Research Report for

A Dynamic Scenario Description Language for Autonomous Vehicles Simulation Testing

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Table of Contents

1. Research Objective and Background of ANTI-CARLA

1.1 Objective

The objective of this research project is to replicate the experiment presented in the ANTI-CARLA paper (Ramakrishna et al., 2022), which describes a new testing framework designed for autonomous vehicles. It uses the CARLA (The Carnegie Learning Architecture) simulation environment to generate adversarial test cases that can help identify potential weaknesses in autonomous driving systems.

1.2 Background of ANTI-CARLA

The original aim of ANTI-CARLA was to employ a combination of Adversarial Machine Learning (AML) and Constraint-based testing (CBT) techniques to generate a diverse set of failure cases and analyze their effect on the system's performance. I am replicating the ANTI-CARLA experiment for two main reasons. Firstly, ANTI-CARLA utilizes a combination of rule-based and machine learning-based approaches to generate challenging scenarios for autonomous vehicles to navigate. This provides a comprehensive and automated testing solution to evaluate the robustness and reliability of autonomous driving systems, as well as simulate various edge cases and failure scenarios, ultimately resulting in improved safety and reliability. ANTI-CARLA's framework, as shown in Figure 1, is a demonstration of this.

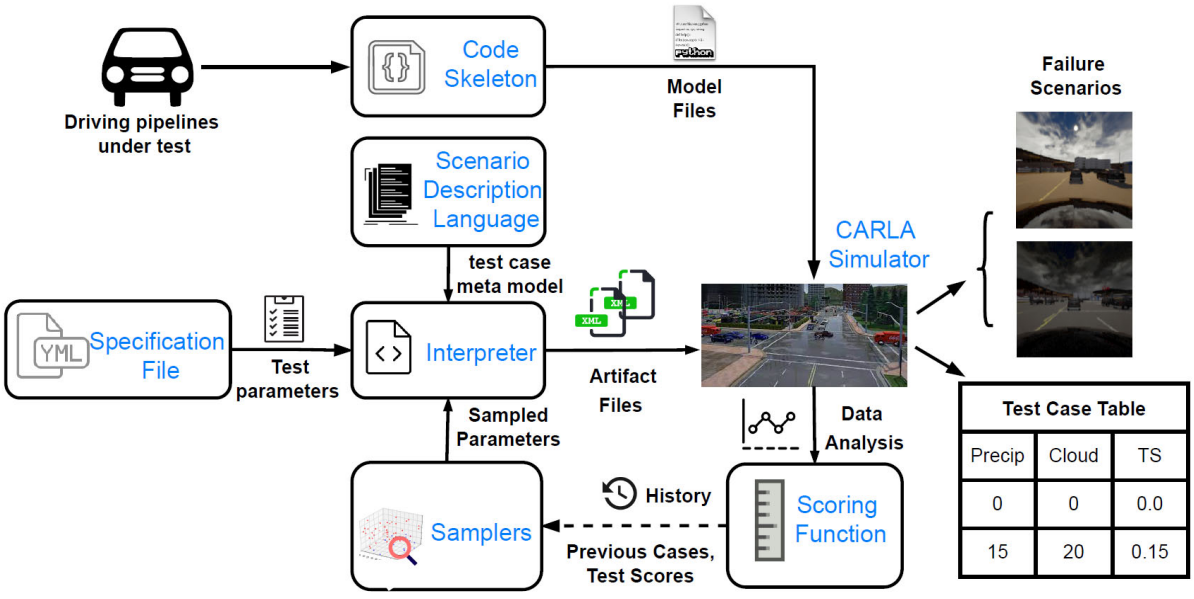

Figure. 1: Overview of the ANTI-CARLA framework for generating test cases that fail an AV system in the CARLA simulator. The driving pipeline and the test specifications are taken as inputs by the framework to generate failure test cases that can be post processed to analyze the problems with the system. (Citied from ANTI-CARLA paper (Ramakrishna et al., 2022))

Secondly, ANTI-CARLA has meaning of universal representative in autonomous driving systems and autonomous vehicle industries. This is due to it being based on CARLA, an open-source autonomous driving simulation platform developed by the Adaptive Systems Research Group at Intel Labs and Carnegie Mellon University. CARLA offers a high-fidelity 3D environment for simulating real-world autonomous driving scenarios, along with APIs and tools for controlling various environmental aspects, such as traffic, weather, and sensors. While relevant technologies are already being used commercially in vehicles such as Tesla, there are still several limitations that need to be addressed. ANTI-CARLA's simulation results can help other researchers effectively and automatically identify a range of failure cases. Additionally, even when the accuracy of Learning by Cheating (LBC) in the CARLA benchmark reaches 100%, it is not always capable of identifying weaknesses in a controller. Therefore, adversarial testing is needed to improve road safety, efficiency, and convenience.

