Language-Driven Interactive Traffic Trajectory Generation

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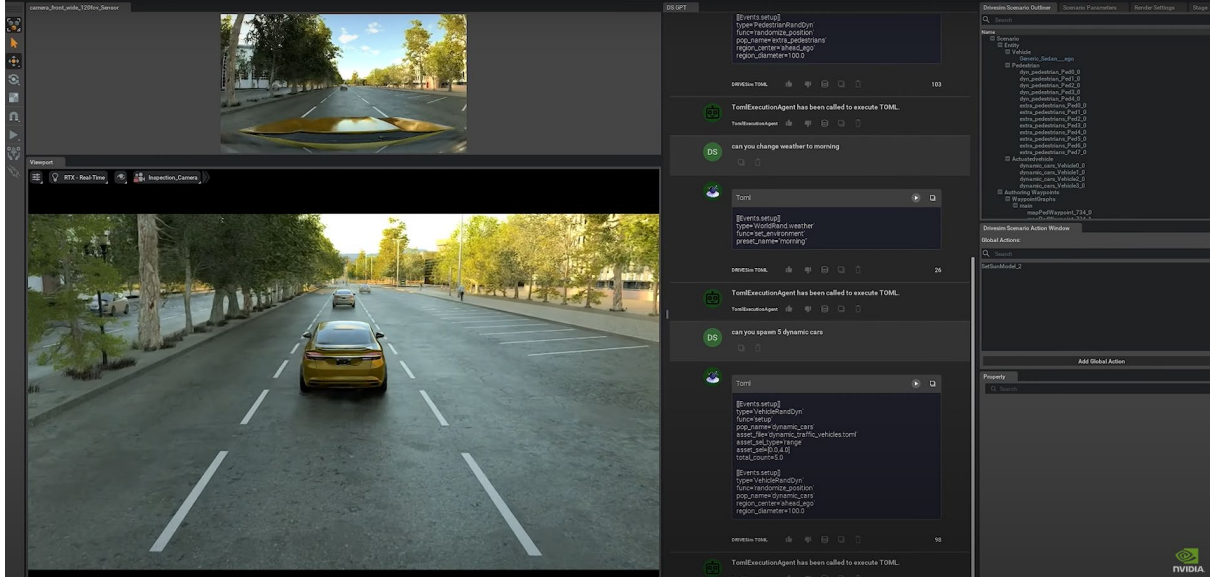
Traffic simulation

- Driving security
- Cost efficiency
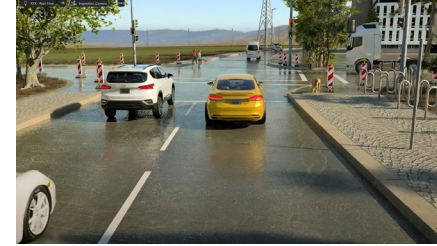- Flexibility and controllability

