N-step Deep Q-Networks

```
!apt-get update && apt-get install -y xvfb
```

```
Unpacking libxkbfile1:amd64 (1:1.1.0-1build3) ...
Selecting previously unselected package x11-xkb-utils.
Preparing to unpack .../3-x11-xkb-utils_7.7+5build4_amd64.deb ...
Unpacking x11-xkb-utils (7.7+5build4) ...
Selecting previously unselected package xfonts-encodings.
Preparing to unpack .../4-xfonts-encodings_1%3a1.0.5-0ubuntu2_all.deb ...
Unpacking xfonts-encodings (1:1.0.5-0ubuntu2) ...
Selecting previously unselected package xfonts-utils.
Preparing to unpack .../5-xfonts-utils_1%3a7.7+6build2_amd64.deb ...
Unpacking xfonts-utils (1:7.7+6build2) ...
Selecting previously unselected package xfonts-base.
Preparing to unpack .../6-xfonts-base_1%3a1.0.5_all.deb ...
Unpacking xfonts-base (1:1.0.5) ...
Selecting previously unselected package xserver-common.
Preparing to unpack .../7-xserver-common_2%3a21.1.4-2ubuntu1.7~22.04.12_all.deb ...
Unpacking xserver-common (2:21.1.4-2ubuntu1.7~22.04.12) ...
Selecting previously unselected package xvfb.
Preparing to unpack .../8-xvfb_2%3a21.1.4-2ubuntu1.7~22.04.12_amd64.deb ...
Unpacking xvfb (2:21.1.4-2ubuntu1.7~22.04.12) ...
Setting up libfontenc1:amd64 (1:1.1.4-1build3) ...
Setting up xfonts-encodings (1:1.0.5-0ubuntu2) ...
Setting up libxkbfile1:amd64 (1:1.1.0-1build3) ...
Setting up libxfont2:amd64 (1:2.0.5-1build1) ...
Setting up x11-xkb-utils (7.7+5build4) ...
Setting up xfonts-utils (1:7.7+6build2) ...
Setting up xfonts-base (1:1.0.5) ...
Setting up xserver-common (2:21.1.4-2ubuntu1.7~22.04.12) ...
Setting up xvfb (2:21.1.4-2ubuntu1.7~22.04.12) ...
Processing triggers for man-db (2.10.2-1) ...
Processing triggers for fontconfig (2.13.1-4.2ubuntu5) ...
Processing triggers for libc-bin (2.35-0ubuntu3.4) ...
/sbin/ldconfig.real: /usr/local/lib/libtbb.so.12 is not a symbolic link

/sbin/ldconfig.real: /usr/local/lib/libumf.so.0 is not a symbolic link

/sbin/ldconfig.real: /usr/local/lib/libtbbmalloc.so.2 is not a symbolic link

/sbin/ldconfig.real: /usr/local/lib/libur_loader.so.0 is not a symbolic link

/sbin/ldconfig.real: /usr/local/lib/libtbbbind_2_5.so.3 is not a symbolic link

/sbin/ldconfig.real: /usr/local/lib/libtcm_debug.so.1 is not a symbolic link

/sbin/ldconfig.real: /usr/local/lib/libur_adapter_level_zero.so.0 is not a symbolic link

/sbin/ldconfig.real: /usr/local/lib/libur_adapter_opencl.so.0 is not a symbolic link

/sbin/ldconfig.real: /usr/local/lib/libtbbbind_2_0.so.3 is not a symbolic link

/sbin/ldconfig.real: /usr/local/lib/libtbbmalloc_proxy.so.2 is not a symbolic link

/sbin/ldconfig.real: /usr/local/lib/libtcm.so.1 is not a symbolic link

/sbin/ldconfig.real: /usr/local/lib/libtbbbind.so.3 is not a symbolic link

/sbin/ldconfig.real: /usr/local/lib/libhwloc.so.15 is not a symbolic link
```

```
!pip install gym[atari,accept-rom-license]==0.23.1
```

```
Collecting gym==0.23.1 (from gym[accept-rom-license,atari]==0.23.1)
  Downloading gym-0.23.1.tar.gz (626 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 626.2/626.2 kB 32.2 MB/s eta 0:00:00
  Installing build dependencies ... done
  Getting requirements to build wheel ... done
  Preparing metadata (pyproject.toml) ... done
Requirement already satisfied: numpy>=1.18.0 in /usr/local/lib/python3.10/dist-packages (from gym==0.23.1->gym[accept-
Requirement already satisfied: cloudpickle>=1.2.0 in /usr/local/lib/python3.10/dist-packages (from gym==0.23.1->gym[ac
Requirement already satisfied: gym_notices>=0.0.4 in /usr/local/lib/python3.10/dist-packages (from gym==0.23.1->gym[ac
Collecting ale-py~=0.7.4 (from gym[accept-rom-license,atari]==0.23.1)
  Downloading ale_py-0.7.5-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.whl.metadata (8.1 kB)
```

```
Collecting autorom~=0.4.2 (from autorom[accept-rom-license]~=0.4.2; extra == "accept-rom-license"->gym[accept-rom-lice
  Downloading AutoROM-0.4.2-py3-none-any.whl.metadata (2.8 kB)
Requirement already satisfied: importlib-resources in /usr/local/lib/python3.10/dist-packages (from ale-py~=0.7.4->gym
Requirement already satisfied: click in /usr/local/lib/python3.10/dist-packages (from autorom~=0.4.2->autorom[accept-r
Requirement already satisfied: requests in /usr/local/lib/python3.10/dist-packages (from autorom~=0.4.2->autorom[accep
Requirement already satisfied: tqdm in /usr/local/lib/python3.10/dist-packages (from autorom~=0.4.2->autorom[accept-ro
Collecting AutoROM.accept-rom-license (from autorom[accept-rom-license]~=0.4.2; extra == "accept-rom-license"->gym[acc
  Downloading AutoROM.accept-rom-license-0.6.1.tar.gz (434 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 434.7/434.7 kB 36.9 MB/s eta 0:00:00
  Installing build dependencies ... done
  Getting requirements to build wheel ... done
  Preparing metadata (pyproject.toml) ... done
Requirement already satisfied: charset-normalizer<4,>=2 in /usr/local/lib/python3.10/dist-packages (from requests->aut
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.10/dist-packages (from requests->autorom~=0.4.2-
Requirement already satisfied: urllib3<3,>=1.21.1 in /usr/local/lib/python3.10/dist-packages (from requests->autorom~=
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.10/dist-packages (from requests->autorom~=
Downloading ale_py-0.7.5-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.whl (1.6 MB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 1.6/1.6 MB 53.2 MB/s eta 0:00:00
Downloading AutoROM-0.4.2-py3-none-any.whl (16 kB)
Building wheels for collected packages: gym, AutoROM.accept-rom-license
  Building wheel for gym (pyproject.toml) ... done
  Created wheel for gym: filename=gym-0.23.1-py3-none-any.whl size=701369 sha256=49ce20cc960b21f9cce2f099fb61c872284ed