2. Procedure of Replicate ANTI-CARLA Environment

A significant challenge in replicating the experiment is the dynamic nature of the computing environment, specifically the Python programming language and the operating systems. Both are continuously evolving, leading to difficulties in reproducing the necessary operating environment to run the ANTI-CARLA framework. Therefore, the process of recreating the ANTI-CARLA environment is further complicated by the deprecation of certain libraries, the consumption of significant time, and compatibility issues, among others.

2.1 Preliminary Experimental Requirements

The ANTI-CARLA paper (Ramakrishna et al., 2022) provides the program for testing. The required experiment package names and supported URLs are listed in the following Table 1.

Package Name	URL
ANTI-CARLA	https://github.com/scope-lab-vu/ANTI-CARLA
GIT for Windows 2.39.2	https://github.com/git-for-windows/git/releases/download/v2.39.2.windows.1/Git-2.39.2-64-bit.exe
Anaconda 2022.05 Windows	https://repo.anaconda.com/archive/Anaconda3-2022.05-Windows-x86_64.exe
Anaconda 2022.05 Linux	https://repo.anaconda.com/archive/Anaconda3-2022.05-Linux-x86_64.sh

Table 1 The links of relevant software

2.2 Windows 10

Initially, I assumed that Python had the ability to run seamlessly across multiple platforms, and thus, I aimed to run ANTI-CARLA on Windows 10. What unfortunately is there may having some compatibility issues, resulting the experiment on Windows 10 was not successful. Then, I tried to recreate the environment on AWS (Amazon Web Services), which is a cloud computing platform that provides a variety of services including virtual host. However, I failed again due to the issues of system coordination and compatibility. The specific experiments are performed on Windows 10 as follows.

2.2.1 Running Environments

The hardware environment used for the experiments includes a physical machine with an Intel Xeon W2245 @3.9GHz CPU, 64GB of memory, and Windows 10 Education Edition operating system (OS). The software environment includes Python 3.7 running inside Anaconda 3 2022.05, the Carla 0.9.14 simulation platform, and Git Bash as the Bash runtime environment. Relevant Python dependencies, please see appendix 1.

2.2.2 Difficulties encountered and Reasons for Termination

There are several difficulties were encountered which led to the termination to continue attempt on Windows 10. Compatibility issues were identified as the primary obstacle, and specifically, the Watchdog module in the leaderboard_evaluator.py file could not be located in the dependent packages. Despite repeated attempts to download the leaderboard from the official website, the same error persisted, as shown in Figure 2. The leaderboard is an essential component of the ANTI-CARLA package as it provides a testing and evaluation platform for autonomous driving algorithms and serves as a benchmark for comparing different models and algorithms. However, due to the persistent error, the environment could not be completed rebuilt. Various attempts were made to re-create the Python 3.7 environment in Anaconda, but the issue could not be resolved.

```
(py37) E:\ANTI-CARLA-C>bash run_evaluation.sh
-----------------------------------------
Simulation0 Execution
-----------------------------------------
[0, 0, 0, 45, 5]
Traceback (most recent call last):
  File "E:/ANTI-CARLA/leaderboard/leaderboard/leaderboard_evaluator.py", line 36, in <module>
    from srunner.scenariomanager.watchdog import Watchdog
ModuleNotFoundError: No module named 'srunner.scenariomanager.watchdog'
```

Figure 2. Anti-Carla error message on Windows 10

2.3 Ubuntu on AWS

Due to time and hardware constraints, I had to search for a powerful computer with high-performance CPU and GPU to run ANTI-CARLA. Fortunately, I found a university workstation, but had to rebuild the Ubuntu system within a virtual machine as reinstalling the OS was against university policy. Although I was able to create the necessary running environment and execute ANTI-CARLA scripts without errors, the hardware limitations of the virtual machine resulted in some experiments not meeting expectations. However, despite these limitations, the ANTI-CARLA experimental environment was successfully reproduced on the Ubuntu system running in VirtualBox.