CARLA Simulator

Traffic simulation

- More accurate scenario generation using generative AI

Scenario edition with language prompt
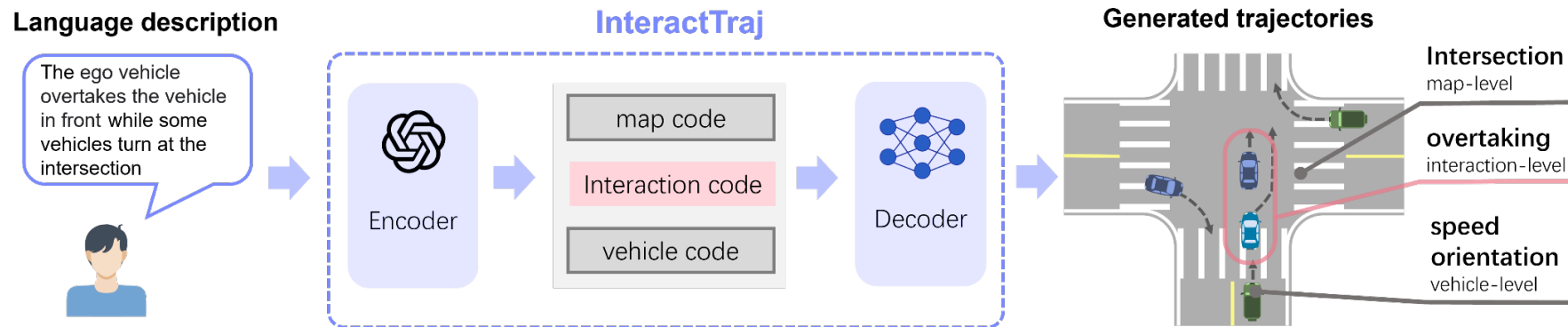

Daytime

Nighttime
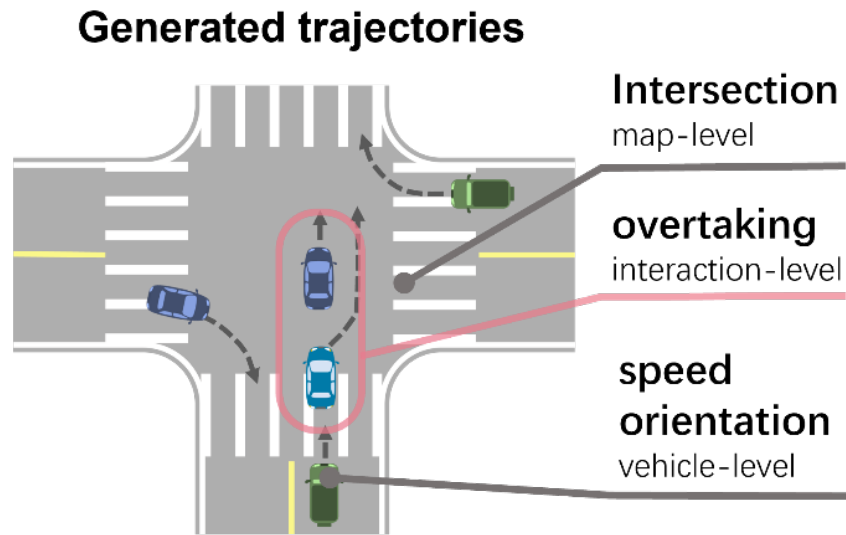

Sunny

Rainy

Omniverse(NVIDIA)

Motivation

- Linking linguistic input and traffic scenarios with numeric codes
- Generating controllable scenarios by focusing on interactions between vehicles

Our approach

- Integration of LLMs and multi-agent interaction modeling.
- Interaction-aware feature aggregation

Generated trajectories

Intersection map-level

overtaking interaction-level

speed orientation vehicle-level

- **Interaction codes I:** $I = \left[(p_j^t, d_j^t) \right]_{\{j \in \{1,...,N\}, t \in T\}}$, where p_j^t / d_j^t represents the relative direction/distance.
- **Vehicle codes V:** $V = [r_i; a_i]_{\{i \in \{1,...,N\}\}}$, where r_i is the trajectory type and a_i represents the vehicle states of agent i.
- **Map codes m:** m contains the information on key map features.

