

CartPole-v0 with DQNAgent

by Mohammad Ayyaz Azeem

Step 01: Installing Dependencies

In [1]:

```
!pip install tensorflow==2.3.0
!pip install gym
!pip install keras
!pip install keras-rl2
!pip install pyglet

Requirement already satisfied: tensorflow==2.3.0 in d:\installed_program\anaconda3\lib\site-packages (2.3.0)
Requirement already satisfied: google-pasta>=0.1.8 in d:\installed_program\anaconda3\lib\site-packages (from tensorflow==2.3.0) (0.2.0)
Requirement already satisfied: opt-einsum>=2.3.2 in d:\installed_program\anaconda3\lib\site-packages (from tensorflow==2.3.0) (3.3.0)
Requirement already satisfied: h5py<2.11.0,>=2.10.0 in d:\installed_program\anaconda3\lib\site-packages (from tensorflow==2.3.0) (2.10.0)
Requirement already satisfied: tensorboard<3,>=2.3.0 in d:\installed_program\anaconda3\lib\site-packages (from tensorflow==2.3.0) (2.4.1)
Requirement already satisfied: scipy==1.4.1 in d:\installed_program\anaconda3\lib\site-packages (from tensorflow==2.3.0) (1.4.1)
Requirement already satisfied: wrapt>=1.11.1 in d:\installed_program\anaconda3\lib\site-packages (from tensorflow==2.3.0) (1.12.1)
Requirement already satisfied: tensorflow-estimator<2.4.0,>=2.3.0 in d:\installed_program\anaconda3\lib\site-packages (from tensorflow==2.3.0) (2.3.0)
Requirement already satisfied: termcolor>=1.1.0 in d:\installed_program\anaconda3\lib\site-packages (from tensorflow==2.3.0) (1.1.0)
Requirement already satisfied: numpy<1.19.0,>=1.16.0 in d:\installed_program\anaconda3\lib\site-packages (from tensorflow==2.3.0) (1.18.5)
Requirement already satisfied: astunparse==1.6.3 in d:\installed_program\anaconda3\lib\site-packages (from tensorflow==2.3.0) (1.6.3)
Requirement already satisfied: gast==0.3.3 in d:\installed_program\anaconda3\lib\site-packages (from tensorflow==2.3.0) (0.3.3)
Requirement already satisfied: six>=1.12.0 in d:\installed_program\anaconda3\lib\site-packages (from tensorflow==2.3.0) (1.15.0)
Requirement already satisfied: wheel>=0.26 in d:\installed_program\anaconda3\lib\site-packages (from tensorflow==2.3.0) (0.36.2)
Requirement already satisfied: keras-preprocessing<1.2,>=1.1.1 in d:\installed_program\anaconda3\lib\site-packages (from tensorflow==2.3.0) (1.1.2)
Requirement already satisfied: grpcio>=1.8.6 in d:\installed_program\anaconda3\lib\site-packages (from tensorflow==2.3.0) (1.32.0)
Requirement already satisfied: absl-py>=0.7.0 in d:\installed_program\anaconda3\lib\site-packages (from tensorflow==2.3.0) (0.11.0)
Requirement already satisfied: protobuf>=3.9.2 in d:\installed_program\anaconda3\lib\site-packages (from tensorflow==2.3.0) (3.15.5)
Requirement already satisfied: google-auth<2,>=1.6.3 in d:\installed_program\anaconda3\lib\site-packages (from tensorflow<3,>=2.3.0->tensorflow==2.3.0) (1.27.1)
