 -12.91]
State 430, Action S, Q-values: [+3.19 +2.80 +2.64 +3.01 -6.72 -4.22]
State 431, Action N, Q-values: [-2.93 -2.33 -3.61 -2.84 -12.03 -12.60]
State 432, Action N, Q-values: [-3.77 -3.04 -3.47 -3.81 -15.79 -13.47]
State 433, Action N, Q-values: [-2.25 -1.54 -2.02 -2.35 -12.72 -12.78]
State 434, Action N, Q-values: [-3.83 -3.08 -3.54 -3.46 -14.40 -12.83]
State 435, Action S, Q-values: [+3.10 +2.79 +2.51 +2.93 -6.52 -4.35]
State 436, Action N, Q-values: [+4.80 +5.62 +3.60 +4.68 -5.69 -3.05]
State 437, Action E, Q-values: [+3.30 +3.51 +3.92 +3.50 -6.96 -5.93]
State 438, Action N, Q-values: [+4.54 +5.69 +3.81 +4.73 -5.64 -3.49]
State 439, Action N, Q-values: [+4.09 +4.89 +4.41 +4.21 -6.37 -4.34]
State 440, Action S, Q-values: [+3.18 +2.84 +2.59 +3.12 -6.41 -4.36]
State 441, Action N, Q-values: [-4.33 -3.78 -4.49 -4.02 -16.51 -13.73]
State 442, Action W, Q-values: [-1.17 -1.15 -1.26 -0.56 -11.21 -11.34]
State 443, Action W, Q-values: [-3.73 -3.71 -3.92 -3.07 -13.93 -13.25]
State 444, Action N, Q-values: [-4.27 -3.73 -4.43 -4.15 -16.86 -13.88]
State 445, Action S, Q-values: [+3.25 +2.89 +2.60 +3.03 -6.46 -4.18]
State 446, Action N, Q-values: [-4.38 -3.75 -4.26 -4.46 -17.26 -14.20]
State 447, Action N, Q-values: [-2.12 -1.52 -1.81 -2.63 -13.82 -12.34]
State 448, Action N, Q-values: [-1.57 -0.56 -1.81 -0.95 -11.57 -11.58]
State 449, Action N, Q-values: [-4.30 -3.82 -4.59 -4.05 -16.92 -13.65]
State 450, Action S, Q-values: [+3.00 +2.80 +2.55 +2.92 -6.29 -4.34]
State 451, Action W, Q-values: [-3.80 -3.52 -3.85 -3.08 -14.68 -12.94]
State 452, Action N, Q-values: [-2.86 -2.31 -2.79 -2.93 -12.18 -11.98]
State 453, Action N, Q-values: [-1.44 -0.60 -0.81 -1.88 -12.40 -11.00]
State 454, Action N, Q-values: [-3.36 -2.40 -2.98 -2.94 -12.41 -12.80]
State 455, Action S, Q-values: [+3.12 +2.90 +2.66 +3.11 -6.51 -4.22]
State 456, Action N, Q-values: [+4.30 +4.96 +3.83 +4.58 -6.34 -3.95]
State 457, Action N, Q-values: [+3.66 +5.06 +3.95 +3.64 -6.18 -4.74]
State 458, Action W, Q-values: [+4.58 +4.60 +3.87 +4.90 -6.17 -3.90]
State 459, Action N, Q-values: [+5.25 +6.49 +5.20 +4.99 -4.59 -2.32]
State 460, Action S, Q-values: [+3.18 +2.91 +2.64 +3.07 -6.71 -4.16]
State 461, Action N, Q-values: [-5.06 -4.42 -5.15 -4.83 -20.15 -15.34]
State 462, Action N, Q-values: [-2.32 -1.48 -2.86 -2.09 -12.69 -12.51]
State 463, Action N, Q-values: [-4.17 -3.79 -4.56 -4.19 -17.02 -14.08]
State 464, Action N, Q-values: [-3.38 -3.07 -3.11 -3.40 -13.99 -13.03]
State 465, Action S, Q-values: [+3.18 +2.88 +2.66 +3.05 -6.67 -4.49]
State 466, Action E, Q-values: [-3.35 -3.38 -3.04 -3.39 -14.18 -13.55]
State 467, Action E, Q-values: [-1.23 -1.19 -0.63 -1.61 -13.17 -12.16]
State 468, Action N, Q-values: [-2.22 -1.52 -2.74 -2.27 -12.63 -12.26]
State 469, Action N, Q-values: [-5.00 -4.41 -5.23 -4.70 -19.78 -15.51]
State 470, Action S, Q-values: [+3.21 +2.90 +2.58 +3.02 -6.80 -4.15]
State 471, Action N, Q-values: [-4.46 -3.90 -4.54 -4.23 -17.63 -13.61]
State 472, Action P, Q-values: [+1.65 +0.41 +1.30 +1.82 +2.92 -6.64]
State 473, Action P, Q-values: [+4.17 +3.30 +2.84 +3.87 +6.02 -2.92]
State 474, Action P, Q-values: [+1.11 +0.35 +1.48 +1.60 +2.88 -6.95]
State 475, Action S, Q-values: [+3.15 +2.98 +2.75 +3.05 -6.62 -4.47]
State 476, Action N, Q-values: [+3.24 +4.42 +2.24 +3.54 -6.45 -1.70]
State 477, Action N, Q-values: [+6.04 +7.75 +7.71 +6.62 -2.63 +2.21]
State 478, Action N, Q-values: [+3.27 +4.36 +1.40 +3.29 -7.50 -3.00]
State 479, Action D, Q-values: [+16.80 +14.55 +14.49 +15.92 +7.01 +20.00]
State 480, Action S, Q-values: [+3.25 +2.87 +2.60 +3.02 -6.56 -4.30]
State 481, Action W, Q-values: [-5.11 -5.23 -5.20 -4.91 -20.08 -16.05]
State 482, Action W, Q-values: [-2.63 -2.60 -2.53 -2.19 -12.89 -12.19]
State 483, Action N, Q-values: [-5.10 -4.39 -5.15 -4.64 -19.47 -14.99]
State 484, Action N, Q-values: [-2.88 -2.31 -2.69 -3.14 -13.58 -12.38]

State 485, Action S, Q-values: [+3.09 +2.84 +2.53 +3.01 -6.13 -4.30]
State 486, Action N, Q-values: [-2.93 -2.30 -2.79 -3.14 -13.99 -12.76]
State 487, Action N, Q-values: [+0.20 +0.42 -0.13 +0.04 -10.03 -10.31]
State 488, Action N, Q-values: [-2.99 -2.32 -2.91 -2.55 -13.20 -12.33]
State 489, Action W, Q-values: [-5.29 -5.25 -5.38 -4.87 -20.75 -16.12]
State 490, Action S, Q-values: [+3.20 +2.65 +2.49 +3.01 -6.33 -4.33]
State 491, Action N, Q-values: [-5.20 -4.44 -5.21 -4.60 -19.42 -15.16]
State 492, Action W, Q-values: [+0.48 -0.55 +0.14 +1.69 -8.94 -10.03]
State 493, Action W, Q-values: [+3.13 +2.76 +3.57 +4.31 -5.49 -4.54]
State 494, Action W, Q-values: [+1.07 -0.71 +0.45 +1.62 -9.30 -9.34]
State 495, Action S, Q-values: [+3.12 +2.76 +2.57 +3.08 -6.73 -4.54]
State 496, Action W, Q-values: [+2.06 +2.23 +2.03 +2.66 -9.45 -7.35]
State 497, Action N, Q-values: [+7.71 +9.74 +7.66 +6.71 -0.93 -0.97]
State 498, Action W, Q-values: [+2.00 +2.25 +1.92 +2.59 -8.58 -7.62]
State 499, Action W, Q-values: [+14.72 +13.17 +14.50 +17.03 +3.15 +5.01]
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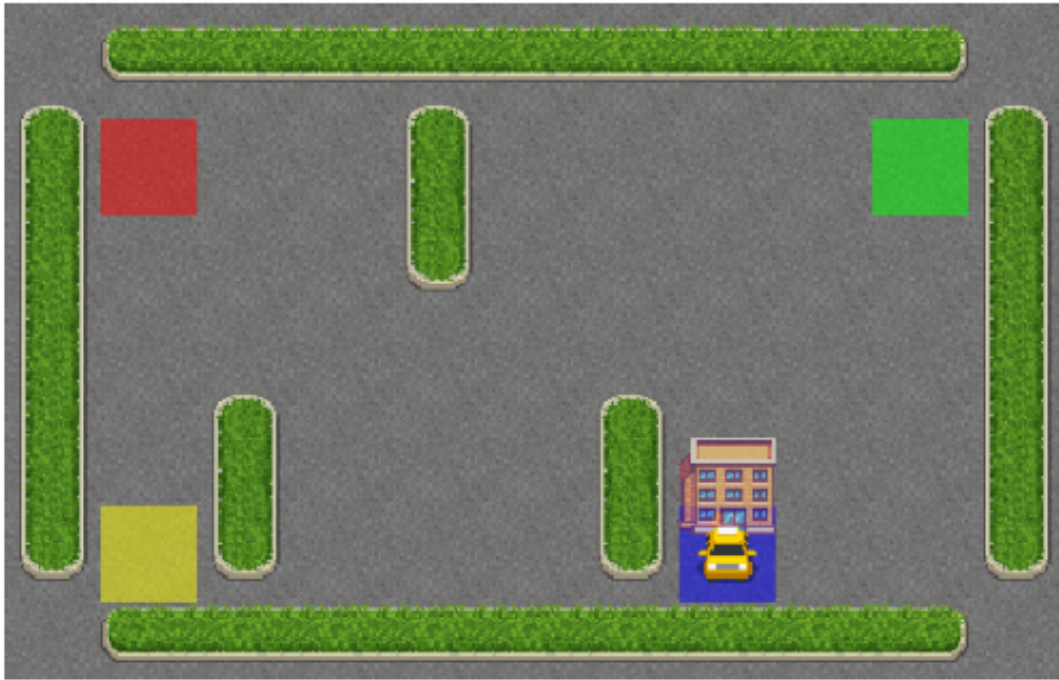
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Episode 998: Total Reward = 14
Episode 999: Total Reward = 4
Episode 1000: Total Reward = 9
Average Reward across all Episodes: = 8.02
CPU times: user 1.02 s, sys: 131 ms, total: 1.15 s
Wall time: 656 ms
```

```
In [85]: # # only to have a look of the test play result
         my_dqn_agent_fine_tuned.test(test_episodes=5, display=True)
```


Taxi-v3 | Episode: 4 | Step: 12

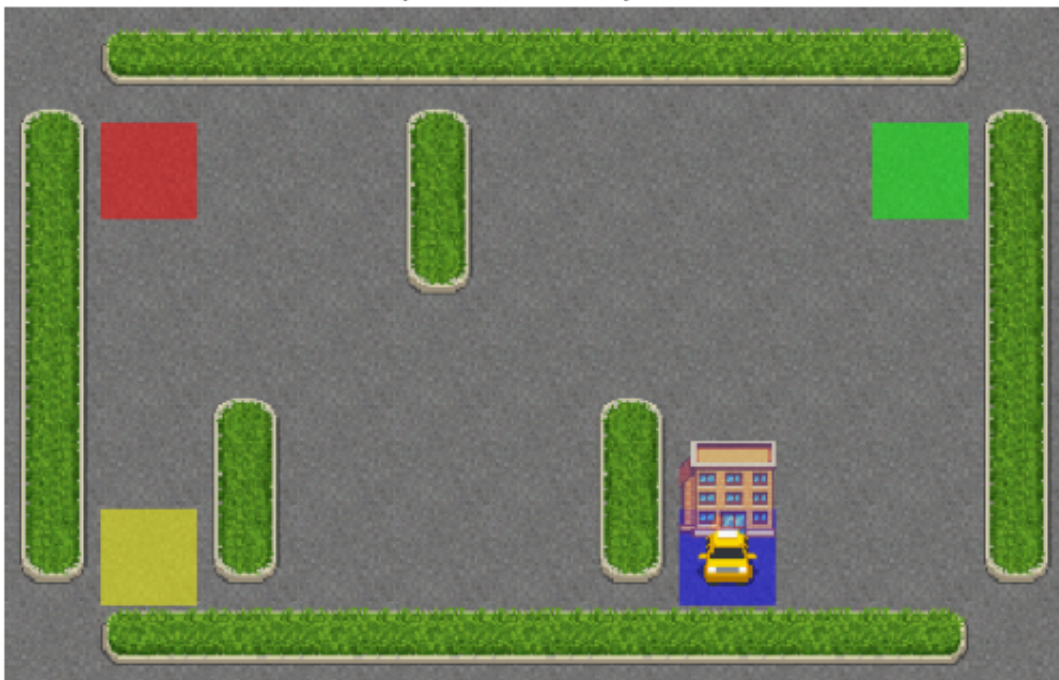


Episode 5: Total Reward = 9

Average Reward across all Episodes: = 8.8

Out[85]: [14, 10, 5, 6, 9]

Taxi-v3 | Episode: 4 | Step: 12



In [86]: `my_dqn_agent_fine_tuned.test_to_gif(filename="taxi_dqn_fine_tuned", episod`

Policy (trained):

State 000, Action S, Q-values: [+3.28 +2.97 +2.57 +3.14 -6.41 -4.24]

State 001, Action P, Q-values: [-0.06 +0.25 -0.07 +0.56 +1.62 -7.34]

State 002, Action P, Q-values: [+4.88 +5.60 +3.82 +5.23 +7.83 -2.38]