Our approach

- Integration of LLMs and multi-agent interaction modeling.
- Interaction-aware feature aggregation
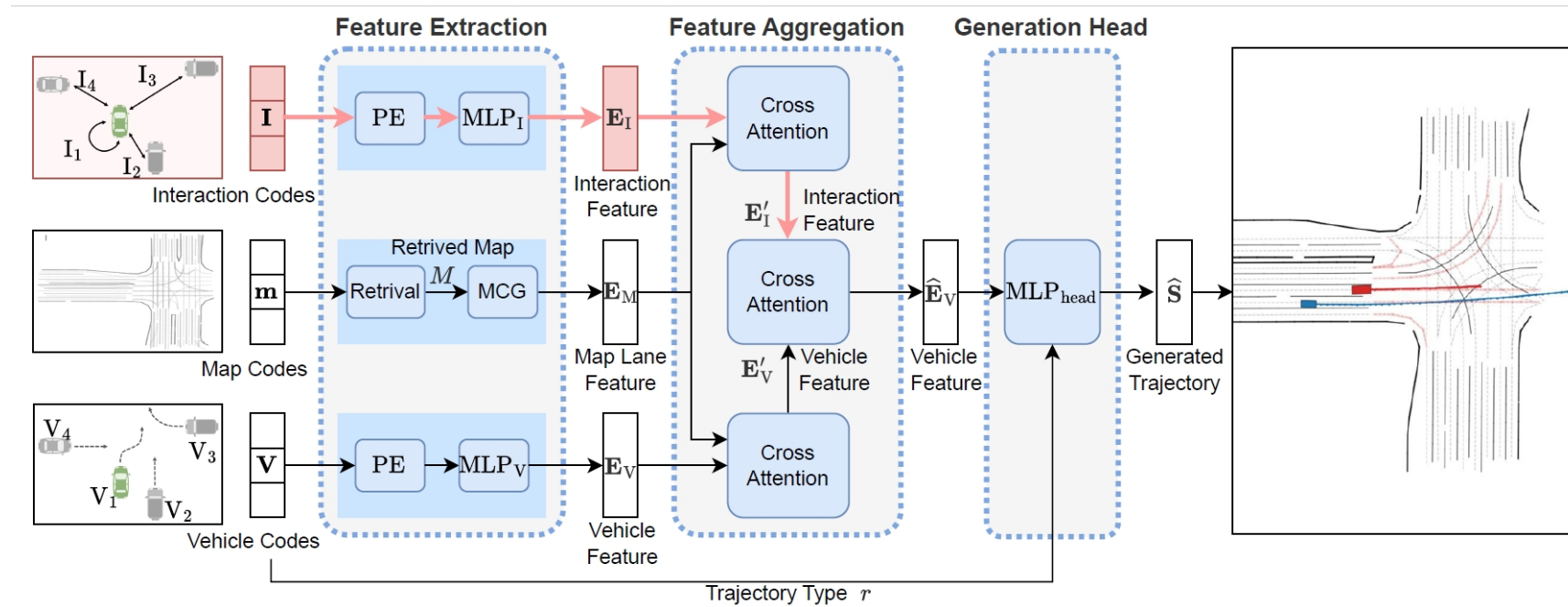
Experiments

- Realism evaluated through a reconstruction approach

Dataset	Method	mADE↓	minADE↓	mFDE↓	minFDE↓	SCR↓	HD↓
WOMD	TrafficGen	9.531	1.440	20.106	3.690	0.086	5.733
	LCTGen	1.262	0.224	2.696	0.463	0.072	1.295
	InteractTraj(w/o I)	1.205	0.207	2.479	0.346	0.090	1.210
	InteractTraj	**1.067**	**0.181**	**2.190**	**0.320**	**0.070**	**1.076**
nuPlan	TrafficGen	9.418	1.416	19.686	3.627	0.082	5.874
	LCTGen	1.161	0.218	2.497	0.448	0.074	1.301
	InteractTraj(w/o I)	1.108	0.181	2.277	0.323	0.070	1.150
	InteractTraj	**0.962**	**0.160**	**1.987**	**0.321**	**0.067**	**1.129**

