I. Abstract

In this work, we propose a transformation-based approach SCTrans to construct simulation scenario files for ADS testing, utilizing existing traffic scenario datasets (i.e., naturalistic movement of road users recorded on public roads) as data sources. Specifically, we try to transform existing traffic scenario recording files into simulation scenario files that are compatible with the most advanced ADS simulation platforms, and this task is formalized as a Model Transformation Problem. Following this idea, we construct a dataset consisting of over 1,900 diverse simulation scenarios, each of which can be directly used to test the state-of-the-art ADSs (i.e., Apollo and Autoware) via high-fidelity simulators (i.e., Carla and LGSVL). The paper titled "SCTrans: Constructing a Large Public Scenario Dataset for Simulation Testing of Autonomous Driving Systems" has been accepted by ICSE'24.

II. Artifact Overview

The artifact contains our curated dataset of simulation scenario files, as well as the prototype of SCTrans. Furthermore, as clarified in §III and §IV, we request our artifact to be evaluated towards two badges, namely the **Available Badge** and the **Reusable Badge**.

Curated Dataset. The current version of our dataset contains 1,994 simulation scenarios, which describe diverse driving situations to test the target ADS. The data sources for constructing this dataset are 1,994 traffic scenario recording files, with 994 selected from CommonRoad[3] 500 selected from inD[4], and 500 selected from highD[6]. For each curated simulation scenario, we provide the scenario configuration files that are compatible with the most advanced ADS simulation platforms (i.e., LGSVL[7]+Apollo[2] and Carla[5]+Autoware[1]) in the open-source community.

Prototype of SCTrans. The implementation of SCTrans is based on the Eclipse Modeling Framework (EMF) (i.e., a well-established model transformation framework). Given a traffic scenario recording file as input, SCTrans can accordingly generate simulation files that are compatible with advanced ADS simulation platforms (i.e., LGSVL+Apollo and Carla+Autoware). For ease of using our simulation scenario files, we enhance the runner scripts (i.e., scripts that parse the simulation scenario files and run the simulation testing) provided by the open-source simulation platforms, fixing several bugs to ensure usability.

III. Request Available Badge

Our simulation scenario dataset and the prototype of SCTrans have been released to the public through permanently accessible repositories (detailed as follows):

❶ The **simulation scenario files** collected in our dataset are available at https://zenodo.org/records/8367158

❷ The **prototype of SCTrans** is available at

- https://archive.softwareheritage.org/browse/origin/?origin_url=https://github.com/seclab-fudan/SCTrans
- https://github.com/seclab-fudan/SCTrans

❸ The **camera-ready version of the paper** is available at https://www.computer.org/csdl/proceedings-article/icse/2024/021700a580/1RLIWAq7Gow

IV. Request Reusable Badge

Here, we design necessary experiments to demonstrate the reusability of our work (i.e., the reusability of our prototype and the reusability of our simulation scenario files).

A. Reusability of Prototype

Environment Setup. We offer a docker-based execution environment for ease of evaluating our prototype.

❶ Download `SCTrans-docker.zip` from https://drive.google.com/drive/folders/1-Q4ZtkRdaNbMP9YB9-D1mkWOT0DdILlf?usp=sharing and unzip it.

❷ Enter `SCTrans-docker/` and build the docker.

```
$ docker build -t sctrans:latest .
$ docker run -it sctrans:latest
```

❸ Before running the experiment, you can run a simple scenario transformation task to verify whether the docker-based execution environment has been correctly set up. After executing the following command, you will get the corresponding description file(`*.json`) and HD map(`*.osm`) at direction `test/`.

```
$ run_sctrans Lgsvl ARG_Carcarana-1_1_I-1-1.cr.
xml $HOME/test/
```

Experiment. In our paper accepted by ICSE'24, we randomly selected 2,000 traffic scenario recording files as data sources to evaluate our prototype. However, re-executing all these 2,000 transformation tasks requires significant computing resources and CPU hours. Therefore, we suggest evaluating the reusability of our prototype only on a limited number of data inputs (i.e., to transform 10 traffic scenario recording files into simulation scenario files). To be specific, you can execute the provided scripts located in the `~/SCTrans/tool/` directory.

```
$ ./run_SCTrans_Lgsvl.sh
$ ./run_SCTrans_openscenario.sh
```

The above commands would run SCTrans on all 10 traffic scenario recording files and generate scenario files respectively for advanced ADS simulation platforms (e.g., LGSVL+Apollo and Carla+Autoware).