  Stored in directory: /root/.cache/pip/wheels/1a/00/fb/fe5cf2860fb9b7bc860e28f00095a1f42c7b726dd6f42d1acc
  Building wheel for AutoROM.accept-rom-license (pyproject.toml) ... done
  Created wheel for AutoROM.accept-rom-license: filename=AutoROM.accept_rom_license-0.6.1-py3-none-any.whl size=446667
  Stored in directory: /root/.cache/pip/wheels/6b/1b/ef/a43ff1a2f1736d5711faa1ba4c1f61be1131b8899e6a057811
Successfully built gym AutoROM.accept-rom-license
Installing collected packages: gym, ale-py, AutoROM.accept-rom-license, autorom
  Attempting uninstall: gym
    Found existing installation: gym 0.25.2
    Uninstalling gym-0.25.2:
      Successfully uninstalled gym-0.25.2
Successfully installed AutoROM.accept-rom-license-0.6.1 ale-py-0.7.5 autorom-0.4.2 gym-0.23.1
```

```
!pip install stable-baselines3==1.4.0
```

```
Collecting stable-baselines3==1.4.0
  Downloading stable_baselines3-1.4.0-py3-none-any.whl.metadata (3.9 kB)
Collecting gym<0.20,>=0.17 (from stable-baselines3==1.4.0)
  Downloading gym-0.19.0.tar.gz (1.6 MB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 1.6/1.6 MB 51.2 MB/s eta 0:00:00
  error: subprocess-exited-with-error

  × python setup.py egg_info did not run successfully.
  │ exit code: 1
  ╰─> See above for output.

  note: This error originates from a subprocess, and is likely not a problem with pip.
  Preparing metadata (setup.py) ... error
error: metadata-generation-failed

× Encountered error while generating package metadata.
╰─> See above for output.

note: This is an issue with the package mentioned above, not pip.
hint: See above for details.
```

```
!pip install pytorch-lightning
```

```
Collecting pytorch-lightning
  Downloading pytorch_lightning-2.4.0-py3-none-any.whl.metadata (21 kB)
Requirement already satisfied: torch>=2.1.0 in /usr/local/lib/python3.10/dist-packages (from pytorch-lightning) (2.5.1
Requirement already satisfied: tqdm>=4.57.0 in /usr/local/lib/python3.10/dist-packages (from pytorch-lightning) (4.66.
Requirement already satisfied: PyYAML>=5.4 in /usr/local/lib/python3.10/dist-packages (from pytorch-lightning) (6.0.2)
Requirement already satisfied: fsspec>=2022.5.0 in /usr/local/lib/python3.10/dist-packages (from fsspec[http]>=2022.5.
Collecting torchmetrics>=0.7.0 (from pytorch-lightning)
  Downloading torchmetrics-1.6.0-py3-none-any.whl.metadata (20 kB)
Requirement already satisfied: packaging>=20.0 in /usr/local/lib/python3.10/dist-packages (from pytorch-lightning) (24
Requirement already satisfied: typing-extensions>=4.4.0 in /usr/local/lib/python3.10/dist-packages (from pytorch-light
Collecting lightning-utilities>=0.10.0 (from pytorch-lightning)
  Downloading lightning_utilities-0.11.9-py3-none-any.whl.metadata (5.2 kB)
Requirement already satisfied: aiohttp!=4.0.0a0,!=4.0.0a1 in /usr/local/lib/python3.10/dist-packages (from fsspec[http
Requirement already satisfied: setuptools in /usr/local/lib/python3.10/dist-packages (from lightning-utilities>=0.10.0
Requirement already satisfied: filelock in /usr/local/lib/python3.10/dist-packages (from torch>=2.1.0->pytorch-lightni
Requirement already satisfied: networkx in /usr/local/lib/python3.10/dist-packages (from torch>=2.1.0->pytorch-lightni
Requirement already satisfied: jinja2 in /usr/local/lib/python3.10/dist-packages (from torch>=2.1.0->pytorch-lightning
Requirement already satisfied: sympy==1.13.1 in /usr/local/lib/python3.10/dist-packages (from torch>=2.1.0->pytorch-li
Requirement already satisfied: mpmath<1.4,>=1.1.0 in /usr/local/lib/python3.10/dist-packages (from sympy==1.13.1->torc
Requirement already satisfied: numpy>1.20.0 in /usr/local/lib/python3.10/dist-packages (from torchmetrics>=0.7.0->pyto
Requirement already satisfied: aiohappyeyeballs>=2.3.0 in /usr/local/lib/python3.10/dist-packages (from aiohttp!=4.0.0
Requirement already satisfied: aiosignal>=1.1.2 in /usr/local/lib/python3.10/dist-packages (from aiohttp!=4.0.0a0,!=4.
Requirement already satisfied: attrs>=17.3.0 in /usr/local/lib/python3.10/dist-packages (from aiohttp!=4.0.0a0,!=4.0.0
Requirement already satisfied: frozenlist>=1.1.1 in /usr/local/lib/python3.10/dist-packages (from aiohttp!=4.0.0a0,!=4
Requirement already satisfied: multidict<7.0,>=4.5 in /usr/local/lib/python3.10/dist-packages (from aiohttp!=4.0.0a0,!
Requirement already satisfied: propcache>=0.2.0 in /usr/local/lib/python3.10/dist-packages (from aiohttp!=4.0.0a0,!=4.
Requirement already satisfied: yarl<2.0,>=1.17.0 in /usr/local/lib/python3.10/dist-packages (from aiohttp!=4.0.0a0,!=4
Requirement already satisfied: async-timeout<6.0,>=4.0 in /usr/local/lib/python3.10/dist-packages (from aiohttp!=4.0.0
Requirement already satisfied: MarkupSafe>=2.0 in /usr/local/lib/python3.10/dist-packages (from jinja2->torch>=2.1.0->
Requirement already satisfied: idna>=2.0 in /usr/local/lib/python3.10/dist-packages (from yarl<2.0,>=1.17.0->aiohttp!=
Downloading pytorch_lightning-2.4.0-py3-none-any.whl (815 kB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 815.2/815.2 kB 41.8 MB/s eta 0:00:00
Downloading lightning_utilities-0.11.9-py3-none-any.whl (28 kB)
Downloading torchmetrics-1.6.0-py3-none-any.whl (926 kB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 926.4/926.4 kB 35.1 MB/s eta 0:00:00
Installing collected packages: lightning-utilities, torchmetrics, pytorch-lightning
Successfully installed lightning-utilities-0.11.9 pytorch-lightning-2.4.0 torchmetrics-1.6.0
```

```
!pip install pyvirtualdisplay
```

```
Collecting pyvirtualdisplay
  Downloading PyVirtualDisplay-3.0-py3-none-any.whl.metadata (943 bytes)
Downloading PyVirtualDisplay-3.0-py3-none-any.whl (15 kB)
Installing collected packages: pyvirtualdisplay
Successfully installed pyvirtualdisplay-3.0
```

