Step 1: Install xvfb & other dependencies

In [2]:

```
!apt-get install x11-utils > /dev/null 2>&1
```

In [3]:

```
!pip install pyglet > /dev/null 2>&1
```

In [4]:

```
!apt-get install -y xvfb python-opengl > /dev/null 2>&1
```

Step 2: Install mujoco

In [5]:

```
# Include this at the top of your colab code

import os

if not os.path.exists('.mujoco_setup_complete'):
    # Get the prereqs
    !apt-get -qq update
    !apt-get -qq install -y libosmesa6-dev libgl1-mesa-glx libglfw3 libgl1-mesa-dev
    # Get Mujoco
    !mkdir ~/.mujoco
    !wget -q https://mujoco.org/download/mujoco210-linux-x86_64.tar.gz -O mujoco.tar
    !tar -zxf mujoco.tar.gz -C "$HOME/.mujoco"
    !rm mujoco.tar.gz
    # Add it to the actively loaded path and the bashrc path (these only do so much)
    !echo 'export LD_LIBRARY_PATH=$LD_LIBRARY_PATH:$HOME/.mujoco/mujoco210/bin' >> ~
    !echo 'export LD_PRELOAD=$LD_PRELOAD:/usr/lib/x86_64-linux-gnu/libGLEW.so' >> ~/
    # THE ANNOYING ONE, FORCE IT INTO LDCONFIG SO WE ACTUALLY GET ACCESS TO IT THIS
    !echo "/root/.mujoco/mujoco210/bin" > /etc/ld.so.conf.d/mujoco_ld_lib_path.conf
    !ldconfig
    # Install Mujoco-py
    !pip3 install -U 'mujoco-py<2.2,>=2.1'
    # run once
    !touch .mujoco_setup_complete

try:
    if _mujoco_run_once:
        pass
except NameError:
    _mujoco_run_once = False

if not _mujoco_run_once:
    # Add it to the actively loaded path and the bashrc path (these only do so much)
    try:
        os.environ['LD_LIBRARY_PATH']=os.environ['LD_LIBRARY_PATH'] + ':/root/.mujoc
    except KeyError:
        os.environ['LD_LIBRARY_PATH']='/root/.mujoco/mujoco210/bin'
    try:
        os.environ['LD_PRELOAD']=os.environ['LD_PRELOAD'] + ':/usr/lib/x86_64-linux-
    except KeyError:
        os.environ['LD_PRELOAD']='/usr/lib/x86_64-linux-gnu/libGLEW.so'
    # presetup so we don't see output on first env initialization
    import mujoco_py
    _mujoco_run_once = True
```

Step 3: Install pyvirtual display

In [6]:

```
!pip install gym pyvirtualdisplay > /dev/null 2>&1
!pip install -U gym>=0.21.0
!pip install -U gym[atari,accept-rom-license]
!pip install -U gym[Robotics,classic_control]
```

```
Requirement already satisfied: gym[accept-rom-license,atari] in /usr/l
ocal/lib/python3.7/dist-packages (0.23.1)
Requirement already satisfied: importlib-metadata>=4.10.0 in /usr/loca
l/lib/python3.7/dist-packages (from gym[accept-rom-license,atari]) (4.
11.3)
Requirement already satisfied: cloudpickle>=1.2.0 in /usr/local/lib/py
thon3.7/dist-packages (from gym[accept-rom-license,atari]) (1.3.0)
Requirement already satisfied: gym-notices>=0.0.4 in /usr/local/lib/py
thon3.7/dist-packages (from gym[accept-rom-license,atari]) (0.0.6)
Requirement already satisfied: numpy>=1.18.0 in /usr/local/lib/python
3.7/dist-packages (from gym[accept-rom-license,atari]) (1.21.5)
Requirement already satisfied: ale-py~=0.7.4 in /usr/local/lib/python
3.7/dist-packages (from gym[accept-rom-license,atari]) (0.7.4)
Requirement already satisfied: autorom[accept-rom-license]~=0.4.2 in /
usr/local/lib/python3.7/dist-packages (from gym[accept-rom-license,ata
ri]) (0.4.2)
Requirement already satisfied: importlib-resources in /usr/local/lib/p
ython3.7/dist-packages (from ale-py~=0.7.4->gym[accept-rom-license,ata
ri]) (5.6.0)
Requirement already satisfied: requests in /usr/local/lib/python3.7/di
st-packages (from autorom[accept-rom-license]~=0.4.2->gym[accept-rom-l
icense,atari]) (2.23.0)
Requirement already satisfied: tqdm in /usr/local/lib/python3.7/dist-p
ackages (from autorom[accept-rom-license]~=0.4.2->gym[accept-rom-licen
se,atari]) (4.64.0)
Requirement already satisfied: click in /usr/local/lib/python3.7/dist-
packages (from autorom[accept-rom-license]~=0.4.2->gym[accept-rom-lice
nse,atari]) (7.1.2)
Requirement already satisfied: AutoROM.accept-rom-license in /usr/loca
l/lib/python3.7/dist-packages (from autorom[accept-rom-license]~=0.4.2
->gym[accept-rom-license,atari]) (0.4.2)
Requirement already satisfied: typing-extensions>=3.6.4 in /usr/local/
lib/python3.7/dist-packages (from importlib-metadata>=4.10.0->gym[acce
pt-rom-license,atari]) (4.1.1)
Requirement already satisfied: zipp>=0.5 in /usr/local/lib/python3.7/d
ist-packages (from importlib-metadata>=4.10.0->gym[accept-rom-license,
atari]) (3.8.0)
Requirement already satisfied: urllib3!=1.25.0,!=1.25.1,<1.26,>=1.21.1
in /usr/local/lib/python3.7/dist-packages (from requests->autorom[acce
pt-rom-license]~=0.4.2->gym[accept-rom-license,atari]) (1.24.3)
Requirement already satisfied: chardet<4,>=3.0.2 in /usr/local/lib/pyt
hon3.7/dist-packages (from requests->autorom[accept-rom-license]~=0.4.
2->gym[accept-rom-license,atari]) (3.0.4)
Requirement already satisfied: idna<3,>=2.5 in /usr/local/lib/python3.
7/dist-packages (from requests->autorom[accept-rom-license]~=0.4.2->gy
m[accept-rom-license,atari]) (2.10)
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/py
thon3.7/dist-packages (from requests->autorom[accept-rom-license]~=0.
4.2->gym[accept-rom-license,atari]) (2021.10.8)
Requirement already satisfied: gym[Robotics,classic_control] in /usr/l
ocal/lib/python3.7/dist-packages (0.23.1)
WARNING: gym 0.23.1 does not provide the extra 'robotics'
Requirement already satisfied: importlib-metadata>=4.10.0 in /usr/loca
l/lib/python3.7/dist-packages (from gym[Robotics,classic_control]) (4.
```

```
11.3)
Requirement already satisfied: cloudpickle>=1.2.0 in /usr/local/lib/py
thon3.7/dist-packages (from gym[Robotics,classic_control]) (1.3.0)
Requirement already satisfied: gym-notices>=0.0.4 in /usr/local/lib/py
thon3.7/dist-packages (from gym[Robotics,classic_control]) (0.0.6)
Requirement already satisfied: numpy>=1.18.0 in /usr/local/lib/python
3.7/dist-packages (from gym[Robotics,classic_control]) (1.21.5)
Requirement already satisfied: pygame==2.1.0 in /usr/local/lib/python
3.7/dist-packages (from gym[Robotics,classic_control]) (2.1.0)
Requirement already satisfied: zipp>=0.5 in /usr/local/lib/python3.7/d
ist-packages (from importlib-metadata>=4.10.0->gym[Robotics,classic_co
ntrol]) (3.8.0)
Requirement already satisfied: typing-extensions>=3.6.4 in /usr/local/
lib/python3.7/dist-packages (from importlib-metadata>=4.10.0->gym[Robo
tics,classic_control]) (4.1.1)
```

