Final Project: Reinforcement Learning for Autonomous Driving in Highway-Env

Course: CSC 580 - Artificial Intelligence II

Group-10

Members:

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DePaul University

Installing required poackages

In [1]:
```
!pip install highway-env
!pip install stable-baselines3
!pip install gymnasium
!pip install opencv-python
!pip install tensorboard
```

```
Requirement already satisfied: highway-env in /opt/anaconda3/lib/python3.12/site-packages
(1.10.1)
Requirement already satisfied: gymnasium>=1.0.0a2 in /opt/anaconda3/lib/python3.12/site-p
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Requirement already satisfied: contourpy>=1.0.1 in /opt/anaconda3/lib/python3.12/site-pac
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Requirement already satisfied: MarkupSafe>=2.1.1 in /opt/anaconda3/lib/python3.12/site-pa
ckages (from werkzeug>=1.0.1->tensorboard) (2.1.3)
```

In [5]:
```python
#importing packages
import os
import time
import glob
import io
import base64
import numpy as np
import gymnasium as gym
import highway_env
import cv2
from stable_baselines3 import DQN
from stable_baselines3.common.monitor import Monitor
from stable_baselines3.common.evaluation import evaluate_policy
from IPython import get_ipython
from IPython.display import HTML, display


try:
    IN_JUPYTER = True
except ImportError:
    IN_JUPYTER = False


if IN_JUPYTER:
    from IPython import get_ipython
```

2) Directory Setup

In [3]:
```python
PROJECT_DIR = os.path.join(os.getcwd(), "Project_DQN1")
LOG_DIR = os.path.join(PROJECT_DIR, "logs")
MODEL_DIR = os.path.join(PROJECT_DIR, "models")
VIDEO_DIR = os.path.join(PROJECT_DIR, "videos")

for folder in [PROJECT_DIR, LOG_DIR, MODEL_DIR, VIDEO_DIR]:
    os.makedirs(folder, exist_ok=True)
```

3) Function Show Video

In [4]:
```python
def show_video(video_path_pattern):
    '''
    Display the latest video in the NoteBook
    '''
    mp4_list = glob.glob(video_path_pattern)
    if not mp4_list:
        print(f" No video found for: {video_path_pattern}")
        return
```

```
        video_path = mp4_list[0]
        with open(video_path, "rb") as f:
            video_data = f.read()
        encoded_video = base64.b64encode(video_data).decode("ascii")
        if IN_JUPYTER:
            display(HTML(data=f'''
                <video width="640" height="480" controls>
                    <source src="data:video/mp4;base64,{encoded_video}" type="video/mp4">
                </video>
            '''))
        else:
            print(f" Video saved: {video_path}")
```

4) Funciton to Create Enviornment

In [5]:
```python
def make_env(env_name="highway-fast-v0"):
    '''
    Created a Configure for the Enviornment using Gym for traning
    '''
    env = gym.make(env_name, render_mode="rgb_array")
    if hasattr(env.unwrapped, "configure"):
        env.unwrapped.configure({
            "lanes_count": 4,
            "vehicles_count": 20,
            "duration": 40,
            "collision_reward": -2,
            "high_speed_reward": 1,
            "reward_speed_range": [20, 30],
            "action": {"type": "DiscreteMetaAction"}
        })
    return Monitor(env)
```

5) Video Recording with OpenCV

In [6]:
```python
def record_with_opencv(frames, out_file="demo.mp4", fps=15):
    '''
    OpennCv package has been used to record the video in 3 different format - MP4,AVC1,X
    '''
    if not frames:
        print("No frames to record.")
        return
    height, width, _ = frames[0].shape
    fourcc = cv2.VideoWriter_fourcc(*'avc1')
    out = cv2.VideoWriter(out_file, fourcc, fps, (width, height))
    for frame in frames:
        bgr_frame = cv2.cvtColor(frame, cv2.COLOR_RGB2BGR)
        out.write(bgr_frame)
    out.release()
    print(f"Created video in these location: {out_file}")
```

6) Traning DQL Models

In [7]:
```python
if __name__ == "__main__":
    ENVIRONMENTS = ["highway-fast-v0", "intersection-v0", "roundabout-v0"]
    LEARNING_RATES = [0.0005, 0.001]
```

```python
GAMMAS = [0.95, 0.8]

TOTAL_TIMESTEPS = 150000

# dictionary to store final results
results = {}

for env_name in ENVIRONMENTS:
    for lr in LEARNING_RATES:
        for gm in GAMMAS:
            run_id = f"{env_name}_DQN_lr{lr}_gm{gm}"
            print(f"TRAINING RUN: {run_id}")

            # Create environment
            vec_env = make_env(env_name)

            tb_log_dir = os.path.join(LOG_DIR, run_id)

            # Create DQN with chosen LR, gamma
            model = DQN(
                "MlpPolicy",
                vec_env,
                policy_kwargs=dict(net_arch=[256, 256]),
                learning_rate=lr,
                gamma=gm,
                verbose=0,
                tensorboard_log=tb_log_dir,
                buffer_size=15000,
                learning_starts=200,
                batch_size=32,
                train_freq=1,
                gradient_steps=1,
                target_update_interval=50,
                exploration_fraction=0.7,
            )

            # Train
            model.learn(total_timesteps=TOTAL_TIMESTEPS)

            # Evaluate
            mean_reward, std_reward = evaluate_policy(model, vec_env, n_eval_episode

            if mean_reward > 0:
                success_rate = (mean_reward - std_reward) / mean_reward
            else:
                success_rate = 0

            print(f" Completed run for env={env_name}, gamma={gm}, lr={lr}")
            print(f"   Final average reward: {mean_reward:.2f}")
            print(f"   Success rate: {success_rate:.2f} \n")

            # Save model
            model_path = os.path.join(MODEL_DIR, f"{run_id}_model")
            model.save(model_path)
            print(f"[INFO] Model saved at: {model_path}\n")

            # Record short video
            demo_env = make_env(env_name)
            if hasattr(demo_env.unwrapped, "config"):
                demo_env.unwrapped.config["simulation_frequency"] = 15

            frames = []
```

```python
                        obs, info = demo_env.reset()
                        done = truncated = False
                        for step in range(300):
                            action, _ = model.predict(obs, deterministic=True)
                            obs, reward, done, truncated, info = demo_env.step(action)
                            frames.append(demo_env.render())
                            if done or truncated:
                                obs, info = demo_env.reset()
                        demo_env.close()

                        video_file = os.path.join(VIDEO_DIR, f"{run_id}_{int(time.time())}.mp4")
                        record_with_opencv(frames, out_file=video_file, fps=15)
                        show_video(video_file)

                        results[run_id] = {
                            "env": env_name,
                            "lr": lr,
                            "gamma": gm,
                            "mean_reward": mean_reward,
                            "std_reward": std_reward,
                            "success_rate": success_rate
                        }

                        # Display TENSORBOARD plot for this run using logs file
                        if IN_JUPYTER:
                            get_ipython().run_line_magic('load_ext', 'tensorboard')
                            get_ipython().run_line_magic('tensorboard', '--logdir ./Project_DQN1

    print("\nFinal Result of All model trained Above\n")
    for i in results:
        print(i)
```

```
TRAINING RUN: highway-fast-v0_DQN_lr0.0005_gm0.95
[INFO] Completed run for env=highway-fast-v0, gamma=0.95, lr=0.0005
    Final average reward: 25.95
    Success rate: 0.42

[INFO] Model saved at: /Users/sanjayuppala/Desktop/CSC 580 AI_2/Project/Project_DQN1/mode
ls/highway-fast-v0_DQN_lr0.0005_gm0.95_model
```
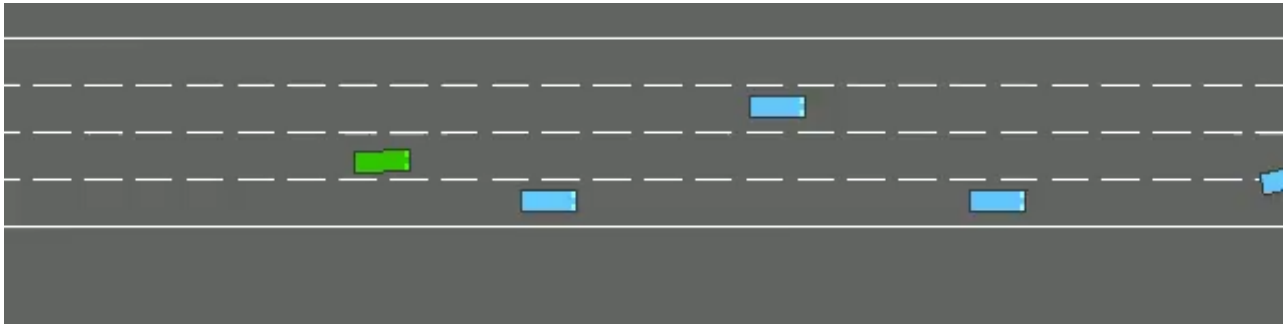
```
2025-03-15 11:37:09.687 python[18575:940228] +[IMKClient subclass]: chose IMKClient_Moder
n
2025-03-15 11:37:09.687 python[18575:940228] +[IMKInputSession subclass]: chose IMKInputS
ession_Modern
```

```
[INFO] Created video: /Users/sanjayuppala/Desktop/CSC 580 AI_2/Project/Project_DQN1/video
s/highway-fast-v0_DQN_lr0.0005_gm0.95_1742056647.mp4
```