Requirement already satisfied: google-auth-oauthlib<0.5,>=0.4.1 in d:\installed_program\anaconda3\lib\site-packages (from tensorflow<3,>=2.3.0->tensorflow==2.3.0) (0.4.3)
Requirement already satisfied: setuptools>=41.0.0 in d:\installed_program\anaconda3\lib\site-packages (from tensorflow<3,>=2.3.0->tensorflow==2.3.0) (52.0.0.post20210125)
Requirement already satisfied: tensorflow-plugin-wit>=1.6.0 in d:\installed_program\anaconda3\lib\site-packages (from tensorflow<3,>=2.3.0->tensorflow==2.3.0) (1.8.0)
Requirement already satisfied: werkzeug>=0.11.15 in d:\installed_program\anaconda3\lib\site-packages (from tensorflow<3,>=2.3.0->tensorflow==2.3.0) (1.0.1)
Requirement already satisfied: requests<3,>=2.21.0 in d:\installed_program\anaconda3\lib\site-packages (from tensorflow<3,>=2.3.0->tensorflow==2.3.0) (2.27.0)
Requirement already satisfied: markdown>=2.6.8 in d:\installed_program\anaconda3\lib\site-packages (from tensorflow<3,>=2.3.0->tensorflow==2.3.0) (3.3.4)
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Requirement already satisfied: rsa<5,>=3.1.4 in d:\installed_program\anaconda3\lib\site-packages (from google-auth<2,>=1.6.3->tensorflow<3,>=2.3.0->tensorflow==2.3.0) (4.7.2)
Requirement already satisfied: requests-oauthlib>=0.7.0 in d:\installed_program\anaconda3\lib\site-packages (from google-auth-oauthlib<0.5,>=0.4.1->tensorflow<3,>=2.3.0->tensorflow==2.3.0) (1.3.0)
Requirement already satisfied: idna<4,>=2.5 in d:\installed_program\anaconda3\lib\site-packages (from requests<3,>=2.21.0->tensorflow<3,>=2.3.0->tensorflow==2.3.0) (2.6)
Requirement already satisfied: charset-normalizer~=2.0.0 in d:\installed_program\anaconda3\lib\site-packages (from requests<3,>=2.21.0->tensorflow<3,>=2.3.0->tensorflow==2.3.0) (2.0.10)
Requirement already satisfied: urllib3<1.27,>=1.21.1 in d:\installed_program\anaconda3\lib\site-packages (from requests<3,>=2.21.0->tensorflow<3,>=2.3.0->tensorflow==2.3.0) (1.22)
Requirement already satisfied: certifi>=2017.4.17 in d:\installed_program\anaconda3\lib\site-packages (from requests<3,>=2.21.0->tensorflow<3,>=2.3.0->tensorflow==2.3.0) (2020.12.5)
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Requirement already satisfied: numpy>=1.18.0 in d:\installed_program\anaconda3\lib\site-packages (from gym) (1.18.5)  
Requirement already satisfied: keras in d:\installed_program\anaconda3\lib\site-packages (2.6.0)  
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Requirement already satisfied: charset-normalizer~>2.0.0 in d:\installed_program\anaconda3\lib\site-packages (from requests<3,>=2.21.0->tensorboard<3,>=2.3.0->tensorflow->keras-rl2) (2.0.10)  
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Requirement already satisfied: oauthlib>=3.0.0 in d:\installed_program\anaconda3\lib\site-packages (from requests-oauthlib>=0.7.0->google-auth-oauthlib<0.5,>=0.4.1->tensorboard<3,>=2.3.0->tensorflow->keras-rl2) (3.1.0)
```

