

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-packages (from highway-env) (1.0.0)

Requirement already satisfied: farama-notifications>=0.0.1 in /opt/anaconda3/lib/python3.12/site-packages (from highway-env) (0.0.4)

Requirement already satisfied: numpy>=1.21.0 in /opt/anaconda3/lib/python3.12/site-packages (from highway-env) (1.26.4)

Requirement already satisfied: pygame>=2.0.2 in /opt/anaconda3/lib/python3.12/site-packages (from highway-env) (2.6.1)

Requirement already satisfied: matplotlib in /opt/anaconda3/lib/python3.12/site-packages (from highway-env) (3.9.2)

Requirement already satisfied: pandas in /opt/anaconda3/lib/python3.12/site-packages (from highway-env) (2.2.2)

Requirement already satisfied: scipy in /opt/anaconda3/lib/python3.12/site-packages (from highway-env) (1.13.1)

Requirement already satisfied: cloudpickle>=1.2.0 in /opt/anaconda3/lib/python3.12/site-packages (from gymnasium>=1.0.0a2->highway-env) (3.0.0)

Requirement already satisfied: typing-extensions>=4.3.0 in /opt/anaconda3/lib/python3.12/site-packages (from gymnasium>=1.0.0a2->highway-env) (4.11.0)

Requirement already satisfied: contourpy>=1.0.1 in /opt/anaconda3/lib/python3.12/site-packages (from matplotlib->highway-env) (1.2.0)

Requirement already satisfied: cycler>=0.10 in /opt/anaconda3/lib/python3.12/site-packages (from matplotlib->highway-env) (0.11.0)

Requirement already satisfied: fonttools>=4.22.0 in /opt/anaconda3/lib/python3.12/site-packages (from matplotlib->highway-env) (4.51.0)

Requirement already satisfied: kiwisolver>=1.3.1 in /opt/anaconda3/lib/python3.12/site-packages (from matplotlib->highway-env) (1.4.4)

Requirement already satisfied: packaging>=20.0 in /opt/anaconda3/lib/python3.12/site-packages (from matplotlib->highway-env) (24.1)

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Requirement already satisfied: python-dateutil>=2.7 in /opt/anaconda3/lib/python3.12/site-packages (from matplotlib->highway-env) (2.9.0.post0)

Requirement already satisfied: pytz>=2020.1 in /opt/anaconda3/lib/python3.12/site-packages (from pandas->highway-env) (2024.1)

Requirement already satisfied: tzdata>=2022.7 in /opt/anaconda3/lib/python3.12/site-packages (from pandas->highway-env) (2023.3)

Requirement already satisfied: six>=1.5 in /opt/anaconda3/lib/python3.12/site-packages (from python-dateutil>=2.7->matplotlib->highway-env) (1.16.0)

Requirement already satisfied: stable-baselines3 in /opt/anaconda3/lib/python3.12/site-packages (2.5.0)

Requirement already satisfied: gymnasium<1.1.0,>=0.29.1 in /opt/anaconda3/lib/python3.12/site-packages (from stable-baselines3) (1.0.0)

Requirement already satisfied: numpy<3.0,>=1.20 in /opt/anaconda3/lib/python3.12/site-packages (from stable-baselines3) (1.26.4)

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Requirement already satisfied: typing-extensions>=4.3.0 in /opt/anaconda3/lib/python3.12/site-packages (from gymnasium<1.1.0,>=0.29.1->stable-baselines3) (4.11.0)

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Requirement already satisfied: fsspec in /opt/anaconda3/lib/python3.12/site-packages (from torch<3.0,>=2.3->stable-baselines3) (2024.6.1)

Requirement already satisfied: setuptools in /opt/anaconda3/lib/python3.12/site-packages (from torch<3.0,>=2.3->stable-baselines3) (75.1.0)

Requirement already satisfied: sympy==1.13.1 in /opt/anaconda3/lib/python3.12/site-packages (from torch<3.0,>=2.3->stable-baselines3) (1.13.1)

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Requirement already satisfied: contourpy>=1.0.1 in /opt/anaconda3/lib/python3.12/site-packages (from matplotlib->stable-baselines3) (1.2.0)

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Requirement already satisfied: fonttools>=4.22.0 in /opt/anaconda3/lib/python3.12/site-packages (from matplotlib->stable-baselines3) (4.51.0)

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Requirement already satisfied: MarkupSafe>=2.0 in /opt/anaconda3/lib/python3.12/site-packages (from jinja2->torch<3.0,>=2.3->stable-baselines3) (2.1.3)

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Requirement already satisfied: packaging in /opt/anaconda3/lib/python3.12/site-packages (from tensorboard) (24.1)

Requirement already satisfied: protobuf!=4.24.0,>=3.19.6 in /opt/anaconda3/lib/python3.12/site-packages (from tensorboard) (4.25.3)
Requirement already satisfied: setuptools>=41.0.0 in /opt/anaconda3/lib/python3.12/site-packages (from tensorboard) (75.1.0)
Requirement already satisfied: six>1.9 in /opt/anaconda3/lib/python3.12/site-packages (from tensorboard) (1.16.0)
Requirement already satisfied: tensorboard-data-server<0.8.0,>=0.7.0 in /opt/anaconda3/lib/python3.12/site-packages (from tensorboard) (0.7.2)
Requirement already satisfied: werkzeug>=1.0.1 in /opt/anaconda3/lib/python3.12/site-packages (from tensorboard) (3.0.3)
Requirement already satisfied: MarkupSafe>=2.1.1 in /opt/anaconda3/lib/python3.12/site-packages (from werkzeug>=1.0.1->tensorboard) (2.1.3)

```
In [2]: #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, PPO
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
from IPython import get_ipython
try:
    IN_JUPYTER = True
except ImportError:
    IN_JUPYTER = False

if IN_JUPYTER:
```

