In [ ]:
```
import itertools
import numpy as np
import pandas as pd
import random
```

In [ ]:
```
class GridWorldEnv:
  def __init__(self, N = 10, M = 10):
    # States of a gridworld
    self.N = N
    self.M = M

    # state space
    self.observation_space = list(itertools.product(range(self.N), range(self.M)
    # action space
    self.action_space = [(0,1), (0,-1), (1,0), (-1,0)]

    self.terminal_states = [(3,3)]
    self.reset()

  def reset(self):
    self.state = (0,0)
    self.is_terminated = False
    self.total_reward = 0

  def get_transition_probaility(self, start_state, action, end_state):
    if start_state in self.terminal_states:
      return 0

    expected_state = tuple(np.array(start_state) + np.array(action))
    if expected_state == end_state:
      return 1

    if expected_state not in self.observation_space and start_state == end_state
      return 1

    return 0

  def get_reward(self, start_state, action, end_state):
    if end_state in self.terminal_states:
      return 10
    else:
      return -1

  def step(self, action):
    if self.state in self.terminal_states:
      self.is_terminated = True
      reward = np.nan
      return self.state, reward, self.is_terminated

    current_state = self.state
    max_prob = 0
    for possible_state in self.observation_space:
      p = self.get_transition_probaility(current_state, action, possible_state)
      if p > max_prob:
        max_prob = p
        next_state = possible_state

    reward = self.get_reward(current_state, action, next_state)
```

```
    self.state = next_state
    self.total_reward += reward

    return self.state, reward, self.is_terminated


class RandomActionAgent:
  def __init__(self, env):
    self.env = env

  def policy(self):
    action = random.choices(self.env.action_space)[0]
    return

  def train(self):
    pass
```

In [ ]:
```
env = GridWorldEnv(5,5)
```

In [ ]:
```
env.state
```

Out[ ]:
```
(0, 0)
```

In [ ]:
```
action = (1, 0)
next_state, reward, is_terminated = env.step(action)

print("Next state: ", next_state)
print("Reward: ", reward)
```

```
Next state:  (1, 0)
Reward:  -1
```

Random walk

In [ ]:
```
class RandomActionAgent:
    def __init__(self, env):
        self.env = env

    def policy(self):
        action = random.choice(self.env.action_space)
        return action
```

In [ ]:
```
env.reset()
agent = RandomActionAgent(env)

while not env.is_terminated:
  current_state = env.state
  action =  agent.policy()
  next_state, reward, is_terminated = env.step(action)
  print(current_state, action, reward, next_state)

env.total_reward
```

```
(0, 0) (0, -1) -1 (0, 0)
(0, 0) (-1, 0) -1 (0, 0)
(0, 0) (1, 0) -1 (1, 0)
(1, 0) (0, -1) -1 (1, 0)
(1, 0) (1, 0) -1 (2, 0)
(2, 0) (0, 1) -1 (2, 1)
(2, 1) (1, 0) -1 (3, 1)
(3, 1) (-1, 0) -1 (2, 1)
(2, 1) (1, 0) -1 (3, 1)
(3, 1) (0, 1) -1 (3, 2)
(3, 2) (0, 1) 10 (3, 3)
(3, 3) (-1, 0) nan (3, 3)
```

Out[ ]: 0

In [ ]:
```
class DPAgent:
  def __init__(self, env):
    self.env = env
    self.gamma = 1

    self.v = dict(zip(self.env.observation_space, np.zeros(self.env.N*self.env.M
    self.is_trained = False


  def policy(self):
    if not self.is_trained:
      action = random.choices(self.env.action_space)[0]
    else:
      s = self.env.state
      max = -np.inf
      for a in self.env.action_space:
        term = 0
        for s_prime in self.env.observation_space:
          term+= self.env.get_transition_probaility(s, a, s_prime) * (self.env.g
        if term > max:
          max = term
          action = a

    return action

  def train(self, iter_limit = 1000):

    print("performing training...")

    self.v = dict(zip(self.env.observation_space, np.zeros(self.env.N*self.env.M

    iter = 0
    while iter< iter_limit:
      for s in self.env.observation_space:
        max = -np.inf
        for a in self.env.action_space:
          term2 = 0
          for s_prime in self.env.observation_space:
            term2+= self.env.get_transition_probaility(s, a, s_prime) * (self.en
          if term2 > max:
            max = term2
        self.v[s] = max
      iter+=1

    self.is_trained = True
```

```
    print(np.array(list(self.v.values())).reshape(self.env.N, self.env.M))
```