2.3.1 Running Environments

The hardware environment used for the experiments includes a virtual machine on AWS equipped with 1 NVIDIA Tesla V100 GPU, 16 vCPUs, 61 GB of memory, and 512 GB of NVMe SSD storage, and Ubuntu Server 22.10 operating system with Remote Desktop Protocol (RDP). The software environment includes

Python 3.7 running inside Anaconda 3 2022.05, the Carla 0.9.14 simulation platform, and relevant Python dependencies demonstrated at appendix 2.

2.3.2 Difficulties encountered

The replicate process of ANTI-CARLA on the Ubuntu on AWS environment encountered difficulties in running the program. Despite installing Anaconda 3 and creating a Python 3.7 environment, along with all the dependencies listed in the requirements.txt file, the terminal still prompted that the Carla package could not be found, despite it being installed as shown by using the pip list command. The error message shown as in Figure 3.

```
(carla-sampling) ubuntu@ip-172-31-28-99:/isis/Carla/ANTI-CARLA$ ./run_evaluation
.sh
-----------------------------------------
Simulation0 Execution
-----------------------------------------
[0, 0, 30, 5]
Traceback (most recent call last):
  File "/isis/Carla/ANTI-CARLA/leaderboard/leaderboard/leaderboard_evaluator.py"
, line 28, in <module>
    import carla
  File "/isis/Carla/CARLA_0.9.10/PythonAPI/carla/dist/carla-0.9.10-py3.7-linux-x
86_64.egg/carla/__init__.py", line 8, in <module>
  File "/isis/Carla/CARLA_0.9.10/PythonAPI/carla/dist/carla-0.9.10-py3.7-linux-x
86_64.egg/carla/libcarla.py", line 9, in <module>
  File "/isis/Carla/CARLA_0.9.10/PythonAPI/carla/dist/carla-0.9.10-py3.7-linux-x
86_64.egg/carla/libcarla.py", line 7, in __bootstrap__
ImportError: /lib/x86_64-linux-gnu/libp11-kit.so.0: undefined symbol: ffi_type_p
ointer, version LIBFFI_BASE_7.0
(carla-sampling) ubuntu@ip-172-31-28-99:/isis/Carla/ANTI-CARLA$
```

Figure 3. Anti-Carla error message on Ubuntu on AWS

2.4 Ubuntu Desktop 22.04.1 LTS in VirtualBox

2.4.1 Operating Environment

A virtual machine environment, which is based on the Windows 10 operating system and hosted by VirtualBox 7.0, equipped with an Intel Xeon W2245 @3.9GHz CPU and has 32GB of memory, and it operates on the Ubuntu Desktop 22.04.1 LTS operating system. The virtual environment includes Anaconda 3 2022.05 and Python 3.7, and it is running the Carla 0.9.14 simulation platform. Relevant Python dependencies, please see Appendix 3.

2.4.2 Adjusting Python Dependencies

To ensure that the relevant ANTI-CARLA scripts could run, I adjusted some dependencies listed in the requirements.txt file. This was necessary as some of the dependencies were no longer supported or needed to be added. The details of these changes can be found in Appendix 4.

2.4.3 Findings

The ANTI-CARLA experiment, being based on the Python 3.7 programming language, poses several challenges with regards to its compatibility with the latest Python version, 3.11. The deprecation of certain libraries and compatibility issues must be addressed systematically and specifically to ensure clear and actionable information. The ANTI-CARLA package specifies the required versions of its dependencies, making it possible to identify specific libraries or packages that may cause issues (please see adjusted Python dependencies in Appendix 4). However, certain dependencies are no longer supported or have gone missing, requiring alternative solutions to be found. For instance, the ANTI-CARLA package does not mention the requirement for a package called "agents", but it was found that the scripts would not run without it.

2.4.4 Result

The ANTI-CARLA experiment research on Ubuntu in VirtualBox showed promising results, with all Python codes running without errors. However, the limited hardware conditions resulted in some experiments not meeting expectations. Despite these limitations, the Ubuntu system running in VirtualBox was able to successfully reproduce the ANTI-CARLA experimental environment as shown in Figure 4.