In [7]:

```
!pip install gym-robotics
```

```
Requirement already satisfied: gym-robotics in /usr/local/lib/python3.
7/dist-packages (0.1.0)
Requirement already satisfied: cloudpickle>=1.2.0 in /usr/local/lib/py
thon3.7/dist-packages (from gym-robotics) (1.3.0)
Requirement already satisfied: importlib-metadata>=4.8.1 in /usr/loca
l/lib/python3.7/dist-packages (from gym-robotics) (4.11.3)
Requirement already satisfied: numpy>=1.18.0 in /usr/local/lib/python
3.7/dist-packages (from gym-robotics) (1.21.5)
Requirement already satisfied: gym>=0.22 in /usr/local/lib/python3.7/d
ist-packages (from gym-robotics) (0.23.1)
Requirement already satisfied: gym-notices>=0.0.4 in /usr/local/lib/py
thon3.7/dist-packages (from gym>=0.22->gym-robotics) (0.0.6)
Requirement already satisfied: zipp>=0.5 in /usr/local/lib/python3.7/d
ist-packages (from importlib-metadata>=4.8.1->gym-robotics) (3.8.0)
Requirement already satisfied: typing-extensions>=3.6.4 in /usr/local/
lib/python3.7/dist-packages (from importlib-metadata>=4.8.1->gym-robot
ics) (4.1.1)
```

In [8]:

```
!pip3 install box2d-py
!pip3 install gym[Box_2D]
```

```
Requirement already satisfied: box2d-py in /usr/local/lib/python3.7/di
st-packages (2.3.8)
Requirement already satisfied: gym[Box_2D] in /usr/local/lib/python3.
7/dist-packages (0.23.1)
WARNING: gym 0.23.1 does not provide the extra 'box_2d'
Requirement already satisfied: gym-notices>=0.0.4 in /usr/local/lib/py
thon3.7/dist-packages (from gym[Box_2D]) (0.0.6)
Requirement already satisfied: cloudpickle>=1.2.0 in /usr/local/lib/py
thon3.7/dist-packages (from gym[Box_2D]) (1.3.0)
Requirement already satisfied: numpy>=1.18.0 in /usr/local/lib/python
3.7/dist-packages (from gym[Box_2D]) (1.21.5)
Requirement already satisfied: importlib-metadata>=4.10.0 in /usr/loca
l/lib/python3.7/dist-packages (from gym[Box_2D]) (4.11.3)
Requirement already satisfied: zipp>=0.5 in /usr/local/lib/python3.7/d
ist-packages (from importlib-metadata>=4.10.0->gym[Box_2D]) (3.8.0)
Requirement already satisfied: typing-extensions>=3.6.4 in /usr/local/
lib/python3.7/dist-packages (from importlib-metadata>=4.10.0->gym[Box_
2D]) (4.1.1)
```

Test your environment

In [9]:

```
import gym
import numpy as np
import matplotlib.pyplot as plt
from IPython import display as ipythondisplay
```

In [10]:

```
from pyvirtualdisplay import Display
display = Display(visible=0, size=(400, 300))
display.start()
```

Out[10]:

```
<pyvirtualdisplay.display.Display at 0x7fa73cffdf50>
```

In [11]:

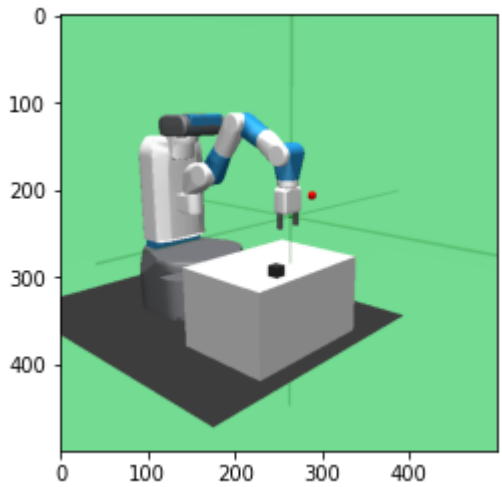
```
# env = gym.make("CartPole-v0")
# env = gym.make("DoubleDunk-v0")
# env = gym.make("SpaceInvaders-v0")
# env = gym.make("Acrobot-v1") # double invert pendulum
# env = gym.make("Ant-v2")
env = gym.make("FetchPickAndPlace-v1")
env.reset()
prev_screen = env.render(mode='rgb_array')
plt.imshow(prev_screen)

for i in range(20):
    action = env.action_space.sample()
    obs, reward, done, info = env.step(action)
    screen = env.render(mode='rgb_array')

    plt.imshow(screen)
    ipythondisplay.clear_output(wait=True)
    ipythondisplay.display(plt.gcf())

    if done:
        break

ipythondisplay.clear_output(wait=True)
env.close()
```