2) Directory Setup

```
In [3]: PROJECT_DIR = os.path.join(os.getcwd(), "Project_PP0")
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) Utility: show_video in Jupyter

```
In [4]: 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"[WARN] 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"[INFO] Video saved: {video_path}")

```

4) Environment Creation

```

In [5]: def make_env(env_name="highway-fast-v0"):
    """
    Created a Configure for the Enviornment using Gym for traning purpose
    """
    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]: def record_with_opencv(frames, out_file="demo.mp4", fps=15):
    """
    OpennCv package has been used to record the video in 3 format - MP4,AVC1,XVID
    """
    if not frames:
        print("[WARN] 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"[INFO] Created video: {out_file}")

```

6) Traing PPO MOdel

```

In [7]: if __name__ == "__main__":
    ENVIRONMENTS = ["highway-fast-v0", "intersection-v0", "roundabout-v0"]
    LEARNING_RATES = [0.0005, 0.001]
    GAMMAS = [0.95, 0.8]

```

```

TOTAL_TIMESTEPS = 10000

# dictionary to store final results
results = {}

for env_name in ENVIRONMENTS:
    for lr in LEARNING_RATES:
        for gm in GAMMAS:
            # Unique run_id
            run_id = f"{env_name}_PPO_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 PPO with chosen LR, gamma
            model = PPO(
                "MlpPolicy",
                vec_env,
                learning_rate=lr,
                gamma=gm,
                n_steps=512,
                batch_size=64,
                n_epochs=10,
                clip_range=0.2,
                verbose=0,
                tensorboard_log=tb_log_dir
            )

            # 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 = []
            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 usnig logs files
if IN_JUPYTER:
    get_ipython().run_line_magic('load_ext', 'tensorboard')
    get_ipython().run_line_magic('tensorboard', '--logdir ./Project_PP0/

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

```

TRAINING RUN: highway-fast-v0_PP0_lr0.0005_gm0.95

[INFO] Completed run for env=highway-fast-v0, gamma=0.95, lr=0.0005

Final average reward: 27.78

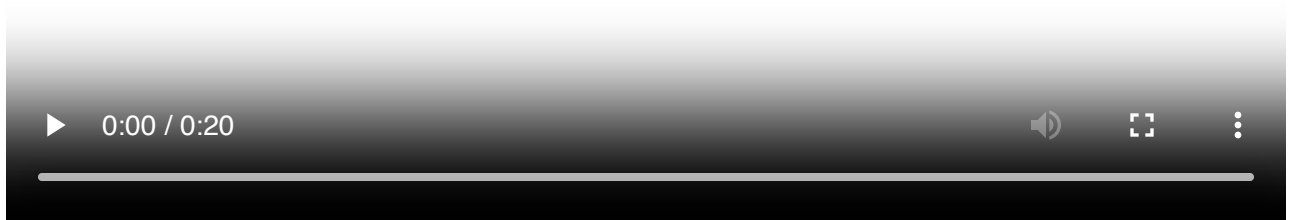
Success rate: 0.98

[INFO] Model saved at: /Users/sanjayuppala/Desktop/CSC 580 AI_2/projrct PP0/Project_PP0/models/highway-fast-v0_PP0_lr0.0005_gm0.95_model

2025-03-15 21:48:40.113 python[25677:1370912] +[IMKClient subclass]: chose IMKClient_Moder

2025-03-15 21:48:40.113 python[25677:1370912] +[IMKInputSession subclass]: chose IMKInputSession_Modern

[INFO] Created video: /Users/sanjayuppala/Desktop/CSC 580 AI_2/projrct PP0/Project_PP0/videos/highway-fast-v0_PP0_lr0.0005_gm0.95_1742093338.mp4



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Name	Size	Date Modified
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.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_PP0_lr0.0005_gm0.8

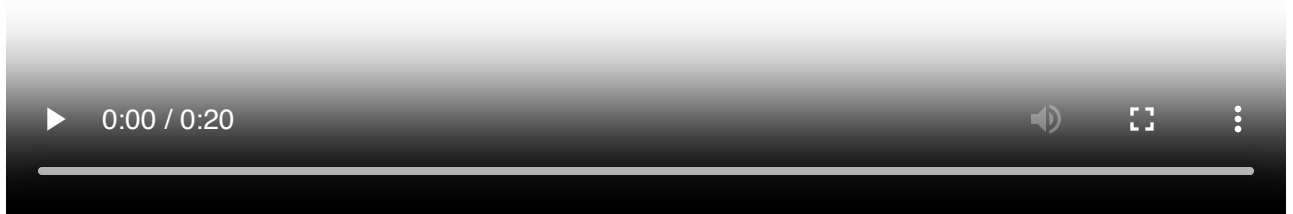
[INFO] Completed run for env=highway-fast-v0, gamma=0.8, lr=0.0005

Final average reward: 23.16

Success rate: 0.56

[INFO] Model saved at: /Users/sanjayuppala/Desktop/CSC 580 AI_2/projrct PP0/Project_PP0/models/highway-fast-v0_PP0_lr0.0005_gm0.8_model

[INFO] Created video: /Users/sanjayuppala/Desktop/CSC 580 AI_2/projrct PP0/Project_PP0/videos/highway-fast-v0_PP0_lr0.0005_gm0.8_1742094755.mp4



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