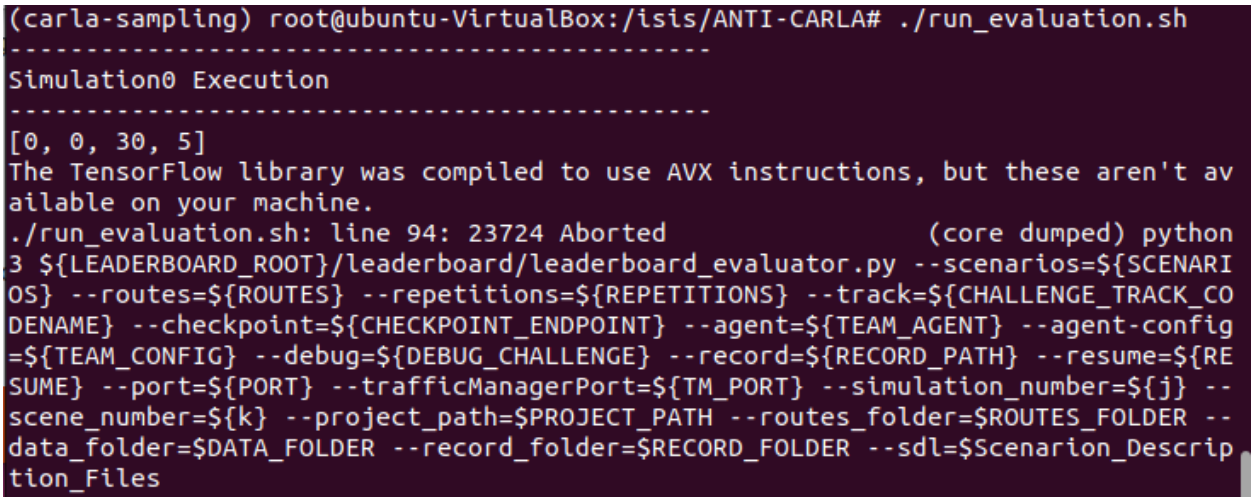

Figure 4. Anti-Carla on Ubuntu

VirtualBox is a free and open-source virtualization software that allows users to run multiple operating systems on one physical machine. In this case, Ubuntu was running as a virtual machine on a Windows host.

Tensorflow is an open-source software library for data flow and differentiable programming across a range of tasks. It is used to build and train machine learning models and is a key component of many artificial intelligence applications. In the ANTI-CARLA experiment, the Agents component uses

Tensorflow, but the virtual machine environment provided by VirtualBox could not support its operation, leading to limited results.

2.4.5 Checking ANTI-CARLA Works

The ANTI-CARLA framework relies on the Carla API to establish communication between ANTI-CARLA and the Carla simulator, enabling the exchange of information and interaction with the simulation. As the running environment on Ubuntu was limited by hardware conditions, I utilized the Carla API to demonstrate that the Carla system can be controlled through API calls, which serves as evidence that ANTI-CARLA can effectively communicate with Carla.

I utilized Python script files located in the 'PythonAPI/examples' folder from the. Specifically, I executed the ‘generate_traffic.py’ file to generate dynamic traffic scenarios, and the ‘dynamic_weather.py’ file to create dynamic weather conditions. These examples were used to demonstrate that the Carla API was functional. Additionally, I utilized the ‘automatic_control.py’ file to generate collision cases in the Carla simulation through automated driving. Figure 5 is a case in Carla’s API controlling where a collision happened. Figure 6 and 7, is an example dynamic weather and relevant weather parameters in Carla.

Figure 5. A collision case in Carla API controlling.

Figure 6. A case in Carla in cloudy and rain weather

```
Microsoft Windows [Version 10.0.19044.2486]
(c) Microsoft Corporation. All rights reserved.

C:\Users\[redacted]\PythonAPI\examples>py -3.7 dynamic_weather.py
Sun(alt: 47.99, azm: 123.05) Storm(clouds=90%, rain=80%, wind=90%)
```

Figure 7. Weather parameters

3. Conclusions

The best work environment I found to replicate the experiment presented in the ANTI-CARLA paper is running in Ubuntu OS. In addition, it was necessary to update relevant Python dependencies and add a key Python module called "agents" to ensure the successful execution of ANTI-CARLA.