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Name	Size	Date Modified
.nofollow/		3/6/25, 4:06:02 AM
.resolve/		3/6/25, 4:06:02 AM
.vol/		3/6/25, 4:06:02 AM
Applications/		3/15/25, 9:12:09 AM
bin/		3/6/25, 4:06:02 AM
cores/		8/4/24, 5:31:41 AM
dev/		3/14/25, 8:24:56 AM
etc/		3/14/25, 8:26:29 AM
home/		3/14/25, 8:26:30 AM
Library/		3/14/25, 8:26:15 AM
opt/		2/10/25, 5:44:30 PM
private/		3/14/25, 8:26:26 AM
sbin/		3/6/25, 4:06:02 AM
System/		3/6/25, 4:06:02 AM
tmp/		3/17/25, 10:21:46 PM
Users/		3/14/25, 8:25:58 AM
usr/		3/6/25, 4:06:02 AM
var/		3/14/25, 8:26:18 AM
Volumes/		3/14/25, 9:18:58 AM
.file	0 B	3/6/25, 4:06:02 AM

```
TRAINING RUN: highway-fast-v0_DQN_lr0.0005_gm0.8
[INFO] Completed run for env=highway-fast-v0, gamma=0.8, lr=0.0005
   Final average reward: 39.07
   Success rate: 1.00

[INFO] Model saved at: /Users/sanjayuppala/Desktop/CSC 580 AI_2/Project/Project_DQN1/mode
ls/highway-fast-v0_DQN_lr0.0005_gm0.8_model

[INFO] Created video: /Users/sanjayuppala/Desktop/CSC 580 AI_2/Project/Project_DQN1/video
s/highway-fast-v0_DQN_lr0.0005_gm0.8_1742058949.mp4
```

The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard
Reusing TensorBoard on port 6006 (pid 19095), started 0:38:20 ago. (Use '!kill 19095' to kill it.)

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Name	Size	Date Modified
.nofollow/		3/6/25, 4:06:02 AM
.resolve/		3/6/25, 4:06:02 AM
.vol/		3/6/25, 4:06:02 AM
Applications/		3/15/25, 9:12:09 AM
bin/		3/6/25, 4:06:02 AM
cores/		8/4/24, 5:31:41 AM
dev/		3/14/25, 8:24:56 AM
etc/		3/14/25, 8:26:29 AM
home/		3/14/25, 8:26:30 AM
Library/		3/14/25, 8:26:15 AM
opt/		2/10/25, 5:44:30 PM
private/		3/14/25, 8:26:26 AM
sbin/		3/6/25, 4:06:02 AM
System/		3/6/25, 4:06:02 AM
tmp/		3/17/25, 10:21:46 PM
Users/		3/14/25, 8:25:58 AM
usr/		3/6/25, 4:06:02 AM
var/		3/14/25, 8:26:18 AM
Volumes/		3/14/25, 9:18:58 AM
.file	0 B	3/6/25, 4:06:02 AM

```
TRAINING RUN: highway-fast-v0_DQN_lr0.001_gm0.95
[INFO] Completed run for env=highway-fast-v0, gamma=0.95, lr=0.001
   Final average reward: 15.79
   Success rate: 0.12

[INFO] Model saved at: /Users/sanjayuppala/Desktop/CSC 580 AI_2/Project/Project_DQN1/mode
ls/highway-fast-v0_DQN_lr0.001_gm0.95_model

[INFO] Created video: /Users/sanjayuppala/Desktop/CSC 580 AI_2/Project/Project_DQN1/video
s/highway-fast-v0_DQN_lr0.001_gm0.95_1742061258.mp4
```
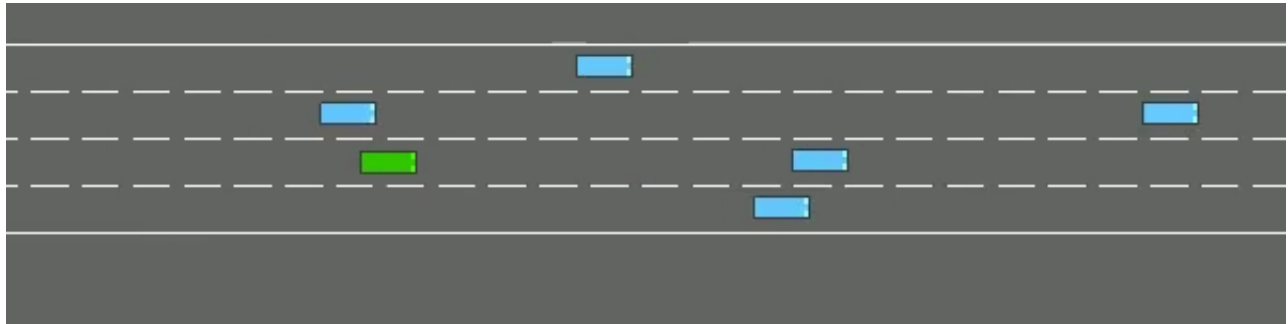
```
0:03 / 0:20
```

The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard
Reusing TensorBoard on port 6006 (pid 19095), started 1:16:49 ago. (Use '!kill 19095' to kill it.)

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Name	Size	Date Modified
.nofollow/		3/6/25, 4:06:02 AM
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.vol/		3/6/25, 4:06:02 AM
Applications/		3/15/25, 9:12:09 AM
bin/		3/6/25, 4:06:02 AM
cores/		8/4/24, 5:31:41 AM
dev/		3/14/25, 8:24:56 AM
etc/		3/14/25, 8:26:29 AM
home/		3/14/25, 8:26:30 AM
Library/		3/14/25, 8:26:15 AM
opt/		2/10/25, 5:44:30 PM
private/		3/14/25, 8:26:26 AM
sbin/		3/6/25, 4:06:02 AM
System/		3/6/25, 4:06:02 AM
tmp/		3/17/25, 10:21:46 PM
Users/		3/14/25, 8:25:58 AM
usr/		3/6/25, 4:06:02 AM
var/		3/14/25, 8:26:18 AM
Volumes/		3/14/25, 9:18:58 AM
.file	0 B	3/6/25, 4:06:02 AM

```
TRAINING RUN: highway-fast-v0_DQN_lr0.001_gm0.8
[INFO] Completed run for env=highway-fast-v0, gamma=0.8, lr=0.001
   Final average reward: 32.32
   Success rate: 0.72

[INFO] Model saved at: /Users/sanjayuppala/Desktop/CSC 580 AI_2/Project/Project_DQN1/mode
ls/highway-fast-v0_DQN_lr0.001_gm0.8_model

[INFO] Created video: /Users/sanjayuppala/Desktop/CSC 580 AI_2/Project/Project_DQN1/video
s/highway-fast-v0_DQN_lr0.001_gm0.8_1742063584.mp4
```

The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard
Reusing TensorBoard on port 6006 (pid 19095), started 1:55:35 ago. (Use '!kill 19095' to kill it.)