- InteractTraj reduces mADE/mFDE by 15.4%/18.7% compared to SoTA methods

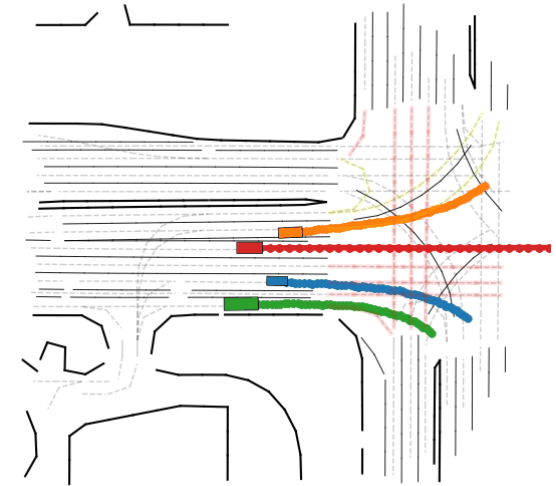# Generalization capability
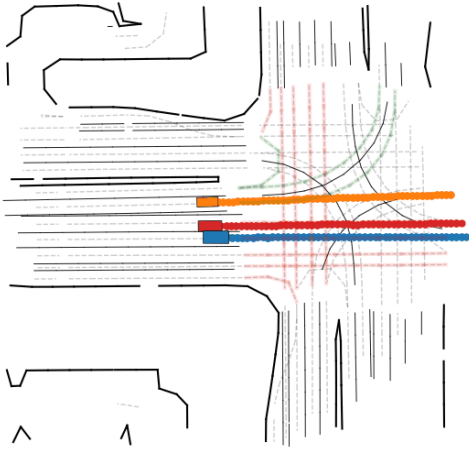
Three cars drive parallel to each other.
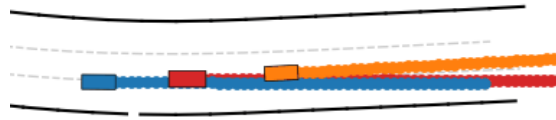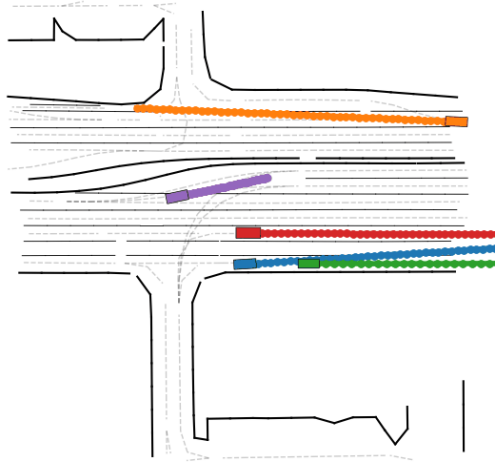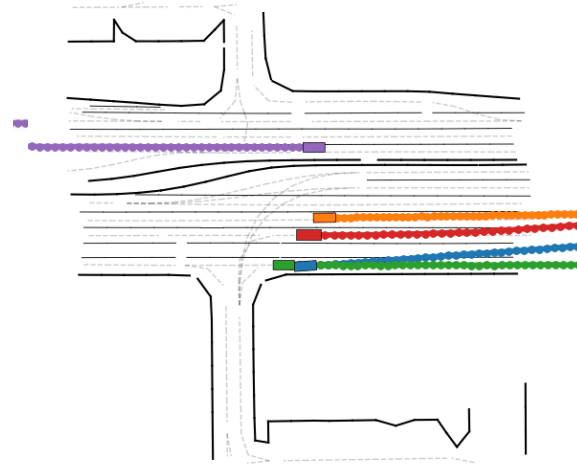
Several cars move in platoon formation.

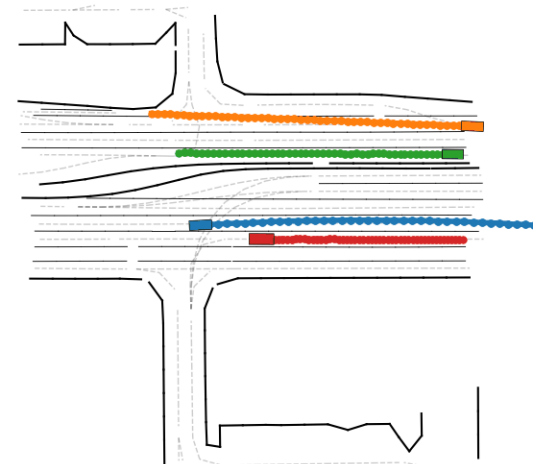Surrounding vehicles pull over as the ambulance approaches.