```
%reload_ext tensorboard
```

Reusing TensorBoard on port 6006 (pid 26105), started 0:23:36 ago. (Use '!kill 26105' to kill it.)

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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_PP0_lr0.001_gm0.95

[INFO] Completed run for env=highway-fast-v0, gamma=0.95, lr=0.001

Final average reward: 29.28

Success rate: 0.95

[INFO] Model saved at: /Users/sanjayuppala/Desktop/CSC 580 AI_2/projrct PP0/Project_PP0/models/highway-fast-v0_PP0_lr0.001_gm0.95_model

[INFO] Created video: /Users/sanjayuppala/Desktop/CSC 580 AI_2/projrct PP0/Project_PP0/videos/highway-fast-v0_PP0_lr0.001_gm0.95_1742096158.mp4



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

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%reload_ext tensorboard
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Reusing TensorBoard on port 6006 (pid 26105), started 0:46:59 ago. (Use '!kill 26105' to kill it.)

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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_PP0_lr0.001_gm0.8

[INFO] Completed run for env=highway-fast-v0, gamma=0.8, lr=0.001

Final average reward: 32.16

Success rate: 0.95

[INFO] Model saved at: /Users/sanjayuppala/Desktop/CSC 580 AI_2/projrct PP0/Project_PP0/models/highway-fast-v0_PP0_lr0.001_gm0.8_model

[INFO] Created video: /Users/sanjayuppala/Desktop/CSC 580 AI_2/projrct PP0/Project_PP0/videos/highway-fast-v0_PP0_lr0.001_gm0.8_1742097591.mp4



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

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%reload_ext tensorboard
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Reusing TensorBoard on port 6006 (pid 26105), started 1:10:52 ago. (Use '!kill 26105' to kill it.)

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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: intersection-v0_PP0_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 should consider upgrading to version `v1`.
```

```
logger.deprecation(
```

```
[INFO] Completed run for env=intersection-v0, gamma=0.95, lr=0.0005
```

```
Final average reward: -0.20
```

```
Success rate: 0.00
```

```
[INFO] Model saved at: /Users/sanjayuppala/Desktop/CSC 580 AI_2/projrct PP0/Project_PP0/models/intersection-v0_PP0_lr0.0005_gm0.95_model
```

```
logger.deprecation(
```

A black video player interface. At the bottom, there is a white progress bar. On the left side of the bar is a play button icon, followed by the text '0:00 / 0:20'. To the right of the time is a speaker icon, then a full screen icon, and finally a menu icon (three vertical dots). The rest of the player area is black.

```
%reload_ext tensorboard
```

```
Reusing TensorBoard on port 6006 (pid 26105), started 1:53:09 ago. (Use '!kill 26105' 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_PP0_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 should consider upgrading to version `v1`.
```

```
    logger.deprecation(
```

```
[INFO] Completed run for env=intersection-v0, gamma=0.8, lr=0.0005
```

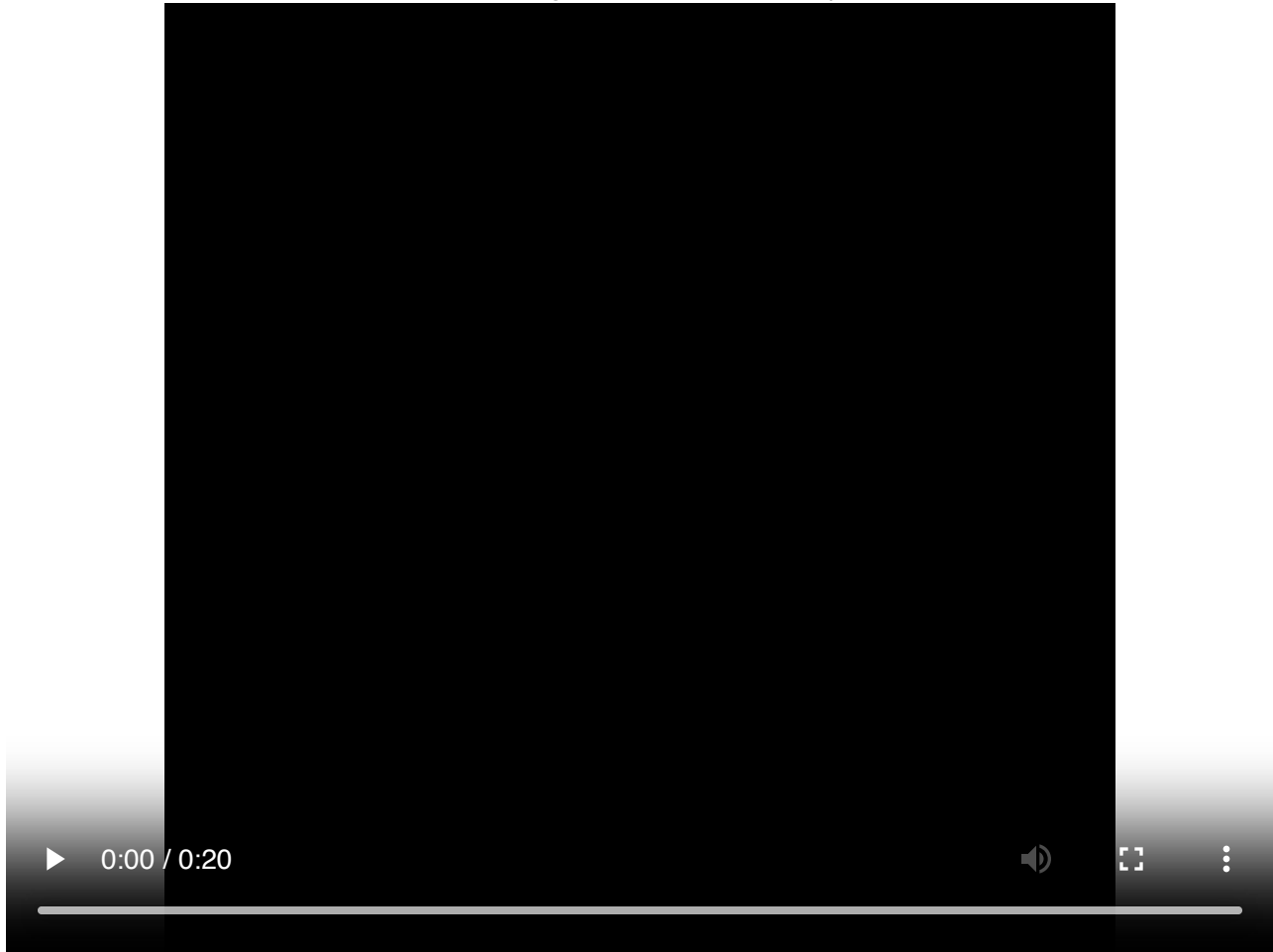
```
    Final average reward: -1.00
```

```
    Success rate: 0.00
```

```
[INFO] Model saved at: /Users/sanjayuppala/Desktop/CSC 580 AI_2/projrct PP0/Project_PP0/models/intersection-v0_PP0_lr0.0005_gm0.8_model
```

```
/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 should consider upgrading to version `v1`.
  logger.deprecation(
```

```
[INFO] Created video: /Users/sanjayuppala/Desktop/CSC 580 AI_2/projrct PP0/Project_PP0/videos/intersection-v0_PP0_lr0.0005_gm0.8_1742102665.mp4
```