Save simulator video

In [12]:

```
import os
import gym
from gym.wrappers import RecordVideo

vdo_path = 'video_rl/'
if not os.path.exists(vdo_path):
    os.mkdir(vdo_path)

# env = gym.make("CartPole-v0")
# env = gym.make("DoubleDunk-v0")
# env = gym.make("SpaceInvaders-v0")
# env = gym.make("Acrobot-v1") # double invert pendulum
# env = gym.make("Ant-v2")

env = RecordVideo(gym.make('Ant-v3'), vdo_path)
env.reset()

for i in range(500):
    action = env.action_space.sample()
    obs, reward, done, info = env.step(action)
    screen = env.render()
    if done:
        break

env.close()
```

```
/usr/local/lib/python3.7/dist-packages/gym/wrappers/record_video.py:4
2: UserWarning: WARN: Overwriting existing videos at /content/video_rl
folder (try specifying a different `video_folder` for the `RecordVideo
` wrapper if this is not desired)
  f"Overwriting existing videos at {self.video_folder} folder (try spe
cifying a different `video_folder` for the `RecordVideo` wrapper if th
is is not desired)"
/usr/local/lib/python3.7/dist-packages/gym/wrappers/monitoring/video_r
ecorder.py:116: DeprecationWarning: WARN: `env.metadata["video.frames_
per_second"] is marked as deprecated and will be replaced with `env.me
tadata["render_fps"]` see https://github.com/openai/gym/pull/2654 (htt
ps://github.com/openai/gym/pull/2654) for more details
  '`env.metadata["video.frames_per_second"] is marked as deprecated an
d will be replaced with `env.metadata["render_fps"]` '


Creating window glfw
```

Policy Gradient and Actor-Critic methods

CartPole example

In [13]:

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

import torch
from torch import nn
import torch.nn.functional as F
from torch import optim
from torch.distributions import Categorical

from IPython import display as ipythondisplay

from pyvirtualdisplay import Display
display = Display(visible=0, size=(400, 300))
display.start()

import os
from gym.wrappers import RecordVideo

vdo_path = 'video_rl/'
if not os.path.exists(vdo_path):
    os.mkdir(vdo_path)
```

In [14]:

```
gamma = 0.95
seed = 0
render = False
log_interval = 10
```

In [15]:

```
env = gym.make("CartPole-v1")
#env = gym.make("SpaceInvaders-v0")
env.seed(seed)
torch.manual_seed(seed)
```

```
/usr/local/lib/python3.7/dist-packages/gym/core.py:173: DeprecationWar
ning: WARN: Function `env.seed(seed)` is marked as deprecated and will
be removed in the future. Please use `env.reset(seed=seed) instead.
  "Function `env.seed(seed)` is marked as deprecated and will be remov
ed in the future. "
```

Out[15]:

```
<torch._C.Generator at 0x7fa62f4e5f90>
```

Policy class

In [16]:

```
class Policy(nn.Module):
    def __init__(self, env):
        super(Policy, self).__init__()
        self.n_inputs = env.observation_space.shape[0]
        #print(self.n_inputs)
        self.n_outputs = env.action_space.n


        self.affine1 = nn.Linear(self.n_inputs, 128)
        self.dropout = nn.Dropout(p=0.6)
        self.affine2 = nn.Linear(128, self.n_outputs)

        self.saved_log_probs = []
        self.rewards = []

    def forward(self, x):
        x = self.affine1(x)
        x = self.dropout(x)
        x = F.relu(x)
        #print(x.shape)
        action_scores = self.affine2(x)
        return F.softmax(action_scores, dim=1)

    def select_action(self, state):
        state = torch.from_numpy(state).float().unsqueeze(0)
        probs = self.forward(state)
        m = Categorical(probs)
        action = m.sample()
        policy.saved_log_probs.append(m.log_prob(action))
        return action.item()
```

In [17]:

```
policy = Policy(env)
optimizer = optim.Adam(policy.parameters(), lr=1e-2)
eps = np.finfo(np.float32).eps.item()
```

In [18]:

```
def finish_episode():
    R = 0
    policy_loss = []
    returns = []
    for r in policy.rewards[::-1]:
        R = r + gamma * R
        returns.insert(0, R)
    returns = torch.tensor(returns)
    returns = (returns - returns.mean()) / (returns.std() + eps)
    for log_prob, R in zip(policy.saved_log_probs, returns):
        policy_loss.append(-log_prob * R)
    optimizer.zero_grad()
    policy_loss = torch.cat(policy_loss).sum()
    policy_loss.backward()
    optimizer.step()
    del policy.rewards[:]
    del policy.saved_log_probs[:]
```

In [19]:

```
from itertools import count
def reinforce():
    running_reward = 10
    for i_episode in count(1):
        state, ep_reward = env.reset(), 0
        for t in range(1, 10000):  # Don't infinite loop while learning
            action = policy.select_action(state)
            state, reward, done, _ = env.step(action)
            if render:
                env.render()
            policy.rewards.append(reward)
            ep_reward += reward
            if done:
                break

        # calculate reward
        # It accepts a list of rewards for the whole episode and needs to calculate
        # the discounted total reward for every step. To do this efficiently,
        # we calculate the reward from the end of the local reward list.
        # The last step of the episode will have the total reward equal to its local
        # The step before the last will have the total reward of ep_reward + gamma *
        running_reward = 0.05 * ep_reward + (1 - 0.05) * running_reward
        finish_episode()
        if i_episode % log_interval == 0:
            print('Episode {}\tLast reward: {:.2f}\tAverage reward: {:.2f}'.format(
                  i_episode, ep_reward, running_reward))
        if running_reward > env.spec.reward_threshold:
            print("Solved! Running reward is now {} and "
                  "the last episode runs to {} time steps!".format(running_reward, t
            break
```

In [20]:

```
reinforce()
env.close()
```

```
Episode 10      Last reward: 36.00      Average reward: 13.12
Episode 20      Last reward: 41.00      Average reward: 18.79
Episode 30      Last reward: 123.00     Average reward: 26.18
Episode 40      Last reward: 110.00     Average reward: 35.54
Episode 50      Last reward: 48.00      Average reward: 53.41
Episode 60      Last reward: 161.00     Average reward: 85.45
Episode 70      Last reward: 39.00      Average reward: 102.08
Episode 80      Last reward: 239.00     Average reward: 133.65
Episode 90      Last reward: 66.00      Average reward: 115.97
Episode 100     Last reward: 106.00     Average reward: 100.27
Episode 110     Last reward: 63.00      Average reward: 83.99
Episode 120     Last reward: 83.00      Average reward: 86.38
Episode 130     Last reward: 282.00     Average reward: 140.05
Episode 140     Last reward: 118.00     Average reward: 157.58
Episode 150     Last reward: 305.00     Average reward: 187.27
Episode 160     Last reward: 305.00     Average reward: 214.26
Episode 170     Last reward: 178.00     Average reward: 232.04
Episode 180     Last reward: 50.00      Average reward: 155.10
Episode 190     Last reward: 36.00      Average reward: 104.39
```

In [21]:

```
env = RecordVideo(gym.make("CartPole-v1"), vdo_path)
is_done = False
state = env.reset()
while not is_done:
    action = policy.select_action(state)

    state, reward, is_done, info = env.step(action)
    # print(reward, is_done)
    screen = env.render(mode='rgb_array')
env.close()
```