In [ ]:
```
env = GridWorldEnv(5,5)
dp_agent = DPAgent(env)

dp_agent.train(iter_limit = 100)
```

```
performing training...
[[ 5.  6.  7.  8.  7.]
 [ 6.  7.  8.  9.  8.]
 [ 7.  8.  9. 10.  9.]
 [ 8.  9. 10.  0. 10.]
 [ 7.  8.  9. 10.  9.]]
```

In [ ]:
```
env = GridWorldEnv(5,5)
dp_agent = DPAgent(env)

dp_agent.train(iter_limit = 100)

env.reset()

while not env.is_terminated:
  current_state = env.state
  action =  dp_agent.policy()
  next_state, reward, is_terminated = env.step(action)
  # print(current_state, action, reward, next_state)

env.total_reward
```

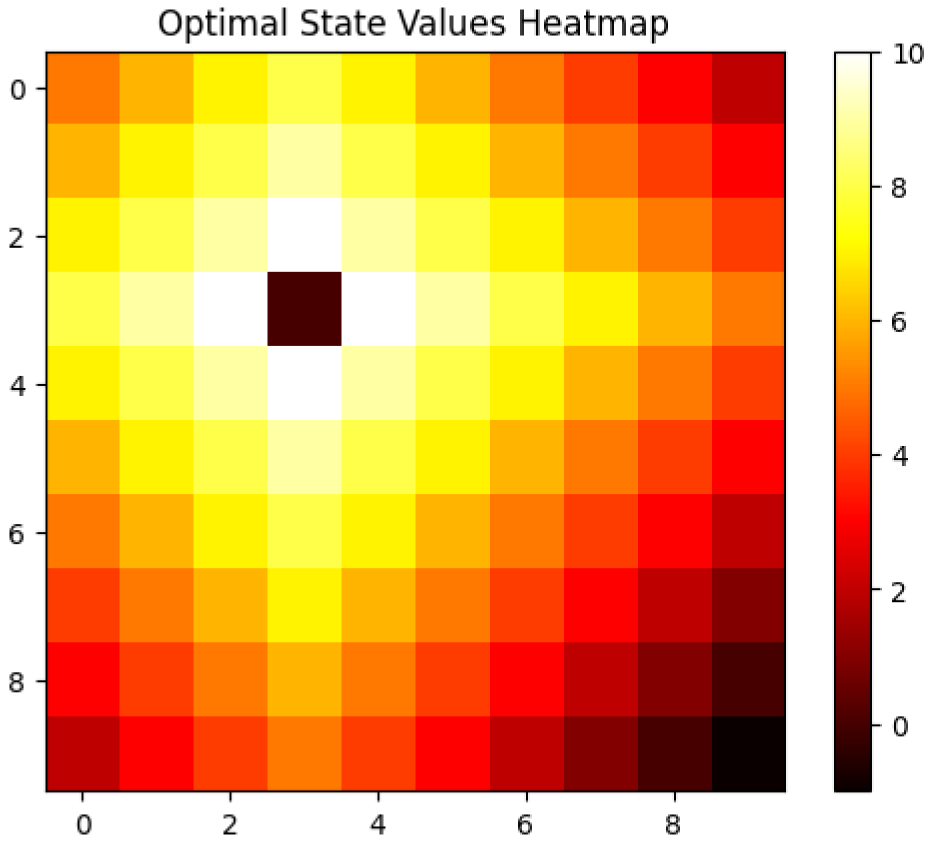
```
performing training...
[[ 5.  6.  7.  8.  7.]
 [ 6.  7.  8.  9.  8.]
 [ 7.  8.  9. 10.  9.]
 [ 8.  9. 10.  0. 10.]
 [ 7.  8.  9. 10.  9.]]
```

Out[ ]: 5

Create a heatmap of optimal state values of 10 X 10 gridworld

In [ ]:
```
import matplotlib.pyplot as plt

# Create a 10x10 gridworld environment
env = GridWorldEnv(10, 10)

# Create a DPAgent and train it
dp_agent = DPAgent(env)
dp_agent.train(iter_limit=100)

# Get the optimal state values from the agent
optimal_state_values = np.array(list(dp_agent.v.values())).reshape(env.N, env.M)

# Create a heatmap of the optimal state values
plt.imshow(optimal_state_values, cmap='hot', interpolation='nearest')
plt.colorbar()
plt.title('Optimal State Values Heatmap')
plt.show()
```

```
performing training...
[[ 5.   6.   7.   8.   7.   6.   5.   4.   3.   2.]
 [ 6.   7.   8.   9.   8.   7.   6.   5.   4.   3.]
 [ 7.   8.   9.  10.   9.   8.   7.   6.   5.   4.]
 [ 8.   9.  10.   0.  10.   9.   8.   7.   6.   5.]
 [ 7.   8.   9.  10.   9.   8.   7.   6.   5.   4.]
 [ 6.   7.   8.   9.   8.   7.   6.   5.   4.   3.]
 [ 5.   6.   7.   8.   7.   6.   5.   4.   3.   2.]
 [ 4.   5.   6.   7.   6.   5.   4.   3.   2.   1.]
 [ 3.   4.   5.   6.   5.   4.   3.   2.   1.   0.]
 [ 2.   3.   4.   5.   4.   3.   2.   1.   0.  -1.]]
```



Optimal state values through value iteration.