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

```
%reload_ext tensorboard
```

Reusing TensorBoard on port 6006 (pid 26105), started 2:35:27 ago. (Use '!kill 26105' 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_PP0_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 should consider upgrading to version `v1`.
```

```
    logger.deprecation(
```

```
[INF0] Completed run for env=intersection-v0, gamma=0.95, lr=0.001
```

```
    Final average reward: 0.20
```

```
    Success rate: -4.83
```

```
[INF0] Model saved at: /Users/sanjayuppala/Desktop/CSC 580 AI_2/projrct PP0/Project_PP0/models/intersection-v0_PP0_lr0.001_gm0.95_model
```

```
logger.deprecation(
```

A black video player interface. At the bottom, there is a white progress bar. On the left side of the bar is a play button icon, followed by the text '0:00 / 0:20'. To the right of the time are three icons: a speaker icon for audio, a square icon for full screen, and a vertical ellipsis icon for a menu. The rest of the player area is solid black.

```
%reload_ext tensorboard
```

```
Reusing TensorBoard on port 6006 (pid 26105), started 3:17:36 ago. (Use '!kill 26105' 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_PP0_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 should consider upgrading to version `v1`.
```

```
    logger.deprecation(
```

```
[INFO] Completed run for env=intersection-v0, gamma=0.8, lr=0.001
```

```
    Final average reward: -0.20
```

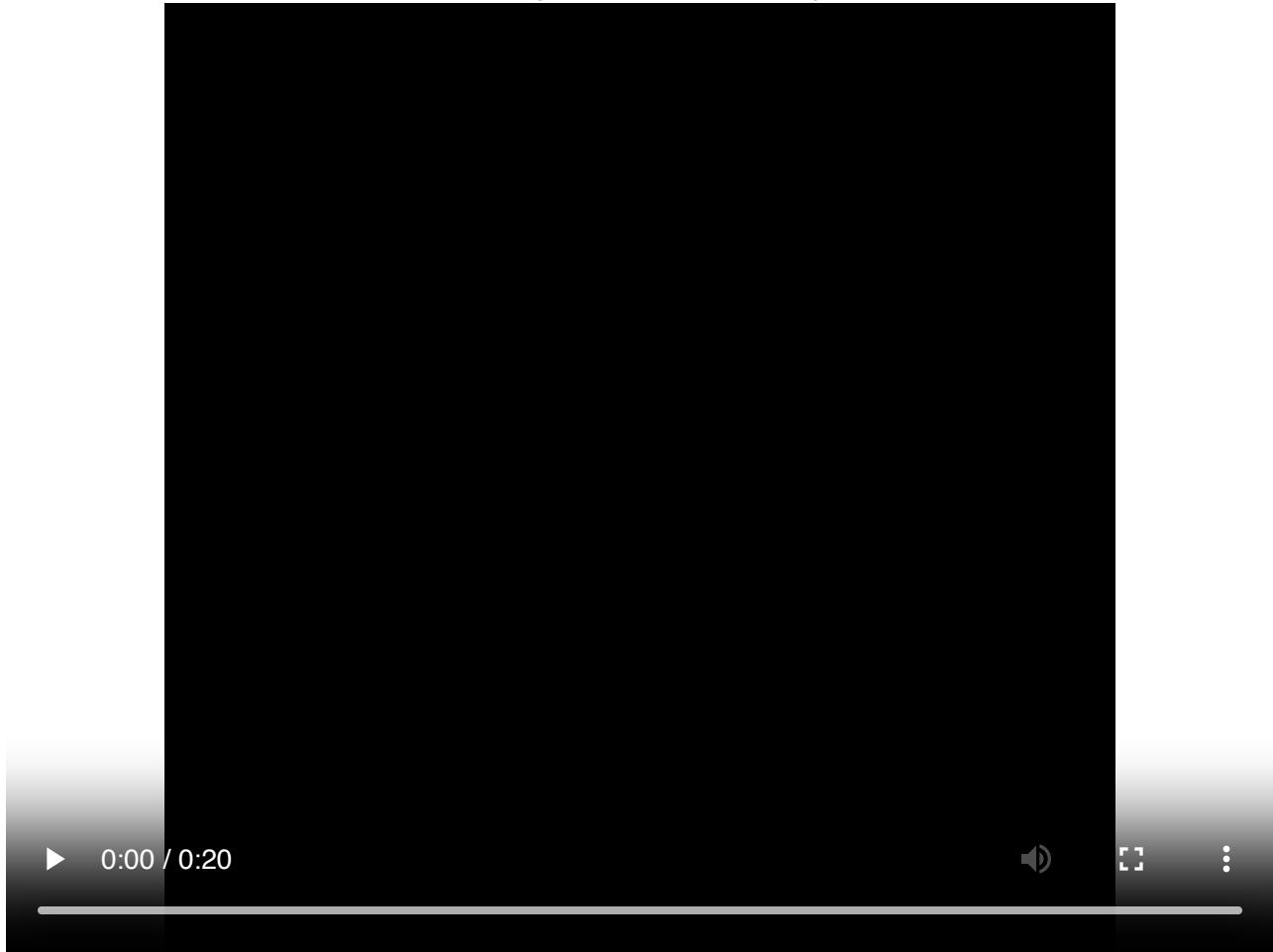
```
    Success rate: 0.00
```