Index of /

Name	Size	Date Modified
.nofollow/		3/6/25, 4:06:02 AM
.resolve/		3/6/25, 4:06:02 AM
.vol/		3/6/25, 4:06:02 AM
Applications/		3/15/25, 9:12:09 AM
bin/		3/6/25, 4:06:02 AM
cores/		8/4/24, 5:31:41 AM
dev/		3/14/25, 8:24:56 AM
etc/		3/14/25, 8:26:29 AM
home/		3/14/25, 8:26:30 AM
Library/		3/14/25, 8:26:15 AM
opt/		2/10/25, 5:44:30 PM
private/		3/14/25, 8:26:26 AM
sbin/		3/6/25, 4:06:02 AM
System/		3/6/25, 4:06:02 AM
tmp/		3/17/25, 10:21:46 PM
Users/		3/14/25, 8:25:58 AM
usr/		3/6/25, 4:06:02 AM
var/		3/14/25, 8:26:18 AM
Volumes/		3/14/25, 9:18:58 AM
.file	0 B	3/6/25, 4:06:02 AM

```
TRAINING RUN: intersection-v0_DQN_lr0.0005_gm0.95
/opt/anaconda3/envs/pytorch-env/lib/python3.10/site-packages/gymnasium/envs/registration.
py:517: DeprecationWarning: WARN: The environment intersection-v0 is out of date. You sho
uld consider upgrading to version `v1`.
  logger.deprecation(
[INFO] Completed run for env=intersection-v0, gamma=0.95, lr=0.0005
   Final average reward: 0.80
   Success rate: 0.50

[INFO] Model saved at: /Users/sanjayuppala/Desktop/CSC 580 AI_2/Project/Project_DQN1/mode
ls/intersection-v0_DQN_lr0.0005_gm0.95_model
```
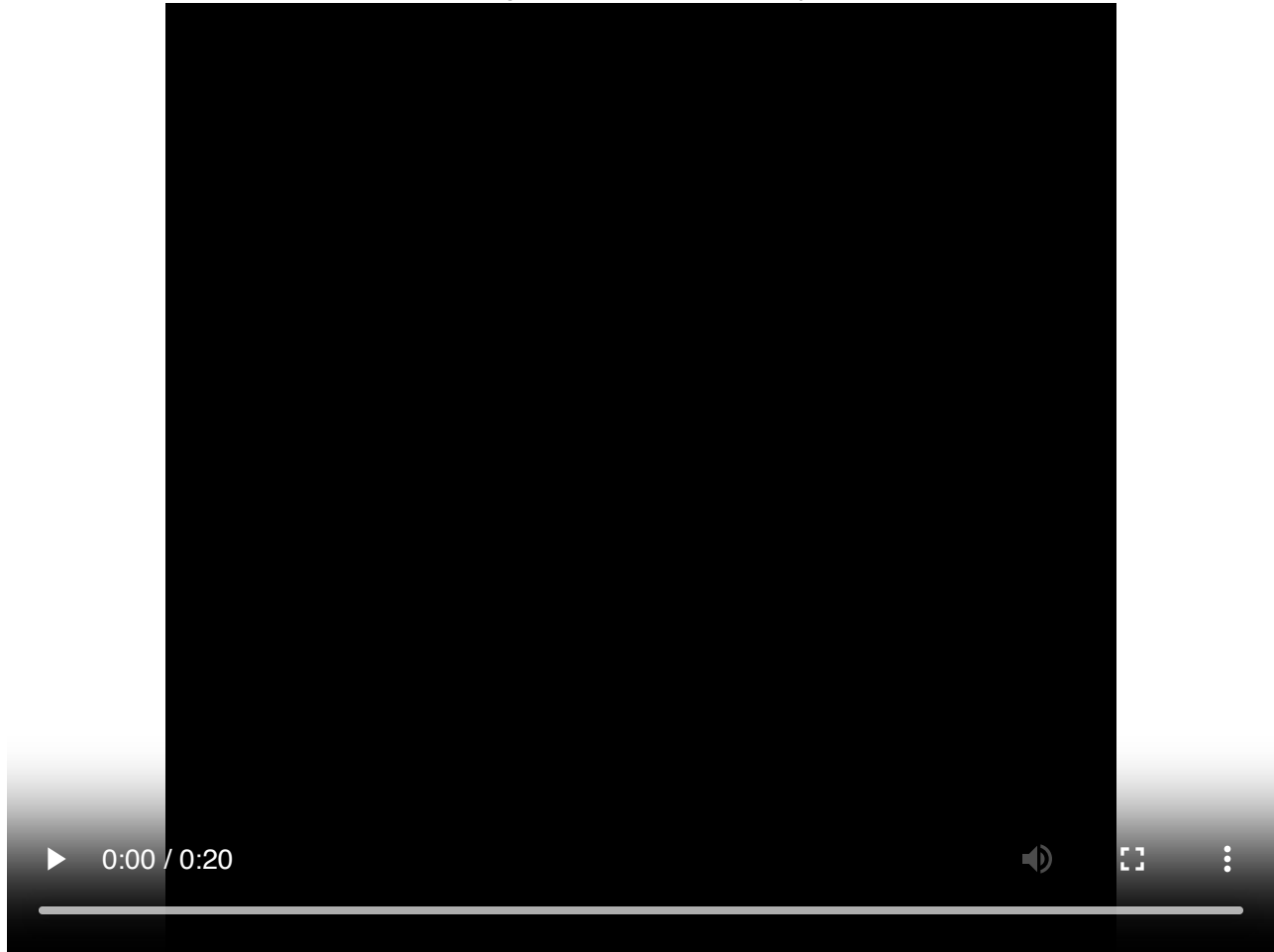
[INFO] Created video: /Users/sanjayuppala/Desktop/CSC 580 AI_2/Project/Project_DQN1/videos/intersection-v0_DQN_lr0.0005_gm0.95_1742067622.mp4

▶ 0:00 / 0:20   ◀))   :]   ⋮

The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard
Reusing TensorBoard on port 6006 (pid 19095), started 3:02:54 ago. (Use '!kill 19095' to kill it.)

Index of /

Name	Size	Date Modified
.nofollow/		3/6/25, 4:06:02 AM
.resolve/		3/6/25, 4:06:02 AM
.vol/		3/6/25, 4:06:02 AM
Applications/		3/15/25, 9:12:09 AM
bin/		3/6/25, 4:06:02 AM
cores/		8/4/24, 5:31:41 AM
dev/		3/14/25, 8:24:56 AM
etc/		3/14/25, 8:26:29 AM
home/		3/14/25, 8:26:30 AM
Library/		3/14/25, 8:26:15 AM
opt/		2/10/25, 5:44:30 PM
private/		3/14/25, 8:26:26 AM
sbin/		3/6/25, 4:06:02 AM
System/		3/6/25, 4:06:02 AM
tmp/		3/17/25, 10:21:46 PM
Users/		3/14/25, 8:25:58 AM
usr/		3/6/25, 4:06:02 AM
var/		3/14/25, 8:26:18 AM
Volumes/		3/14/25, 9:18:58 AM
.file	0 B	3/6/25, 4:06:02 AM

```
TRAINING RUN: intersection-v0_DQN_lr0.0005_gm0.8
/opt/anaconda3/envs/pytorch-env/lib/python3.10/site-packages/gymnasium/envs/registration.
py:517: DeprecationWarning: WARN: The environment intersection-v0 is out of date. You sho
uld consider upgrading to version `v1`.
  logger.deprecation(
[INFO] Completed run for env=intersection-v0, gamma=0.8, lr=0.0005
   Final average reward: -0.20
   Success rate: 0.00

[INFO] Model saved at: /Users/sanjayuppala/Desktop/CSC 580 AI_2/Project/Project_DQN1/mode
ls/intersection-v0_DQN_lr0.0005_gm0.8_model
```
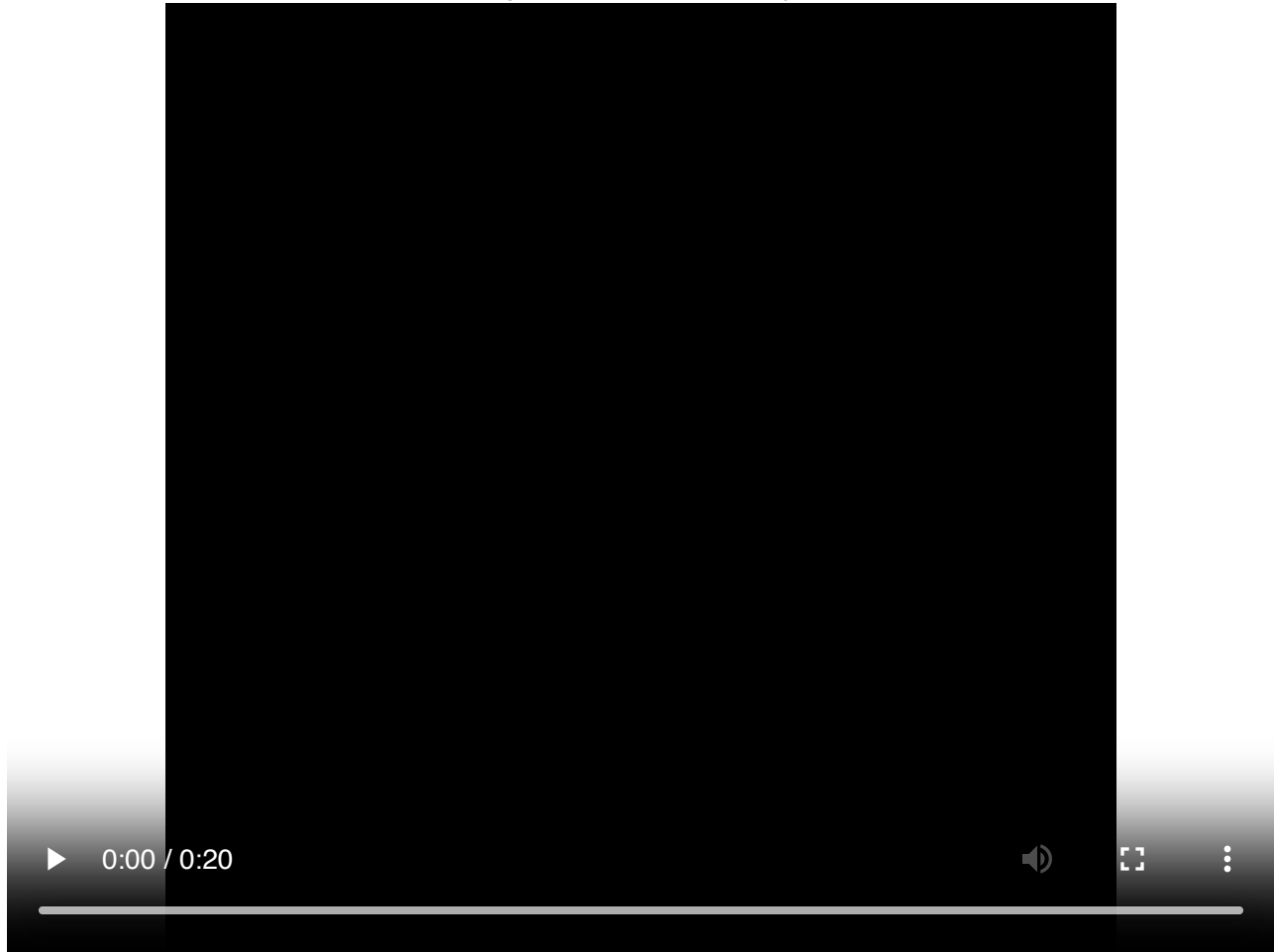
[INFO] Created video: /Users/sanjayuppala/Desktop/CSC 580 AI_2/Project/Project_DQN1/video
s/intersection-v0_DQN_lr0.0005_gm0.8_1742071668.mp4

