

MOSAT: Finding Safety Violations of Autonomous Driving Systems Using Multi-Objective Genetic Algorithm

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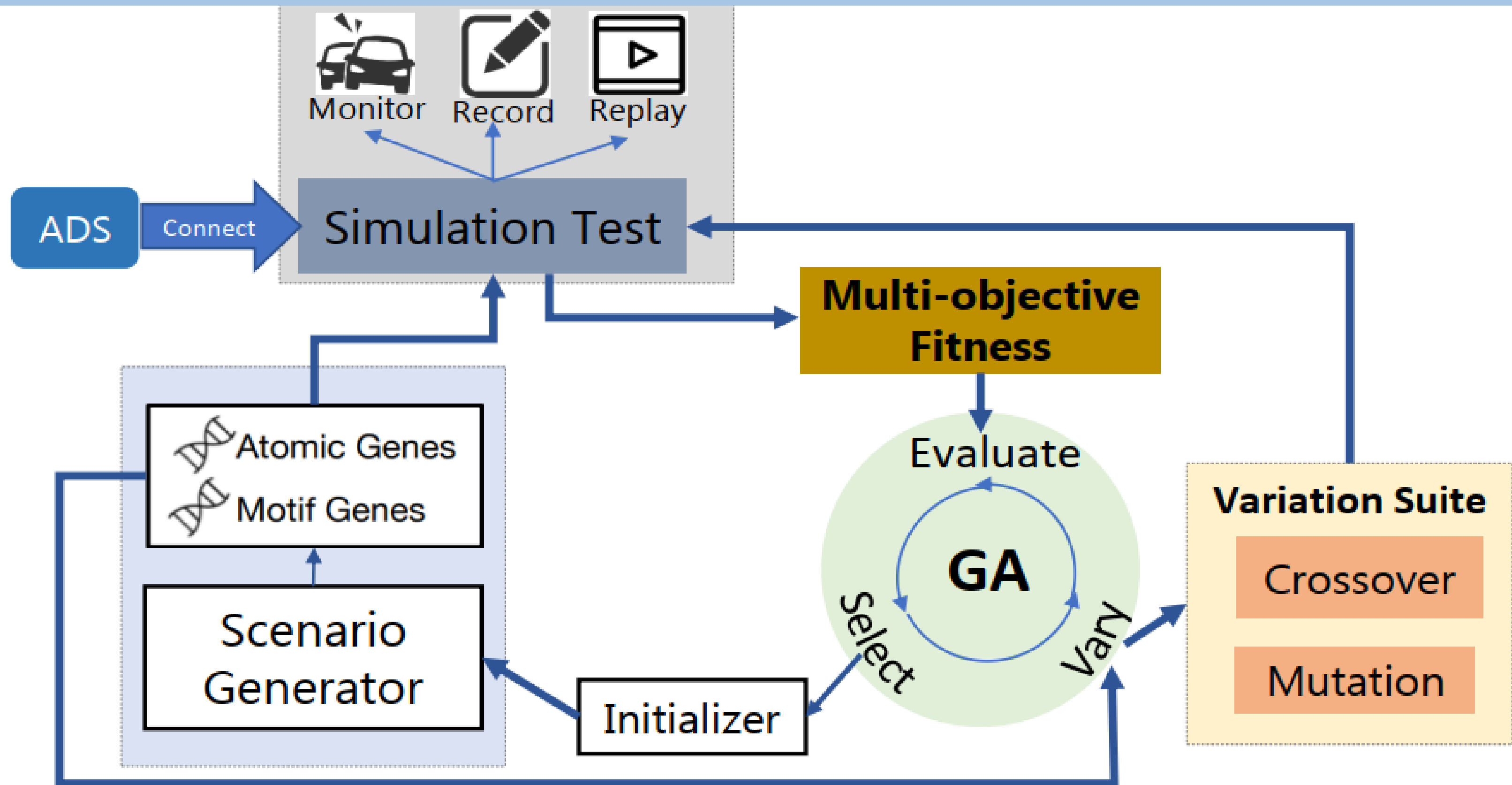
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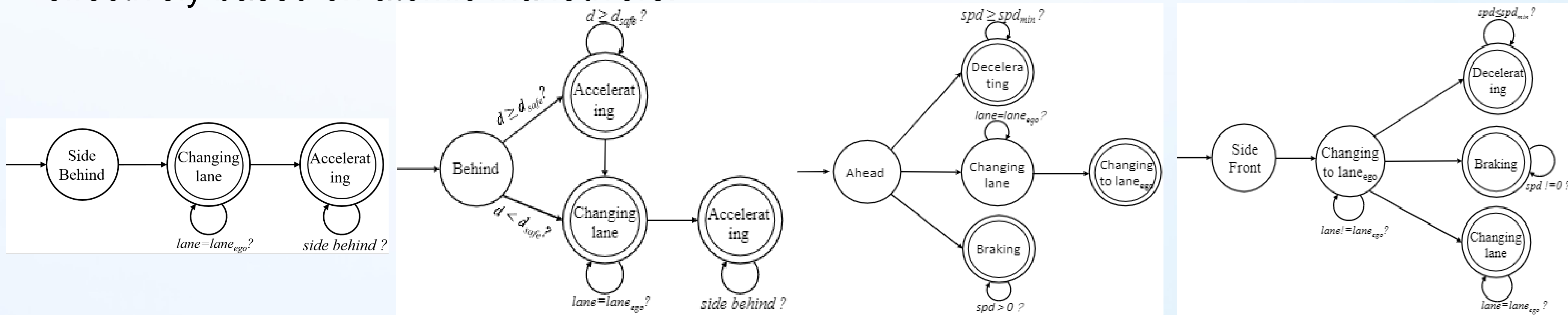
Motivation