```
[INFO] Model saved at: /Users/sanjayuppala/Desktop/CSC 580 AI_2/projrct PP0/Project_PP0/models/intersection-v0_PP0_lr0.001_gm0.8_model
```

```
/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(  
    deprecation_warning=DeprecationWarning(
```

```
[INFO] Created video: /Users/sanjayuppala/Desktop/CSC 580 AI_2/projrct PP0/Project_PP0/vi  
deos/intersection-v0_PP0_lr0.001_gm0.8_1742107729.mp4
```



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

```
%reload_ext tensorboard
```

Reusing TensorBoard on port 6006 (pid 26105), started 3:59:51 ago. (Use '!kill 26105' 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_PP0_lr0.0005_gm0.95

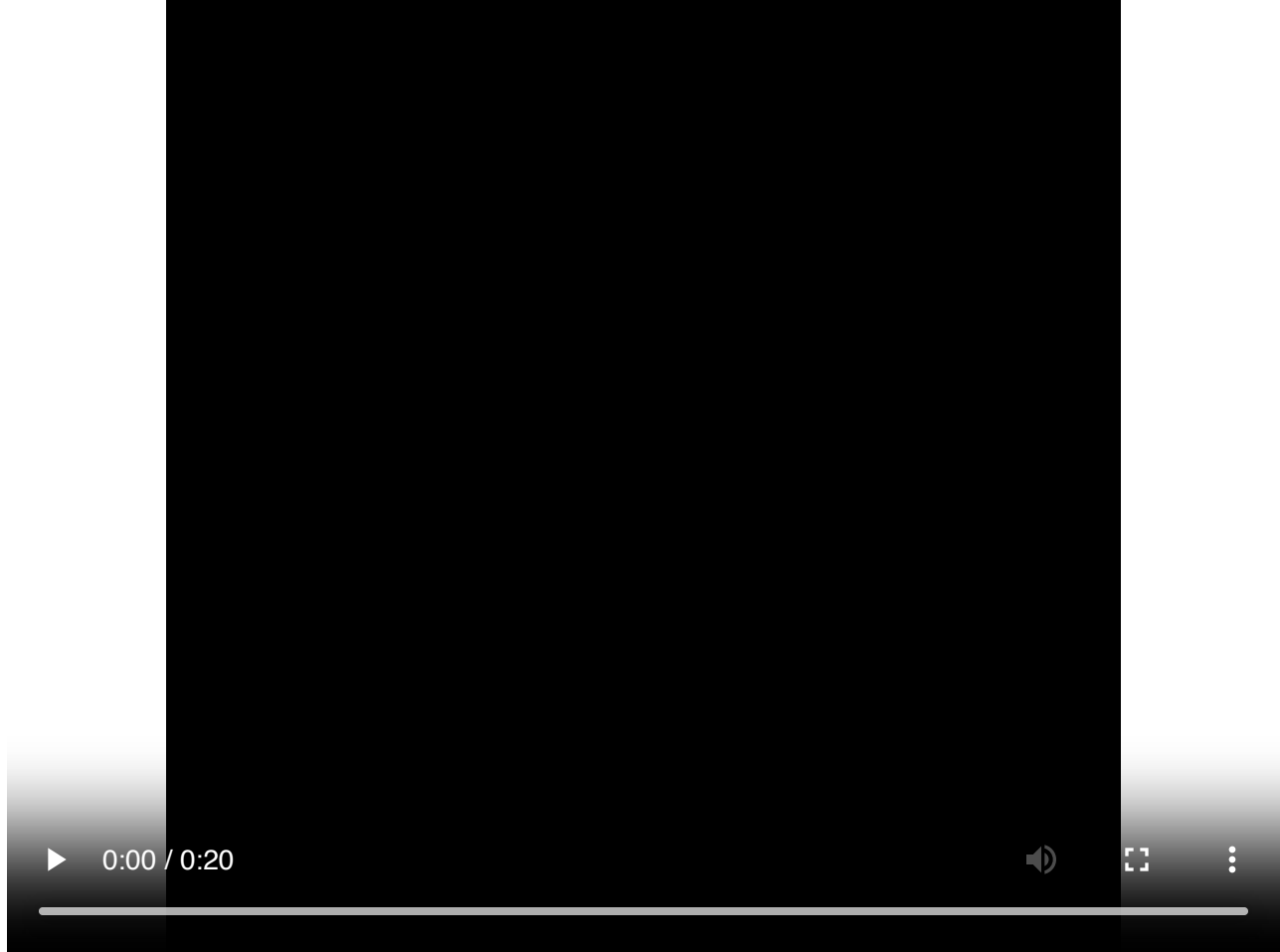
[INFO] Completed run for env=roundabout-v0, gamma=0.95, lr=0.0005

Final average reward: 6.67

Success rate: 0.65

[INFO] Model saved at: /Users/sanjayuppala/Desktop/CSC 580 AI_2/projrct PP0/Project_PP0/models/roundabout-v0_PP0_lr0.0005_gm0.95_model

[INFO] Created video: /Users/sanjayuppala/Desktop/CSC 580 AI_2/projrct PP0/Project_PP0/videos/roundabout-v0_PP0_lr0.0005_gm0.95_1742109255.mp4



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