Setup virtual display

```
from pyvirtualdisplay import Display
Display(visible=False, size=(1400, 900)).start()
```

```
<pyvirtualdisplay.display.Display at 0x7efe99f76fe0>
```

Import the necessary code libraries

```
import copy
import torch
import random
import gym
import matplotlib

import numpy as np
import matplotlib.pyplot as plt

import torch.nn.functional as F

from collections import deque, namedtuple
from IPython.display import HTML
from base64 import b64encode

from torch import nn
from torch.utils.data import DataLoader
from torch.utils.data.dataset import IterableDataset
from torch.optim import AdamW

from pytorch_lightning import LightningModule, Trainer

from gym.wrappers import TransformObservation, NormalizeObservation, \
  NormalizeReward, RecordVideo, RecordEpisodeStatistics, AtariPreprocessing


device = 'cuda:0' if torch.cuda.is_available() else 'cpu'
num_gpus = torch.cuda.device_count()
```

```
def display_video(episode=0):
  video_file = open(f'/content/videos/rl-video-episode-{episode}.mp4', "r+b").read()
  video_url = f"data:video/mp4;base64,{b64encode(video_file).decode()}"
  return HTML(f"<video width=600 controls><source src='{video_url}'></video>")
```

```
/usr/local/lib/python3.10/dist-packages/ipykernel/ipkernel.py:283: DeprecationWarning: `should_run_async` will not cal
  and should_run_async(code)
```

Create the Deep Q-Network

```
import math
from torch.nn.init import kaiming_uniform_, zeros_

class NoisyLinear(nn.Module):

  def __init__(self, in_features, out_features, sigma):
    super(NoisyLinear, self).__init__()
    self.w_mu = nn.Parameter(torch.empty((out_features, in_features)))
    self.w_sigma = nn.Parameter(torch.empty((out_features, in_features)))
    self.b_mu = nn.Parameter(torch.empty((out_features)))
    self.b_sigma = nn.Parameter(torch.empty((out_features)))

    kaiming_uniform_(self.w_mu, a=math.sqrt(5))
    kaiming_uniform_(self.w_sigma, a=math.sqrt(5))
    zeros_(self.b_mu)
    zeros_(self.b_sigma)

  def forward(self, x, sigma=0.5):
    if self.training:
      w_noise = torch.normal(0, sigma, size=self.w_mu.size()).to(device)
      b_noise = torch.normal(0, sigma, size=self.b_mu.size()).to(device)
      return F.linear(x, self.w_mu + self.w_sigma * w_noise, self.b_mu + self.b_sigma * b_noise)
    else:
      return F.linear(x, self.W_mu, self.b_mu)
```

```
class DQN(nn.Module):

  def __init__(self, hidden_size, obs_shape, n_actions, sigma=0.5):
    super().__init__()

    self.conv = nn.Sequential(
      nn.Conv2d(obs_shape[0], 64, kernel_size=3),
      nn.MaxPool2d(kernel_size=4),
      nn.ReLU(),
      nn.Conv2d(64, 64, kernel_size=3),
      nn.MaxPool2d(kernel_size=4),
      nn.ReLU(),
    )
    conv_out_size = self._get_conv_out(obs_shape)
    print(conv_out_size)
    self.head = nn.Sequential(
      NoisyLinear(conv_out_size, hidden_size, sigma=sigma),
      nn.ReLU(),
    )

    self.fc_adv = NoisyLinear(hidden_size, n_actions, sigma=sigma)
    self.fc_value = NoisyLinear(hidden_size, 1, sigma=sigma)

  def _get_conv_out(self, shape):
    conv_out = self.conv(torch.zeros(1, *shape))
    return int(np.prod(conv_out.size()))

  def forward(self, x):
    x = self.conv(x.float()).view(x.size()[0], -1)
    x = self.head(x)
    adv = self.fc_adv(x)
    value = self.fc_value(x)
    return value + adv - torch.mean(adv, dim=1, keepdim=True)
```

Create the policy

```
def greedy(state, net):
  state = torch.tensor([state]).to(device)
  q_values = net(state)
  _, action = torch.max(q_values, dim=1)
  action = int(action.item())
  return action
```

Create the replay buffer

```
class ReplayBuffer:

  def __init__(self, capacity):
    self.buffer = deque(maxlen=capacity)
    self.priorities = deque(maxlen=capacity)
    self.capacity = capacity
    self.alpha = 0.0  # anneal.
    self.beta = 1.0  # anneal.
    self.max_priority = 0.0

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

  def append(self, experience):
    self.buffer.append(experience)
    self.priorities.append(self.max_priority)

  def update(self, index, priority):
    if priority > self.max_priority:
      self.max_priority = priority
    self.priorities[index] = priority

  def sample(self, batch_size):
    prios = np.array(self.priorities, dtype=np.float64) + 1e-4 # Stability constant.
    prios = prios ** self.alpha
    probs = prios / prios.sum()

    weights = (self.__len__() * probs) ** -self.beta
    weights = weights / weights.max()

    idx = random.choices(range(self.__len__()), weights=probs, k=batch_size)
    sample = [(i, weights[i], *self.buffer[i]) for i in idx]
    return sample
```

```
class RLDataset(IterableDataset):

  def __init__(self, buffer, sample_size=400):
    self.buffer = buffer
    self.sample_size = sample_size

  def __iter__(self):
    for experience in self.buffer.sample(self.sample_size):
      yield experience
```

Create the environment

```
env = gym.make('PongNoFrameskip-v4')
```

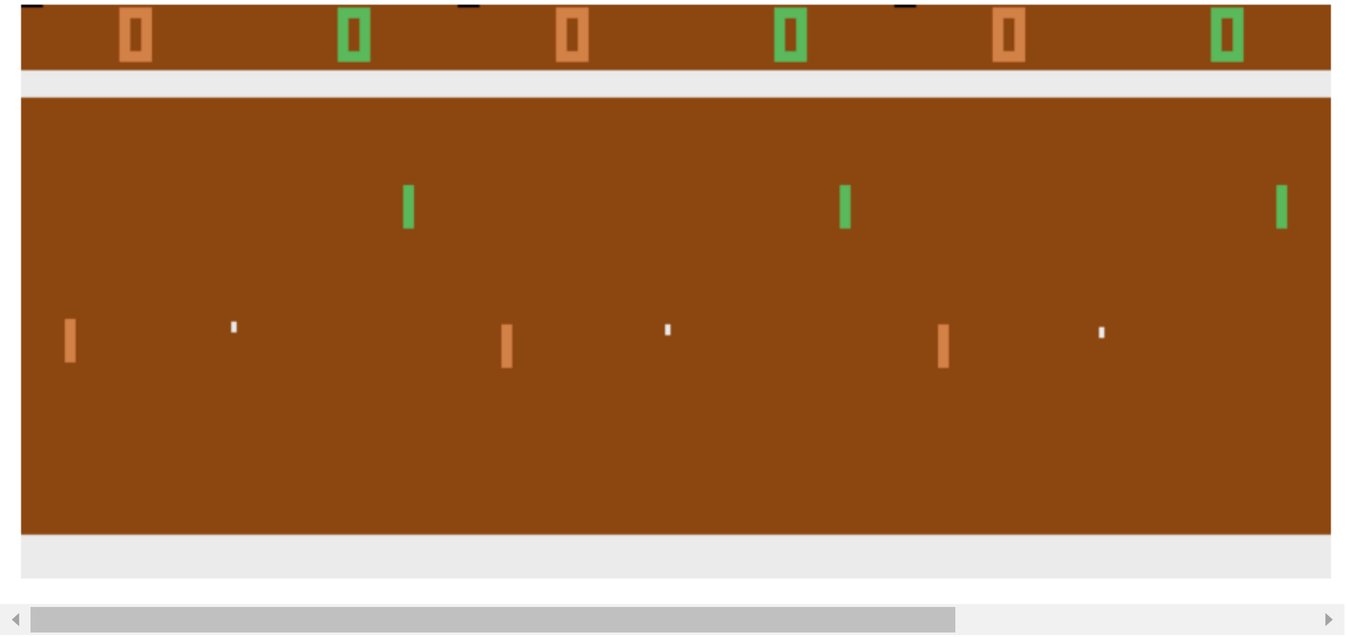
```
env.observation_space, env.action_space
```

```
(Box(0, 255, (210, 160, 3), uint8), Discrete(6))
```

```
frames = []
i = 60
skip = 1
obs = env.reset()
done = False

while not done:
  frames.append(obs)
  obs, _, done, _ = env.step(env.action_space.sample())
```

```
frames = np.hstack([frames[i], frames[i+skip], frames[i+2*skip]])
plt.figure(figsize=(12, 8))
plt.axis('off')
plt.imshow(frames)
```

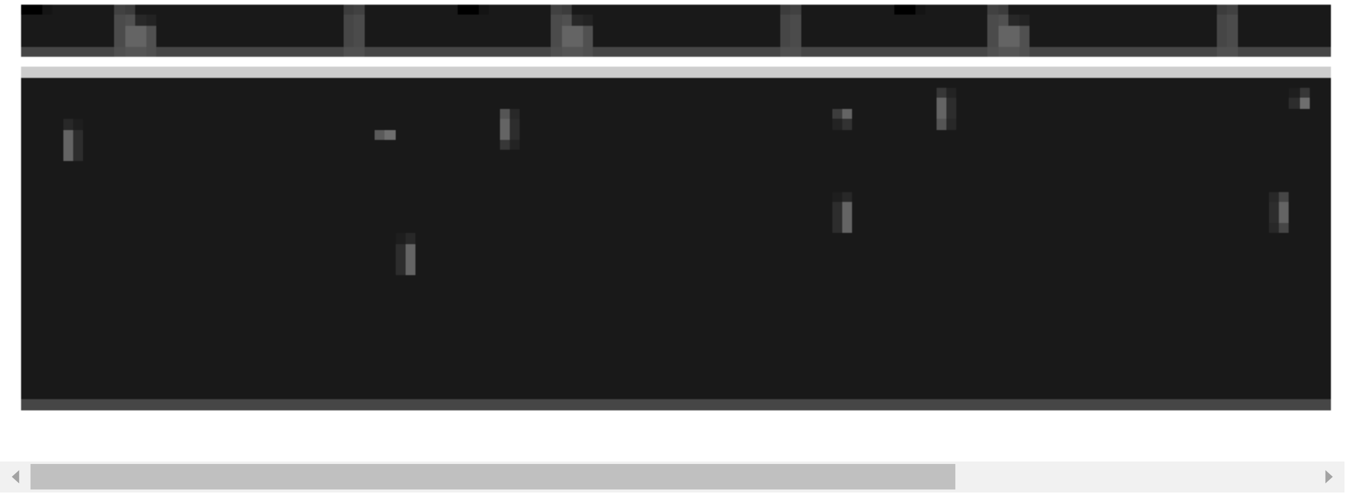
```
<matplotlib.image.AxesImage at 0x7efdc832b400>
```



```
env = AtariPreprocessing(env, frame_skip=8, screen_size=42)
```

```
frames = []
i = 170
skip = 1
obs = env.reset()
done = False

while not done:
  frames.append(obs)
  obs, _, done, _ = env.step(env.action_space.sample())

img = np.hstack([frames[i], frames[i+skip], frames[i+2*skip]])
plt.figure(figsize=(12, 8))
plt.axis('off')
plt.imshow(img, cmap='gray')
```

```
<matplotlib.image.AxesImage at 0x7efdc712f1c0>
```