Despite the hardware limitations, this research to replicate ANTI-CARLA experiment achieved its expected results to a limited extent. The reason is, 'agents' module depended on TensorFlow, however, the virtual machine in VirtualBox was unable to support the operation for TensorFlow to provide the full reproduction of the ANTI-CARLA scenario.

This research found out the limitations of rebuilt ANTI-CARLA running environment, and provided a reference for future researchers that could avoid some problems.

Appendix

Appendix 1. Dependencies on Windows 10

Package	Version
absl-py	1.4.0
agents	1.4.0
Arpeggio	2.0.0
astor	0.8.1
astunparse	1.6.3
attrs	19.3.0
backcall	0.1.0
bleach	3.1.4
cachetools	4.0.0
carla	0.9.14
certifi	2018.8.24
chardet	3.0.4
click	7.1.1
cloudpickle	2.2.1
colorama	0.4.6
configparser	4.0.2
cycler	0.10.0
decorator	4.4.2
defusedxml	0.6.0
dictor	0.1.11
docker-pycreds	0.4.0
elementpath	1.3.3
entrypoints	0.3
flatbuffers	23.1.21
future	0.18.2
gast	0.4.0
gitdb	4.0.2
GitPython	3.1.0
google-auth	1.11.3
google-auth-oauthlib	0.4.1
google-pasta	0.2.0
gql	0.2.0
graphql-core	1.1
grpcio	1.27.2
gym	0.26.2
gym-notices	0.0.8
h5py	2.10.0
idna	2.9

imageio	2.8.0
imgaug	0.4.0
importlib-metadata	6.0.0
ipykernel	5.2.0
ipython	7.13.0
ipython-genutils	0.2.0
ipywidgets	7.5.1
jedi	0.16.0
Jinja2	2.11.1
joblib	0.14.1
jsonschema	3.2.0
jupyter-client	6.1.2
jupyter-core	4.6.3
keras	2.11.0
Keras-Applications	1.0.8
Keras-Preprocessing	1.1.2
kiwisolver	1.1.0
libclang	15.0.6.1
llvmlite	0.39.1
lxml	4.9.2
Markdown	3.2.1
MarkupSafe	2.1.2
matplotlib	3.0.3
mistune	0.8.4
natsort	8.2.0
nbconvert	5.6.1
nbformat	5.0.4
networkx	2.2
notebook	6.0.3
numba	0.56.4
numpy	1.21.6
nvidia-ml-py3	7.352.0
oauthlib	3.1.0
open3d	0.9.0.0
opencv-python	4.2.0.32
opt-einsum	3.3.0
packaging	23
pandas	1.1.5
pandocfilters	1.4.2
parso	0.6.2
pathtools	0.1.2
pexpect	4.8.0
pickleshare	0.7.5

Pillow	7.0.0
pip	22.3.1
prometheus-client	0.7.1
promise	2.3
prompt-toolkit	3.0.5
protobuf	3.11.3
psutil	5.7.0
ptyprocess	0.6.0
py-trees	0.8.3
pyasn1	0.4.8
pyasn1-modules	0.2.8
pydot	1.4.1
pygame	2.1.2
Pygments	2.6.1
pyparsing	2.4.6
pyrsistent	0.16.0
python-dateutil	2.8.1
pytorch-lightning	0.7.1
pytz	2019.3
PyWavelets	1.1.1
pywin32	305
pywinpty	2.0.10
PyYAML	5.3
pyzmq	19.0.0
requests	2.23.0
requests-oauthlib	1.3.0
rsa	4
ruamel.yaml	0.17.21
ruamel.yaml.clib	0.2.7
scikit-image	0.16.2
scikit-learn	0.22.2.post1
scipy	1.4.1
Send2Trash	1.5.0
sentry-sdk	0.14.2
setuptools	65.6.3
Shapely	1.7.0
shortuuid	1.0.1
six	1.14.0
smmap	3.0.1
subprocess32	3.5.4
tabulate	0.9.0
tensorboard	2.11.2
tensorboard-data-server	0.6.1

tensorboard-plugin-wit	1.8.1
tensorflow	2.11.0
tensorflow-estimator	2.11.0
tensorflow-gpu	1.14.0
tensorflow-intel	2.11.0
tensorflow-io-gcs-filesystem	0.30.0
termcolor	2.2.0
terminado	0.8.3
testpath	0.4.4
textX	3.0.0
torch	1.8.1
torchvision	0.9.1
tornado	6.0.4
tqdm	4.43.0
traitlets	4.3.3
typing_extensions	4.4.0
urllib3	1.25.8
wandb	0.8.29
watchdog	0.10.2
wcwidth	0.1.9
webencodings	0.5.1
Werkzeug	2.2.2
wheel	0.38.4
widgetsnbextension	3.5.1
wincertstore	0.2
wrapt	1.14.1
xmlschema	1.0.18
zipp	3.1.0