▶ 0:00 / 0:20   ◀))   ⬜   ⋮

The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard
Reusing TensorBoard on port 6006 (pid 19095), started 4:10:20 ago. (Use '!kill 19095' to
kill it.)

Index of /

Name	Size	Date Modified
.nofollow/		3/6/25, 4:06:02 AM
.resolve/		3/6/25, 4:06:02 AM
.vol/		3/6/25, 4:06:02 AM
Applications/		3/15/25, 9:12:09 AM
bin/		3/6/25, 4:06:02 AM
cores/		8/4/24, 5:31:41 AM
dev/		3/14/25, 8:24:56 AM
etc/		3/14/25, 8:26:29 AM
home/		3/14/25, 8:26:30 AM
Library/		3/14/25, 8:26:15 AM
opt/		2/10/25, 5:44:30 PM
private/		3/14/25, 8:26:26 AM
sbin/		3/6/25, 4:06:02 AM
System/		3/6/25, 4:06:02 AM
tmp/		3/17/25, 10:21:46 PM
Users/		3/14/25, 8:25:58 AM
usr/		3/6/25, 4:06:02 AM
var/		3/14/25, 8:26:18 AM
Volumes/		3/14/25, 9:18:58 AM
.file	0 B	3/6/25, 4:06:02 AM

```
TRAINING RUN: intersection-v0_DQN_lr0.001_gm0.95
/opt/anaconda3/envs/pytorch-env/lib/python3.10/site-packages/gymnasium/envs/registration.
py:517: DeprecationWarning: WARN: The environment intersection-v0 is out of date. You sho
uld consider upgrading to version `v1`.
  logger.deprecation(
[INFO] Completed run for env=intersection-v0, gamma=0.95, lr=0.001
   Final average reward: -0.40
   Success rate: 0.00

[INFO] Model saved at: /Users/sanjayuppala/Desktop/CSC 580 AI_2/Project/Project_DQN1/mode
ls/intersection-v0_DQN_lr0.001_gm0.95_model
```
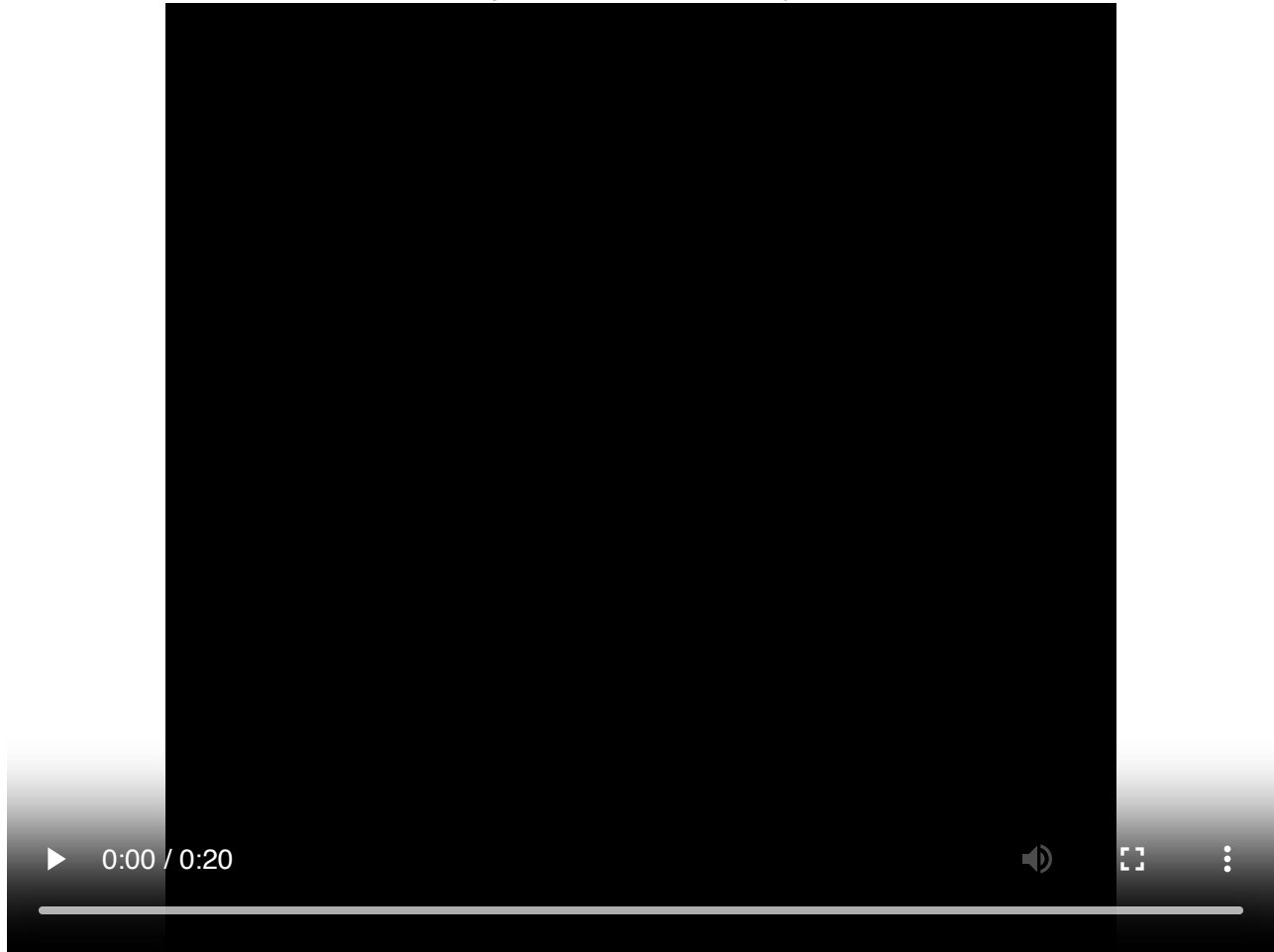
[INFO] Created video: /Users/sanjayuppala/Desktop/CSC 580 AI_2/Project/Project_DQN1/video
s/intersection-v0_DQN_lr0.001_gm0.95_1742075711.mp4

The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard
Reusing TensorBoard on port 6006 (pid 19095), started 5:17:43 ago. (Use '!kill 19095' to
kill it.)