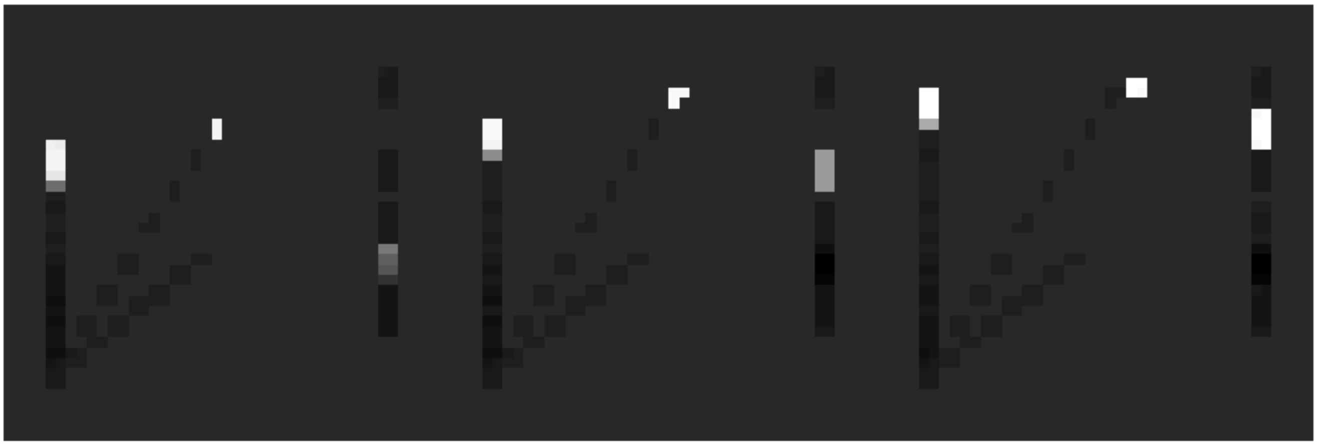


```
env = NormalizeObservation(env)
```

```
frames = []
i = 120
skip = 1
```

```
for i in range(20):
  obs = env.reset()
  done = False
  while not done:
    frames.append(obs)
    obs, _, done, _ = env.step(env.action_space.sample())

img = np.hstack([frames[i], frames[i+skip], frames[i+2*skip]])
plt.figure(figsize=(12, 8))
plt.axis('off')
plt.imshow(img.squeeze(), cmap='gray')
```

```
<matplotlib.image.AxesImage at 0x7efdc712f040>
```



```
def create_environment(name):
  env = gym.make(name)
  env = RecordVideo(env, 'videos', episode_trigger=lambda e: e % 100 == 0)
  env = RecordEpisodeStatistics(env)
  env = AtariPreprocessing(env, frame_skip=8, screen_size=42)
  env = TransformObservation(env, lambda x: x[np.newaxis,:,:])
  env.observation_space = gym.spaces.Box(low=0, high=1, shape=(1, 42, 42), dtype=np.float32)
  env = NormalizeObservation(env)
  env = NormalizeReward(env)
  return env
```

```
env = create_environment('PongNoFrameskip-v4')
frames = []
for episode in range(10):
  done = False
  obs = env.reset()
  while not done:
    frames.append(obs)
    action = env.action_space.sample()
    obs, _, done, _ = env.step(action)
```

```
/usr/local/lib/python3.10/dist-packages/gym/wrappers/monitoring/video_recorder.py:341: DeprecationWarning: Use shutil.
  if distutils.spawn.find_executable("avconv") is not None:
/usr/local/lib/python3.10/dist-packages/gym/wrappers/monitoring/video_recorder.py:421: DeprecationWarning: distutils V
  if distutils.version.LooseVersion(
```

```
display_video(episode=0)
```