State 003, Action P, Q-values: [+0.83 +1.55 +0.80 +1.53 +2.93 -6.61]

State 004, Action S, Q-values: [-4.90 -5.50 -5.24 -5.03 -20.64 -16.31]

State 005, Action S, Q-values: [+3.30 +3.01 +2.70 +3.12 -6.39 -4.10]

State 006, Action S, Q-values: [-4.91 -5.56 -5.04 -4.93 -20.70 -15.53]

State 007, Action E, Q-values: [-3.11 -3.47 -3.08 -3.16 -12.66 -12.61]

State 008, Action S, Q-values: [+1.50 +0.41 -0.06 +0.83 -10.00 -10.78]
State 009, Action S, Q-values: [-2.36 -3.56 -3.31 -3.10 -14.26 -13.08]
State 010, Action S, Q-values: [+3.26 +2.81 +2.52 +3.06 -6.52 -4.19]
State 011, Action S, Q-values: [-1.47 -2.78 -2.56 -2.35 -12.11 -12.46]
State 012, Action S, Q-values: [-3.60 -4.53 -4.08 -4.12 -16.06 -13.86]
State 013, Action S, Q-values: [-2.23 -3.08 -2.39 -3.00 -12.47 -11.94]
State 014, Action S, Q-values: [-3.75 -4.26 -3.83 -4.30 -16.79 -13.16]
State 015, Action S, Q-values: [+3.17 +2.82 +2.56 +3.01 -6.71 -4.35]
State 016, Action D, Q-values: [+14.84 +16.31 +14.28 +15.92 +6.97 +20.00]
State 017, Action S, Q-values: [+2.93 +1.86 +2.87 +2.03 -7.93 -3.28]
State 018, Action S, Q-values: [+9.71 +7.32 +6.03 +7.68 -2.44 +1.72]
State 019, Action S, Q-values: [+4.43 +2.97 +4.42 +3.40 -6.99 -2.36]
State 020, Action S, Q-values: [+3.22 +2.85 +2.48 +3.01 -6.76 -4.35]
State 021, Action W, Q-values: [-1.03 -0.72 -0.06 +0.44 -9.34 -10.39]
State 022, Action W, Q-values: [+3.76 +4.76 +5.00 +5.98 -3.84 -3.49]
State 023, Action W, Q-values: [-0.09 +1.06 +1.00 +1.65 -6.93 -9.67]
State 024, Action S, Q-values: [-4.40 -4.88 -4.79 -4.75 -18.36 -15.41]
State 025, Action S, Q-values: [+3.47 +2.99 +2.87 +3.23 -6.43 -4.25]
State 026, Action S, Q-values: [-4.35 -5.17 -5.01 -4.92 -19.51 -15.92]
State 027, Action S, Q-values: [-2.31 -3.37 -2.71 -3.01 -13.71 -12.42]
State 028, Action S, Q-values: [+0.30 -0.57 -0.64 +0.24 -10.21 -11.01]
State 029, Action S, Q-values: [-3.09 -3.64 -3.62 -3.56 -13.99 -13.10]
State 030, Action S, Q-values: [+3.27 +2.78 +2.51 +3.03 -6.59 -4.37]
State 031, Action S, Q-values: [-2.31 -4.09 -3.06 -2.71 -13.42 -12.33]
State 032, Action S, Q-values: [-3.05 -3.98 -3.42 -3.97 -15.86 -13.81]
State 033, Action S, Q-values: [-1.47 -2.32 -2.20 -2.04 -12.00 -12.50]
State 034, Action S, Q-values: [-3.08 -4.10 -3.60 -3.51 -13.81 -13.16]
State 035, Action S, Q-values: [+3.32 +3.08 +2.67 +3.20 -6.81 -4.15]
State 036, Action W, Q-values: [+14.31 +14.31 +15.02 +17.04 +3.69 +6.29]
State 037, Action S, Q-values: [+4.47 +2.76 +3.00 +2.45 -6.66 -4.86]
State 038, Action S, Q-values: [+7.35 +5.38 +5.41 +6.56 -4.70 -1.64]
State 039, Action S, Q-values: [+6.02 +3.99 +4.28 +3.09 -5.51 -4.88]
State 040, Action S, Q-values: [+3.25 +2.79 +2.64 +3.08 -6.21 -4.29]
State 041, Action S, Q-values: [-3.71 -4.37 -4.46 -4.10 -16.32 -13.92]
State 042, Action S, Q-values: [-0.75 -1.57 -2.01 -1.25 -11.01 -11.77]
State 043, Action S, Q-values: [-3.06 -3.81 -3.87 -3.43 -15.18 -13.57]
State 044, Action E, Q-values: [-1.43 -1.28 -0.56 -0.99 -11.63 -10.91]
State 045, Action S, Q-values: [+2.91 +2.51 +2.35 +2.71 -6.89 -4.53]
State 046, Action E, Q-values: [-1.55 -1.91 -0.57 -1.49 -12.44 -11.90]
State 047, Action E, Q-values: [+1.53 +1.80 +2.93 +1.89 -7.58 -7.07]
State 048, Action S, Q-values: [-0.60 -1.79 -1.99 -1.13 -11.51 -11.94]
State 049, Action S, Q-values: [-3.76 -4.34 -4.05 -4.08 -15.88 -13.16]
State 050, Action S, Q-values: [+3.22 +2.76 +2.43 +2.97 -6.35 -4.15]
State 051, Action S, Q-values: [-3.08 -3.80 -3.73 -3.60 -14.66 -13.32]
State 052, Action S, Q-values: [-2.34 -3.17 -2.64 -2.78 -13.39 -12.51]
State 053, Action E, Q-values: [-0.98 -1.56 -0.74 -1.37 -11.60 -11.64]
State 054, Action S, Q-values: [-2.35 -3.51 -3.00 -3.25 -12.66 -12.63]
State 055, Action S, Q-values: [+3.06 +2.69 +2.45 +2.93 -6.80 -4.29]
State 056, Action S, Q-values: [+6.00 +4.55 +3.25 +4.93 -5.04 -3.23]
State 057, Action E, Q-values: [+10.77 +12.61 +14.33 +12.15 +2.30 +3.75]
State 058, Action S, Q-values: [+6.02 +3.97 +3.27 +4.09 -5.28 -5.14]
State 059, Action S, Q-values: [+7.24 +5.30 +6.04 +6.12 -4.94 -2.05]
State 060, Action S, Q-values: [+3.21 +2.92 +2.60 +3.01 -6.56 -4.18]
State 061, Action W, Q-values: [-4.36 -5.23 -5.10 -4.36 -17.92 -15.38]
State 062, Action S, Q-values: [-1.63 -2.18 -2.42 -1.73 -12.10 -11.74]
State 063, Action W, Q-values: [-3.75 -4.17 -4.42 -3.74 -16.24 -14.30]
State 064, Action E, Q-values: [-0.61 -0.65 +0.47 -1.01 -9.32 -9.21]

State 065, Action S, Q-values: [+3.23 +3.08 +2.71 +3.12 -6.40 -4.01]
State 066, Action E, Q-values: [-0.37 -0.98 +0.45 -0.52 -9.25 -8.79]
State 067, Action E, Q-values: [+2.33 +3.10 +4.39 +2.32 -3.71 -5.76]
State 068, Action S, Q-values: [-1.52 -2.42 -3.07 -1.95 -10.98 -12.01]
State 069, Action W, Q-values: [-4.38 -4.87 -4.83 -4.36 -18.00 -14.76]
State 070, Action S, Q-values: [+3.12 +2.52 +2.40 +2.87 -6.66 -4.36]
State 071, Action S, Q-values: [-3.75 -4.63 -4.76 -3.82 -16.93 -14.56]
State 072, Action S, Q-values: [-1.52 -2.39 -2.55 -2.39 -12.45 -12.44]
State 073, Action S, Q-values: [+0.48 -0.80 -0.77 -1.05 -10.67 -11.38]
State 074, Action S, Q-values: [-1.50 -2.41 -2.71 -2.11 -12.56 -12.60]
State 075, Action S, Q-values: [+3.32 +2.95 +2.70 +3.08 -6.39 -4.11]
State 076, Action W, Q-values: [+4.38 +2.93 +2.29 +4.38 -6.86 -5.45]
State 077, Action E, Q-values: [+11.91 +14.38 +17.02 +13.46 +2.02 +2.86]
State 078, Action S, Q-values: [+4.38 +2.61 +2.19 +4.36 -5.76 -5.82]
State 079, Action S, Q-values: [+9.75 +7.13 +6.53 +6.24 -0.80 -0.70]
State 080, Action S, Q-values: [+3.22 +2.87 +2.59 +3.06 -6.32 -4.25]
State 081, Action W, Q-values: [-4.87 -5.45 -5.12 -4.86 -20.10 -15.52]
State 082, Action W, Q-values: [-2.47 -3.00 -2.63 -2.37 -13.82 -12.61]
State 083, Action W, Q-values: [-4.40 -4.89 -4.69 -4.32 -17.96 -14.42]
State 084, Action P, Q-values: [-0.10 +0.38 +0.20 +0.59 +1.62 -7.31]
State 085, Action S, Q-values: [+3.23 +2.99 +2.68 +3.13 -6.48 -4.03]
State 086, Action P, Q-values: [-0.11 +0.45 +0.17 +0.52 +1.63 -7.40]