```
%reload_ext tensorboard
```

Reusing TensorBoard on port 6006 (pid 26105), started 4:25:17 ago. (Use '!kill 26105' 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_PP0_lr0.0005_gm0.8

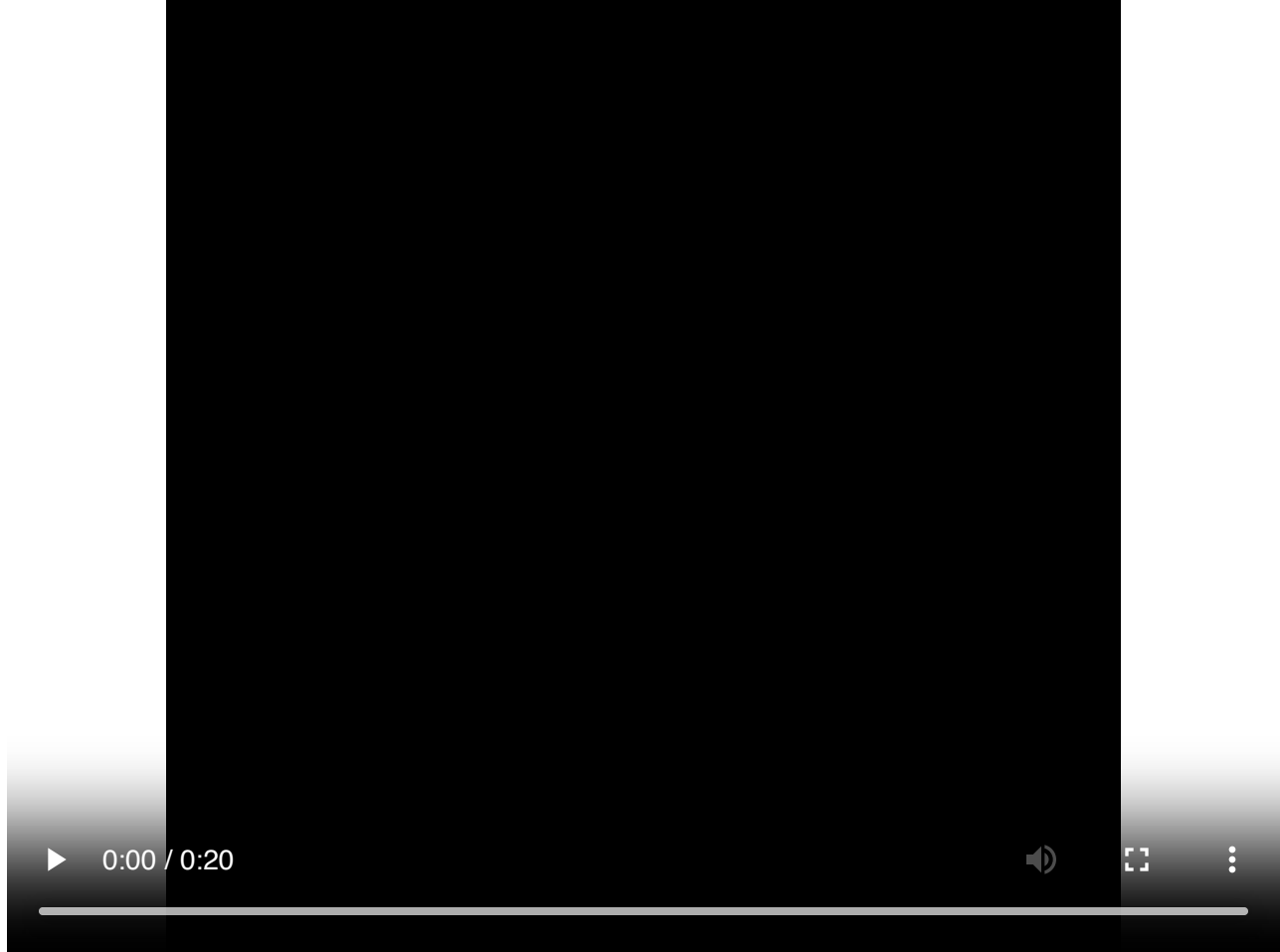
[INFO] Completed run for env=roundabout-v0, gamma=0.8, lr=0.0005

Final average reward: 7.67

Success rate: 1.00

[INFO] Model saved at: /Users/sanjayuppala/Desktop/CSC 580 AI_2/projrct PP0/Project_PP0/models/roundabout-v0_PP0_lr0.0005_gm0.8_model

[INFO] Created video: /Users/sanjayuppala/Desktop/CSC 580 AI_2/projrct PP0/Project_PP0/videos/roundabout-v0_PP0_lr0.0005_gm0.8_1742110818.mp4



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