Step 02: Testing Random Environment with OpenAI Gym

```
In [2]: import gym  
import random
```

Setting up the environment

```
In [3]: env = gym.make('CartPole-v0') #make method to build our cartpole environment  
states = env.observation_space.shape[0] # to look at all different states  
actions = env.action_space.n # the number of actions
```

type of states and action

```
In [4]: type(states), type(actions)
```

Out[4]: (int, int)

number of states and action

```
In [5]: states, actions
```

Out[5]: (4, 2)

actions = 2 meaning Left or Right movement of cartpole

...

visualize our cartpole by taking random steps and create reward (max reward is 200 points)

```
In [6]: episodes = 15  
for i in range(1, episodes+1):  
    state = env.reset()  
    done = False  
    score = 0  
  
    while not done:  
        env.render() # allows us to see our cart in action  
        action = random.choice([0,1]) # random choice left or right  
        n_state, reward, done, info = env.step(action) # taking a random step,  
        score+=reward # based on our step we will get reward and we accumulate a score, at the end  
        print('Episode:{} Score: {}'.format(i,score))
```

d:\installed_program\anaconda3\lib\site-packages\pyglet>window_init__.py:667: UserWarning:
Your graphics drivers do not support OpenGL 2.0.
You may experience rendering issues or crashes.
Microsoft Corporation
GDI Generic
1.1.0
warnings.warn(message)
Episode:1 Score: 51.0
Episode:2 Score: 30.0
Episode:3 Score: 15.0
Episode:4 Score: 14.0
Episode:5 Score: 14.0
Episode:6 Score: 9.0
Episode:7 Score: 25.0
Episode:8 Score: 12.0
Episode:9 Score: 18.0
Episode:10 Score: 14.0
Episode:11 Score: 10.0
Episode:12 Score: 22.0
Episode:13 Score: 15.0
Episode:14 Score: 31.0
Episode:15 Score: 15.0

Step 03. Create a Deep Learning Model with Keras

importing relevant dependencies

```
In [7]:  
import numpy as np  
import tensorflow  
from tensorflow import keras  
from tensorflow.keras import layers  
from tensorflow.keras.models import Sequential # allow us to build sequential model with keras  
from tensorflow.keras.layers import Dense, Flatten # 2 different types of layers  
from tensorflow.keras.optimizers import Adam # adam optimizer
```

create a build_model function that helps us finalize a model, for the final layer we tried with softmax activation function but the results were not encouraging, so we used linear activation function and achieved better results

```
In [8]:  
def build_model(states, actions):  
    model= tensorflow.keras.models.Sequential()  
    model.add(tensorflow.keras.layers.Flatten(input_shape=(1,states))) # states = 4  
    model.add(tensorflow.keras.layers.Dense(24, activation='relu'))  
    model.add(tensorflow.keras.layers.Dense(24, activation='relu'))  
    model.add(tensorflow.keras.layers.Dense(actions, activation='linear')) # actions = 2 at the end  
    return model
```

```
In [9]:  
model=build_model(states,actions)
```

Step 04: Visualizing the model

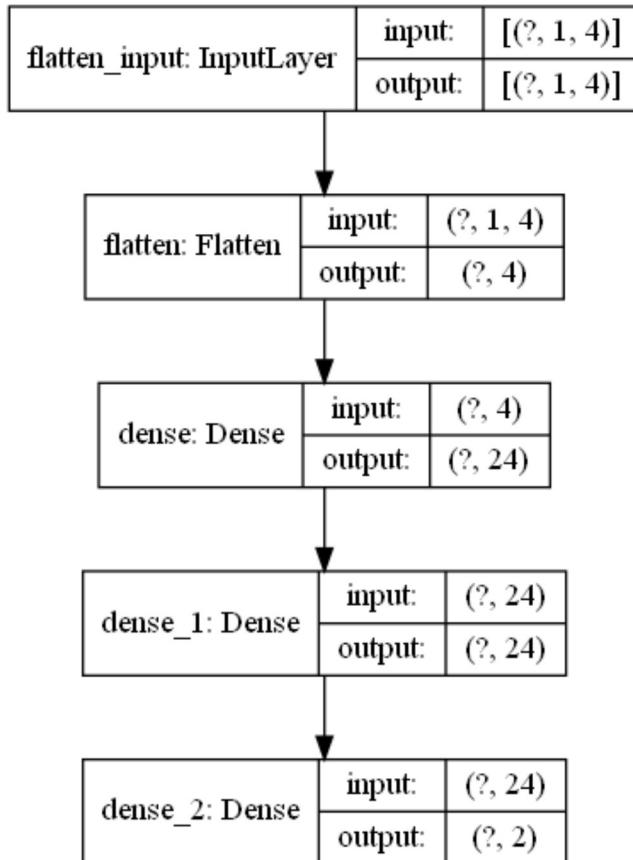
```
In [10]:  
model.summary()
```

```
Model: "sequential"  
=====  
Layer (type)          Output Shape         Param #  
=====  
flatten (Flatten)     (None, 4)           0  
dense (Dense)         (None, 24)          120  
=====  
dense_1 (Dense)       (None, 24)          600  
=====  
dense_2 (Dense)       (None, 2)           50  
=====  
Total params: 770  
Trainable params: 770  
Non-trainable params: 0
```

visualize the model, with plot_model

```
In [11]:  
#from keras.utils.vis_utils import plot_model  
tensorflow.keras.utils.plot_model(model, to_file='model_plot.png', show_shapes=True, show_layer_r
```