Index of /

Name	Size	Date Modified
.nofollow/		3/6/25, 4:06:02 AM
.resolve/		3/6/25, 4:06:02 AM
.vol/		3/6/25, 4:06:02 AM
Applications/		3/15/25, 9:12:09 AM
bin/		3/6/25, 4:06:02 AM
cores/		8/4/24, 5:31:41 AM
dev/		3/14/25, 8:24:56 AM
etc/		3/14/25, 8:26:29 AM
home/		3/14/25, 8:26:30 AM
Library/		3/14/25, 8:26:15 AM
opt/		2/10/25, 5:44:30 PM
private/		3/14/25, 8:26:26 AM
sbin/		3/6/25, 4:06:02 AM
System/		3/6/25, 4:06:02 AM
tmp/		3/17/25, 10:21:46 PM
Users/		3/14/25, 8:25:58 AM
usr/		3/6/25, 4:06:02 AM
var/		3/14/25, 8:26:18 AM
Volumes/		3/14/25, 9:18:58 AM
.file	0 B	3/6/25, 4:06:02 AM

```
TRAINING RUN: intersection-v0_DQN_lr0.001_gm0.8
/opt/anaconda3/envs/pytorch-env/lib/python3.10/site-packages/gymnasium/envs/registration.
py:517: DeprecationWarning: WARN: The environment intersection-v0 is out of date. You sho
uld consider upgrading to version `v1`.
  logger.deprecation(
[INFO] Completed run for env=intersection-v0, gamma=0.8, lr=0.001
   Final average reward: 0.40
   Success rate: -2.00

[INFO] Model saved at: /Users/sanjayuppala/Desktop/CSC 580 AI_2/Project/Project_DQN1/mode
ls/intersection-v0_DQN_lr0.001_gm0.8_model
```
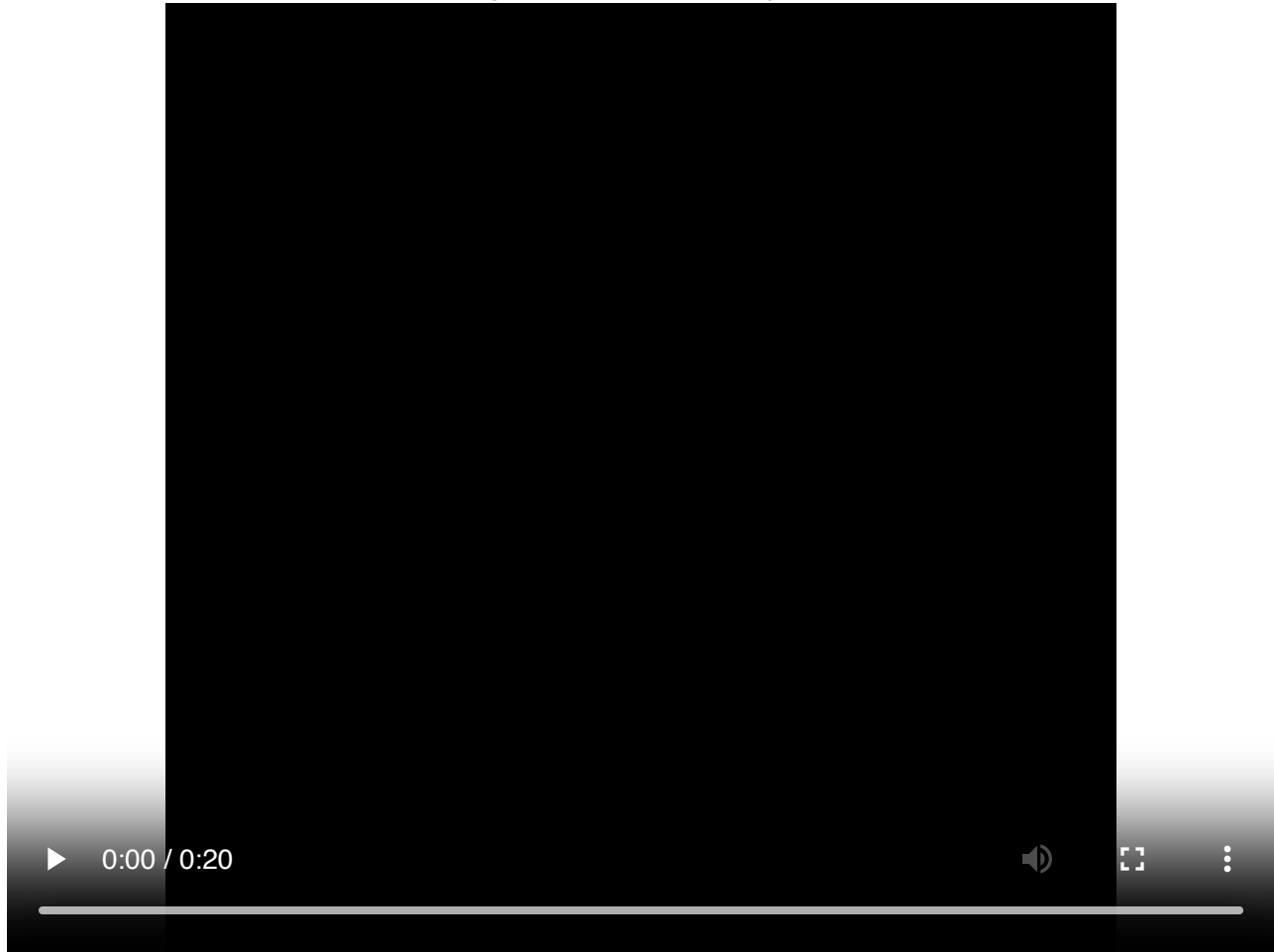
[INFO] Created video: /Users/sanjayuppala/Desktop/CSC 580 AI_2/Project/Project_DQN1/video
s/intersection-v0_DQN_lr0.001_gm0.8_1742079596.mp4

The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard
Reusing TensorBoard on port 6006 (pid 19095), started 6:22:28 ago. (Use '!kill 19095' to
kill it.)