State 087, Action P, Q-values: [+3.70 +3.99 +3.56 +3.65 +6.03 -3.29]
State 088, Action S, Q-values: [-2.37 -3.00 -2.69 -2.39 -12.23 -11.67]
State 089, Action S, Q-values: [-4.93 -5.45 -5.27 -4.94 -20.98 -16.05]
State 090, Action S, Q-values: [+3.45 +3.05 +2.83 +3.23 -6.38 -4.01]
State 091, Action W, Q-values: [-4.41 -5.04 -4.95 -4.37 -18.80 -15.04]
State 092, Action W, Q-values: [-2.35 -3.09 -3.02 -2.31 -12.91 -12.67]
State 093, Action S, Q-values: [-0.53 -1.72 -1.38 -0.90 -11.77 -12.03]
State 094, Action S, Q-values: [-2.41 -2.98 -2.69 -2.45 -13.69 -12.37]
State 095, Action S, Q-values: [+3.19 +2.82 +2.65 +3.02 -6.58 -4.27]
State 096, Action S, Q-values: [+2.94 +1.94 +1.73 +2.93 -8.86 -2.00]
State 097, Action D, Q-values: [+14.26 +15.56 +15.42 +14.72 +7.18 +20.00]
State 098, Action S, Q-values: [+2.91 +1.61 +1.71 +2.90 -9.06 -2.11]
State 099, Action S, Q-values: [+7.81 +6.31 +6.30 +7.76 -3.15 +2.51]
State 100, Action S, Q-values: [+3.22 +2.98 +2.77 +3.15 -6.67 -4.24]
State 101, Action N, Q-values: [-0.72 +0.46 -1.23 -0.34 -10.31 -10.44]
State 102, Action N, Q-values: [+3.43 +6.00 +4.66 +4.63 -3.80 -4.64]
State 103, Action N, Q-values: [+0.32 +1.45 +0.16 +0.99 -8.88 -7.90]
State 104, Action S, Q-values: [-4.35 -5.24 -4.54 -4.71 -19.09 -14.91]
State 105, Action S, Q-values: [+3.26 +2.86 +2.73 +3.05 -6.36 -4.10]
State 106, Action E, Q-values: [-4.43 -4.75 -4.40 -4.53 -18.70 -14.71]
State 107, Action S, Q-values: [-2.37 -3.50 -2.59 -2.72 -13.49 -11.99]
State 108, Action S, Q-values: [+2.91 +0.10 +1.31 +0.98 -9.12 -8.98]
State 109, Action S, Q-values: [-1.54 -2.99 -2.83 -2.08 -12.07 -12.33]
State 110, Action S, Q-values: [+3.40 +2.96 +2.71 +3.16 -6.58 -4.03]
State 111, Action S, Q-values: [-0.54 -2.57 -2.09 -1.51 -11.42 -12.13]
State 112, Action S, Q-values: [-2.99 -4.01 -3.07 -3.49 -13.79 -12.17]
State 113, Action S, Q-values: [-1.45 -2.72 -1.68 -1.87 -11.96 -11.81]
State 114, Action S, Q-values: [-3.03 -4.24 -3.48 -3.45 -13.60 -12.63]
State 115, Action S, Q-values: [+3.22 +2.92 +2.57 +3.15 -6.54 -4.17]
State 116, Action N, Q-values: [+12.08 +17.03 +13.22 +14.35 +2.41 +4.76]
State 117, Action S, Q-values: [+4.38 +1.61 +4.31 +3.51 -5.37 -5.63]
State 118, Action S, Q-values: [+11.91 +7.63 +8.14 +9.07 +1.23 +1.08]
State 119, Action S, Q-values: [+6.03 +2.92 +5.86 +4.86 -5.05 -3.94]
State 120, Action S, Q-values: [+3.08 +2.80 +2.53 +3.01 -6.44 -4.43]
State 121, Action N, Q-values: [-1.55 -0.46 -1.48 -0.50 -10.38 -10.07]

State 122, Action N, Q-values: [+2.04 +4.33 +3.41 +4.30 -6.68 -6.18]
State 123, Action W, Q-values: [-1.19 +0.51 -0.08 +0.57 -9.29 -10.20]
State 124, Action S, Q-values: [-3.80 -4.48 -4.24 -3.98 -15.94 -13.72]
State 125, Action S, Q-values: [+3.22 +2.84 +2.46 +3.11 -6.39 -4.44]
State 126, Action S, Q-values: [-3.73 -4.31 -4.11 -4.21 -15.83 -13.54]
State 127, Action S, Q-values: [-1.56 -2.66 -2.01 -2.09 -10.41 -11.45]
State 128, Action S, Q-values: [+1.63 -0.48 +0.63 +1.52 -7.86 -10.17]
State 129, Action S, Q-values: [-2.37 -3.75 -2.96 -2.41 -12.64 -12.16]
State 130, Action S, Q-values: [+3.62 +3.22 +2.88 +3.40 -6.20 -4.00]
State 131, Action W, Q-values: [-1.52 -2.85 -2.10 -1.51 -11.99 -12.15]
State 132, Action S, Q-values: [-2.37 -3.25 -2.97 -2.94 -13.21 -12.19]
State 133, Action S, Q-values: [-0.50 -1.93 -1.01 -1.19 -10.55 -11.24]
State 134, Action S, Q-values: [-2.32 -3.43 -3.27 -3.61 -12.80 -13.04]
State 135, Action S, Q-values: [+3.33 +2.99 +2.82 +3.20 -6.69 -4.08]
State 136, Action N, Q-values: [+10.16 +14.33 +12.36 +13.13 +2.43 +3.02]
State 137, Action S, Q-values: [+5.96 +3.16 +4.03 +3.31 -3.19 -3.17]
State 138, Action S, Q-values: [+9.12 +6.73 +7.52 +9.04 -2.12 +0.64]
State 139, Action S, Q-values: [+7.82 +4.92 +5.82 +5.33 -2.52 -1.48]
State 140, Action S, Q-values: [+3.08 +2.72 +2.50 +2.93 -6.57 -4.36]
State 141, Action S, Q-values: [-3.03 -4.24 -4.16 -3.60 -14.86 -13.36]
State 142, Action S, Q-values: [+0.45 -1.40 -1.34 -0.11 -8.68 -10.35]
State 143, Action S, Q-values: [-2.29 -3.28 -3.08 -2.91 -12.30 -12.07]
State 144, Action E, Q-values: [-2.54 -1.50 -1.45 -2.22 -11.78 -11.65]
State 145, Action S, Q-values: [+3.15 +2.78 +2.66 +3.02 -6.58 -4.44]
State 146, Action N, Q-values: [-2.64 -1.51 -1.55 -1.98 -11.82 -11.71]
State 147, Action E, Q-values: [-0.61 +1.62 +1.66 -0.23 -8.41 -9.93]
State 148, Action S, Q-values: [+0.44 -1.46 -1.16 -0.15 -9.89 -10.85]
State 149, Action S, Q-values: [-3.06 -3.98 -3.70 -3.43 -14.03 -12.82]
State 150, Action S, Q-values: [+3.26 +2.83 +2.63 +3.10 -6.90 -4.26]
State 151, Action S, Q-values: [-2.34 -3.53 -3.60 -3.03 -13.27 -12.53]
State 152, Action S, Q-values: [-1.47 -3.12 -1.83 -2.43 -11.55 -11.35]
State 153, Action E, Q-values: [+0.50 -1.65 +0.52 -0.31 -10.68 -11.82]
State 154, Action S, Q-values: [-1.50 -2.58 -1.59 -2.01 -11.48 -11.50]
State 155, Action S, Q-values: [+3.21 +3.04 +2.64 +3.09 -6.11 -4.22]
State 156, Action S, Q-values: [+7.77 +4.99 +4.97 +6.23 -1.81 -0.84]
State 157, Action E, Q-values: [+8.00 +11.88 +11.88 +9.72 +1.04 +0.84]
State 158, Action S, Q-values: [+7.74 +4.66 +5.19 +6.12 -2.11 -1.19]
State 159, Action E, Q-values: [+8.26 +6.36 +8.95 +7.16 -2.64 -0.96]
State 160, Action S, Q-values: [+3.04 +2.67 +2.42 +2.90 -6.45 -4.48]
State 161, Action S, Q-values: [-3.75 -4.28 -4.08 -3.75 -15.38 -13.29]
State 162, Action S, Q-values: [-0.56 -2.25 -2.02 -0.58 -10.39 -11.22]
State 163, Action S, Q-values: [-3.08 -4.21 -4.16 -3.08 -14.55 -13.28]
State 164, Action E, Q-values: [-1.77 -0.68 -0.58 -1.93 -10.68 -11.44]
State 165, Action S, Q-values: [+3.24 +2.81 +2.59 +3.03 -6.52 -4.26]
State 166, Action E, Q-values: [-1.74 -0.62 -0.59 -1.34 -11.20 -10.63]
State 167, Action E, Q-values: [+0.86 +2.91 +2.93 +1.01 -8.26 -7.61]
State 168, Action S, Q-values: [-0.58 -2.02 -2.03 -0.59 -11.12 -11.94]
State 169, Action S, Q-values: [-3.70 -4.57 -4.33 -3.92 -16.59 -13.81]
State 170, Action S, Q-values: [+3.36 +3.10 +2.78 +3.19 -6.31 -4.23]