Out [11]:



visualize the model, with visualkeras

In [12]:

```
!pip install visualkeras
```

```
Requirement already satisfied: visualkeras in d:\installed_program\anaconda3\lib\site-packages (0.0.2)
Requirement already satisfied: aggdraw>=1.3.11 in d:\installed_program\anaconda3\lib\site-packages (from visualkeras) (1.3.12)
Requirement already satisfied: numpy>=1.18.1 in d:\installed_program\anaconda3\lib\site-packages (from visualkeras) (1.18.5)
Requirement already satisfied: pillow>=6.2.0 in d:\installed_program\anaconda3\lib\site-packages (from visualkeras) (8.1.0)
```

In [13]:

```
import visualkeras
```

In [14]:

```
visualkeras.layered_view(model, to_file="model.png")
```

Out [14]:



Step 05: Build agent with Keras-RL

In [15]:

```
from rl.agents import DQNAgent
from rl.policy import BoltzmannQPolicy
from rl.memory import SequentialMemory
```

In [16]:

```
def build_agent(model, actions):
    policy=BoltzmannQPolicy()
    memory=SequentialMemory(limit=50000, window_length=1)
    dqn=DQNAgent(model=model,
                 memory=memory,
                 policy=policy,
                 nb_actions=actions,
                 nb_steps_warmup=10,
                 target_model_update=1e-2
                )
    return dqn
```

the first line is used in the following box to avoid this error: AttributeError: 'Sequential' object has no attribute '_compile_time_distribution_strategy'

```

In [17]: model=build_model(states,actions) # if we comment the first line we get the above error
dqn = build_agent(model,actions)
dqn.compile(tensorflow.keras.optimizers.Adam(lr=1e-3), metrics=['mae'])
dqn.fit(env,nb_steps=50000,visualize=False,verbose=1)

Training for 50000 steps ...
Interval 1 (0 steps performed)
WARNING:tensorflow:From d:\installed_program\anaconda3\lib\site-packages\tensorflow\python\keras\engine\training_v1.py:2070: Model.state_updates (from tensorflow.python.keras.engine.training) is deprecated and will be removed in a future version.
Instructions for updating:
This property should not be used in TensorFlow 2.0, as updates are applied automatically.
    1/10000 [........................] - ETA: 28:01 - reward: 1.0000
d:\installed_program\anaconda3\lib\site-packages\rl\memory.py:37: UserWarning: Not enough entries to sample without replacement. Consider increasing your warm-up phase to avoid oversampling!
    warnings.warn('Not enough entries to sample without replacement. Consider increasing your warm-up phase to avoid oversampling!')
10000/10000 [=====] - 89s 9ms/step - reward: 1.0000
1004 episodes - episode_reward: 95.192 [10.000, 200.000] - loss: 3.311 - mae: 19.183 - mean_q: 38.718

Interval 2 (10000 steps performed)
10000/10000 [=====] - 87s 9ms/step - reward: 1.0000
51 episodes - episode_reward: 196.627 [166.000, 200.000] - loss: 5.742 - mae: 37.028 - mean_q: 74.488

Interval 3 (20000 steps performed)
10000/10000 [=====] - 96s 10ms/step - reward: 1.0000
51 episodes - episode_reward: 197.255 [168.000, 200.000] - loss: 4.786 - mae: 38.700 - mean_q: 77.698

Interval 4 (30000 steps performed)
10000/10000 [=====] - 103s 10ms/step - reward: 1.0000
50 episodes - episode_reward: 199.880 [194.000, 200.000] - loss: 6.237 - mae: 38.725 - mean_q: 77.743

Interval 5 (40000 steps performed)
10000/10000 [=====] - 89s 9ms/step - reward: 1.0000
done, took 464.930 seconds