Appendix 1. Dependencies on Windows 10

Appendix 2. Dependencies on Ubuntu

Package	Version
absl-py	1.4.0
addict	2.4.0
agents	1.4.0
aiohttp	3.8.3
aiosignal	1.3.1
anyio	3.6.2
appdirs	1.4.4
argon2-cffi	21.3.0
argon2-cffi-bindings	21.2.0
Arpeggio	2.0.0

astunparse	1.6.3
asynctest	0.13.0
async-timeout	4.0.2
attrs	22.2.0
backcall	0.2.0
backoff	2.2.1
beautifulsoup4	4.11.1
bleach	6.0.0
cachetools	5.3.0
carla	0.9.14
certifi	2022.12.7
cffi	1.15.1
chardet	5.1.0
charset-normalizer	2.1.1
click	8.1.3
cloudpickle	2.2.1
ConfigArgParse	1.5.3
configparser	5.3.0
cycler	0.11.0
dash	2.8.0
dash-core-components	2.0.0
dash-html-components	2.0.0
dash-table	5.0.0
debugpy	1.6.6
decorator	5.1.1
defusedxml	0.7.1
dictor	0.1.11
docker-pycreds	0.4.0
elementpath	3.0.2
entrypoints	0.4
fastjsonschema	2.16.2
Flask	2.2.2
flatbuffers	23.1.21
fonttools	4.38.0
frozenlist	1.3.3
fsspec	2023.1.0
future	0.18.3
gast	0.4.0
gitdb	4.0.10
GitPython	3.1.30
google-auth	2.16.0
google-auth-oauthlib	0.4.6
google-pasta	0.2.0

gql	3.4.0
graphql-core	3.2.3
grpcio	1.51.1
gym	0.26.2
gym-notices	0.0.8
h5py	3.8.0
idna	3.4
imageio	2.25.0
imgaug	0.4.0
importlib-metadata	6.0.0
importlib-resources	5.10.2
ipykernel	6.16.2
ipython	7.34.0
ipython-genutils	0.2.0
ipywidgets	8.0.4
itsdangerous	2.1.2
jedi	0.18.2
Jinja2	3.1.2
joblib	1.2.0
jsonschema	4.17.3
jupyter_client	7.4.9
jupyter_core	4.12.0
jupyterlab-pygments	0.2.2
jupyterlab-widgets	3.0.5
jupyter-server	1.23.5
keras	2.11.0
kiwisolver	1.4.4
libclang	15.0.6.1
lightning-utilities	0.6.0.post0
llvmlite	0.39.1
lxml	4.9.2
Markdown	3.4.1
MarkupSafe	2.1.2
matplotlib	3.5.3
matplotlib-inline	0.1.6
mistune	2.0.4
multidict	6.0.4
natsort	8.2.0
nbclassic	0.5.1
nbclient	0.7.2
nbconvert	7.2.9
nbformat	5.5.0
nest-asyncio	1.5.6

networkx	2.6.3
notebook	6.5.2
notebook_shim	0.2.2
numba	0.56.4
numpy	1.21.6
nvidia-cublas-cu11	11.10.3.66
nvidia-cuda-nvrtc-cu11	11.7.99
nvidia-cuda-runtime-cu11	11.7.99
nvidia-cudnn-cu11	8.5.0.96
nvidia-ml-py3	7.352.0
oauthlib	3.2.2
open3d	0.16.0
opencv-python	4.7.0.68
opt-einsum	3.3.0
packaging	23
pandas	1.3.5
pandocfilters	1.5.0
parso	0.8.3
pathtools	0.1.2
pexpect	4.8.0
pickleshare	0.7.5
Pillow	9.4.0
pip	22.3.1
pkgutil_resolve_name	1.3.10
plotly	5.13.0
prometheus-client	0.16.0
promise	2.3
prompt-toolkit	3.0.36
protobuf	3.19.6
psutil	5.9.4
ptyprocess	0.7.0
pyasn1	0.4.8
pyasn1-modules	0.2.8
pycparser	2.21
pydot	1.4.2
pygame	2.1.2
Pygments	2.14.0
pyparsing	3.0.9
pyquaternion	0.9.9
pyrsistent	0.19.3
python-dateutil	2.8.2
pytorch-lightning	1.9.0
py-trees	2.1.6