State 171, Action S, Q-values: [-3.07 -3.66 -3.27 -3.07 -13.18 -12.37]
State 172, Action S, Q-values: [-0.57 -2.22 -2.26 -1.22 -10.66 -12.00]
State 173, Action S, Q-values: [+1.65 -0.38 -0.26 +0.03 -10.72 -9.21]
State 174, Action S, Q-values: [-0.46 -2.23 -2.05 -1.65 -11.45 -11.96]
State 175, Action S, Q-values: [+3.03 +2.66 +2.36 +2.82 -6.54 -4.65]
State 176, Action S, Q-values: [+6.01 +3.13 +3.50 +5.94 -5.16 -3.48]
State 177, Action N, Q-values: [+9.94 +14.34 +14.31 +11.29 +1.75 +2.46]
State 178, Action W, Q-values: [+5.78 +3.67 +4.21 +6.00 -4.07 -2.35]

State 179, Action S, Q-values: [+11.94 +8.32 +8.05 +8.40 +0.07 +1.96]
State 180, Action S, Q-values: [+3.35 +3.00 +2.70 +3.14 -6.24 -4.11]
State 181, Action W, Q-values: [-4.36 -5.65 -4.71 -4.32 -18.42 -15.15]
State 182, Action W, Q-values: [-1.67 -2.67 -2.21 -1.50 -12.02 -11.33]
State 183, Action S, Q-values: [-3.73 -4.45 -4.25 -3.77 -15.92 -13.91]
State 184, Action N, Q-values: [-0.63 +0.42 -0.27 -0.59 -9.45 -9.13]
State 185, Action S, Q-values: [+3.42 +3.02 +2.67 +3.16 -6.69 -4.04]
State 186, Action N, Q-values: [-0.80 +0.40 -0.83 -0.42 -9.88 -10.10]
State 187, Action N, Q-values: [+2.00 +4.38 +3.92 +1.70 -5.07 -6.43]
State 188, Action W, Q-values: [-1.57 -3.11 -2.26 -1.54 -12.80 -11.30]
State 189, Action S, Q-values: [-4.33 -5.05 -4.79 -4.39 -18.57 -15.01]
State 190, Action S, Q-values: [+3.09 +2.72 +2.41 +2.93 -6.23 -4.23]
State 191, Action W, Q-values: [-3.79 -4.68 -4.05 -3.72 -16.09 -13.79]
State 192, Action S, Q-values: [-1.46 -2.79 -1.81 -1.69 -12.84 -11.67]
State 193, Action S, Q-values: [+0.49 -1.32 -0.37 +0.19 -9.96 -10.98]
State 194, Action S, Q-values: [-1.49 -2.86 -2.06 -1.96 -12.67 -12.20]
State 195, Action W, Q-values: [+3.02 +2.86 +2.81 +3.07 -6.81 -4.41]
State 196, Action W, Q-values: [+4.35 +2.12 +3.46 +4.39 -5.95 -5.06]
State 197, Action N, Q-values: [+12.09 +17.04 +14.77 +13.66 +3.54 +4.25]
State 198, Action W, Q-values: [+4.34 +1.95 +3.17 +4.37 -6.84 -5.70]
State 199, Action S, Q-values: [+9.77 +5.95 +7.59 +8.80 -0.07 -0.87]
State 200, Action S, Q-values: [+3.22 +2.84 +2.62 +3.16 -6.61 -4.45]
State 201, Action N, Q-values: [-1.73 -0.55 -2.10 -1.21 -11.05 -11.63]
State 202, Action N, Q-values: [+2.53 +4.39 +2.38 +3.10 -6.29 -5.59]
State 203, Action N, Q-values: [-0.81 +0.43 -1.52 -0.46 -10.94 -11.24]
State 204, Action E, Q-values: [-4.21 -4.79 -3.73 -4.30 -17.53 -13.83]
State 205, Action S, Q-values: [+3.33 +3.07 +2.67 +3.20 -6.40 -4.04]
State 206, Action E, Q-values: [-4.39 -4.25 -3.73 -3.96 -16.61 -14.09]
State 207, Action E, Q-values: [-2.05 -2.98 -1.54 -1.96 -12.39 -11.93]
State 208, Action S, Q-values: [+4.34 +1.21 +2.19 +2.98 -6.44 -6.99]
State 209, Action S, Q-values: [-0.57 -2.34 -1.76 -1.47 -10.68 -11.30]
State 210, Action S, Q-values: [+3.14 +3.00 +2.60 +3.09 -6.58 -4.27]
State 211, Action S, Q-values: [+0.39 -1.64 -1.00 -0.21 -10.08 -9.94]
State 212, Action E, Q-values: [-3.08 -3.12 -2.43 -2.66 -11.56 -12.10]
State 213, Action E, Q-values: [-1.64 -2.03 -0.48 -1.39 -12.78 -11.92]
State 214, Action E, Q-values: [-3.21 -3.48 -2.32 -2.82 -12.63 -12.90]
State 215, Action S, Q-values: [+3.03 +2.79 +2.54 +2.99 -6.58 -4.31]
State 216, Action N, Q-values: [+10.17 +14.31 +10.87 +12.06 +2.10 +2.60]
State 217, Action E, Q-values: [+3.68 +4.15 +5.97 +3.94 -4.03 -4.72]
State 218, Action S, Q-values: [+14.33 +9.62 +10.12 +11.79 +1.35 +3.58]
State 219, Action E, Q-values: [+4.64 +5.25 +7.82 +5.80 -3.34 -2.93]
State 220, Action S, Q-values: [+3.33 +3.00 +2.66 +3.20 -6.45 -4.04]
State 221, Action W, Q-values: [-2.59 -1.45 -3.16 -1.43 -11.76 -12.96]
State 222, Action N, Q-values: [+1.02 +2.90 +0.94 +2.88 -7.88 -7.45]
State 223, Action W, Q-values: [-1.93 -0.56 -2.14 -0.55 -11.95 -11.60]
State 224, Action E, Q-values: [-3.89 -3.64 -3.05 -3.75 -15.41 -13.37]
State 225, Action S, Q-values: [+3.33 +2.84 +2.67 +3.14 -6.66 -4.18]
State 226, Action E, Q-values: [-3.41 -3.57 -3.04 -3.63 -14.11 -12.69]
State 227, Action E, Q-values: [-1.56 -2.39 -0.58 -2.68 -11.61 -12.01]
State 228, Action W, Q-values: [+1.62 +0.43 +1.41 +2.90 -8.45 -7.36]
State 229, Action W, Q-values: [-1.99 -2.42 -2.38 -1.42 -11.05 -12.55]
State 230, Action S, Q-values: [+3.27 +2.89 +2.53 +3.08 -6.07 -4.28]
State 231, Action W, Q-values: [-1.51 -1.92 -1.95 -0.59 -11.01 -11.30]
State 232, Action E, Q-values: [-2.55 -2.54 -1.59 -2.54 -12.26 -11.86]
State 233, Action E, Q-values: [-0.57 -1.23 +0.48 -1.24 -11.37 -10.07]
State 234, Action E, Q-values: [-2.39 -2.86 -1.53 -2.49 -12.48 -12.15]
State 235, Action S, Q-values: [+3.29 +2.82 +2.59 +3.08 -6.83 -4.29]

State 236, Action N, Q-values: [+8.34 +11.89 +8.84 +11.88 -0.05 +0.71]
State 237, Action E, Q-values: [+4.45 +6.33 +7.73 +4.63 -2.22 -3.60]
State 238, Action W, Q-values: [+9.22 +8.71 +9.10 +11.92 +1.30 +0.81]
State 239, Action E, Q-values: [+6.92 +7.78 +9.75 +7.02 +0.03 +0.58]
State 240, Action S, Q-values: [+3.18 +2.85 +2.50 +2.92 -6.59 -4.20]
State 241, Action W, Q-values: [-2.77 -3.04 -3.30 -2.28 -12.28 -12.52]
State 242, Action W, Q-values: [-0.28 +0.31 +0.09 +1.62 -7.80 -9.42]
State 243, Action W, Q-values: [-2.42 -2.50 -2.71 -1.46 -11.27 -11.76]
State 244, Action E, Q-values: [-3.30 -2.32 -2.29 -3.19 -13.10 -12.10]
State 245, Action S, Q-values: [+3.22 +2.94 +2.68 +3.15 -6.29 -4.15]
State 246, Action E, Q-values: [-3.52 -2.39 -2.35 -3.22 -13.06 -12.73]
State 247, Action E, Q-values: [-1.56 +0.32 +0.42 -1.34 -9.95 -10.87]
State 248, Action W, Q-values: [+0.92 -0.55 +0.18 +1.63 -10.23 -9.62]
State 249, Action W, Q-values: [-2.90 -3.88 -3.84 -2.27 -12.76 -13.18]
State 250, Action S, Q-values: [+3.21 +2.77 +2.55 +3.01 -6.92 -4.23]
State 251, Action W, Q-values: [-2.30 -2.85 -2.93 -1.48 -12.42 -12.62]
State 252, Action E, Q-values: [-1.48 -2.04 -0.56 -1.68 -11.41 -11.41]
State 253, Action E, Q-values: [+0.94 -0.23 +1.54 +0.32 -8.40 -7.37]
State 254, Action E, Q-values: [-1.44 -1.91 -0.58 -1.76 -10.31 -10.46]