```
%reload_ext tensorboard
```

Reusing TensorBoard on port 6006 (pid 26105), started 4:51:20 ago. (Use '!kill 26105' 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_PP0_lr0.001_gm0.95

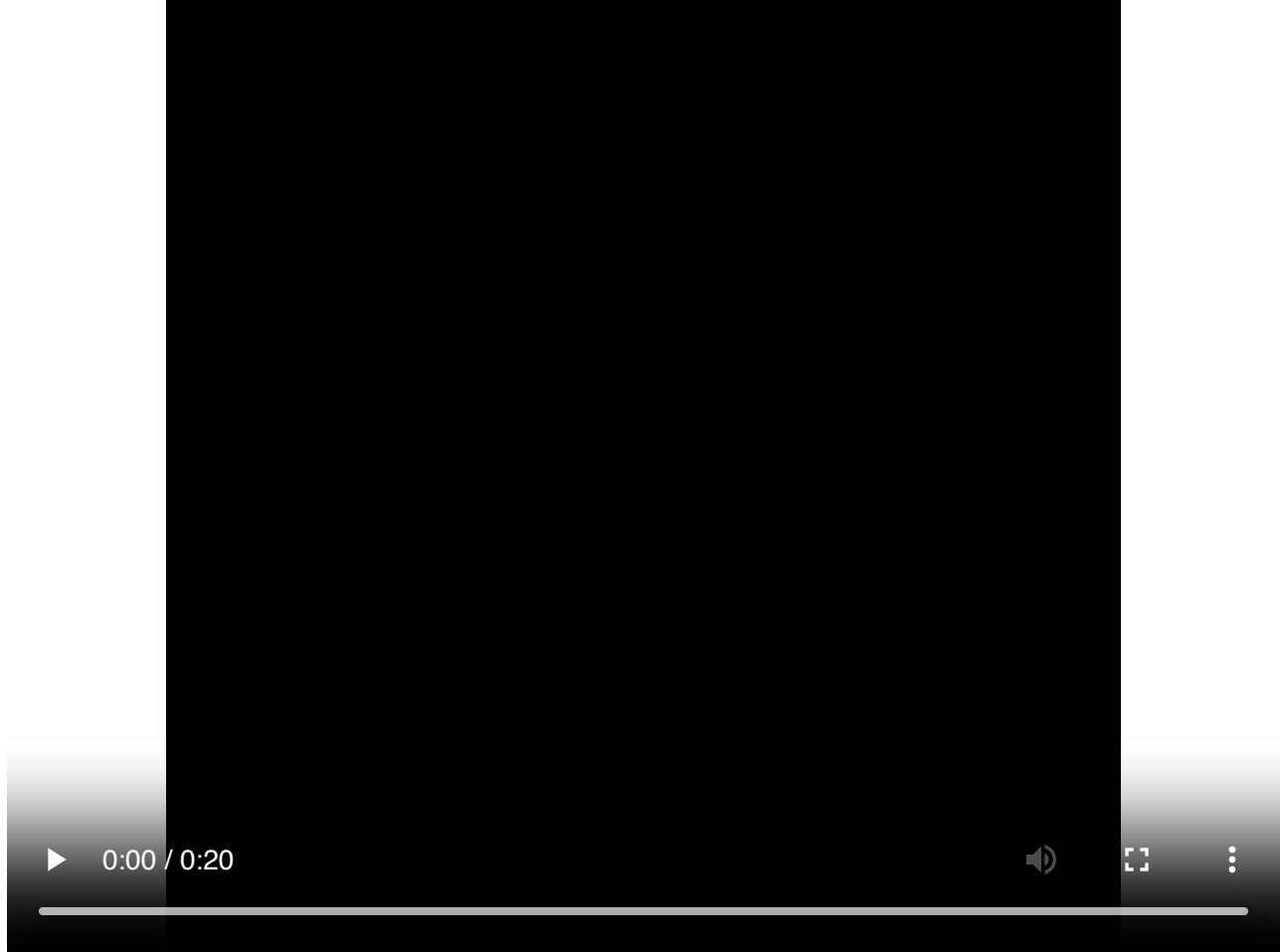
[INFO] Completed run for env=roundabout-v0, gamma=0.95, lr=0.001

Final average reward: 5.46

Success rate: 0.48

[INFO] Model saved at: /Users/sanjayuppala/Desktop/CSC 580 AI_2/projrct PP0/Project_PP0/models/roundabout-v0_PP0_lr0.001_gm0.95_model

[INFO] Created video: /Users/sanjayuppala/Desktop/CSC 580 AI_2/projrct PP0/Project_PP0/videos/roundabout-v0_PP0_lr0.001_gm0.95_1742112391.mp4



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