Index of /

Name	Size	Date Modified
.nofollow/		3/6/25, 4:06:02 AM
.resolve/		3/6/25, 4:06:02 AM
.vol/		3/6/25, 4:06:02 AM
Applications/		3/15/25, 9:12:09 AM
bin/		3/6/25, 4:06:02 AM
cores/		8/4/24, 5:31:41 AM
dev/		3/14/25, 8:24:56 AM
etc/		3/14/25, 8:26:29 AM
home/		3/14/25, 8:26:30 AM
Library/		3/14/25, 8:26:15 AM
opt/		2/10/25, 5:44:30 PM
private/		3/14/25, 8:26:26 AM
sbin/		3/6/25, 4:06:02 AM
System/		3/6/25, 4:06:02 AM
tmp/		3/17/25, 10:21:46 PM
Users/		3/14/25, 8:25:58 AM
usr/		3/6/25, 4:06:02 AM
var/		3/14/25, 8:26:18 AM
Volumes/		3/14/25, 9:18:58 AM
.file	0 B	3/6/25, 4:06:02 AM

```
TRAINING RUN: roundabout-v0_DQN_lr0.0005_gm0.95
[INFO] Completed run for env=roundabout-v0, gamma=0.95, lr=0.0005
   Final average reward: 6.81
   Success rate: 0.72

[INFO] Model saved at: /Users/sanjayuppala/Desktop/CSC 580 AI_2/Project/Project_DQN1/mode
ls/roundabout-v0_DQN_lr0.0005_gm0.95_model

[INFO] Created video: /Users/sanjayuppala/Desktop/CSC 580 AI_2/Project/Project_DQN1/video
s/roundabout-v0_DQN_lr0.0005_gm0.95_1742081952.mp4
```
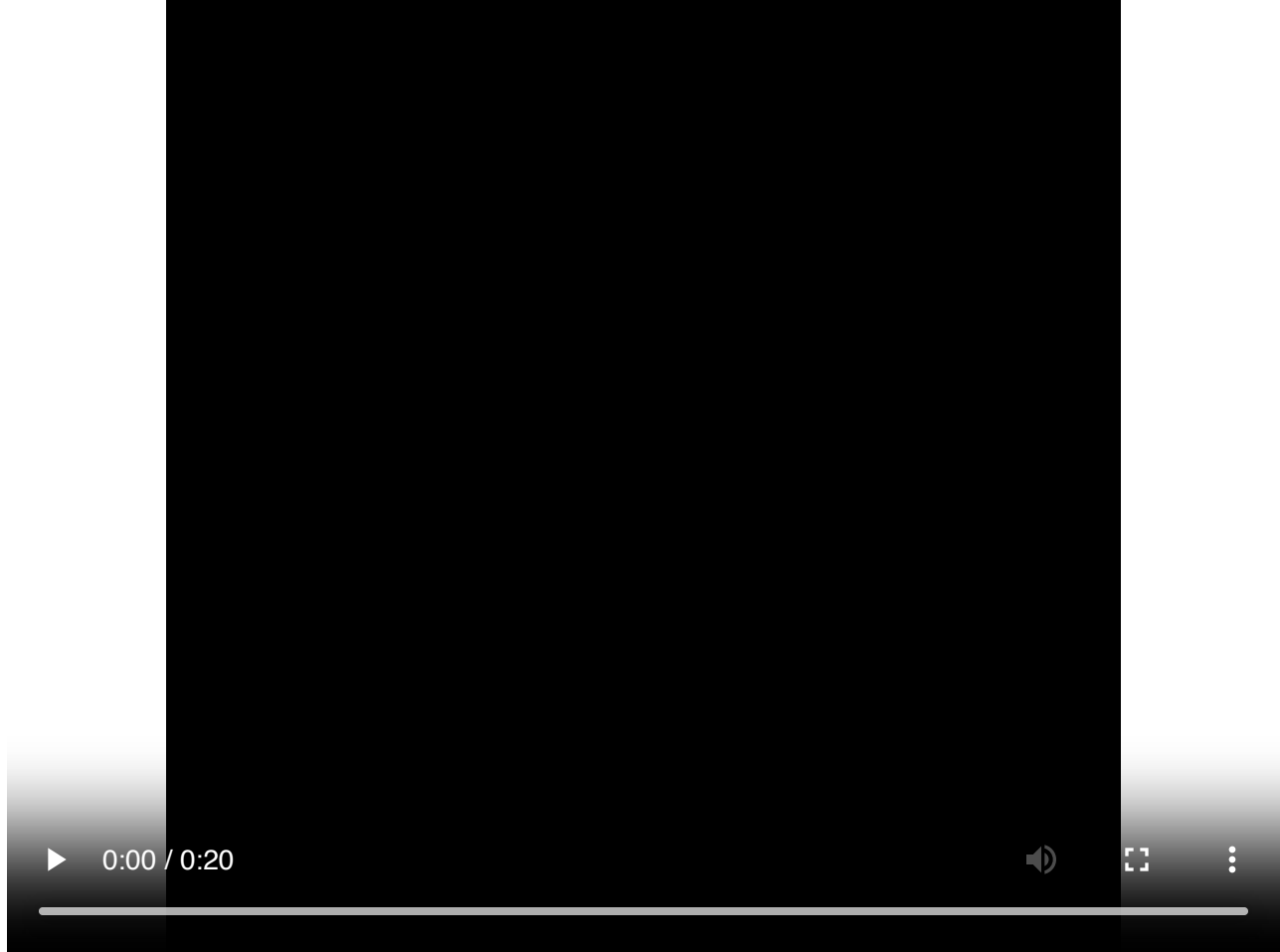
▶ 0:00 / 0:20 🔊 ⛶ ⋮

The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard
Reusing TensorBoard on port 6006 (pid 19095), started 7:01:44 ago. (Use '!kill 19095' to
kill it.)

Index of /

Name	Size	Date Modified
.nofollow/		3/6/25, 4:06:02 AM
.resolve/		3/6/25, 4:06:02 AM
.vol/		3/6/25, 4:06:02 AM
Applications/		3/15/25, 9:12:09 AM
bin/		3/6/25, 4:06:02 AM
cores/		8/4/24, 5:31:41 AM
dev/		3/14/25, 8:24:56 AM
etc/		3/14/25, 8:26:29 AM
home/		3/14/25, 8:26:30 AM
Library/		3/14/25, 8:26:15 AM
opt/		2/10/25, 5:44:30 PM
private/		3/14/25, 8:26:26 AM
sbin/		3/6/25, 4:06:02 AM
System/		3/6/25, 4:06:02 AM
tmp/		3/17/25, 10:21:46 PM
Users/		3/14/25, 8:25:58 AM
usr/		3/6/25, 4:06:02 AM
var/		3/14/25, 8:26:18 AM
Volumes/		3/14/25, 9:18:58 AM
.file	0 B	3/6/25, 4:06:02 AM

```
TRAINING RUN: roundabout-v0_DQN_lr0.0005_gm0.8
[INFO] Completed run for env=roundabout-v0, gamma=0.8, lr=0.0005
   Final average reward: 5.11
   Success rate: 0.42

[INFO] Model saved at: /Users/sanjayuppala/Desktop/CSC 580 AI_2/Project/Project_DQN1/mode
ls/roundabout-v0_DQN_lr0.0005_gm0.8_model

[INFO] Created video: /Users/sanjayuppala/Desktop/CSC 580 AI_2/Project/Project_DQN1/video
s/roundabout-v0_DQN_lr0.0005_gm0.8_1742084330.mp4
```
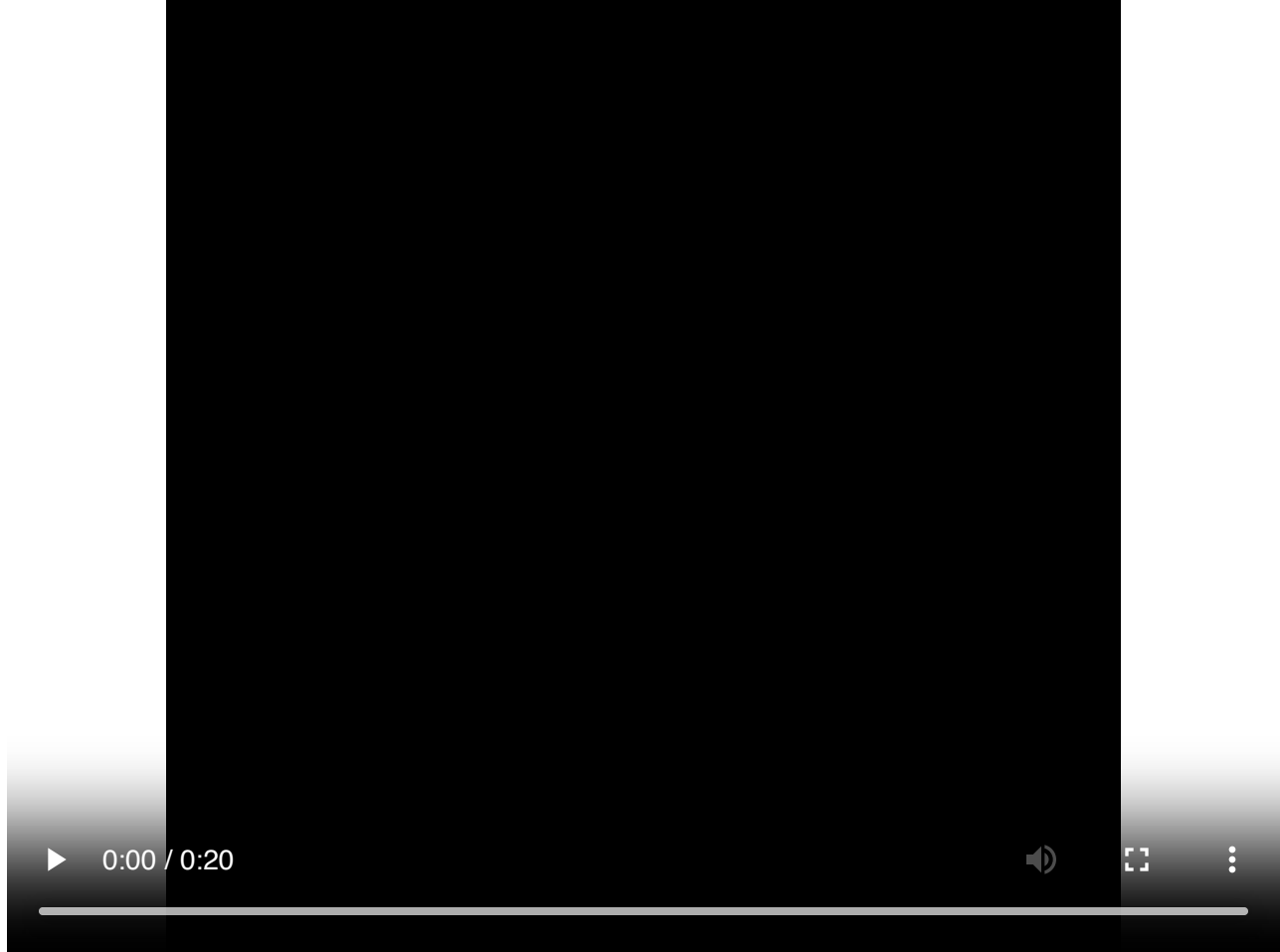
```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard
Reusing TensorBoard on port 6006 (pid 19095), started 7:41:22 ago. (Use '!kill 19095' to
kill it.)
```