pytz	2022.7.1
PyWavelets	1.3.0
PyYAML	6
pyzmq	25.0.0
requests	2.28.2
requests-oauthlib	1.3.1
rsa	4.9
ruamel.yaml	0.17.21
ruamel.yaml.clib	0.2.7
scikit-image	0.19.3
scikit-learn	1.0.2
scipy	1.7.3
Send2Trash	1.8.0
sentry-sdk	1.14.0
setproctitle	1.3.2
setuptools	65.6.3
shapely	2.0.0
shortuuid	1.0.11
six	1.16.0
sklearn	0.0.post2
smmap	5.0.0
sniffio	1.3.0
soupsieve	2.3.2.post1
subprocess32	3.5.4
tabulate	0.9.0
tenacity	8.1.0
tensorboard	2.11.2
tensorboard-data-server	0.6.1
tensorboard-plugin-wit	1.8.1
tensorflow	2.11.0
tensorflow-estimator	2.11.0
tensorflow-io-gcs-filesystem	0.30.0
termcolor	2.2.0
terminado	0.17.1
testpath	0.6.0
textX	3.0.0
threadpoolctl	3.1.0
tifffile	2021.11.2
tinycss2	1.2.1
torch	1.13.1
torchmetrics	0.11.0
torchvision	0.14.1
tornado	6.2

tqdm	4.64.1
traitlets	5.8.1
typing_extensions	4.4.0
urllib3	1.26.14
wandb	0.13.9
watchdog	2.2.1
wcwidth	0.2.6
webencodings	0.5.1
websocket-client	1.5.0
Werkzeug	2.2.2
wheel	0.37.1
widgetsnbextension	4.0.5
wrapt	1.14.1
xmlschema	2.1.1
yarl	1.8.2
zipp	3.11.0

Appendix 2. Dependencies on Ubuntu

Appendix 3. Adjusted Dependencies on Ubuntu

Dependency	Required version	Updated version to avoid errors
dictor		
pygame		
tabulate		
textx		
sklearn		>=0.23.2
lxml		>=4.6.2
numba		>=0.48.0
natsort		>=7.0.1
pandas		>=1.2.3
ruamel_yaml	==0.16.12	>=0.16.12
absl-py	==0.9.0	>=0.9.0
attrs	==19.3.0	>=19.3.0
backcall	==0.1.0	>=0.1.0
bleach	==3.1.4	>=3.1.4
cachetools	==4.0.0	>=4.0.0
certifi	==2018.8.24	>=2018.8.24
chardet	==3.0.4	>=3.0.4
click	==7.1.1	>=7.1.1
configparser	==4.0.2	>=4.0.2
cycler	==0.10.0	>=0.10.0
decorator	==4.4.2	>=4.4.2
defusedxml	==0.6.0	>=0.6.0