2:02 / 2:02

Create the Deep Q-Learning algorithm

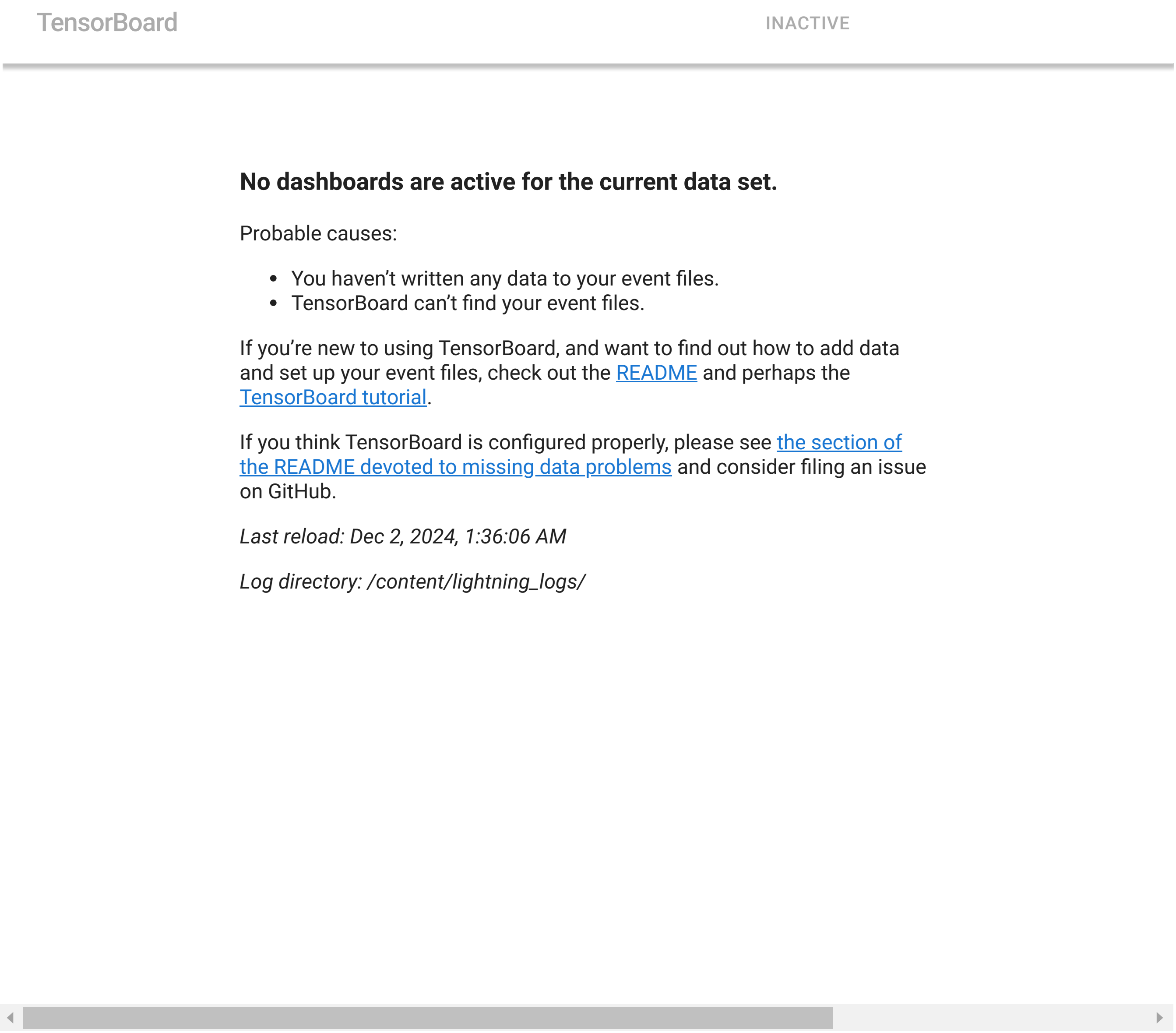
```
class DeepQLearning(LightningModule):

  # Initialize.
  def __init__(self, env_name, policy=greedy, capacity=100_000,
               batch_size=256, lr=1e-3, hidden_size=128, gamma=0.99,
               loss_fn=F.smooth_l1_loss, optim=AdamW, samples_per_epoch=10_000,
               sync_rate=10, sigma=0.5, a_start=0.5, a_end=0.0, a_last_episode=100,
               b_start=0.4, b_end=1.0, b_last_episode=100, n_steps=3):

    super().__init__()
    self.env = create_environment(env_name)

    obs_size = self.env.observation_space.shape
    n_actions = self.env.action_space.n

    self.q_net = DQN(hidden_size, obs_size, n_actions, sigma=sigma)

    self.target_q_net = copy.deepcopy(self.q_net)

    self.policy = policy
    self.buffer = ReplayBuffer(capacity=capacity)

    self.save_hyperparameters()

    while len(self.buffer) < self.hparams.samples_per_epoch:
      print(f"{len(self.buffer)} samples in experience buffer. Filling...")
      self.play_episode()
```

```
@torch.no_grad()
def play_episode(self, policy=None):
  state = self.env.reset()
  done = False
  transitions = []

  while not done:
    if policy:
      action = policy(state, self.q_net)
    else:
      action = self.env.action_space.sample()

    next_state, reward, done, info = self.env.step(action)
    exp = (state, action, reward, done, next_state)
    transitions.append(exp)
    state = next_state

  for i, (s, a, r, d, ns) in enumerate(transitions):
    batch = transitions[i:i+self.hparams.n_steps]
    ret = sum([t[2] * self.hparams.gamma**j for j, t in enumerate(batch)])
    _, _, _, ld, ls = batch[-1]
    self.buffer.append((s, a, ret, ld, ls))

# Forward.
def forward(self, x):
  return self.q_net(x)

# Configure optimizers.
def configure_optimizers(self):
  q_net_optimizer = self.hparams.optim(self.q_net.parameters(), lr=self.hparams.lr)
  return [q_net_optimizer]

# Create dataloader.
def train_dataloader(self):
  dataset = RLDataset(self.buffer, self.hparams.samples_per_epoch)
  dataloader = DataLoader(
      dataset=dataset,
      batch_size=self.hparams.batch_size
  )
  return dataloader

# Training step.
def training_step(self, batch, batch_idx):
  indices, weights, states, actions, returns, dones, next_states = batch
  weights = weights.unsqueeze(1)
  actions = actions.unsqueeze(1)
  returns = returns.unsqueeze(1)
  dones = dones.unsqueeze(1)

  state_action_values = self.q_net(states).gather(1, actions)

  with torch.no_grad():
    _, next_actions = self.q_net(next_states).max(dim=1, keepdim=True)
    next_action_values = self.target_q_net(next_states).gather(1, next_actions)
    next_action_values[dones] = 0.0

  expected_state_action_values = returns + self.hparams.gamma**self.hparams.n_steps * next_action_values

  td_errors = (state_action_values - expected_state_action_values).abs().detach()

  for idx, e in zip(indices, td_errors):
    self.buffer.update(idx, e.item())

  loss = weights * self.hparams.loss_fn(state_action_values, expected_state_action_values, reduction='none')
  loss = loss.mean()

  self.log('episode/Q-Error', loss)
  return loss

# Training epoch end.
def on_train_epoch_end(self):
  alpha = max(
      self.hparams.a_end,
      self.hparams.a_start - self.current_epoch / self.hparams.a_last_episode
  )
  beta = min(
      self.hparams.b_end,
      self.hparams.b_start + self.current_epoch / self.hparams.b_last_episode
  )
  self.buffer.alpha = alpha
  self.buffer.beta = beta

  self.play_episode(policy=self.policy)
  self.log('episode/Return', self.env.return_queue[-1])

  if self.current_epoch % self.hparams.sync_rate == 0:
    self.target_q_net.load_state_dict(self.q_net.state_dict())
```