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Name	Size	Date Modified
.nofollow/		3/6/25, 4:06:02 AM
.resolve/		3/6/25, 4:06:02 AM
.vol/		3/6/25, 4:06:02 AM
Applications/		3/15/25, 9:12:09 AM
bin/		3/6/25, 4:06:02 AM
cores/		8/4/24, 5:31:41 AM
dev/		3/14/25, 8:24:56 AM
etc/		3/14/25, 8:26:29 AM
home/		3/14/25, 8:26:30 AM
Library/		3/14/25, 8:26:15 AM
opt/		2/10/25, 5:44:30 PM
private/		3/14/25, 8:26:26 AM
sbin/		3/6/25, 4:06:02 AM
System/		3/6/25, 4:06:02 AM
tmp/		3/17/25, 10:21:46 PM
Users/		3/14/25, 8:25:58 AM
usr/		3/6/25, 4:06:02 AM
var/		3/14/25, 8:26:18 AM
Volumes/		3/14/25, 9:18:58 AM
.file	0 B	3/6/25, 4:06:02 AM

```
TRAINING RUN: roundabout-v0_DQN_lr0.001_gm0.95
[INFO] Completed run for env=roundabout-v0, gamma=0.95, lr=0.001
   Final average reward: 4.67
   Success rate: 0.45

[INFO] Model saved at: /Users/sanjayuppala/Desktop/CSC 580 AI_2/Project/Project_DQN1/mode
ls/roundabout-v0_DQN_lr0.001_gm0.95_model

[INFO] Created video: /Users/sanjayuppala/Desktop/CSC 580 AI_2/Project/Project_DQN1/video
s/roundabout-v0_DQN_lr0.001_gm0.95_1742086720.mp4
```
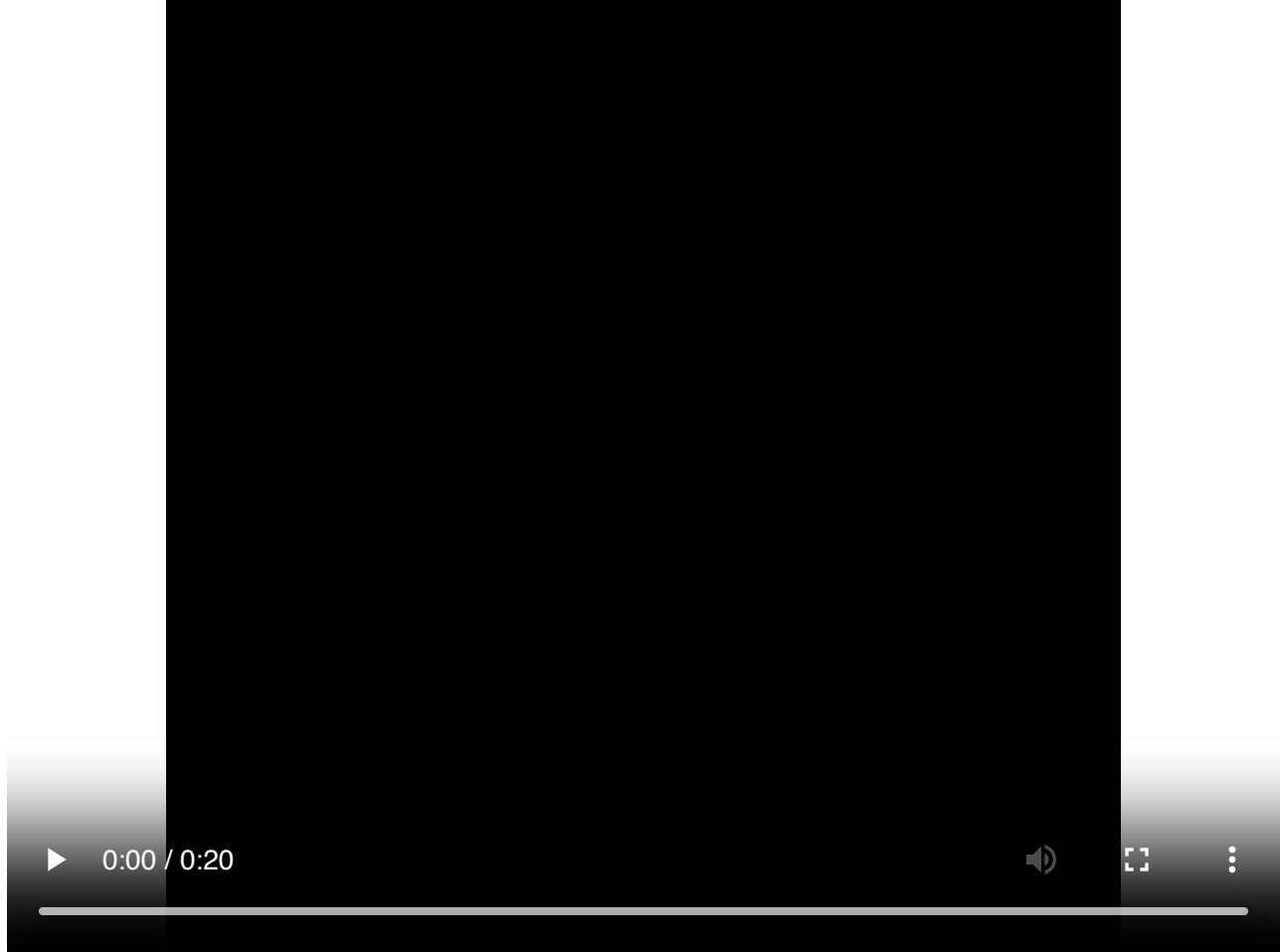
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard
Reusing TensorBoard on port 6006 (pid 19095), started 8:21:11 ago. (Use '!kill 19095' to kill it.)