```
/usr/local/lib/python3.7/dist-packages/gym/wrappers/record_video.py:4
2: UserWarning: WARN: Overwriting existing videos at /content/video_rl
folder (try specifying a different `video_folder` for the `RecordVideo
` wrapper if this is not desired)
  f"Overwriting existing videos at {self.video_folder} folder (try spe
cifying a different `video_folder` for the `RecordVideo` wrapper if th
is is not desired)"
/usr/local/lib/python3.7/dist-packages/gym/wrappers/monitoring/video_r
ecorder.py:116: DeprecationWarning: WARN: `env.metadata["video.frames_
per_second"] is marked as deprecated and will be replaced with `env.me
tadata["render_fps"]` see https://github.com/openai/gym/pull/2654 (htt
ps://github.com/openai/gym/pull/2654) for more details
  '`env.metadata["video.frames_per_second"] is marked as deprecated an
d will be replaced with `env.metadata["render_fps"]` '
```

Policy Gradinet (PG)

PG on CartPole

In [22]:

```
import gym
from collections import namedtuple


class PolicyNet(torch.nn.Module):
    def __init__(self, input_size, output_size, hidden_layer_size=64):
        super(PolicyNet, self).__init__()
        self.fc1 = torch.nn.Linear(input_size, hidden_layer_size)
        self.fc2 = torch.nn.Linear(hidden_layer_size, output_size)
        self.softmax = torch.nn.Softmax(dim=0)

    def forward(self, x):
        x = torch.from_numpy(x).float()
        return self.softmax(self.fc2(torch.nn.functional.relu(self.fc1(x))))

    def get_action_and_logp(self, x):
        action_prob = self.forward(x)
        m = torch.distributions.Categorical(action_prob)
        action = m.sample()
        logp = m.log_prob(action)
        return action.item(), logp

    def act(self, x):
        action, _ = self.get_action_and_logp(x)
        return action


class ValueNet(torch.nn.Module):
    def __init__(self, input_size, hidden_layer_size=64):
        super(ValueNet, self).__init__()
        self.fc1 = torch.nn.Linear(input_size, hidden_layer_size)
        self.fc2 = torch.nn.Linear(hidden_layer_size, 1)

    def forward(self, x):
        x = torch.from_numpy(x).float()
        return self.fc2(torch.nn.functional.relu(self.fc1(x)))


def vpg(env, num_iter=200, num_traj=10, max_num_steps=1000, gamma=0.98,
        policy_learning_rate=0.01, value_learning_rate=0.01,
        policy_saved_path='vpg_policy.pt', value_saved_path='vpg_value.pt'):
    input_size = env.observation_space.shape[0]
    output_size = env.action_space.n
    Trajectory = namedtuple('Trajectory', 'states actions rewards dones logp')

    def collect_trajectory():
        state_list = []
        action_list = []
        reward_list = []
        dones_list = []
        logp_list = []
        state = env.reset()
        done = False
        steps = 0
        while not done and steps <= max_num_steps:
            action, logp = policy.get_action_and_logp(state)
            newstate, reward, done, _ = env.step(action)
            #reward = reward + float(state[0])
            state_list.append(state)
```

```
            action_list.append(action)
            reward_list.append(reward)
            dones_list.append(done)
            logp_list.append(logp)
            steps += 1
            state = newstate

        traj = Trajectory(states=state_list, actions=action_list,
                          rewards=reward_list, logp=logp_list, dones=dones_list)
        return traj

    def calc_returns(rewards):
        dis_rewards = [gamma**i * r for i, r in enumerate(rewards)]
        return [sum(dis_rewards[i:]) for i in range(len(dis_rewards))]

    policy = PolicyNet(input_size, output_size)
    value = ValueNet(input_size)
    policy_optimizer = torch.optim.Adam(
        policy.parameters(), lr=policy_learning_rate)
    value_optimizer = torch.optim.Adam(
        value.parameters(), lr=value_learning_rate)

    mean_return_list = []
    for it in range(num_iter):
        traj_list = [collect_trajectory() for _ in range(num_traj)]
        returns = [calc_returns(traj.rewards) for traj in traj_list]

        policy_loss_terms = [-1. * traj.logp[j] * (returns[i][j] - value(traj.states
                             for i, traj in enumerate(traj_list) for j in range(len(

        policy_loss = 1. / num_traj * torch.cat(policy_loss_terms).sum()
        policy_optimizer.zero_grad()
        policy_loss.backward()
        policy_optimizer.step()

        value_loss_terms = [1. / len(traj.actions) * (value(traj.states[j]) - return
                            for i, traj in enumerate(traj_list) for j in range(len(t
        value_loss = 1. / num_traj * torch.cat(value_loss_terms).sum()
        value_optimizer.zero_grad()
        value_loss.backward()
        value_optimizer.step()

        mean_return = 1. / num_traj * \
            sum([traj_returns[0] for traj_returns in returns])
        mean_return_list.append(mean_return)
        if it % 10 == 0:
            print('Iteration {}: Mean Return = {}'.format(it, mean_return))
            torch.save(policy.state_dict(), policy_saved_path)
            torch.save(value.state_dict(), value_saved_path)
    return policy, mean_return_list
```

In [23]:

```
import gym
import matplotlib.pyplot as plt

vdo_path = 'video_rl2/'
if not os.path.exists(vdo_path):
    print("No folder ", vdo_path, 'exist. Create the folder')
    os.mkdir(vdo_path)
    print("Create directory finished")
else:
    print(vdo_path, 'existed, do nothing')

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

agent, mean_return_list = vpg(env, num_iter=200, max_num_steps=500, gamma=1.0,
                              num_traj=5)

#env = RecordVideo(gym.make("CartPole-v1"), vdo_path, force=True)
env = RecordVideo(gym.make("CartPole-v1"), vdo_path)

plt.plot(mean_return_list)
plt.xlabel('Iteration')
plt.ylabel('Mean Return')
plt.savefig('vpg_returns.png', format='png', dpi=300)

state = env.reset()
for t in range(1000):
    action = agent.act(state)
    env.render()
    state, reward, done, _ = env.step(action)
    if done:
        break
env.close()
```

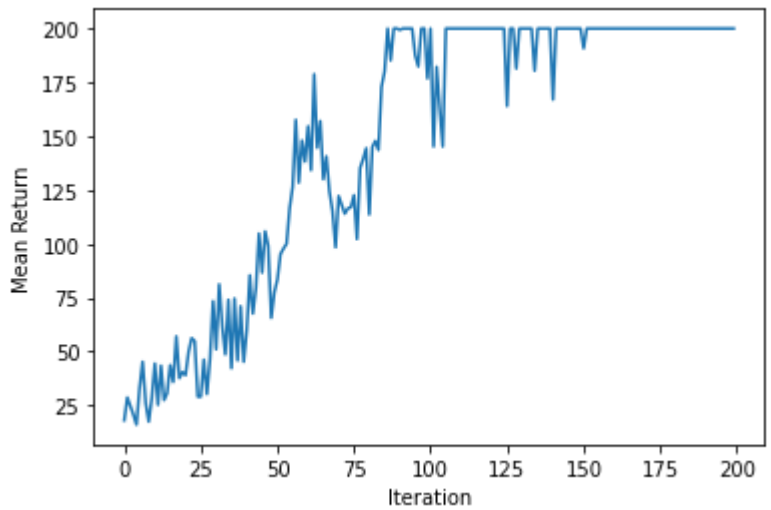
```
video_rl2/ existed, do nothing
Iteration 0: Mean Return = 18.0