Controllability of generated scenarios

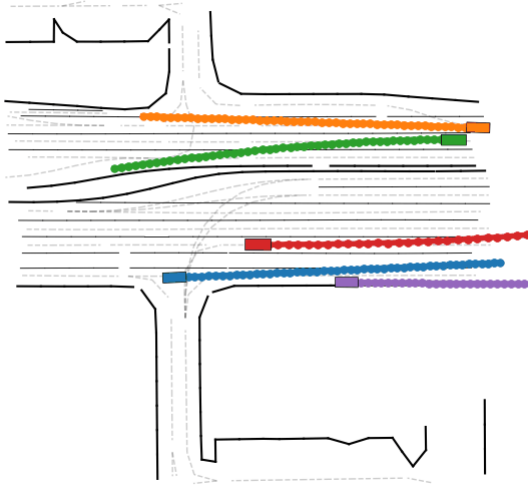Generate a more complex scenario on a two-way highway, while ego car driving straight forward.

Generate a more complex scenario on a two-way highway, while ego car making a left lane change.

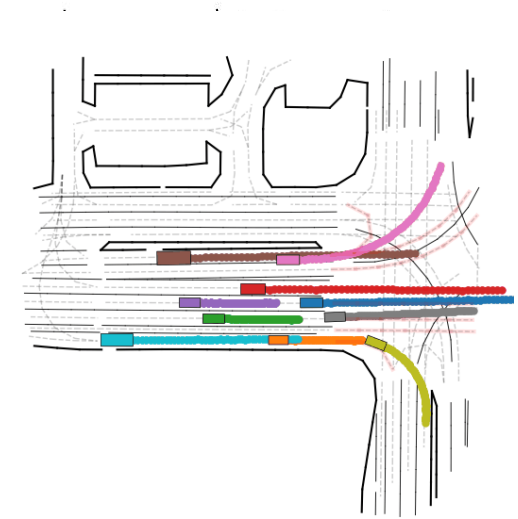Generate a more complex scenario on a two-way highway, while ego car being overtaken.

Versatility in generating complex scenarios

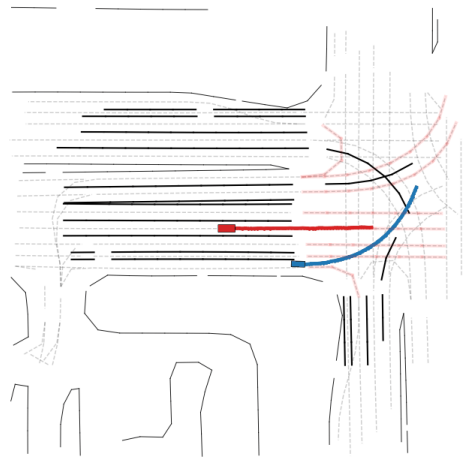Generate a more complex scenario on a two-way highway.

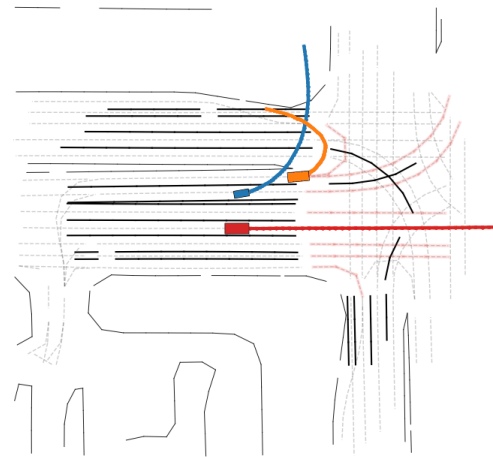Generate a more complex scenario at an intersection.