docker-pycreds	==0.4.0	>=0.4.0
elementpath	==1.3.3	>=1.3.3
entrypoints	==0.3	>=0.3
future	==0.18.2	>=0.18.2
gitdb	==4.0.2	>=4.0.2
GitPython	==3.1.0	>=3.1.0
google-auth	==1.11.3	>=1.11.3
google-auth-oauthlib	==0.4.1	>=0.4.1
gql	==0.2.0	>=0.2.0
graphql-core	==1.1	>=1.1
grpcio	==1.27.2	>=1.27.2
idna	==2.9	>=2.9
imageio	==2.8.0	>=2.8.0
imgaug	==0.4.0	>=0.4.0
importlib-metadata	==1.6.0	>=1.6.0
ipykernel	==5.2.0	>=5.2.0
ipython	==7.13.0	>=7.13.0
ipython-genutils	==0.2.0	>=0.2.0
ipywidgets	==7.5.1	>=7.5.1
jedi	==0.16.0	>=0.16.0
Jinja2	==2.11.1	>=2.11.1
joblib	==0.14.1	>=0.14.1
jsonschema	==3.2.0	>=3.2.0
jupyter-client	==6.1.2	>=6.1.2
jupyter-core	==4.6.3	>=4.6.3
kiwisolver	==1.1.0	>=1.1.0
Markdown	==3.2.1	>=3.2.1
MarkupSafe	==1.1.1	>=1.1.1
matplotlib	==3.0.3	>=3.0.3
mistune	==0.8.4	>=0.8.4
nbconvert	==5.6.1	>=5.6.1
nbformat	==5.0.4	>=5.0.4
networkx	==2.2	>=2.2
notebook	==6.0.3	>=6.0.3
numpy	==1.18.1	>=1.18.1
nvidia-ml-py3	==7.352.0	>=7.352.0
oauthlib	==3.1.0	>=3.1.0
open3d	==0.9.0.0	>=0.9.0.0
opencv-python	==4.2.0.32	>=4.2.0.32
pandocfilters	==1.4.2	>=1.4.2
parso	==0.6.2	>=0.6.2
pathtools	==0.1.2	>=0.1.2
pexpect	==4.8.0	>=4.8.0

pickleshare	==0.7.5	>=0.7.5
Pillow	==7.0.0	>=7.0.0
prometheus-client	==0.7.1	>=0.7.1
promise	==2.3	>=2.3
prompt-toolkit	==3.0.5	>=3.0.5
protobuf	==3.11.3	>=3.11.3
psutil	==5.7.0	>=5.7.0
ptyprocess	==0.6.0	>=0.6.0
py-trees	==0.8.3	>=0.8.3
pyasn1	==0.4.8	>=0.4.8
pyasn1-modules	==0.2.8	>=0.2.8
pydot	==1.4.1	>=1.4.1
Pygments	==2.6.1	>=2.6.1
pyparsing	==2.4.6	>=2.4.6
pyrsistent	==0.16.0	>=0.16.0
python-dateutil	==2.8.1	>=2.8.1
pytorch-lightning	==0.7.1	>=0.7.1
pytz	==2019.3	>=2019.3
PyWavelets	==1.1.1	>=1.1.1
PyYAML	==5.3	>=5.3
pyzmq	==19.0.0	>=19.0.0
requests	==2.23.0	>=2.23.0
requests-oauthlib	==1.3.0	>=1.3.0
rsa	==4	>=4
scikit-image	==0.16.2	>=0.16.2
scikit-learn	==0.22.2.post1	>=0.22.2.post1
scipy	==1.4.1	>=1.4.1
Send2Trash	==1.5.0	>=1.5.0
sentry-sdk	==0.14.2	>=0.14.2
Shapely	==1.7.0	>=1.7.0
shortuuid	==1.0.1	>=1.0.1
six	==1.14.0	>=1.14.0
smmap	==3.0.1	>=3.0.1
subprocess32	==3.5.4	>=3.5.4
tensorboard	==1.14.0	>=1.14.0
terminado	==0.8.3	>=0.8.3
testpath	==0.4.4	>=0.4.4
torch	==1.5.1	>=1.5.1
torchvision	==0.6.1	>=0.6.1
tornado	==6.0.4	>=6.0.4
tqdm	==4.43.0	>=4.43.0
traitlets	==4.3.3	>=4.3.3
urllib3	==1.25.8	>=1.25.8

wandb	==0.8.29	>=0.8.29
watchdog	==0.10.2	>=0.10.2
wcwidth	==0.1.9	>=0.1.9
webencodings	==0.5.1	>=0.5.1
Werkzeug	==1.0.0	>=1.0.0
widgetsnbextension	==3.5.1	>=3.5.1
xmlschema	==1.0.18	>=1.0.18
zipp	==3.1.0	>=3.1.0
h5py	==2.10.0	>=2.10.0
agents*		==1.4.0

*Not required in original codes, but it is essential for running.

Appendix 3. Adjusted Dependencies on Ubuntu

References

Ramakrishna, S., Luo, B., Kuhn, C. B., Karsai, G., & Dubey, A. (2022). ANTI-CARLA: An Adversarial Testing Framework for Autonomous Vehicles in CARLA. In (pp. 2620-2627): IEEE.