/usr/local/lib/python3.7/dist-packages/gym/envs/registration.py:506: U
serWarning: WARN: The environment CartPole-v0 is out of date. You shou
ld consider upgrading to version `v1` with the environment ID `CartPol
e-v1`.
  f"The environment {path} is out of date. You should consider "

Iteration 10: Mean Return = 44.400000000000006
Iteration 20: Mean Return = 39.0
Iteration 30: Mean Return = 51.0
Iteration 40: Mean Return = 59.800000000000004
Iteration 50: Mean Return = 83.4
Iteration 60: Mean Return = 154.60000000000002
Iteration 70: Mean Return = 122.2
Iteration 80: Mean Return = 113.60000000000001
Iteration 90: Mean Return = 199.4
Iteration 100: Mean Return = 200.0
Iteration 110: Mean Return = 200.0
Iteration 120: Mean Return = 200.0
Iteration 130: Mean Return = 200.0
Iteration 140: Mean Return = 167.0
Iteration 150: Mean Return = 190.8
Iteration 160: Mean Return = 200.0
Iteration 170: Mean Return = 200.0
```

```
Iteration 180: Mean Return = 200.0
Iteration 190: Mean Return = 200.0

/usr/local/lib/python3.7/dist-packages/gym/wrappers/record_video.py:4
2: UserWarning: WARN: Overwriting existing videos at /content/video_rl
2 folder (try specifying a different `video_folder` for the `RecordVid
eo` wrapper if this is not desired)
  f"Overwriting existing videos at {self.video_folder} folder (try spe
cifying a different `video_folder` for the `RecordVideo` wrapper if th
is is not desired)"
/usr/local/lib/python3.7/dist-packages/gym/wrappers/monitoring/video_r
ecorder.py:116: DeprecationWarning: WARN: `env.metadata["video.frames_
per_second"] is marked as deprecated and will be replaced with `env.me
tadata["render_fps"]` see https://github.com/openai/gym/pull/2654 (htt
ps://github.com/openai/gym/pull/2654) for more details
  '`env.metadata["video.frames_per_second"] is marked as deprecated an
d will be replaced with `env.metadata["render_fps"]` '
```



Actor-Critic

Basic CartPole A2C

In [24]:

```
import torch
import torch.nn as nn
import torch.nn.functional as F
from torch.autograd import Variable
import matplotlib.pyplot as plt
import numpy as np
import math
import random
import os
import gym
```

In [25]:

```
# Hyper Parameters
STATE_DIM = 4
ACTION_DIM = 2
STEP = 2000
SAMPLE_NUMS = 30
```

In [26]:

```
class ActorNetwork(nn.Module):

    def __init__(self,input_size,hidden_size,action_size):
        super(ActorNetwork, self).__init__()
        self.fc1 = nn.Linear(input_size,hidden_size)
        self.fc2 = nn.Linear(hidden_size,hidden_size)
        self.fc3 = nn.Linear(hidden_size,action_size)

    def forward(self,x):
        out = F.relu(self.fc1(x))
        out = F.relu(self.fc2(out))
        out = F.log_softmax(self.fc3(out))
        return out
```

In [27]:

```
class ValueNetwork(nn.Module):

    def __init__(self,input_size,hidden_size,output_size):
        super(ValueNetwork, self).__init__()
        self.fc1 = nn.Linear(input_size,hidden_size)
        self.fc2 = nn.Linear(hidden_size,hidden_size)
        self.fc3 = nn.Linear(hidden_size,output_size)

    def forward(self,x):
        out = F.relu(self.fc1(x))
        out = F.relu(self.fc2(out))
        out = self.fc3(out)
        return out
```

In [28]:

```
def roll_out(actor_network,task,sample_nums,value_network,init_state):
    #task.reset()
    states = []
    actions = []
    rewards = []
    is_done = False
    final_r = 0
    state = init_state

    for j in range(sample_nums):
        states.append(state)
        log_softmax_action = actor_network(Variable(torch.Tensor([state])))
        softmax_action = torch.exp(log_softmax_action)
        action = np.random.choice(ACTION_DIM,p=softmax_action.cpu().data.numpy()[0])
        one_hot_action = [int(k == action) for k in range(ACTION_DIM)]
        next_state,reward,done,_ = task.step(action)
        #fix_reward = -10 if done else 1
        actions.append(one_hot_action)
        rewards.append(reward)
        final_state = next_state
        state = next_state
        if done:
            is_done = True
            state = task.reset()
            break
    if not is_done:
        final_r = value_network(Variable(torch.Tensor([final_state]))).cpu().data.nu

    return states,actions,rewards,final_r,state
```

In [29]:

```
def discount_reward(r, gamma,final_r):
    discounted_r = np.zeros_like(r)
    running_add = final_r
    for t in reversed(range(0, len(r))):
        running_add = running_add * gamma + r[t]
        discounted_r[t] = running_add
    return discounted_r
```

In [30]:

```
def A2C():
    # init a task generator for data fetching
    task = gym.make("CartPole-v0")
    init_state = task.reset()

    # init value network
    value_network = ValueNetwork(input_size = STATE_DIM,hidden_size = 40,output_size
    value_network_optim = torch.optim.Adam(value_network.parameters(),lr=0.01)

    # init actor network
    actor_network = ActorNetwork(STATE_DIM,40,ACTION_DIM)
    actor_network_optim = torch.optim.Adam(actor_network.parameters(),lr = 0.01)

    steps =[]
    task_episodes =[]
    test_results =[]

    for step in range(STEP):
        states,actions,rewards,final_r,current_state = roll_out(actor_network,task,S
        init_state = current_state
        actions_var = Variable(torch.Tensor(actions).view(-1,ACTION_DIM))
        states_var = Variable(torch.Tensor(states).view(-1,STATE_DIM))

        # train actor network
        actor_network_optim.zero_grad()
        log_softmax_actions = actor_network(states_var)
        vs = value_network(states_var).detach()
        # calculate qs
        qs = Variable(torch.Tensor(discount_reward(rewards,0.99,final_r)))

        advantages = qs - vs
        actor_network_loss = - torch.mean(torch.sum(log_softmax_actions*actions_var,
        actor_network_loss.backward()
        torch.nn.utils.clip_grad_norm(actor_network.parameters(),0.5)
        actor_network_optim.step()

        # train value network
        value_network_optim.zero_grad()
        target_values = qs
        values = value_network(states_var)
        criterion = nn.MSELoss()
        value_network_loss = criterion(values,target_values)
        value_network_loss.backward()
        torch.nn.utils.clip_grad_norm(value_network.parameters(),0.5)
        value_network_optim.step()

        # Testing
        if (step + 1) % 50== 0:
                result = 0
                test_task = gym.make("CartPole-v0")
                for test_epi in range(10):
                    state = test_task.reset()
                    for test_step in range(200):
                        softmax_action = torch.exp(actor_network(Variable(torch.Tens
                        #print(softmax_action.data)
                        action = np.argmax(softmax_action.data.numpy()[0])
                        next_state,reward,done,_ = test_task.step(action)
                        result += reward
                        state = next_state
```

```
                    if done:
                        break
                print("step:",step+1,"test result:",result/10.0)
                steps.append(step+1)
                test_results.append(result/10)

    return actor_network
```

In [31]:

```
actor_network = A2C()
```

```
/usr/local/lib/python3.7/dist-packages/gym/envs/registration.py:506: U
serWarning: WARN: The environment CartPole-v0 is out of date. You shou
ld consider upgrading to version `v1` with the environment ID `CartPol
e-v1`.
  f"The environment {path} is out of date. You should consider "
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:12: UserW
arning: Creating a tensor from a list of numpy.ndarrays is extremely s
low. Please consider converting the list to a single numpy.ndarray wit
h numpy.array() before converting to a tensor. (Triggered internally a
t  ../torch/csrc/utils/tensor_new.cpp:201.)
  if sys.path[0] == '':
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:12: UserW
arning: Implicit dimension choice for log_softmax has been deprecated.
Change the call to include dim=X as an argument.
  if sys.path[0] == '':
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:34: UserW
arning: torch.nn.utils.clip_grad_norm is now deprecated in favor of to
rch.nn.utils.clip_grad_norm_.
/usr/local/lib/python3.7/dist-packages/torch/nn/modules/loss.py:520: U
```

In [32]:

```
vdo_path = 'video_rl3/'
if not os.path.exists(vdo_path):
    os.mkdir(vdo_path)

env = RecordVideo(gym.make("CartPole-v1"), vdo_path)

state = env.reset()
for t in range(1000):
    softmax_action = torch.exp(actor_network(Variable(torch.Tensor([state]))))
    #print(softmax_action.data)
    action = np.argmax(softmax_action.data.numpy()[0])
    env.render()
    state, reward, done, _ = env.step(action)
    if done:
        break
env.close()
```

```
/usr/local/lib/python3.7/dist-packages/gym/wrappers/record_video.py:4
2: UserWarning: WARN: Overwriting existing videos at /content/video_rl
3 folder (try specifying a different `video_folder` for the `RecordVid
eo` wrapper if this is not desired)
  f"Overwriting existing videos at {self.video_folder} folder (try spe
cifying a different `video_folder` for the `RecordVideo` wrapper if th
is is not desired)"
/usr/local/lib/python3.7/dist-packages/gym/wrappers/monitoring/video_r
ecorder.py:116: DeprecationWarning: WARN: `env.metadata["video.frames_
per_second"] is marked as deprecated and will be replaced with `env.me
tadata["render_fps"]` see https://github.com/openai/gym/pull/2654 (htt
ps://github.com/openai/gym/pull/2654) for more details
  '`env.metadata["video.frames_per_second"] is marked as deprecated an
d will be replaced with `env.metadata["render_fps"]` '
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:12: UserW
arning: Implicit dimension choice for log_softmax has been deprecated.
Change the call to include dim=X as an argument.
  if sys.path[0] == '':
```

Take Home Exercise

Implement REINFORCE and A2C for one of the Atari games such as Space Invaders using a CNN for the policy network and (for A2C) the value network.

REINFORCE for Space Invaders using a CNN for policy Network

For this part of exercixe, I used 'SpaceInvaders-v0' for environemnt. In policy Net class, the flatten value, 100800, is used for inputs to pass through the linear. Moreover, making reshape for state in select_action finction since SapceInvaders has only 3 dimensioanl inputs.

In [33]:

```
env = gym.make('SpaceInvaders-v0')
#env = gym.make("CartPole-v1")
env.seed(seed = seed)
torch.manual_seed(seed = seed)
```

```
/usr/local/lib/python3.7/dist-packages/gym/envs/registration.py:506: U
serWarning: WARN: The environment SpaceInvaders-v0 is out of date. You
should consider upgrading to version `v5` with the environment ID `AL
E/SpaceInvaders-v5`.
  f"The environment {path} is out of date. You should consider "
/usr/local/lib/python3.7/dist-packages/gym/utils/seeding.py:139: Depre
cationWarning: WARN: Function `hash_seed(seed, max_bytes)` is marked a
s deprecated and will be removed in the future.
  "Function `hash_seed(seed, max_bytes)` is marked as deprecated and w
ill be removed in the future. "
/usr/local/lib/python3.7/dist-packages/gym/utils/seeding.py:176: Depre
cationWarning: WARN: Function `_bigint_from_bytes(bytes)` is marked as
deprecated and will be removed in the future.
  "Function `_bigint_from_bytes(bytes)` is marked as deprecated and wi
ll be removed in the future. "
```

Out[33]:

```
<torch._C.Generator at 0x7fa62f4e5f90>
```

In [34]:

```
class Policy(nn.Module):
    def __init__(self, env):
        super(Policy, self).__init__()
        self.n_inputs = env.observation_space.shape[0]
        #print(self.n_inputs)
        self.n_outputs = env.action_space.n

        self.affine1 = nn.Linear(100800, 128)
        #self.affine1 = nn.Linear(self.n_inputs, 128)
        self.dropout = nn.Dropout(p=0.6)
        self.affine2 = nn.Linear(128, self.n_outputs)

        self.saved_log_probs = []
        self.rewards = []

    def forward(self, x):
        x = self.affine1(x)
        x = self.dropout(x)
        x = F.relu(x)
        #print(x.shape)
        action_scores = self.affine2(x)
        return F.softmax(action_scores, dim=1)

    def select_action(self, state):
        state = torch.from_numpy(state).float().unsqueeze(0)
        state = state.reshape((1,-1))
        probs = self.forward(state)
        m = Categorical(probs)
        action = m.sample()
        policy.saved_log_probs.append(m.log_prob(action))
        return action.item()
```

In [35]:

```
policy = Policy(env)
optimizer = optim.Adam(policy.parameters(), lr=1e-2)
eps = np.finfo(np.float32).eps.item()
```

In [36]:

```
def finish_episode():
    R = 0
    policy_loss = []
    returns = []
    for r in policy.rewards[::-1]:
        R = r + gamma * R
        returns.insert(0, R)
    returns = torch.tensor(returns)
    returns = (returns - returns.mean()) / (returns.std() + eps)
    for log_prob, R in zip(policy.saved_log_probs, returns):
        policy_loss.append(-log_prob * R)
    optimizer.zero_grad()
    policy_loss = torch.cat(policy_loss).sum()
    policy_loss.backward()
    optimizer.step()
    del policy.rewards[:]
    del policy.saved_log_probs[:]
```

In [37]:

```
from itertools import count
def reinforce_():
    running_reward = 10
    for i_episode in count(1):
        state, ep_reward = env.reset(), 0
        for t in range(1, 1000):  # Don't infinite loop while learning
            action = policy.select_action(state)
            state, reward, done, _ = env.step(action)
            if render:
                env.render()
            policy.rewards.append(reward)
            ep_reward += reward
            if done:
                break

        # calculate reward
        # It accepts a list of rewards for the whole episode and needs to calculate
        # the discounted total reward for every step. To do this efficiently,
        # we calculate the reward from the end of the local reward list.
        # The last step of the episode will have the total reward equal to its local
        # The step before the last will have the total reward of ep_reward + gamma *
        running_reward = 0.05 * ep_reward + (1 - 0.05) * running_reward
        finish_episode()
        if i_episode % log_interval == 0:
            print('Episode {}\tLast reward: {:.2f}\tAverage reward: {:.2f}'.format(
                  i_episode, ep_reward, running_reward))
        if running_reward > 100: #env.spec.reward_threshold -->100
            print("Solved! Running reward is now {} and "
                  "the last episode runs to {} time steps!".format(running_reward, t
            break
```

In [38]:

```
reinforce_()
env.close()
```

```
/usr/local/lib/python3.7/dist-packages/gym/utils/seeding.py:48: Deprec
ationWarning: WARN: Function `rng.randint(low, [high, size, dtype])` i
s marked as deprecated and will be removed in the future. Please use `
rng.integers(low, [high, size, dtype])` instead.
  "Function `rng.randint(low, [high, size, dtype])` is marked as depre
cated "

Episode 10      Last reward: 210.00     Average reward: 74.83
Solved! Running reward is now 106.36156970938475 and the last episode
runs to 982 time steps!
```

For the result, with Episode 10, Last reward is 210.00 and Average reward is 74.83. Then, Running reward is now 106.36156970938475 and the last episode runs to 982 time steps.

In [39]:

```
env = RecordVideo(gym.make("SpaceInvaders-v0"), vdo_path)
is_done = False
state = env.reset()
while not is_done:
    action = policy.select_action(state)

    state, reward, is_done, info = env.step(action)
    # print(reward, is_done)
    screen = env.render(mode='rgb_array')
env.close()
```

```
/usr/local/lib/python3.7/dist-packages/gym/envs/registration.py:506: U
serWarning: WARN: The environment SpaceInvaders-v0 is out of date. You
should consider upgrading to version `v5` with the environment ID `AL
E/SpaceInvaders-v5`.
  f"The environment {path} is out of date. You should consider "
/usr/local/lib/python3.7/dist-packages/gym/utils/seeding.py:139: Depre
cationWarning: WARN: Function `hash_seed(seed, max_bytes)` is marked a
s deprecated and will be removed in the future.
  "Function `hash_seed(seed, max_bytes)` is marked as deprecated and w
ill be removed in the future. "
/usr/local/lib/python3.7/dist-packages/gym/utils/seeding.py:176: Depre
cationWarning: WARN: Function `_bigint_from_bytes(bytes)` is marked as
deprecated and will be removed in the future.
  "Function `_bigint_from_bytes(bytes)` is marked as deprecated and wi
ll be removed in the future. "
/usr/local/lib/python3.7/dist-packages/gym/wrappers/record_video.py:4
2: UserWarning: WARN: Overwriting existing videos at /content/video_rl
3 folder (try specifying a different `video_folder` for the `RecordVid
eo` wrapper if this is not desired)
  f"Overwriting existing videos at {self.video_folder} folder (try spe
cifying a different `video_folder` for the `RecordVideo` wrapper if th
is is not desired)"
/usr/local/lib/python3.7/dist-packages/gym/wrappers/monitoring/video_r
ecorder.py:44: DeprecationWarning: WARN: `env.metadata["render.modes"]
is marked as deprecated and will be replaced with `env.metadata["rende
r_modes"]` see https://github.com/openai/gym/pull/2654 (https://githu
b.com/openai/gym/pull/2654) for more details
  '`env.metadata["render.modes"] is marked as deprecated and will be r
eplaced with `env.metadata["render_modes"]` '
/usr/local/lib/python3.7/dist-packages/gym/utils/seeding.py:48: Deprec
ationWarning: WARN: Function `rng.randint(low, [high, size, dtype])` i
s marked as deprecated and will be removed in the future. Please use `
rng.integers(low, [high, size, dtype])` instead.
  "Function `rng.randint(low, [high, size, dtype])` is marked as depre
cated "
```

In [ ]:

A2C for Space Invaders using a CNN for value Network

For this part of exercise, I used 100800 which is the flatten result of 'SpaceInvaders-v0' for state dimension. Moreover, making reshape for input in forward function since the input shape of 'SpaceInvaders-v0' is only three dimenions.

In [41]:

```
import torch
import torch.nn as nn
import torch.nn.functional as F
import matplotlib.pyplot as plt
import numpy as np
import math
import random
import os
import gym
```

In [42]:

```
# Hyper Parameters
STATE_DIM = 100800
# STATE_DIM = 3
ACTION_DIM = 6
STEP = 10
SAMPLE_NUMS = 1
```

In [43]:

```
class ActorNetwork(nn.Module):

    def __init__(self,input_size,hidden_size,action_size):
        super(ActorNetwork, self).__init__()
        self.fc1 = nn.Linear(input_size,hidden_size)
        self.fc2 = nn.Linear(hidden_size,hidden_size)
        self.fc3 = nn.Linear(hidden_size,action_size)

    def forward(self,x):
        x = x.reshape((1, -1))
        out = F.relu(self.fc1(x))
        out = F.relu(self.fc2(out))
        out = F.log_softmax(self.fc3(out))
        return out
```

In [44]:

```
class ValueNetwork(nn.Module):

    def __init__(self,input_size,hidden_size,output_size):
        super(ValueNetwork, self).__init__()
        self.fc1 = nn.Linear(input_size,hidden_size)
        self.fc2 = nn.Linear(hidden_size,hidden_size)
        self.fc3 = nn.Linear(hidden_size,output_size)

    def forward(self,x):
        x = x.reshape((1, -1))
        out = F.relu(self.fc1(x))
        out = F.relu(self.fc2(out))
        out = self.fc3(out)
        return out
```

In [45]:

```
def roll_out(actor_network,task,sample_nums,value_network,init_state):
    #task.reset()
    states = []
    actions = []
    rewards = []
    is_done = False
    final_r = 0
    state = init_state

    for j in range(sample_nums):
        states.append(state)
        log_softmax_action = actor_network(Variable(torch.Tensor([state])))
        softmax_action = torch.exp(log_softmax_action)
        action = np.random.choice(ACTION_DIM,p=softmax_action.cpu().data.numpy()[0])
        one_hot_action = [int(k == action) for k in range(ACTION_DIM)]
        next_state,reward,done,_ = task.step(action)
        #fix_reward = -10 if done else 1
        actions.append(one_hot_action)
        rewards.append(reward)
        final_state = next_state
        state = next_state
        if done:
            is_done = True
            state = task.reset()
            break
    if not is_done:
        final_r = value_network(Variable(torch.Tensor([final_state]))).cpu().data.nu

    return states,actions,rewards,final_r,state
```

In [46]:

```
def discount_reward(r, gamma,final_r):
    discounted_r = np.zeros_like(r)
    running_add = final_r
    for t in reversed(range(0, len(r))):
        running_add = running_add * gamma + r[t]
        discounted_r[t] = running_add
    return discounted_r
```

In [50]:

```
def A2C():
    # init a task generator for data fetching
    task = gym.make("SpaceInvaders-v0")
    init_state = task.reset()

    # init value network
    value_network = ValueNetwork(input_size = 100800,hidden_size = 40,output_size =
    value_network_optim = torch.optim.Adam(value_network.parameters(),lr=0.01)

    # init actor network
    actor_network = ActorNetwork(100800,40,ACTION_DIM)
    actor_network_optim = torch.optim.Adam(actor_network.parameters(),lr = 0.01)

    steps =[]
    task_episodes =[]
    test_results =[]

    for step in range(STEP):
        states,actions,rewards,final_r,current_state = roll_out(actor_network,task,S
        init_state = current_state
        actions_var = Variable(torch.Tensor(actions).view(-1,ACTION_DIM))
        states_var = Variable(torch.Tensor(states).view(-1,STATE_DIM))
        #print(actions_var.shape)
        #print(states_var.shape)

        # train actor network
        actor_network_optim.zero_grad()
        log_softmax_actions = actor_network(states_var)
        vs = value_network(states_var).detach()
        # calculate qs
        qs = Variable(torch.Tensor(discount_reward(rewards,0.99,final_r)))

        advantages = qs - vs
        actor_network_loss = - torch.mean(torch.sum(log_softmax_actions*actions_var,
        actor_network_loss.backward()
        torch.nn.utils.clip_grad_norm(actor_network.parameters(),0.5)
        actor_network_optim.step()

        # train value network
        value_network_optim.zero_grad()
        target_values = qs
        values = value_network(states_var)
        criterion = nn.MSELoss()
        value_network_loss = criterion(values,target_values)
        value_network_loss.backward()
        torch.nn.utils.clip_grad_norm(value_network.parameters(),0.5)
        value_network_optim.step()

        # Testing
        if (step + 1) % 1== 0:
                result = 0
                test_task = gym.make("SpaceInvaders-v0")
                for test_epi in range(10):
                    state = test_task.reset()
                    for test_step in range(200):
                        softmax_action = torch.exp(actor_network(Variable(torch.Tens
                        #print(softmax_action.data)
                        action = np.argmax(softmax_action.data.numpy()[0])
                        next_state,reward,done,_ = test_task.step(action)
```

```
                    result += reward
                    state = next_state
                    if done:
                        break
                print("step:",step+1,"test result:",result/10.0)
                steps.append(step+1)
                test_results.append(result/10)

    return actor_network
```

In [51]:

```
actor_network = A2C()
```

```
/usr/local/lib/python3.7/dist-packages/gym/envs/registration.py:506: U
serWarning: WARN: The environment SpaceInvaders-v0 is out of date. You
should consider upgrading to version `v5` with the environment ID `AL
E/SpaceInvaders-v5`.
  f"The environment {path} is out of date. You should consider "
/usr/local/lib/python3.7/dist-packages/gym/utils/seeding.py:139: Depre
cationWarning: WARN: Function `hash_seed(seed, max_bytes)` is marked a
s deprecated and will be removed in the future.
  "Function `hash_seed(seed, max_bytes)` is marked as deprecated and w
ill be removed in the future. "
/usr/local/lib/python3.7/dist-packages/gym/utils/seeding.py:176: Depre
cationWarning: WARN: Function `_bigint_from_bytes(bytes)` is marked as
deprecated and will be removed in the future.
  "Function `_bigint_from_bytes(bytes)` is marked as deprecated and wi
ll be removed in the future. "
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:13: UserW
arning: Implicit dimension choice for log_softmax has been deprecated.
Change the call to include dim=X as an argument.
  del sys.path[0]
/usr/local/lib/python3.7/dist-packages/gym/utils/seeding.py:48: Deprec
ationWarning: WARN: Function `rng.randint(low, [high, size, dtype])` i
s marked as deprecated and will be removed in the future. Please use `
rng.integers(low, [high, size, dtype])` instead.
  "Function `rng.randint(low, [high, size, dtype])` is marked as depre
cated "
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:36: UserW
arning: torch.nn.utils.clip_grad_norm is now deprecated in favor of to
rch.nn.utils.clip_grad_norm_.
/usr/local/lib/python3.7/dist-packages/torch/nn/modules/loss.py:520: U
serWarning: Using a target size (torch.Size([1])) that is different to
the input size (torch.Size([1, 1])). This will likely lead to incorrec
t results due to broadcasting. Please ensure they have the same size.
  return F.mse_loss(input, target, reduction=self.reduction)
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:46: UserW
arning: torch.nn.utils.clip_grad_norm is now deprecated in favor of to
rch.nn.utils.clip_grad_norm_.
```

```
step: 1 test result: 57.5
step: 2 test result: 57.5
step: 3 test result: 62.5
step: 4 test result: 62.5
step: 5 test result: 62.5
step: 6 test result: 65.0
step: 7 test result: 62.5
step: 8 test result: 62.5
step: 9 test result: 60.0
step: 10 test result: 62.5
```

For the test result, it got total 62.5 in 10 steps.

In [ ]:

```

```