Result Verification. The output files including scenario description files(`*.json`, `*.xosc`), HD maps(`*.osm`) and log files(`*.log`) are located in `SCTrans-output/`. You can obtain the overall transformation results by running the following script:

```
$ python3 check_log.py
```

B. Reusability of Curated Simulation Scenario Files

Environment Setup. To verify the reusability of our scenario files, we suggest dynamically executing these scenario files with advanced ADS simulation platforms (e.g., LGSVL+Apollo). However, since the setup process of ADS simulation platforms (e.g., LGSVL+Apollo) is quite time-consuming and expert-dependent, we offer a VM image (i.e., VMware ESXi image) which contains ready-to-use ADS simulation platforms, the prototype of SCTrans and our curated simulation scenario files. The hardware/software requirements to run this image include: ❶ VMware ESXi; ❷ 32+ GB memory; ❸ NVIDIA GPU, 4GB+ RAM, support NVIDIA 470 driver; ❹ 16+ CPU cores. You can download the VM image at https://drive.google.com/drive/folders/1-Q4ZtkRdaNbMP9YB9-D1mkWOT0DdILlf?usp=sharing.

After downloading the VM image, you can accordingly create a workstation virtual machine (detailed as follows).

1) In VMware Workstation, File → New → Virtual Machine.
2) Select Custom and click Next.
3) Select Hardware Compatibility ≥`Workstation 14.x`.
4) In the Guest Operating System Installation selection screen, select I will install the Operating System later and click Next.
5) Select the guest operating system `Linux`, including the version `Ubuntu 64-bit`. Click Next.
6) Provide a file name (e.g. SCTrans) and choose the location where you want to save the virtual machine. Click Next.
7) Adjust the number of processors and number of cores per processor (recommended Total processor cores ≥ 16) and then click Next.
8) Adjust the amount of memory (recommended ≥ 32GB).
9) Select the desired networking type `NAT` and click Next.
10) Select Use an Existing Virtual Disk and click Next.
11) Click Browse and navigate to the location of the unzipped SCTrans-VM.vmdk file.
12) Select the .vmdk file and click Next.
13) Review the settings displayed in the Summary window.
14) Click Finish then your virtual machine is now created and Click Start to start up the virtual machine.

Note for Environment Setup: For reviewers that cannot satisfy the hardware/software requirements for running VM image, we also provide videos of executing the 10 simulation scenario files at our server and you can quickly verify the reusability of our simulation scenario files by watching these videos. These videos are available at https://drive.google.com/drive/folders/1-Q4ZtkRdaNbMP9YB9-D1mkWOT0DdILlf?usp=sharing.

Experiment (with VM image). After properly loading and running the VM image, The commands for running a simulation test are as follows:

❶ Run the LGSVL simulator and wait for about 10 seconds then you will see ”API ready!” in the simulator:

```
$ resim
```

❷ Open a new shell and enter the Apollo directory:

```
$ cd ˜/apollo && su sctrans
```

❸ Enter the built Apollo docker. If docker is not running, then run the second command first.

```
$ bash docker/scripts/dev_into.sh
$ bash docker/scripts/dev_start.sh
```

❹ Then enter the docker and restart the Apollo dreamview. You can open the dreamview web: http://localhost:8888/ if succeed.

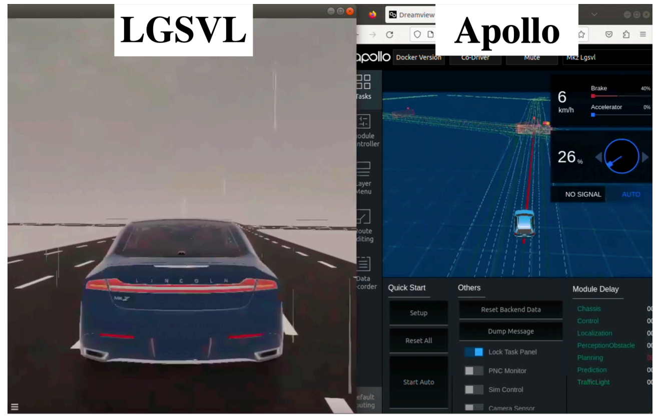

Fig. 1. A running example of LGSVL+Apollo Simulation Platform.

```
$ ./scripts/bootstrap_lgsvl.sh restart
```

❺ Still in the docker, run the Apollo bridge to connect to the simulator:

```
$ ./scripts/bridge.sh &
```

❻ After that, open another new shell and run a simulation test with a specific simulation scenario file. Sometimes it might take about one minute for Apollo to start.

```
$ ftest SCENARIO_FILE_NAME.json
```

Result Verification. The ADS simulation platform can work properly (e.g., build the 3D virtual environment, connect to the target ADS and control the ADS-equipped vehicle in the virtual environment) only when the given simulation scenario files are both syntactically and semantically correct. Hence, we suggest manually obversing the execution status (e.g., 3D virtual driving environments and the driving behaviors of ADS) of these simulation scenario files to verify the reusability of our dataset. As shown in Figure 1, the virtual environments can be observed on the driving simulator (e.g., LGSVL), and the ADS runtime behaviors can be observed on its control panel (e.g., Apollo dreamview).

REFERENCES

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