State 255, Action S, Q-values: [+3.26 +2.66 +2.55 +3.00 -6.82 -4.21]
State 256, Action W, Q-values: [+7.53 +7.24 +7.12 +9.75 -0.84 -0.15]
State 257, Action N, Q-values: [+6.28 +9.70 +9.67 +6.27 -1.55 -1.89]
State 258, Action W, Q-values: [+7.92 +6.64 +6.93 +9.71 -0.80 +0.63]
State 259, Action E, Q-values: [+8.03 +9.53 +11.91 +8.68 +0.51 -0.06]
State 260, Action S, Q-values: [+3.21 +2.78 +2.46 +3.01 -6.41 -4.40]
State 261, Action W, Q-values: [-3.59 -3.67 -3.96 -3.04 -14.51 -13.43]
State 262, Action W, Q-values: [-1.38 -0.46 -1.09 +0.43 -9.76 -11.34]
State 263, Action W, Q-values: [-2.96 -3.28 -3.42 -2.32 -12.93 -12.78]
State 264, Action E, Q-values: [-2.44 -1.46 -1.44 -2.29 -11.57 -11.47]
State 265, Action S, Q-values: [+3.40 +3.01 +2.70 +3.19 -6.22 -4.03]
State 266, Action E, Q-values: [-2.58 -1.52 -1.49 -2.11 -11.66 -11.07]
State 267, Action E, Q-values: [-0.22 +1.61 +1.63 -0.05 -9.67 -8.77]
State 268, Action W, Q-values: [-0.51 -1.34 -1.44 +0.45 -10.74 -11.50]
State 269, Action W, Q-values: [-3.85 -3.99 -3.92 -3.05 -15.34 -13.82]
State 270, Action S, Q-values: [+3.26 +2.83 +2.44 +3.07 -6.71 -4.30]
State 271, Action W, Q-values: [-3.34 -3.53 -3.37 -2.37 -12.94 -13.15]
State 272, Action S, Q-values: [+0.47 -1.76 -1.06 -1.35 -9.52 -11.17]
State 273, Action S, Q-values: [+2.90 +0.41 +1.76 +1.89 -7.49 -6.31]
State 274, Action S, Q-values: [+0.41 -1.57 -1.38 -1.20 -10.80 -11.00]
State 275, Action S, Q-values: [+3.17 +2.98 +2.62 +3.02 -6.52 -4.17]
State 276, Action W, Q-values: [+5.08 +6.13 +4.87 +7.82 -2.97 -2.69]
State 277, Action N, Q-values: [+7.82 +11.87 +11.82 +8.40 +0.53 +0.00]
State 278, Action W, Q-values: [+5.98 +4.88 +5.30 +7.72 -2.16 -1.77]
State 279, Action S, Q-values: [+14.28 +9.54 +9.94 +10.85 +0.94 +3.50]
State 280, Action S, Q-values: [+3.15 +2.76 +2.56 +2.99 -6.38 -4.47]
State 281, Action W, Q-values: [-4.58 -4.75 -4.50 -3.69 -17.85 -14.76]
State 282, Action W, Q-values: [-1.43 -1.93 -1.58 -0.51 -11.12 -11.23]
State 283, Action W, Q-values: [-3.50 -4.06 -3.69 -3.04 -14.23 -13.18]
State 284, Action N, Q-values: [-1.75 -0.49 -1.58 -1.51 -11.77 -11.68]
State 285, Action S, Q-values: [+3.05 +2.68 +2.44 +2.89 -6.67 -4.27]
State 286, Action N, Q-values: [-2.08 -0.62 -1.55 -1.57 -11.72 -11.86]
State 287, Action N, Q-values: [+0.93 +2.92 +2.25 +1.41 -7.84 -7.77]
State 288, Action W, Q-values: [-1.38 -2.14 -1.40 -0.58 -11.71 -12.24]
State 289, Action W, Q-values: [-4.27 -5.24 -4.40 -3.71 -17.45 -14.65]
State 290, Action S, Q-values: [+3.24 +2.95 +2.67 +3.16 -6.37 -4.27]
State 291, Action W, Q-values: [-3.83 -3.88 -3.50 -2.97 -14.99 -13.06]
State 292, Action S, Q-values: [-0.54 -2.03 -1.33 -0.82 -10.82 -11.48]

State 293, Action W, Q-values: [+1.46 -0.09 +0.81 +1.66 -7.78 -10.14]
State 294, Action S, Q-values: [-0.53 -1.84 -1.28 -0.57 -11.05 -11.39]
State 295, Action S, Q-values: [+3.04 +2.45 +2.37 +2.82 -6.53 -4.52]
State 296, Action W, Q-values: [+3.65 +4.15 +4.70 +6.01 -4.11 -4.27]
State 297, Action N, Q-values: [+9.97 +14.34 +12.32 +10.96 +2.05 +2.21]
State 298, Action W, Q-values: [+3.55 +4.14 +5.04 +5.97 -4.40 -4.39]
State 299, Action W, Q-values: [+11.91 +8.49 +9.64 +11.95 +0.66 +2.36]
State 300, Action S, Q-values: [+3.23 +2.99 +2.61 +3.09 -6.19 -4.22]
State 301, Action N, Q-values: [-2.47 -1.45 -2.07 -1.96 -12.74 -12.14]
State 302, Action N, Q-values: [+0.97 +2.89 +2.17 +2.11 -9.07 -8.12]
State 303, Action N, Q-values: [-1.71 -0.57 -1.83 -1.34 -12.03 -11.65]
State 304, Action N, Q-values: [-5.25 -4.44 -5.12 -4.87 -19.67 -15.34]
State 305, Action S, Q-values: [+3.19 +2.67 +2.31 +2.83 -6.50 -4.19]
State 306, Action N, Q-values: [-5.19 -4.39 -4.96 -4.74 -19.75 -14.97]
State 307, Action N, Q-values: [-3.00 -2.39 -3.07 -2.77 -11.39 -11.49]
State 308, Action S, Q-values: [+5.95 +2.03 +4.14 +4.28 -4.81 -4.97]
State 309, Action S, Q-values: [+0.44 -1.65 -0.32 -0.19 -7.55 -8.97]
State 310, Action S, Q-values: [+3.18 +2.98 +2.70 +3.10 -6.66 -4.19]
State 311, Action S, Q-values: [+1.54 -0.48 +0.87 +0.53 -7.59 -8.26]
State 312, Action N, Q-values: [-3.88 -3.11 -3.62 -3.45 -13.98 -12.41]
State 313, Action N, Q-values: [-2.39 -1.50 -1.76 -2.30 -13.00 -11.76]
State 314, Action N, Q-values: [-3.89 -3.14 -3.68 -3.52 -14.43 -13.15]
State 315, Action S, Q-values: [+3.45 +3.05 +2.72 +3.25 -6.54 -3.94]
State 316, Action N, Q-values: [+7.98 +11.90 +9.46 +9.97 +1.26 +0.50]
State 317, Action N, Q-values: [+1.69 +4.37 +4.07 +2.75 -6.30 -7.45]
State 318, Action S, Q-values: [+16.99 +11.45 +13.68 +14.33 +3.18 +5.48]
State 319, Action N, Q-values: [+3.20 +6.04 +5.07 +4.70 -4.66 -4.87]
State 320, Action S, Q-values: [+3.25 +2.90 +2.57 +3.09 -6.54 -4.31]
State 321, Action N, Q-values: [-3.12 -2.33 -3.80 -3.02 -11.99 -12.96]
State 322, Action N, Q-values: [-0.50 +1.63 +0.25 +0.65 -7.89 -10.68]
State 323, Action N, Q-values: [-2.55 -1.51 -2.78 -2.13 -12.47 -12.02]
State 324, Action N, Q-values: [-4.52 -3.80 -4.31 -4.06 -17.71 -13.77]
State 325, Action S, Q-values: [+3.01 +2.75 +2.57 +2.90 -6.54 -4.51]
State 326, Action N, Q-values: [-4.49 -3.77 -4.16 -4.16 -17.54 -13.38]
State 327, Action E, Q-values: [-2.41 -1.64 -1.52 -1.84 -12.54 -12.11]
State 328, Action N, Q-values: [+0.31 +1.60 -0.01 +0.73 -9.83 -9.84]
State 329, Action N, Q-values: [-2.99 -2.32 -2.76 -2.89 -12.66 -11.86]
State 330, Action S, Q-values: [+3.20 +3.01 +2.55 +3.10 -6.48 -4.17]
State 331, Action N, Q-values: [-2.75 -1.50 -2.60 -1.67 -12.48 -12.32]
State 332, Action N, Q-values: [-3.23 -2.48 -2.85 -2.73 -11.71 -11.69]
State 333, Action E, Q-values: [-1.98 -0.73 -0.60 -1.52 -11.73 -11.36]
State 334, Action N, Q-values: [-3.27 -2.44 -2.81 -2.90 -13.11 -12.27]
State 335, Action S, Q-values: [+3.35 +3.00 +2.84 +3.16 -6.32 -4.00]
State 336, Action N, Q-values: [+6.19 +8.55 +5.79 +7.19 -3.18 -1.56]
State 337, Action E, Q-values: [+2.99 +5.41 +5.70 +4.71 -5.86 -4.99]
State 338, Action N, Q-values: [+6.54 +9.16 +6.55 +7.65 -2.03 -0.84]
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State 340, Action S, Q-values: [+3.26 +2.94 +2.77 +3.13 -6.72 -4.36]
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State 350, Action S, Q-values: [+3.15 +2.82 +2.55 +3.05 -6.84 -4.30]
State 351, Action W, Q-values: [-3.09 -2.35 -2.94 -2.33 -12.49 -11.71]
State 352, Action N, Q-values: [-2.62 -1.56 -1.73 -2.36 -13.59 -12.61]
State 353, Action N, Q-values: [-0.84 +0.37 -0.67 -0.61 -10.80 -10.86]
State 354, Action N, Q-values: [-1.99 -1.57 -1.81 -1.77 -12.61 -12.04]
State 355, Action S, Q-values: [+3.16 +3.01 +2.55 +3.10 -6.88 -4.31]
State 356, Action N, Q-values: [+4.39 +6.66 +5.19 +6.24 -4.81 -3.16]
State 357, Action N, Q-values: [+4.87 +7.44 +6.53 +4.73 -3.10 -3.15]
State 358, Action N, Q-values: [+4.78 +7.31 +5.45 +6.83 -3.87 -2.54]
State 359, Action N, Q-values: [+6.20 +9.07 +7.33 +6.49 -2.10 -2.31]
State 360, Action S, Q-values: [+3.30 +2.89 +2.73 +3.17 -6.57 -4.22]
State 361, Action N, Q-values: [-4.29 -3.77 -4.55 -4.14 -17.35 -13.85]
State 362, Action N, Q-values: [-1.57 -0.51 -1.51 -1.20 -10.89 -10.80]
State 363, Action N, Q-values: [-3.74 -3.09 -3.82 -3.39 -13.99 -12.33]
State 364, Action E, Q-values: [-3.15 -2.45 -2.24 -3.00 -13.60 -12.37]
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State 372, Action S, Q-values: [+1.61 -0.66 -0.05 +0.25 -7.52 -9.27]
State 373, Action S, Q-values: [+4.36 +1.90 +2.24 +3.81 -6.85 -5.18]
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State 376, Action N, Q-values: [+3.31 +6.01 +4.75 +4.77 -3.60 -4.76]
State 377, Action N, Q-values: [+6.23 +9.69 +9.66 +7.77 +0.27 -0.99]
State 378, Action N, Q-values: [+3.35 +5.98 +4.26 +5.13 -3.33 -5.02]
State 379, Action S, Q-values: [+16.97 +11.25 +12.15 +14.09 +3.31 +4.75]
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State 381, Action N, Q-values: [-4.94 -4.30 -5.09 -4.38 -19.75 -14.84]
State 382, Action N, Q-values: [-2.48 -1.50 -1.90 -1.94 -13.20 -12.25]
State 383, Action W, Q-values: [-4.55 -3.75 -4.45 -3.73 -16.32 -13.93]
State 384, Action N, Q-values: [-2.42 -1.41 -1.54 -2.49 -13.55 -12.76]
State 385, Action S, Q-values: [+3.18 +2.76 +2.48 +3.00 -6.62 -4.32]
State 386, Action N, Q-values: [-2.51 -1.55 -2.04 -2.27 -12.99 -12.44]
State 387, Action N, Q-values: [-0.71 +1.57 +0.98 -0.10 -8.42 -11.52]
State 388, Action N, Q-values: [-2.48 -1.54 -2.02 -1.89 -11.93 -11.56]
State 389, Action N, Q-values: [-5.13 -4.38 -5.17 -4.43 -19.11 -14.85]
State 390, Action S, Q-values: [+3.32 +2.98 +2.77 +3.27 -6.56 -4.18]
State 391, Action W, Q-values: [-4.33 -3.80 -4.53 -3.79 -16.01 -13.20]
State 392, Action W, Q-values: [+0.38 -1.47 -0.48 +0.47 -9.09 -10.24]
State 393, Action S, Q-values: [+3.01 +1.06 +2.18 +2.89 -8.13 -6.83]
State 394, Action W, Q-values: [+0.42 -1.21 -0.69 +0.50 -9.86 -10.96]
State 395, Action S, Q-values: [+3.16 +2.93 +2.69 +3.12 -6.42 -4.23]
State 396, Action N, Q-values: [+2.11 +4.25 +3.39 +3.88 -7.32 -6.46]
State 397, Action N, Q-values: [+7.87 +11.89 +9.43 +8.46 +0.78 -0.44]
State 398, Action N, Q-values: [+2.62 +4.32 +3.28 +4.17 -7.11 -5.56]
State 399, Action S, Q-values: [+14.32 +9.97 +11.51 +12.87 +2.04 +4.34]
State 400, Action S, Q-values: [+3.27 +2.97 +2.66 +3.08 -6.66 -4.17]
State 401, Action N, Q-values: [-2.93 -2.31 -2.79 -3.11 -13.12 -12.63]
State 402, Action N, Q-values: [+1.01 +1.81 +0.09 +1.47 -9.49 -10.35]
State 403, Action N, Q-values: [-2.10 -1.30 -2.02 -1.95 -12.81 -12.15]
State 404, Action N, Q-values: [-5.82 -5.01 -5.82 -5.29 -21.82 -16.63]
State 405, Action S, Q-values: [+3.16 +2.89 +2.61 +2.99 -6.23 -4.30]
State 406, Action N, Q-values: [-5.31 -4.93 -5.38 -5.17 -21.07 -16.10]

State 407, Action N, Q-values: [-3.64 -3.12 -3.79 -3.60 -14.92 -13.26]
State 408, Action P, Q-values: [+5.41 +4.27 +3.76 +5.09 +7.83 -2.40]
State 409, Action P, Q-values: [+0.39 +0.44 +0.62 +0.88 +1.61 -7.36]
State 410, Action S, Q-values: [+3.01 +2.81 +2.44 +2.91 -6.48 -4.51]
State 411, Action P, Q-values: [+1.13 +0.29 +1.44 +1.54 +2.88 -6.69]
State 412, Action N, Q-values: [-4.30 -3.73 -4.36 -4.01 -17.07 -13.29]
State 413, Action N, Q-values: [-2.99 -2.35 -2.84 -3.02 -14.10 -12.54]
State 414, Action N, Q-values: [-4.42 -3.76 -4.42 -4.21 -17.46 -14.15]
State 415, Action S, Q-values: [+2.98 +2.80 +2.60 +2.91 -6.65 -4.71]
State 416, Action N, Q-values: [+7.57 +9.77 +6.80 +8.32 -1.94 +2.09]
State 417, Action N, Q-values: [+1.95 +2.93 +1.35 +1.84 -8.76 -2.48]
State 418, Action D, Q-values: [+16.82 +14.52 +16.75 +16.17 +7.40 +19.98]
State 419, Action N, Q-values: [+2.95 +4.46 +3.07 +3.28 -5.96 -1.56]
State 420, Action S, Q-values: [+3.16 +2.71 +2.47 +2.93 -6.48 -4.28]
State 421, Action N, Q-values: [-3.47 -3.11 -3.92 -3.46 -13.84 -12.91]
State 422, Action N, Q-values: [-0.57 +0.48 -0.97 -0.30 -10.33 -10.35]
State 423, Action N, Q-values: [-2.95 -2.33 -3.24 -3.16 -14.13 -13.02]
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State 425, Action S, Q-values: [+3.06 +2.68 +2.33 +2.94 -6.85 -4.48]
State 426, Action N, Q-values: [-5.02 -4.40 -5.10 -4.87 -20.21 -15.40]
State 427, Action N, Q-values: [-2.96 -2.30 -2.70 -3.05 -13.58 -12.95]
State 428, Action N, Q-values: [+0.18 +0.48 -1.10 +0.18 -9.09 -10.40]
State 429, Action N, Q-values: [-3.59 -3.07 -3.71 -3.51 -14.46 -12.91]
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State 433, Action N, Q-values: [-2.25 -1.54 -2.02 -2.35 -12.72 -12.78]
State 434, Action N, Q-values: [-3.83 -3.08 -3.54 -3.46 -14.40 -12.83]
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State 436, Action N, Q-values: [+4.80 +5.62 +3.60 +4.68 -5.69 -3.05]
State 437, Action E, Q-values: [+3.30 +3.51 +3.92 +3.50 -6.96 -5.93]
State 438, Action N, Q-values: [+4.54 +5.69 +3.81 +4.73 -5.64 -3.49]
State 439, Action N, Q-values: [+4.09 +4.89 +4.41 +4.21 -6.37 -4.34]
State 440, Action S, Q-values: [+3.18 +2.84 +2.59 +3.12 -6.41 -4.36]
State 441, Action N, Q-values: [-4.33 -3.78 -4.49 -4.02 -16.51 -13.73]
State 442, Action W, Q-values: [-1.17 -1.15 -1.26 -0.56 -11.21 -11.34]
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State 444, Action N, Q-values: [-4.27 -3.73 -4.43 -4.15 -16.86 -13.88]
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State 446, Action N, Q-values: [-4.38 -3.75 -4.26 -4.46 -17.26 -14.20]
State 447, Action N, Q-values: [-2.12 -1.52 -1.81 -2.63 -13.82 -12.34]
State 448, Action N, Q-values: [-1.57 -0.56 -1.81 -0.95 -11.57 -11.58]
State 449, Action N, Q-values: [-4.30 -3.82 -4.59 -4.05 -16.92 -13.65]
State 450, Action S, Q-values: [+3.00 +2.80 +2.55 +2.92 -6.29 -4.34]
State 451, Action W, Q-values: [-3.80 -3.52 -3.85 -3.08 -14.68 -12.94]
State 452, Action N, Q-values: [-2.86 -2.31 -2.79 -2.93 -12.18 -11.98]
State 453, Action N, Q-values: [-1.44 -0.60 -0.81 -1.88 -12.40 -11.00]
State 454, Action N, Q-values: [-3.36 -2.40 -2.98 -2.94 -12.41 -12.80]
State 455, Action S, Q-values: [+3.12 +2.90 +2.66 +3.11 -6.51 -4.22]
State 456, Action N, Q-values: [+4.30 +4.96 +3.83 +4.58 -6.34 -3.95]
State 457, Action N, Q-values: [+3.66 +5.06 +3.95 +3.64 -6.18 -4.74]
State 458, Action W, Q-values: [+4.58 +4.60 +3.87 +4.90 -6.17 -3.90]
State 459, Action N, Q-values: [+5.25 +6.49 +5.20 +4.99 -4.59 -2.32]
State 460, Action S, Q-values: [+3.18 +2.91 +2.64 +3.07 -6.71 -4.16]
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State 462, Action N, Q-values: [-2.32 -1.48 -2.86 -2.09 -12.69 -12.51]
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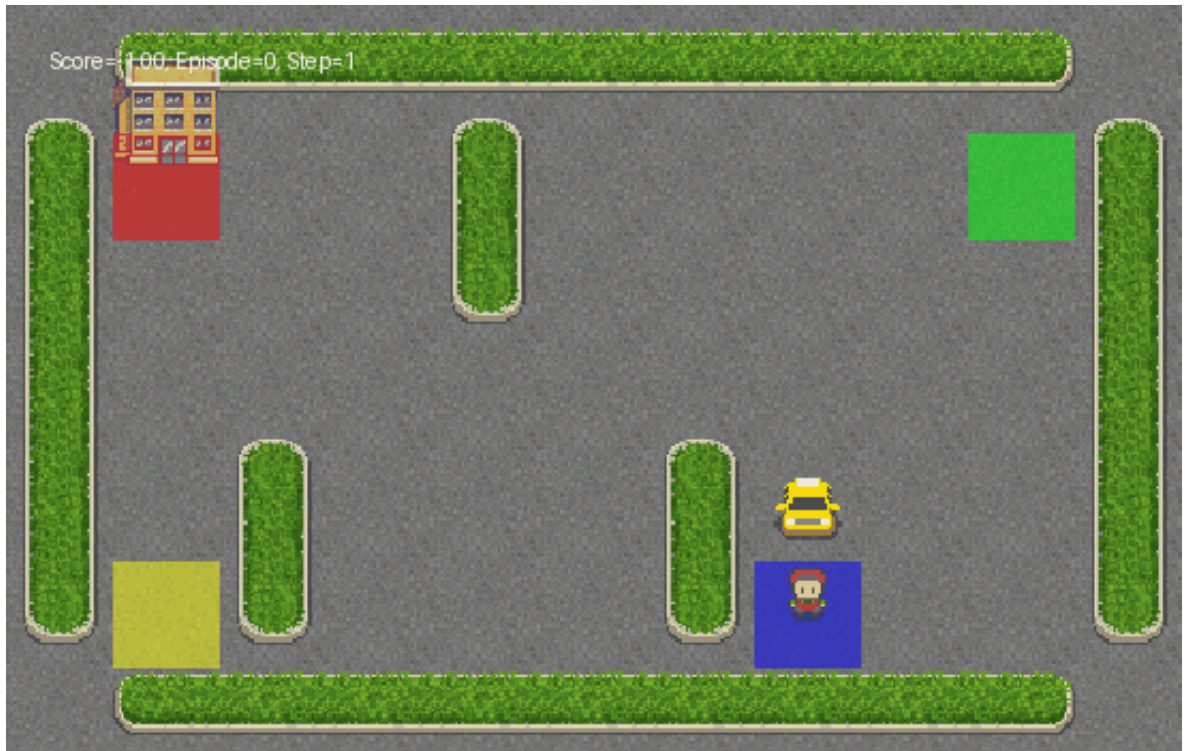
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State 471, Action N, Q-values: [-4.46 -3.90 -4.54 -4.23 -17.63 -13.61]
State 472, Action P, Q-values: [+1.65 +0.41 +1.30 +1.82 +2.92 -6.64]
State 473, Action P, Q-values: [+4.17 +3.30 +2.84 +3.87 +6.02 -2.92]
State 474, Action P, Q-values: [+1.11 +0.35 +1.48 +1.60 +2.88 -6.95]
State 475, Action S, Q-values: [+3.15 +2.98 +2.75 +3.05 -6.62 -4.47]
State 476, Action N, Q-values: [+3.24 +4.42 +2.24 +3.54 -6.45 -1.70]
State 477, Action N, Q-values: [+6.04 +7.75 +7.71 +6.62 -2.63 +2.21]
State 478, Action N, Q-values: [+3.27 +4.36 +1.40 +3.29 -7.50 -3.00]
State 479, Action D, Q-values: [+16.80 +14.55 +14.49 +15.92 +7.01 +20.00]
State 480, Action S, Q-values: [+3.25 +2.87 +2.60 +3.02 -6.56 -4.30]
State 481, Action W, Q-values: [-5.11 -5.23 -5.20 -4.91 -20.08 -16.05]
State 482, Action W, Q-values: [-2.63 -2.60 -2.53 -2.19 -12.89 -12.19]
State 483, Action N, Q-values: [-5.10 -4.39 -5.15 -4.64 -19.47 -14.99]
State 484, Action N, Q-values: [-2.88 -2.31 -2.69 -3.14 -13.58 -12.38]
State 485, Action S, Q-values: [+3.09 +2.84 +2.53 +3.01 -6.13 -4.30]
State 486, Action N, Q-values: [-2.93 -2.30 -2.79 -3.14 -13.99 -12.76]
State 487, Action N, Q-values: [+0.20 +0.42 -0.13 +0.04 -10.03 -10.31]
State 488, Action N, Q-values: [-2.99 -2.32 -2.91 -2.55 -13.20 -12.33]
State 489, Action W, Q-values: [-5.29 -5.25 -5.38 -4.87 -20.75 -16.12]
State 490, Action S, Q-values: [+3.20 +2.65 +2.49 +3.01 -6.33 -4.33]
State 491, Action N, Q-values: [-5.20 -4.44 -5.21 -4.60 -19.42 -15.16]
State 492, Action W, Q-values: [+0.48 -0.55 +0.14 +1.69 -8.94 -10.03]
State 493, Action W, Q-values: [+3.13 +2.76 +3.57 +4.31 -5.49 -4.54]
State 494, Action W, Q-values: [+1.07 -0.71 +0.45 +1.62 -9.30 -9.34]
State 495, Action S, Q-values: [+3.12 +2.76 +2.57 +3.08 -6.73 -4.54]
State 496, Action W, Q-values: [+2.06 +2.23 +2.03 +2.66 -9.45 -7.35]
State 497, Action N, Q-values: [+7.71 +9.74 +7.66 +6.71 -0.93 -0.97]
State 498, Action W, Q-values: [+2.00 +2.25 +1.92 +2.59 -8.58 -7.62]
State 499, Action W, Q-values: [+14.72 +13.17 +14.50 +17.03 +3.15 +5.01]
episodes: 0, acton: 0, state: 272
episodes: 0, acton: 0, state: 372
episodes: 0, acton: 4, state: 472
episodes: 0, acton: 1, state: 476
episodes: 0, acton: 1, state: 376
episodes: 0, acton: 3, state: 276
episodes: 0, acton: 3, state: 256
episodes: 0, acton: 1, state: 236
episodes: 0, acton: 1, state: 136
episodes: 0, acton: 3, state: 36
episodes: 0, acton: 5, state: 16
Episode 1: Total Reward = 10
episodes: 1, acton: 0, state: 31
episodes: 1, acton: 3, state: 131
episodes: 1, acton: 0, state: 111
episodes: 1, acton: 0, state: 211
episodes: 1, acton: 0, state: 311
episodes: 1, acton: 4, state: 411
episodes: 1, acton: 1, state: 419
episodes: 1, acton: 1, state: 319
episodes: 1, acton: 2, state: 219

```
episodes: 1, acton: 2, state: 239
episodes: 1, acton: 2, state: 259
episodes: 1, acton: 0, state: 279
episodes: 1, acton: 0, state: 379
episodes: 1, acton: 5, state: 479
Episode 2: Total Reward = 7
episodes: 2, acton: 0, state: 33
episodes: 2, acton: 0, state: 133
episodes: 2, acton: 2, state: 233
episodes: 2, acton: 2, state: 253
episodes: 2, acton: 0, state: 273
episodes: 2, acton: 0, state: 373
episodes: 2, acton: 4, state: 473
episodes: 2, acton: 1, state: 477
episodes: 2, acton: 1, state: 377
episodes: 2, acton: 1, state: 277
episodes: 2, acton: 1, state: 177
episodes: 2, acton: 2, state: 77
episodes: 2, acton: 5, state: 97
Episode 3: Total Reward = 8
episodes: 3, acton: 1, state: 426
episodes: 3, acton: 1, state: 326
episodes: 3, acton: 2, state: 226
episodes: 3, acton: 2, state: 246
episodes: 3, acton: 2, state: 266
episodes: 3, acton: 1, state: 286
episodes: 3, acton: 1, state: 186
episodes: 3, acton: 4, state: 86
episodes: 3, acton: 0, state: 98
episodes: 3, acton: 3, state: 198
episodes: 3, acton: 3, state: 178
episodes: 3, acton: 0, state: 158
episodes: 3, acton: 3, state: 258
episodes: 3, acton: 3, state: 238
episodes: 3, acton: 0, state: 218
episodes: 3, acton: 0, state: 318
episodes: 3, acton: 5, state: 418
Episode 4: Total Reward = 4
episodes: 4, acton: 1, state: 328
episodes: 4, acton: 3, state: 228
episodes: 4, acton: 0, state: 208
episodes: 4, acton: 0, state: 308
episodes: 4, acton: 4, state: 408
episodes: 4, acton: 1, state: 416
episodes: 4, acton: 1, state: 316
episodes: 4, acton: 1, state: 216
episodes: 4, acton: 1, state: 116
episodes: 4, acton: 5, state: 16
Episode 5: Total Reward = 11
Saving gif...Done!