```

Out[17]: <tensorflow.python.keras.callbacks.History at 0x12dfca117f0>

```

In [18]: import numpy as np
scores=dqn.test(env, nb_episodes=100, visualize=False)
print('mean result: {}'.format(np.mean(scores.history['episode_reward'])))

```

```

Testing for 100 episodes ...
Episode 1: reward: 200.000, steps: 200
Episode 2: reward: 200.000, steps: 200
Episode 3: reward: 200.000, steps: 200
Episode 4: reward: 200.000, steps: 200
Episode 5: reward: 200.000, steps: 200
Episode 6: reward: 200.000, steps: 200
Episode 7: reward: 200.000, steps: 200
Episode 8: reward: 200.000, steps: 200
Episode 9: reward: 200.000, steps: 200
Episode 10: reward: 200.000, steps: 200
Episode 11: reward: 200.000, steps: 200
Episode 12: reward: 200.000, steps: 200
Episode 13: reward: 200.000, steps: 200
Episode 14: reward: 200.000, steps: 200
Episode 15: reward: 200.000, steps: 200
Episode 16: reward: 200.000, steps: 200
Episode 17: reward: 200.000, steps: 200
Episode 18: reward: 200.000, steps: 200
Episode 19: reward: 200.000, steps: 200
Episode 20: reward: 200.000, steps: 200
Episode 21: reward: 200.000, steps: 200
Episode 22: reward: 200.000, steps: 200
Episode 23: reward: 200.000, steps: 200
Episode 24: reward: 200.000, steps: 200
Episode 25: reward: 200.000, steps: 200
Episode 26: reward: 200.000, steps: 200
Episode 27: reward: 200.000, steps: 200
Episode 28: reward: 200.000, steps: 200
Episode 29: reward: 200.000, steps: 200
Episode 30: reward: 200.000, steps: 200
Episode 31: reward: 200.000, steps: 200
Episode 32: reward: 200.000, steps: 200
Episode 33: reward: 200.000, steps: 200
Episode 34: reward: 200.000, steps: 200
Episode 35: reward: 200.000, steps: 200
Episode 36: reward: 200.000, steps: 200

```

```
Episode 37: reward: 200.000, steps: 200
Episode 38: reward: 200.000, steps: 200
Episode 39: reward: 200.000, steps: 200
Episode 40: reward: 200.000, steps: 200
Episode 41: reward: 200.000, steps: 200
Episode 42: reward: 200.000, steps: 200
Episode 43: reward: 200.000, steps: 200
Episode 44: reward: 200.000, steps: 200
Episode 45: reward: 200.000, steps: 200
Episode 46: reward: 200.000, steps: 200
Episode 47: reward: 200.000, steps: 200
Episode 48: reward: 200.000, steps: 200
Episode 49: reward: 200.000, steps: 200
Episode 50: reward: 200.000, steps: 200
Episode 51: reward: 200.000, steps: 200
Episode 52: reward: 200.000, steps: 200
Episode 53: reward: 200.000, steps: 200
Episode 54: reward: 200.000, steps: 200
Episode 55: reward: 200.000, steps: 200
Episode 56: reward: 200.000, steps: 200
Episode 57: reward: 200.000, steps: 200
Episode 58: reward: 200.000, steps: 200
Episode 59: reward: 200.000, steps: 200
Episode 60: reward: 200.000, steps: 200
Episode 61: reward: 200.000, steps: 200
Episode 62: reward: 200.000, steps: 200
Episode 63: reward: 200.000, steps: 200
Episode 64: reward: 200.000, steps: 200
Episode 65: reward: 200.000, steps: 200
Episode 66: reward: 200.000, steps: 200
Episode 67: reward: 200.000, steps: 200
Episode 68: reward: 200.000, steps: 200
Episode 69: reward: 200.000, steps: 200
Episode 70: reward: 200.000, steps: 200
Episode 71: reward: 200.000, steps: 200
Episode 72: reward: 200.000, steps: 200
Episode 73: reward: 200.000, steps: 200
Episode 74: reward: 200.000, steps: 200
Episode 75: reward: 200.000, steps: 200
Episode 76: reward: 200.000, steps: 200
Episode 77: reward: 200.000, steps: 200
Episode 78: reward: 200.000, steps: 200
Episode 79: reward: 200.000, steps: 200
Episode 80: reward: 200.000, steps: 200
Episode 81: reward: 200.000, steps: 200
Episode 82: reward: 200.000, steps: 200
Episode 83: reward: 200.000, steps: 200
Episode 84: reward: 200.000, steps: 200
Episode 85: reward: 200.000, steps: 200
Episode 86: reward: 200.000, steps: 200
Episode 87: reward: 200.000, steps: 200
Episode 88: reward: 200.000, steps: 200
Episode 89: reward: 200.000, steps: 200
Episode 90: reward: 200.000, steps: 200
Episode 91: reward: 200.000, steps: 200
Episode 92: reward: 200.000, steps: 200
Episode 93: reward: 200.000, steps: 200
Episode 94: reward: 200.000, steps: 200
Episode 95: reward: 200.000, steps: 200
Episode 96: reward: 200.000, steps: 200
Episode 97: reward: 200.000, steps: 200
Episode 98: reward: 200.000, steps: 200
Episode 99: reward: 200.000, steps: 200
Episode 100: reward: 200.000, steps: 200
mean result: 200.0
```

```
In [19]: print('mean result: {}'.format(np.mean(scores.history['episode_reward'])))
```

```
mean result: 200.0
```

```
visualize for 10 examples
```

```
In [20]: _ = dqn.test(env, nb_episodes = 10, visualize=True)
```

```
Testing for 10 episodes ...
Episode 1: reward: 200.000, steps: 200
Episode 2: reward: 200.000, steps: 200
Episode 3: reward: 200.000, steps: 200
Episode 4: reward: 200.000, steps: 200
Episode 5: reward: 200.000, steps: 200
Episode 6: reward: 200.000, steps: 200
Episode 7: reward: 200.000, steps: 200
Episode 8: reward: 200.000, steps: 200
Episode 9: reward: 200.000, steps: 200
Episode 10: reward: 200.000, steps: 200
```

Step 06: Reloading Agent from Memory

Running the following command we can save the weights of our model and reload later on

```
In [21]: dqn.save_weights('dqn_weights.h5f', overwrite=True)
```

now we delete the already created model, dqn agent and environment, and recreate the whole scenario again and use the above saved model in h5f format to obtain the result

```
In [22]: del model  
del dqn  
del env
```

rebuilding functions and dqn agent agent

```
In [23]: env=gym.make('CartPole-v0')  
actions=env.action_space.n  
states = env.observation_space.shape[0]  
model=build_model(states,actions)  
dqn=build_agent(model,actions)  
dqn.compile(tensorflow.keras.optimizers.Adam(lr=1e-3), metrics=['mae'])
```

reload weights now

```
In [24]: dqn.load_weights('dqn_weights.h5f')
```

```
In [25]: _=dqn.test(env, nb_episodes=5, visualize=True)
```

Testing for 5 episodes ...

```
d:\installed_program\anaconda3\lib\site-packages\pyglet>window\__init__.py:667: UserWarning:  
Your graphics drivers do not support OpenGL 2.0.  
You may experience rendering issues or crashes.  
Microsoft Corporation  
GDI Generic  
1.1.0  
warnings.warn(message)  
Episode 1: reward: 200.000, steps: 200  
Episode 2: reward: 200.000, steps: 200  
Episode 3: reward: 200.000, steps: 200  
Episode 4: reward: 200.000, steps: 200  
Episode 5: reward: 200.000, steps: 200
```

-----END-----

```
In [ ]:
```