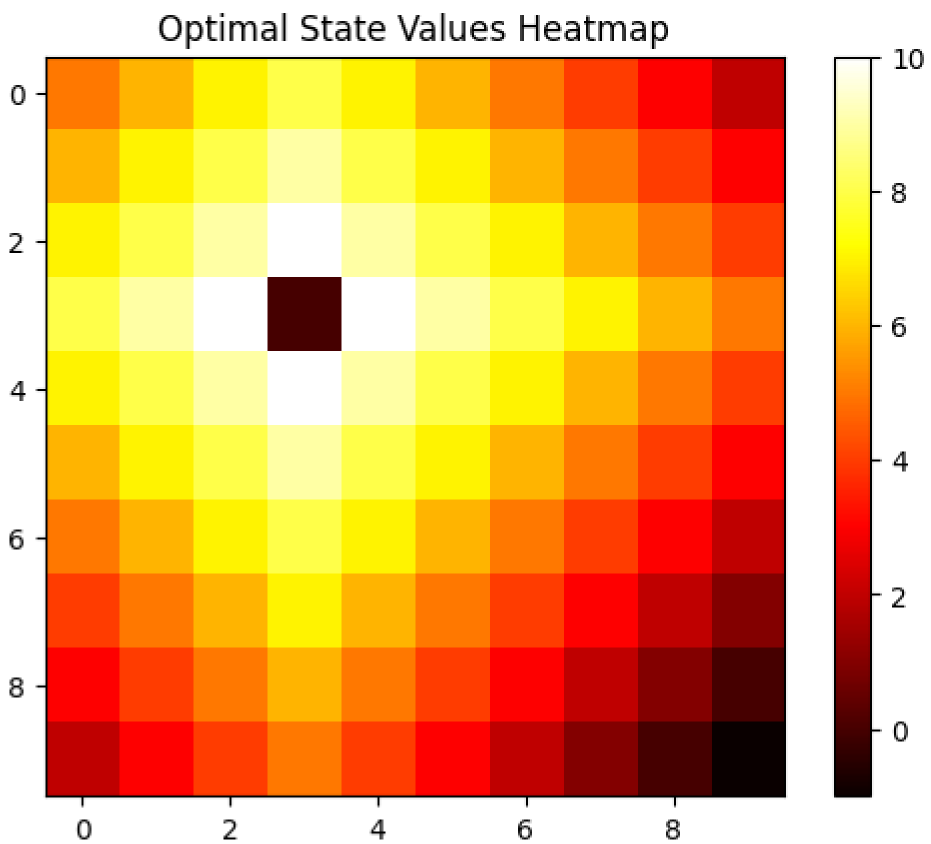
```
In [ ]: def value_iteration(env, gamma=0.99, theta=1e-4):
            V = {s: 0 for s in env.states}  # Initialize value function

            while True:
                delta = 0  # Initialize delta to track changes in value function
                for s in env.states:  # For each state in the environment
                    v = V[s]  # Store the current value of state s
                    V[s] = max(sum(p * (r + gamma * V[s_]) for p, s_, r, _ in env.transi
                    delta = max(delta, abs(v - V[s]))  # Update delta

                if delta < theta:  # If the value function has converged
                    break

            return V
```

What are the average total rewards that the agent gets, with and without training.

```
In [ ]: def calculate_average_rewards(env, agent, trained_agent, episodes=1000):
            total_reward_untrained = 0
```

```
    total_reward_trained = 0

    for _ in range(episodes):
        state = env.reset()
        done = False

        while not done:
            action = agent.policy(state)
            next_state, reward, done, _ = env.step(action)
            total_reward_untrained += reward
            state = next_state

        state = env.reset()
        done = False

        while not done:
            action = trained_agent.policy(state)
            next_state, reward, done, _ = env.step(action)
            total_reward_trained += reward
            state = next_state

    average_reward_untrained = total_reward_untrained / episodes
    average_reward_trained = total_reward_trained / episodes

    return average_reward_untrained, average_reward_trained
```

In [ ]:
```
plt.imshow(optimal_state_values, cmap='hot', interpolation='nearest')
plt.colorbar()
plt.title('Optimal State Values Heatmap')
plt.show()
```



In [ ]: