Lab 5: Windy Frozen Lake Nondeterministic world!

Reinforcement Learning with TensorFlow&OpenAI Gym

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Deterministic

```python
# Register FrozenLake with is_slippery False
register(
    id='FrozenLake-v3',
    entry_point='gym.envs.toy_text:FrozenLakeEnv',
    kwargs={'map_name' : '4x4', 'is_slippery': False}
)

env = gym.make('FrozenLake-v3')
```

```
SFFF
FHFH
FFFH
HFFG

SFFF
FHFH
FFFH
HFFG
  (Right)
('State: ', 1, 'Action: ', 2,
SFFF
FHFH
FFFH
HFFG
  (Right)
('State: ', 2, 'Action: ', 2,
SFFF
FHFH
FFFH
HFFG
```

```
  (Down)
('State: ', 6, 'Action: ', 1,
SFFF
FHFH
FFFH
HFFG
  (Down)
('State: ', 10, 'Action: ', 1,
SFFF
FHFH
FFFH
HFFG
  (Down)
('State: ', 14, 'Action: ', 1,
SFFF
FHFH
FFFH
HFFG
  (Right)
('State: ', 15, 'Action: ', 2,
('Finished with reward', 1.0)
```

Stochastic (non-deterministic)

```python
# is_slippery True
env = gym.make('FrozenLake-v0')
```

```
SFFF
FHFH
FFFH
HFFG

SFFF
FHFH
FFFH
HFFG
  (Right)
('State: ', 0, 'Action: ', 2,
SFFF
FHFH
FFFH
HFFG
  (Right)
('State: ', 4, 'Action: ', 2,
SFFF
FHFH
FFFH
HFFG
  (Down)
('State: ', 5, 'Action: ', 1,
('Finished with reward', 0.0)
```

```
SFFF
FHFH
FFFH
HFFG
  (Right)
('State: ', 0, 'Action: ', 2,
SFFF
FHFH
FFFH
HFFG
  (Right)
('State: ', 1, 'Action: ', 2,
SFFF
FHFH
FFFH
HFFG
  (Right)
('State: ', 1, 'Action: ', 2,
SFFF
FHFH
FFFH
HFFG
  (Right)
('State: ', 5, 'Action: ', 2,
('Finished with reward', 0.0)
```

Q-learning algorithm for deterministic

For each s, a initialize table entry $\hat{Q}(s,a) \leftarrow 0$

Observe current state s

Do forever:

- Select an action a and execute it
- Receive immediate reward r
- Observe the new state s'
- Update the table entry for $\hat{Q}(s,a)$ as follows:

$$\hat{Q}(s,a) \leftarrow r + \gamma \max_{a'} \hat{Q}(s',a')$$

- $s \leftarrow s'$

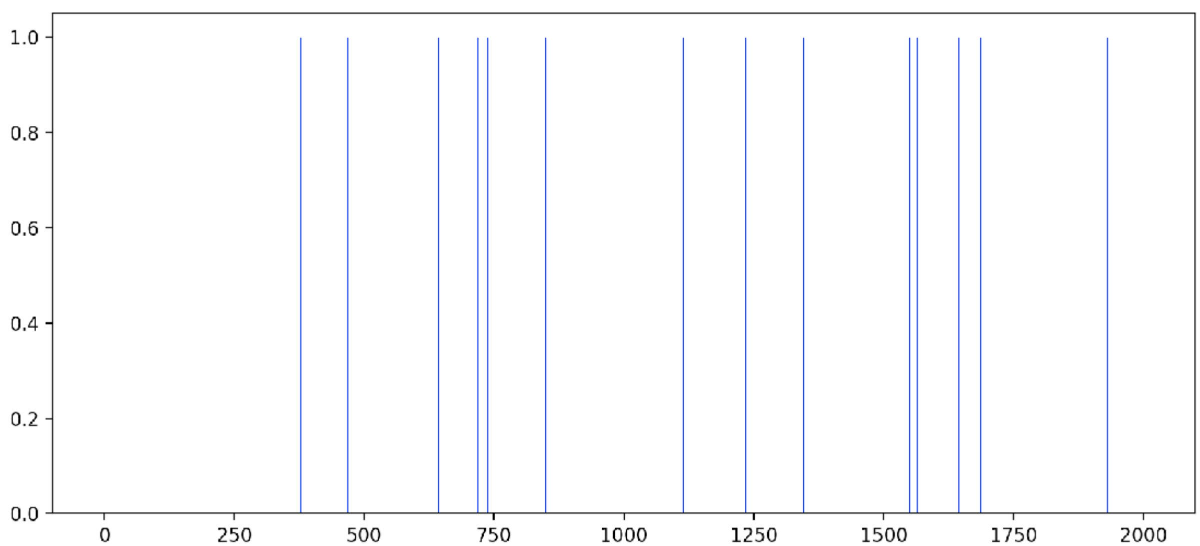
Machine Learning, T. Mitchell, McGraw Hill, 1997

Our previous Q-learning does not work

$$\hat{Q}(s,a) \leftarrow r + \gamma \max_{a'} \hat{Q}(s',a')$$

```
env = gym.make('FrozenLake-v0')
```

Score over time: 0.0165



Q-learning algorithm

For each s, a initialize table entry $\hat{Q}(s,a) \leftarrow 0$

Observe current state s

Do forever:

- Select an action a and execute it
- Receive immediate reward r
- Observe the new state s'
- Update the table entry for $\hat{Q}(s,a)$ as follows:

$$Q(s,a) \leftarrow (1-\alpha)Q(s,a) + \alpha[r + \gamma \max_{a'} Q(s',a')]$$

- $s \leftarrow s'$

Machine Learning, T. Mitchell, McGraw Hill, 1997

Q-learning algorithm

For each s, a initialize table entry $\hat{Q}(s,a) \leftarrow 0$

Observe current state s

Do forever:

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$$Q(s,a) \leftarrow (1-\alpha)Q(s,a) + \alpha[r + \gamma \max_{a'} Q(s', a')]$$

- $s \leftarrow s'$

```
# Update Q-Table with new knowledge using learning rate
Q[state,action] = (1-learning_rate) * Q[state,action] \
    + learning_rate*(reward + dis * np.max(Q[new_state, :]))
```

Code: Setup

```
import gym
import numpy as np
import matplotlib.pyplot as plt

env = gym.make('FrozenLake-v0')

# Initialize table with all zeros
Q = np.zeros([env.observation_space.n,env.action_space.n])

# Set learning parameters
learning_rate = .85
dis = .99
num_episodes = 2000
```

Code: Q-learning

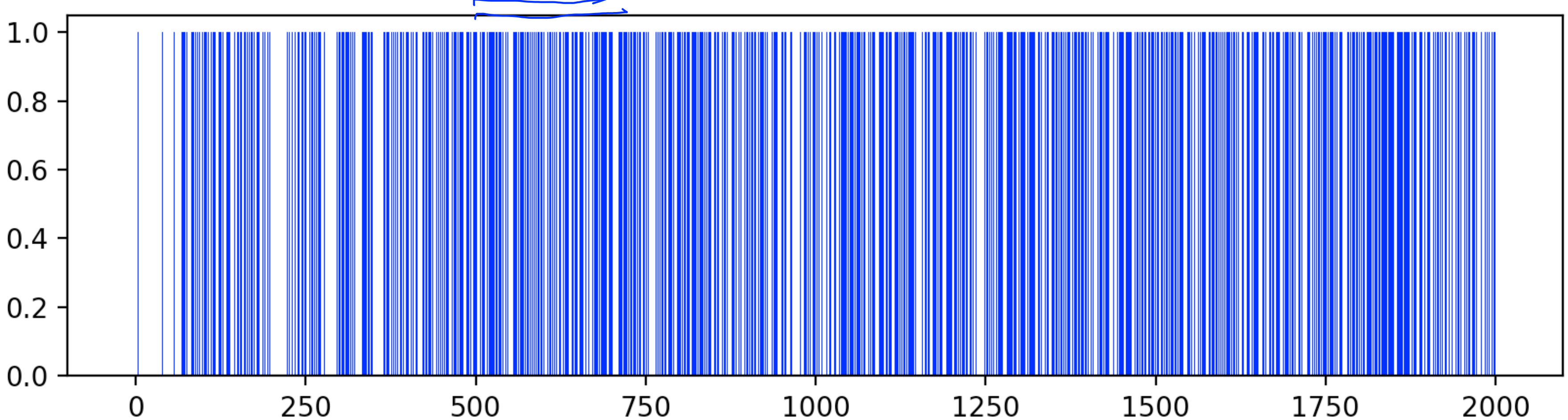
```
# create lists to contain total rewards and steps per episode
rList = []
for i in range(num_episodes):
    # Reset environment and get first new observation
    state = env.reset()
    rAll = 0
    done = False

    # The Q-Table learning algorithm
    while not done:
        # Choose an action by greedily (with noise) picking from Q table
        action = np.argmax(Q[state, :] + np.random.randn(1, env.action_space.n) / (i + 1))

        # Get new state and reward from environment
        new_state, reward, done,_ = env.step(action)

        # Update Q-Table with new knowledge using learning rate
        Q[state,action] = (1-learning_rate) * Q[state,action] \
            + learning_rate*(reward + dis * np.max(Q[new_state, :]))

        rAll += reward
        state = new_state

    rList.append(rAll)
```

$$Q(s,a) \leftarrow (1-\alpha)Q(s,a) + \alpha[r + \gamma \max_{a'} Q(s',a')]$$

Code: Report results

```
print("Score over time: " + str(sum(rList)/num_episodes))
print("Final Q-Table Values")
print(Q)
plt.bar(range(len(rList)), rList, color="blue")
plt.show()
```

Score over time: 0.653



Next

(Deep) Q-Network with TensorFlow!