```
%reload_ext tensorboard
```

Reusing TensorBoard on port 6006 (pid 26105), started 5:17:33 ago. (Use '!kill 26105' 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_PP0_lr0.001_gm0.8

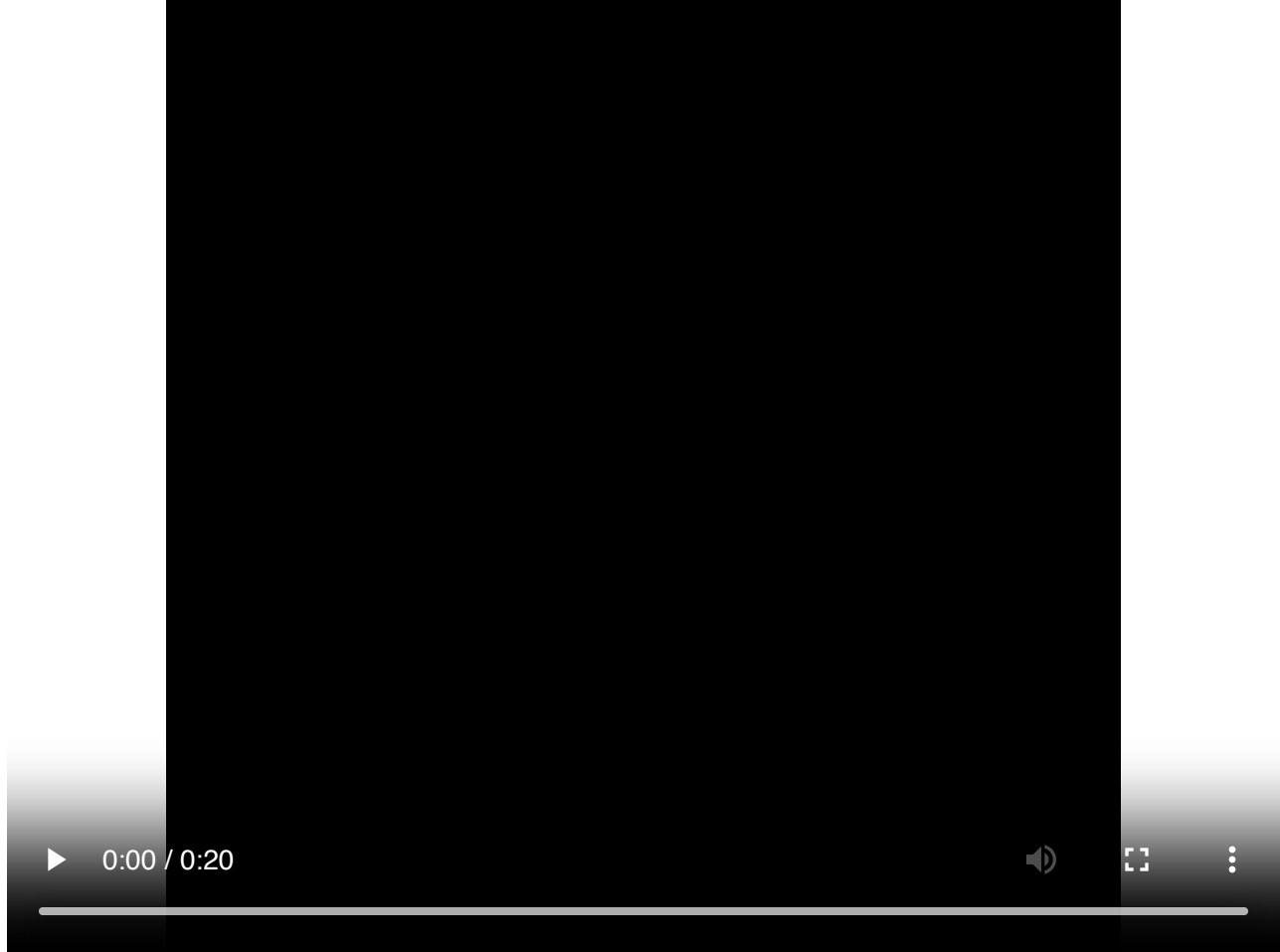
[INFO] Completed run for env=roundabout-v0, gamma=0.8, lr=0.001

Final average reward: 7.67

Success rate: 1.00

[INFO] Model saved at: /Users/sanjayuppala/Desktop/CSC 580 AI_2/projrct PP0/Project_PP0/models/roundabout-v0_PP0_lr0.001_gm0.8_model

[INFO] Created video: /Users/sanjayuppala/Desktop/CSC 580 AI_2/projrct PP0/Project_PP0/videos/roundabout-v0_PP0_lr0.001_gm0.8_1742113961.mp4



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

```
%reload_ext tensorboard
```

Reusing TensorBoard on port 6006 (pid 26105), started 5:43:43 ago. (Use '!kill 26105' 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_PP0_lr0.0005_gm0.95
highway-fast-v0_PP0_lr0.0005_gm0.8
highway-fast-v0_PP0_lr0.001_gm0.95
highway-fast-v0_PP0_lr0.001_gm0.8
intersection-v0_PP0_lr0.0005_gm0.95
intersection-v0_PP0_lr0.0005_gm0.8
intersection-v0_PP0_lr0.001_gm0.95
intersection-v0_PP0_lr0.001_gm0.8
roundabout-v0_PP0_lr0.0005_gm0.95
roundabout-v0_PP0_lr0.0005_gm0.8
roundabout-v0_PP0_lr0.001_gm0.95
roundabout-v0_PP0_lr0.001_gm0.8

```
In [18]: !pkill -f tensorboard # For Linux/macOS
```

```
In [19]: %load_ext tensorboard
%tensorboard --logdir ./Project_PP0/logs --port=6006
```

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 [ ]:
```