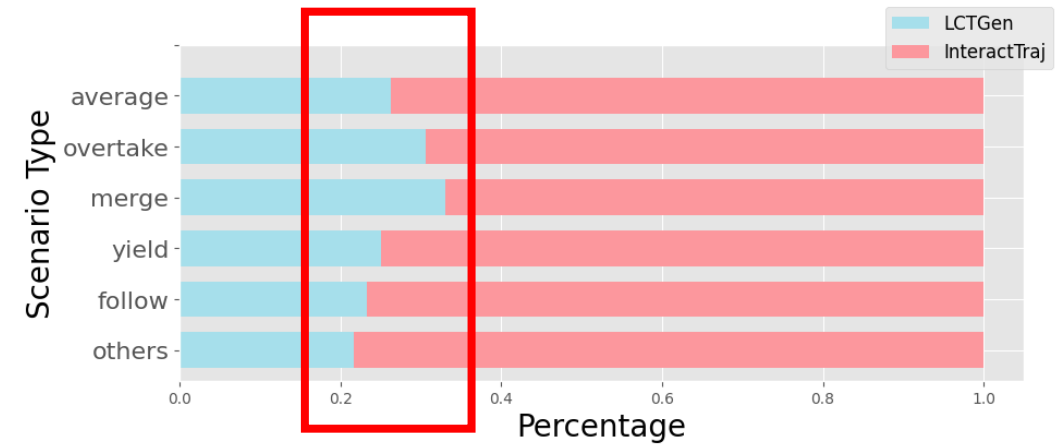Generate a more complex scenario with ten vehicles.

User study

- A vehicle is avoiding an approaching left-turning vehicle
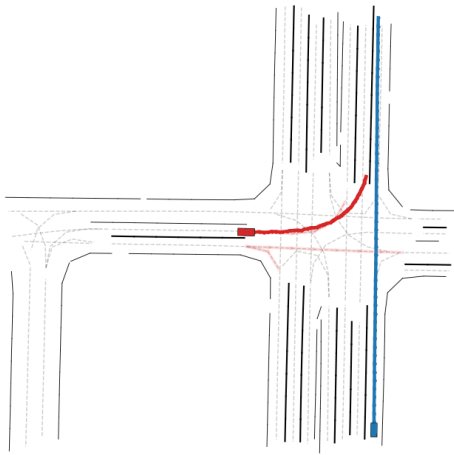

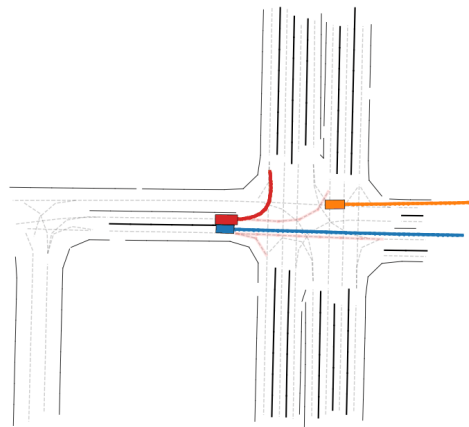InteractTraj(ours)

Baseline model

Users' preferences of generated trajectories
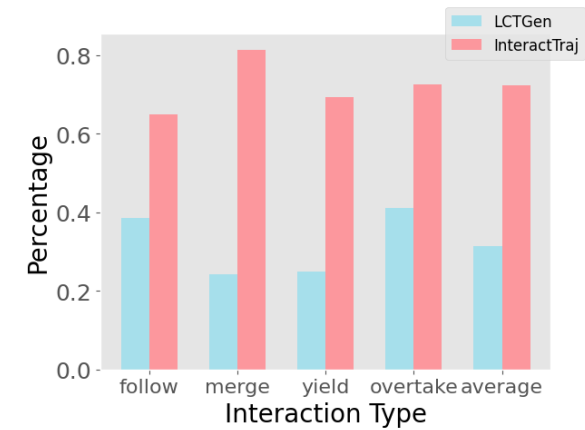
User study

- The sedan yields to the oncoming ambulance. [yielding]

InteractTraj(ours)

Baseline model

Percentage of users considering the generated scenarios fit the interaction types.