Purge logs and run the visualization tool (Tensorboard)

```
!rm -r /content/lightning_logs/
!rm -r /content/videos/
%load_ext tensorboard
%tensorboard --logdir /content/lightning_logs/
```

```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard
```



No dashboards are active for the current data set.

Probable causes:

- You haven’t written any data to your event files.
- TensorBoard can’t find your event files.

If you’re new to using TensorBoard, and want to find out how to add data and set up your event files, check out the README and perhaps the TensorBoard tutorial.

If you think TensorBoard is configured properly, please see the section of the README devoted to missing data problems and consider filing an issue on GitHub.

Last reload: Dec 2, 2024, 1:36:06 AM

Log directory: /content/lightning_logs/

Train the policy

```
import pytorch_lightning as pl
import warnings
warnings.filterwarnings('ignore')
```

```
algo = DeepQLearning(
  'PongNoFrameskip-v4',
  lr=1e-4,
  sigma=0.5,
  hidden_size=256,
  a_last_episode=8_000,
  b_last_episode=8_000,
  n_steps=8
)

trainer = pl.Trainer(
    accelerator="gpu" if num_gpus else "cpu", # Use 'gpu' if num_gpus is greater than 0, otherwise use 'cpu'
    devices=1, # Specify the number of GPUs or 'auto' for automatic detection
    max_epochs=3000,
    log_every_n_steps=1
)

trainer.fit(algo)
```

```
0 samples in experience buffer. Filling...
497 samples in experience buffer. Filling...
923 samples in experience buffer. Filling...
1412 samples in experience buffer. Filling...
1867 samples in experience buffer. Filling...
2249 samples in experience buffer. Filling...
2759 samples in experience buffer. Filling...
3253 samples in experience buffer. Filling...
3693 samples in experience buffer. Filling...
4184 samples in experience buffer. Filling...
4565 samples in experience buffer. Filling...
5028 samples in experience buffer. Filling...
5463 samples in experience buffer. Filling...
5936 samples in experience buffer. Filling...
6385 samples in experience buffer. Filling...
6767 samples in experience buffer. Filling...
7147 samples in experience buffer. Filling...
7571 samples in experience buffer. Filling...
8037 samples in experience buffer. Filling...
8456 samples in experience buffer. Filling...
8946 samples in experience buffer. Filling...
9444 samples in experience buffer. Filling...
9923 samples in experience buffer. Filling...
INFO:pytorch_lightning.utilities.rank_zero:GPU available: True (cuda), used: True
INFO:pytorch_lightning.utilities.rank_zero:TPU available: False, using: 0 TPU cores
INFO:pytorch_lightning.utilities.rank_zero:HPU available: False, using: 0 HPUs
INFO:pytorch_lightning.accelerators.cuda:LOCAL_RANK: 0 - CUDA_VISIBLE_DEVICES: [0]
INFO:pytorch_lightning.callbacks.model_summary:
  | Name         | Type | Params | Mode 
----------------------------------------------
0 | q_net        | DQN  | 172 K  | train
1 | target_q_net | DQN  | 172 K  | train
----------------------------------------------
345 K     Trainable params
0         Non-trainable params
345 K     Total params
1.382     Total estimated model params size (MB)
26        Modules in train mode
0         Modules in eval mode
```

Epoch 1302: 40/? [00:01<00:00, 21.90it/s, v_num=0]

```
INFO:pytorch_lightning.utilities.rank_zero:
Detected KeyboardInterrupt, attempting graceful shutdown ...
---------------------------------------------------------------------------
KeyboardInterrupt                         Traceback (most recent call last)
/usr/local/lib/python3.10/dist-packages/pytorch_lightning/trainer/call.py in _call_and_handle_interrupt(trainer,
trainer_fn, *args, **kwargs)
     46             return trainer.strategy.launcher.launch(trainer_fn, *args, trainer=trainer, **kwargs)
---> 47         return trainer_fn(*args, **kwargs)
     48 
```

15 frames

```
KeyboardInterrupt: 

During handling of the above exception, another exception occurred:

NameError                                 Traceback (most recent call last)
/usr/local/lib/python3.10/dist-packages/pytorch_lightning/trainer/call.py in _call_and_handle_interrupt(trainer,
trainer_fn, *args, **kwargs)
     62         if isinstance(launcher, _SubprocessScriptLauncher):
     63             launcher.kill(_get_sigkill_signal())
---> 64         exit(1)
     65 
     66     except BaseException as exception:

NameError: name 'exit' is not defined
```

Next steps: Explain error

Check the resulting policy

```
display_video(episode=1300)
```