- **Background:** Autonomous Driving Systems (ADSs) are complicated and the safety of ADSs is significantly important. Therefore, ADSs must be evaluated thoroughly before they are deployed into real world.
- **Challenges** of ADS simulation testing
 - ✓ Perturbations to ADS are not challengeable enough
 - ✓ High searching cost due to high-dimensional and complex input space
 - ✓ Low diversity: repeatedly find safety violations similar to ones already discovered
 - ✓ Short duration: cannot assess ADSs in long-mile driving

Methodology (MOSAT)



- **Modeling Driving Maneuvers:** introduce motif pattern which can create perturbations to ADS effectively based on atomic maneuvers.

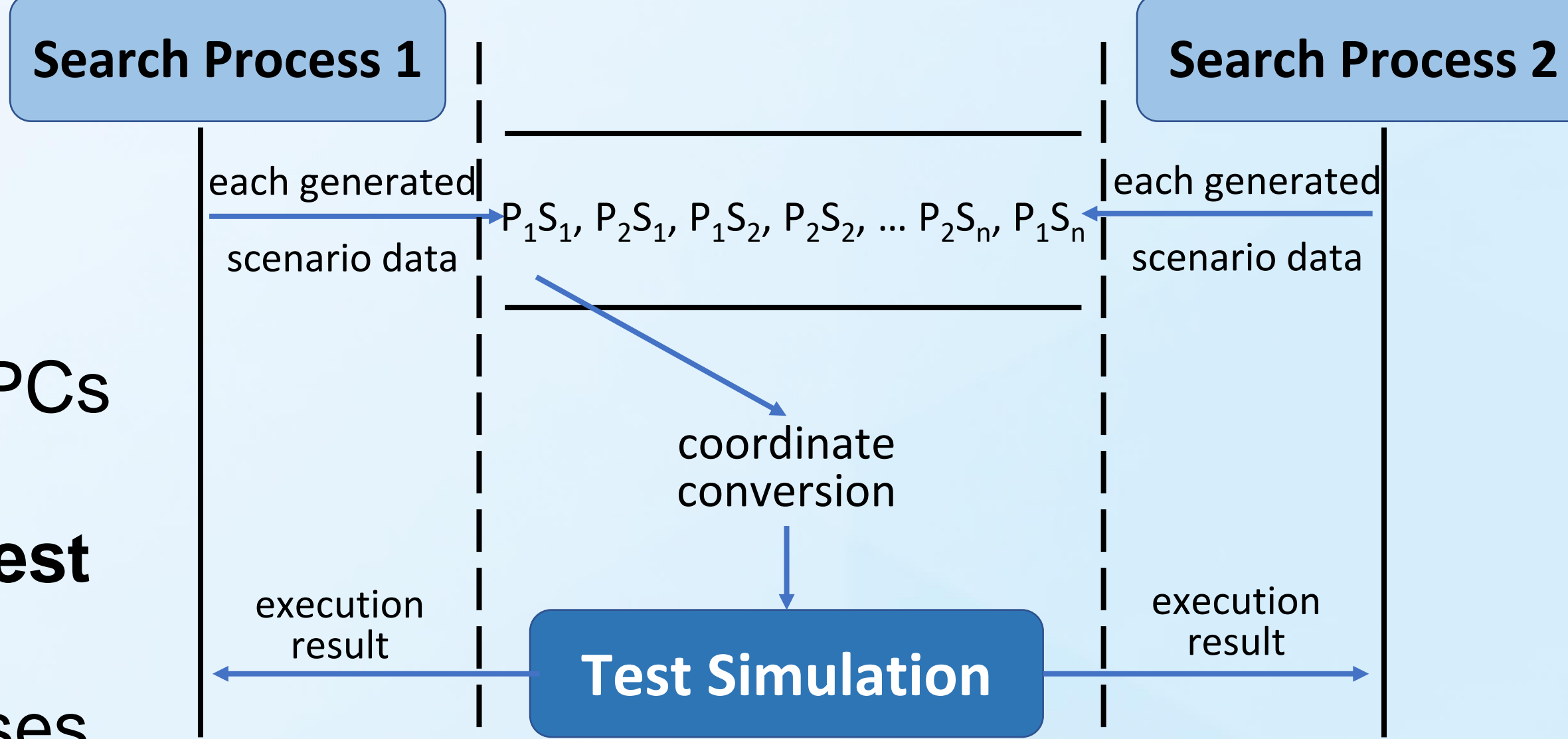


Multi-Objective Search

- risks of AV: high probability of ego's collision
- perturbations to AV: ego's driving offset from planned route, and shaper actions (e.g., emergency braking) during driving
- scenario diversity: different trajectories of NPCs from found safety-violation scenarios

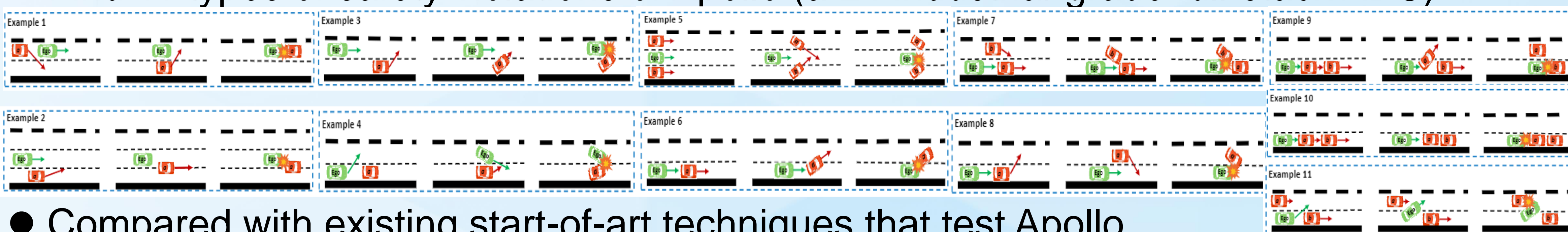
Spatiotemporally Continuous Simulation Test

- assess ADS in long-mile driving
- parallel execution of multiple search processes



Experimental Results

- Find 11 types of safety violations of Apollo (a L4 industrial-grade full-stack ADS)



- Compared with existing start-of-art techniques that test Apollo

- find more 6 types of safety violations
- more distinct ego's safety-violation scenarios
- lower time cost of scenario generation and execution

Comparison with AV-Fuzzer			Comparison with VERIFAI			
	MOSAT	AV-Fuzzer		CE	BO	HA
Safety violation types	11	5	Safety violation types	4	3	3
Time cost for one scenario	24s	55s	Time cost for one scenario	54s	35s	29s
Number of scenarios to expose one safety violation	27	121	Number of scenarios to expose one safety violation	3	4	4
Time to find out all safety violation types	19h	21h	Time to find out all safety violation types	0.8h	0.6h	0.5h
Euclidean distance across types of safety violations	72.23	65.35	Euclidean distance across types of safety violations	26.86	20.07	18.34