Average Reward across all Episodes: = 8.0
```

```
In [87]: # display the captured GIF
display.Image(data=open("./gifs/taxi_dqn_fine_tuned.gif",'rb').read(), fo
# "taxi_dqn_fine_tuned"
```

```
Out[87]: <IPython.core.display.Image object>
```

If the above display function is not working, here is the previously prepared `taxi_dqn_fine_tuned.gif`



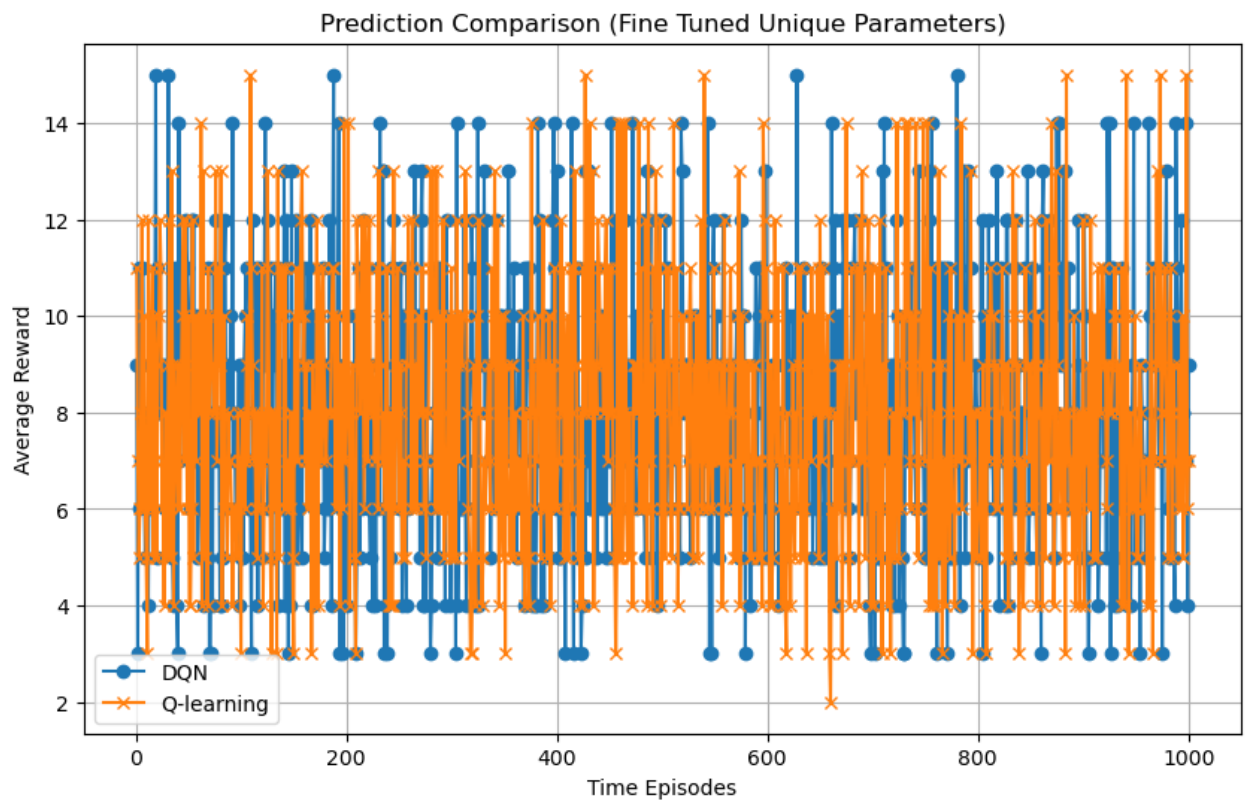
Compare the prediction of fine tuned models

```
In [90]: # my_q_agent_fine_tuned_avg_reward_lst )
# my_dqn_agent_fine_tuned_avg_reward_lst)
```

```
In [91]: x = range(1,1000 + 1)

plt.figure(figsize=(10, 6))
plt.plot(x, my_dqn_agent_fine_tuned_avg_reward_lst, label='DQN', marker='x')
plt.plot(x, my_q_agent_fine_tuned_avg_reward_lst, label='Q-learning', marker='o')

# titles and labels
plt.title('Prediction Comparison (Fine Tuned Unique Parameters)')
plt.xlabel('Time Episodes')
plt.ylabel('Average Reward')
plt.legend()
# display
plt.grid(True)
plt.show()
```



Discussion

Controlled Parameters Limitations in Training and Performance

The initial approach of using controlled parameters for both Q-learning and Deep Q-Network (DQN) algorithms showed significant differences in learning patterns and performance. Q-learning demonstrated rapid improvement during the early episodes of the training phase, converging to an average score of 7-8 after around 5,000 episodes. This quick convergence highlights the fact that Q-learning is rather efficient in this Taxi game environment.

However, it is important to note that a one-to-one direct comparison using controlled parameters for both algorithms is not a good idea at all. The learning rate α and discount factor γ impact Q-learning and DQN differently, probably due to their design difference. Especially, DQN has additional parameters such as network synchronization rate τ , batch size, and the neural network's weights and biases, which have no counterparts in the traditional Q-learning algorithm.

There is drastic difference between the performance of Q-learning and DQN with the controlled parameters $\alpha = 0.5$, $\gamma = 0.95$. DQN showed a gradual improvement up to 50,000 episodes but then plateaued at around -200 average reward which is significantly underperforming if compared to Q-learning. This stagnation in DQN training and performance suggests that the selected values might be suitable for Q-learning but only suboptimal for DQN.

Optimized Performance through Unique Parameter Tuning

Q-learning and DQN show more promising result with manually fine-tuned unique

parameters. With the tailored parameters, both Q-learning and DQN optimized to similar performance levels, converging to an average score of 7-8 over 1,000 test runs.

Q-learning shows a rapid learning curve just like before, stabilizing at the optimal performance level after approximately 5,000 training episodes.

DQN, in contrast, when properly fine-tuned, exhibited a different learning trajectory than before. DQN initially varies in its average training score but began to improve significantly after 10,000 episodes. The DQN algorithm gradually converged toward higher scores, eventually matching Q-learning's performance after about 75,000 episodes of training.

A few highlights:

- Algorithm specific parameters matter for performance (controlled parameters comparison simply does not work)
- Under the Taxi environment, DQN and Q-learning can be on par in performance when given sufficient and appropriate training time, episodes, and parameters
- Q-learning's rapid convergence shows a great fit for small environment like Taxi game and DQN properly has more potential in handling more complex environments

Conclusion

Convergence

Q-learning demonstrated consistent convergence to an optimal policy which align with its theoretical design. In contrast, DQN, by the nature of its design, does not necessarily guarantee convergence to an optimal policy. Despite that, our fine-tuned DQN model achieved performance on par with Q-learning in the Taxi environment. That is, DQN can provide a "good enough" policy for prediction.

Small-Scale Environments

For problem with limited action and observation spaces, such as the Taxi game, the performance difference between Q-learning and DQN was minimal. This result suggests that, perhaps in a Discrete environment the added complexity of DQN is probably not advantages. Where the Q-learning, which guarantees optimal policy, should be a better tool of choice.

Efficiency

Q-learning exhibited rapid convergence within thousands of episodes in the training phase. DQN, while capable of reaching similar performance as Q-learning eventually, required substantially more episodes and computational resources. The difference in efficiency is an important consideration for applications, especially in resource-

constrained situations.

Setting a Benchmark

The project highlighted the need for more robust benchmarking methodology to compare the performance of the reinforcement learning models. Data Structure and Algorithmic Analysis can always rely on metric like the Big O notation for performance comparison. In contrast, the reinforcement learning performance comparison in this project lacks some kind of standard metric as the performance can be influenced by various factors, including hardware specifications, system load, and even environmental conditions. Further study in reinforcement learning is needed in order to learn how to utilize standardized metrics to measure the models.

Potential Improvement

I think there are still room for me to improve and optimize the Q-learning and DQN implementations and comparison. Maybe like fine-tuning hyperparameters, optimizing network architecture for DQN, and exploring different network synchronization values and strategies. Also, testing the algorithms on multiple Gymnasium environment, for example, compare between Discrete Space and Continuous Space. Or to put the algorithms to test and compare between different games of Discrete space like Taxi game vs Cliff walking. Further, the algorithms can also be tested in a more complex environment, like a bigger and more complex map for the Taxi agent to perform in.

Final Thoughts

Overall, I found the project to be interesting, challenging yet rewarding, especially when I get to see the Taxi agent navigating its way through the map and picking-up/dropping-off the passenger correctly.

Reference: Please include all relevant links (git, video, etc)

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