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Name	Size	Date Modified
.nofollow/		3/6/25, 4:06:02 AM
.resolve/		3/6/25, 4:06:02 AM
.vol/		3/6/25, 4:06:02 AM
Applications/		3/15/25, 9:12:09 AM
bin/		3/6/25, 4:06:02 AM
cores/		8/4/24, 5:31:41 AM
dev/		3/14/25, 8:24:56 AM
etc/		3/14/25, 8:26:29 AM
home/		3/14/25, 8:26:30 AM
Library/		3/14/25, 8:26:15 AM
opt/		2/10/25, 5:44:30 PM
private/		3/14/25, 8:26:26 AM
sbin/		3/6/25, 4:06:02 AM
System/		3/6/25, 4:06:02 AM
tmp/		3/17/25, 10:21:46 PM
Users/		3/14/25, 8:25:58 AM
usr/		3/6/25, 4:06:02 AM
var/		3/14/25, 8:26:18 AM
Volumes/		3/14/25, 9:18:58 AM
.file	0 B	3/6/25, 4:06:02 AM

```
TRAINING RUN: roundabout-v0_DQN_lr0.001_gm0.8
[INFO] Completed run for env=roundabout-v0, gamma=0.8, lr=0.001
   Final average reward: 5.47
   Success rate: 0.47

[INFO] Model saved at: /Users/sanjayuppala/Desktop/CSC 580 AI_2/Project/Project_DQN1/mode
ls/roundabout-v0_DQN_lr0.001_gm0.8_model

[INFO] Created video: /Users/sanjayuppala/Desktop/CSC 580 AI_2/Project/Project_DQN1/video
s/roundabout-v0_DQN_lr0.001_gm0.8_1742089119.mp4
```
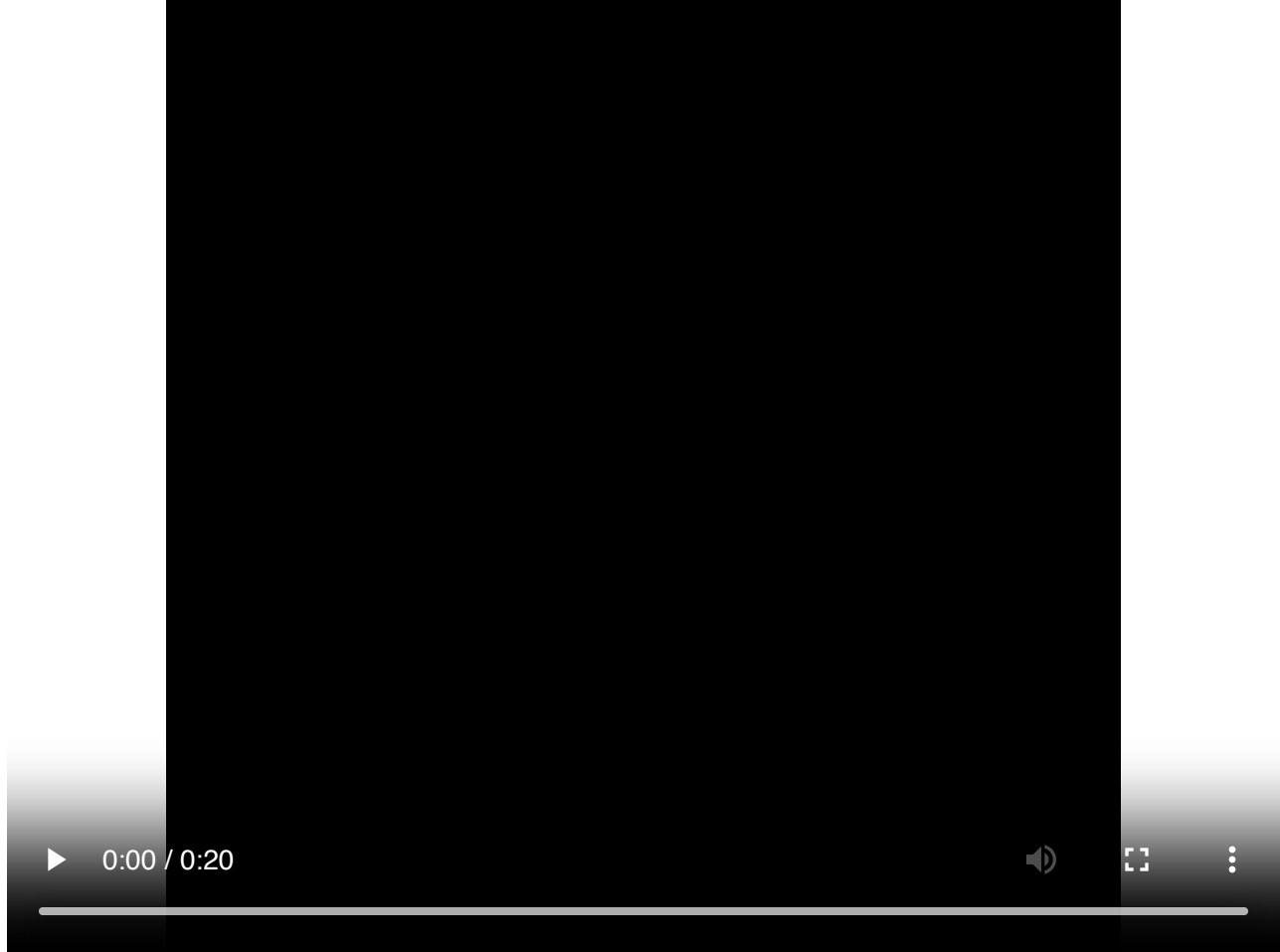
```
The tensorboard extension is already loaded. To reload it, use:
  %reload_ext tensorboard
Reusing TensorBoard on port 6006 (pid 19095), started 9:01:10 ago. (Use '!kill 19095' to
kill it.)
```

Index of /

Name	Size	Date Modified
.nofollow/		3/6/25, 4:06:02 AM
.resolve/		3/6/25, 4:06:02 AM
.vol/		3/6/25, 4:06:02 AM
Applications/		3/15/25, 9:12:09 AM
bin/		3/6/25, 4:06:02 AM
cores/		8/4/24, 5:31:41 AM
dev/		3/14/25, 8:24:56 AM
etc/		3/14/25, 8:26:29 AM
home/		3/14/25, 8:26:30 AM
Library/		3/14/25, 8:26:15 AM
opt/		2/10/25, 5:44:30 PM
private/		3/14/25, 8:26:26 AM
sbin/		3/6/25, 4:06:02 AM
System/		3/6/25, 4:06:02 AM
tmp/		3/17/25, 10:21:46 PM
Users/		3/14/25, 8:25:58 AM
usr/		3/6/25, 4:06:02 AM
var/		3/14/25, 8:26:18 AM
Volumes/		3/14/25, 9:18:58 AM
.file	0 B	3/6/25, 4:06:02 AM

```
Final Result of All model trained Above

highway-fast-v0_DQN_lr0.0005_gm0.95
highway-fast-v0_DQN_lr0.0005_gm0.8
highway-fast-v0_DQN_lr0.001_gm0.95
highway-fast-v0_DQN_lr0.001_gm0.8
intersection-v0_DQN_lr0.0005_gm0.95
intersection-v0_DQN_lr0.0005_gm0.8
intersection-v0_DQN_lr0.001_gm0.95
intersection-v0_DQN_lr0.001_gm0.8
roundabout-v0_DQN_lr0.0005_gm0.95
roundabout-v0_DQN_lr0.0005_gm0.8
roundabout-v0_DQN_lr0.001_gm0.95
roundabout-v0_DQN_lr0.001_gm0.8
```

```
In [3]: %load_ext tensorboard
        %tensorboard --logdir ./Project_DQN1/logs --port=6006
```

Index of /

Name	Size	Date Modified
.nofollow/		3/6/25, 4:06:02 AM
.resolve/		3/6/25, 4:06:02 AM
.vol/		3/6/25, 4:06:02 AM
Applications/		3/15/25, 9:12:09 AM
bin/		3/6/25, 4:06:02 AM
cores/		8/4/24, 5:31:41 AM
dev/		3/14/25, 8:24:56 AM
etc/		3/14/25, 8:26:29 AM
home/		3/14/25, 8:26:30 AM
Library/		3/14/25, 8:26:15 AM
opt/		2/10/25, 5:44:30 PM
private/		3/14/25, 8:26:26 AM
sbin/		3/6/25, 4:06:02 AM
System/		3/6/25, 4:06:02 AM
tmp/		3/17/25, 10:21:46 PM
Users/		3/14/25, 8:25:58 AM
usr/		3/6/25, 4:06:02 AM
var/		3/14/25, 8:26:18 AM
Volumes/		3/14/25, 9:18:58 AM
.file	0 B	3/6/25, 4:06:02 AM

```
In [7]: if IN_JUPYTER:
            get_ipython().run_line_magic('load_ext', 'tensorboard')
            get_ipython().run_line_magic('tensorboard', '--logdir ./Project_DQN1
```

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

Index of /

Name	Size	Date Modified
.nofollow/		3/6/25, 4:06:02 AM
.resolve/		3/6/25, 4:06:02 AM
.vol/		3/6/25, 4:06:02 AM
Applications/		3/15/25, 9:12:09 AM
bin/		3/6/25, 4:06:02 AM
cores/		8/4/24, 5:31:41 AM
dev/		3/14/25, 8:24:56 AM
etc/		3/14/25, 8:26:29 AM
home/		3/14/25, 8:26:30 AM
Library/		3/14/25, 8:26:15 AM
opt/		2/10/25, 5:44:30 PM
private/		3/14/25, 8:26:26 AM
sbin/		3/6/25, 4:06:02 AM
System/		3/6/25, 4:06:02 AM
tmp/		3/17/25, 10:21:46 PM
Users/		3/14/25, 8:25:58 AM
usr/		3/6/25, 4:06:02 AM
var/		3/14/25, 8:26:18 AM
Volumes/		3/14/25, 9:18:58 AM
.file	0 B	3/6/25, 4:06:02 AM

In [ ]: