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realtwin: A Unified Simulation Scenario Generation Tool for Mobility Research

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Summary

Real-Twin[1] is a unified, **simulation platform-agnostic scenario generation tool designed to streamline and standardize the evaluation of emerging mobility technologies**. It provides an end-to-end framework that includes robust workflows, integrated tools, and comprehensive metrics to generate, calibrate, and benchmark microscopic traffic simulation scenarios across multiple platforms.

Key Features

- **Unified Scenario Generation** : Generate transferable, simulation-ready scenarios from heterogeneous data sources using a consistent workflow.
- **Automated Calibration Workflow** : Bridges simulation and real-world data, minimizing manual effort and making traffic simulation more accessible to researchers and engineers.
- **Simulation Platform Compatibility** : Supports **SUMO** , **VISSIM** , and **AIMSUN** for cross-platform scenario generation and benchmarking. Enables reliable comparisons and reproducibility across different simulation tools.
- **Consistent Scenarios across Different Simulators** : Generate comparable simulation scenarios across different microscopic traffic simulators, providing users the ability to conduct benchmarking and cross-validation that are crucial for ensuring the reliability and reproducibility of simulation results.
- **Emerging Technology Support** : Includes a scenario database and pipeline for studying **autonomous vehicles (AVs)** , with planned extensions to **CAVs** , **EVs** , and other advanced technologies.

Statement of need

Microscopic traffic simulation, which modeling individual vehicle trajectories within a network, is a vital tool for urban planners, traffic engineers, and researchers. However, integrating heterogeneous data sources and generating calibrated scenarios for simulators remains a major challenge. The realtwin package addresses this gap by providing a streamlined workflow for scenario generation and calibration, seamlessly bridging diverse traffic datasets and simulator inputs to make detailed simulation accessible to users of all expertise levels. Using realtwin to generate a real-world traffic scenario in SUMO (Lopez et al., 2018), VISSIM (VISSIM, 2022), and AIMSUN (Aimsun, 2022. [Online]), realtwin's ability is demonstrated in the construction of realistic and consistent traffic scenarios in different simulators (Chu et al., 2003; Ehlert & Rothkrantz, 2001; Hidas, 2002).

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Microscopic traffic simulation depends on precisely defined scenario elements (network topology, traffic demand, and control infrastructure) to yield realistic, reproducible results (Passos et al., 2011). In practice, these elements derive from diverse sources (e.g., GIS files, demand databases, signal timing plans) and must be converted into simulator-specific formats (e.g., SUMO, VISSIM, AIMSUN). This conversion typically entails extensive manual post-processing, such as translating OD matrices into routes, mapping lane configurations into network files, or tuning car-following parameters for a target market share of Level 2 autonomous vehicles (Chen et al., 2024; Guastella et al., 2023; Renninger et al., 2024; SAE, 2021). Even small intersections can require tens of minutes to prepare, while city-scale studies may demand days or weeks of data integration. Moreover, minor inconsistencies in geometry or behavior parameters across simulators hinder cross-validation and systematic comparison of emerging technologies (e.g., CAVs, EVs) on mobility, energy consumption, and safety.

The **realtwin** package addresses these challenges by automating the end-to-end scenario generation and calibration workflow for multiple microscopic simulators. Users supply high-level inputs (demand matrices, control logic) and **realtwin** automatically assembles simulation-ready files for SUMO, VISSIM, and AIMSUN. Behind the scenes, the **realtwin** package maintains a unified internal representation of each scenario element (network, demand, infrastructure, vehicle types), applies consistent car-following and lane-changing conversions (including adjustments for partial automation levels), and outputs properly structured simulator files. By encapsulating common data transformations (for example, converting shapefile attributes to SUMO's XML schema or translating signal phase plans into VISSIM's controller format), realtwin dramatically reduces the manual effort required to build and calibrate microscopic scenarios.

Moreover, the **realtwin** package provides a built-in database and pipeline for generating scenarios that incorporate emerging technologies. Current functionality supports stochastic insertion of Level 2 and higher autonomy vehicles in SUMO; planned extensions will enable similar workflows for VISSIM and AIMSUN, as well as EV charging behavior models. This extensible architecture allows researchers to define consistent vehicle-composition parameters (e.g., 50 % Level 2 automation) and seamlessly incorporate them into each supported simulator. As a result, realtwin not only accelerates scenario preparation, reducing setup time from days to a few minutes, but also ensures cross-simulator consistency, enabling rigorous benchmarking and reproducible studies of how innovations like connected/autonomous vehicles affect traffic flow, energy use, and safety outcomes (Shao et al., 2023; Wang et al., 2025; Xu et al., 2025).

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Design Framework

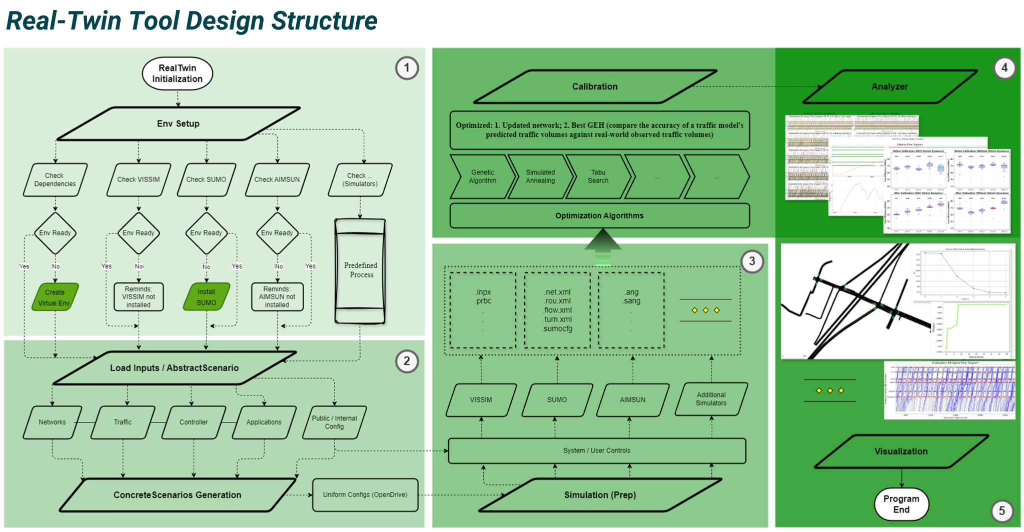

Figure 1: realtwin Design Framework

Hands-On Tutorial

For detailed documentation: [Official Documentation]

```python
import realtwin as rt

# Please refer to the official documentation for more details
# on RealTwin preparation before running the simulation

if __name__ == '__main__':

    # Step 1: Prepare your configuration file (in YAML format)
    CONFIG_FILE = "./realtwin_config.yaml"

    # Step 2: initialize the realtwin object
    twin = rt.RealTwin(input_config_file=CONFIG_FILE, verbose=True)

    # Step 3: check simulator env: if SUMO, VISSIM, Aimsun, etc... are installed
    twin.env_setup(sel_sim=["SUMO", "VISSIM"])

    # Step 4: Create Matchup Table from SUMO network
    updated_sumo_net = r"./datasets/example2/chatt.net.xml"
    twin.generate_inputs(incl_sumo_net=updated_sumo_net)

    # BEFORE step 5, there are three steps to be performed:
    # 1. Prepare Traffic Demand Data and
    #    save it to Traffic Folder in input directory
    # 2. Prepare Control Data (Signal) and
    #    save to Control Folder in input directory
    # 3. Manually fill in the Matchup Table in the input directory
```

```python
# Step 5: generate abstract scenario
twin.generate_abstract_scenario()

# AFTER step 5,
# Double-check the Matchup Table in input directory to ensure it is correct.

# Step 6: generate scenarios
twin.generate_concrete_scenario()

# Step 7: simulate the scenario
twin.prepare_simulation()

# Step 8: perform calibration, Available algorithms:
#    GA: Genetic Algorithm, SA: Simulated Annealing, TS: Tabu Search
twin.calibrate(sel_algo={"turn_inflow": "GA", "behavior": "GA"})
```


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