UCR College of Engineering- Center for Environmental Research & Technology

TOYOTA InfoTech Envisioning Mobility

AUTOMATED VEHICLES SYMPOSIUM 2019
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Unity-Based AV Simulation with V2X Communication and Human-in-the-loop Integration

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Presenting @ Automated Vehicle Symposium, Orlando

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Unity Game Engine

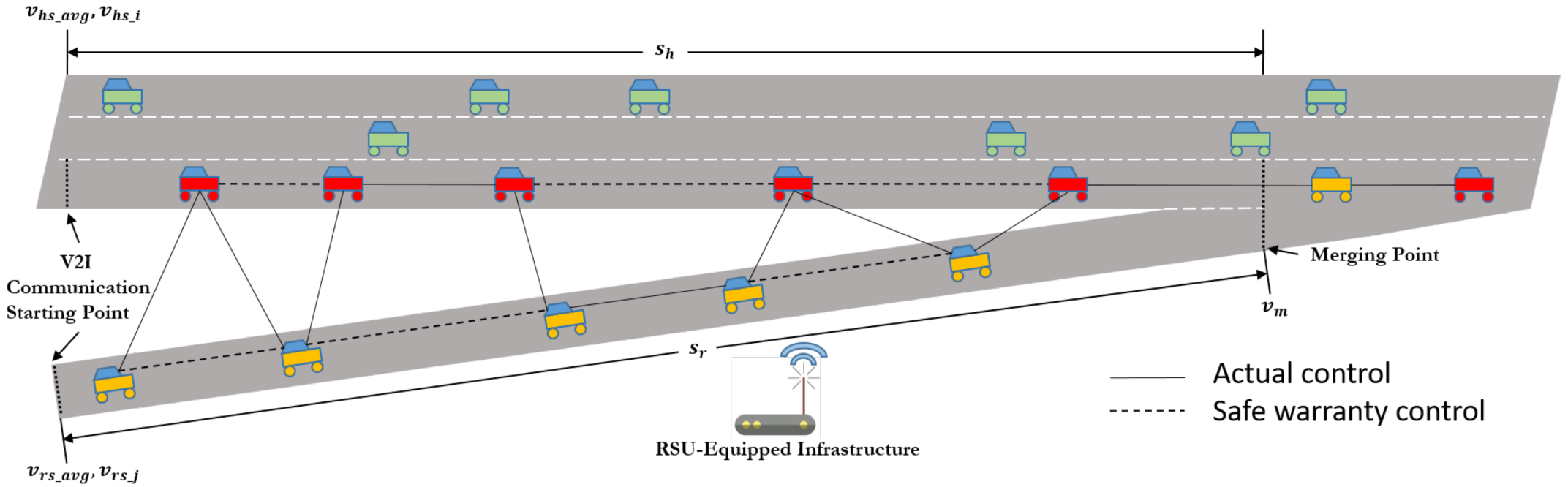
- **Unity game engine integrates a custom rendering engine with the Nvidia PhysX physics engine and the open-source Microsoft's .NET libraries "Mono"**

- **Advantages of using Unity3D:**
  - **Graphics and visualization**
  - **Integration of driving simulator**
  - **Asset store**
  - **Documentation and community**

(Source: LGSVL)

Cooperative Merging at Highway On-Ramps

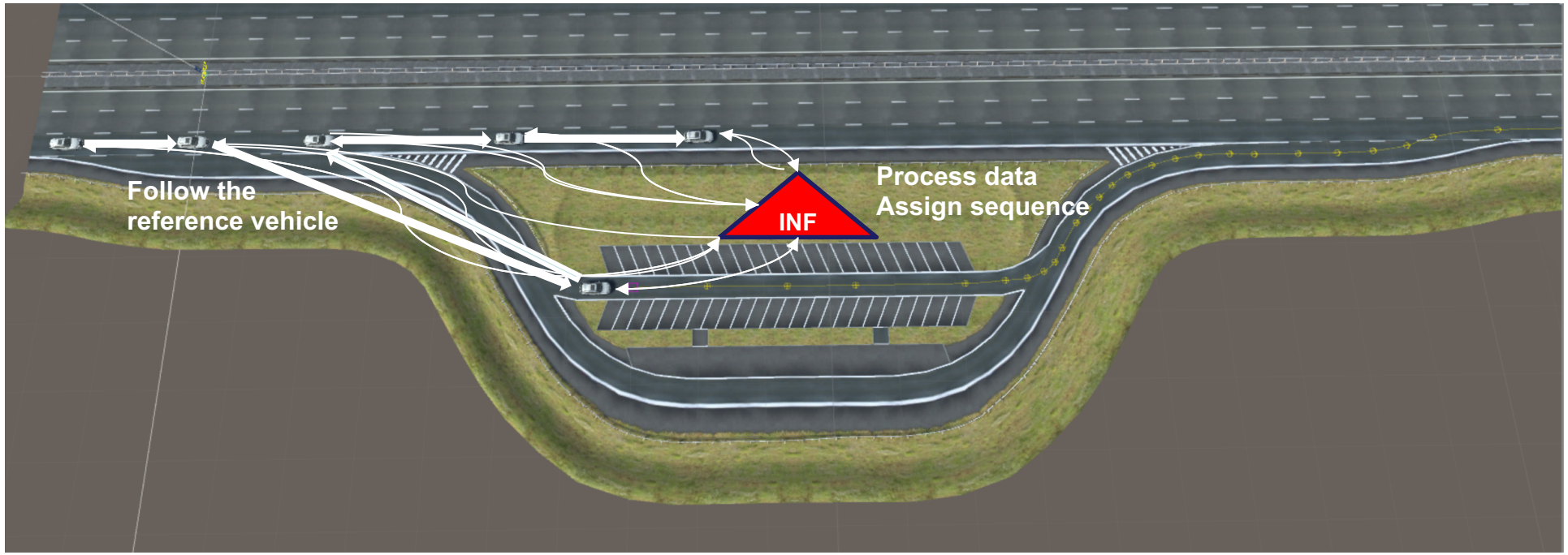
- **Cooperative merging at highway on-ramps**
  - **Take advantage of V2V and I2V communication**
  - **Adopt "ghost vehicle" concept**
  - **Complete longitudinal formation before merging**



(Reference: Wang et al, Cooperative ramp merging system: Agent-based modeling and simulation using game engine, SAE International Journal of Connected and Automated Vehicles, 2019)

Cooperative Merging at Highway On-Ramps

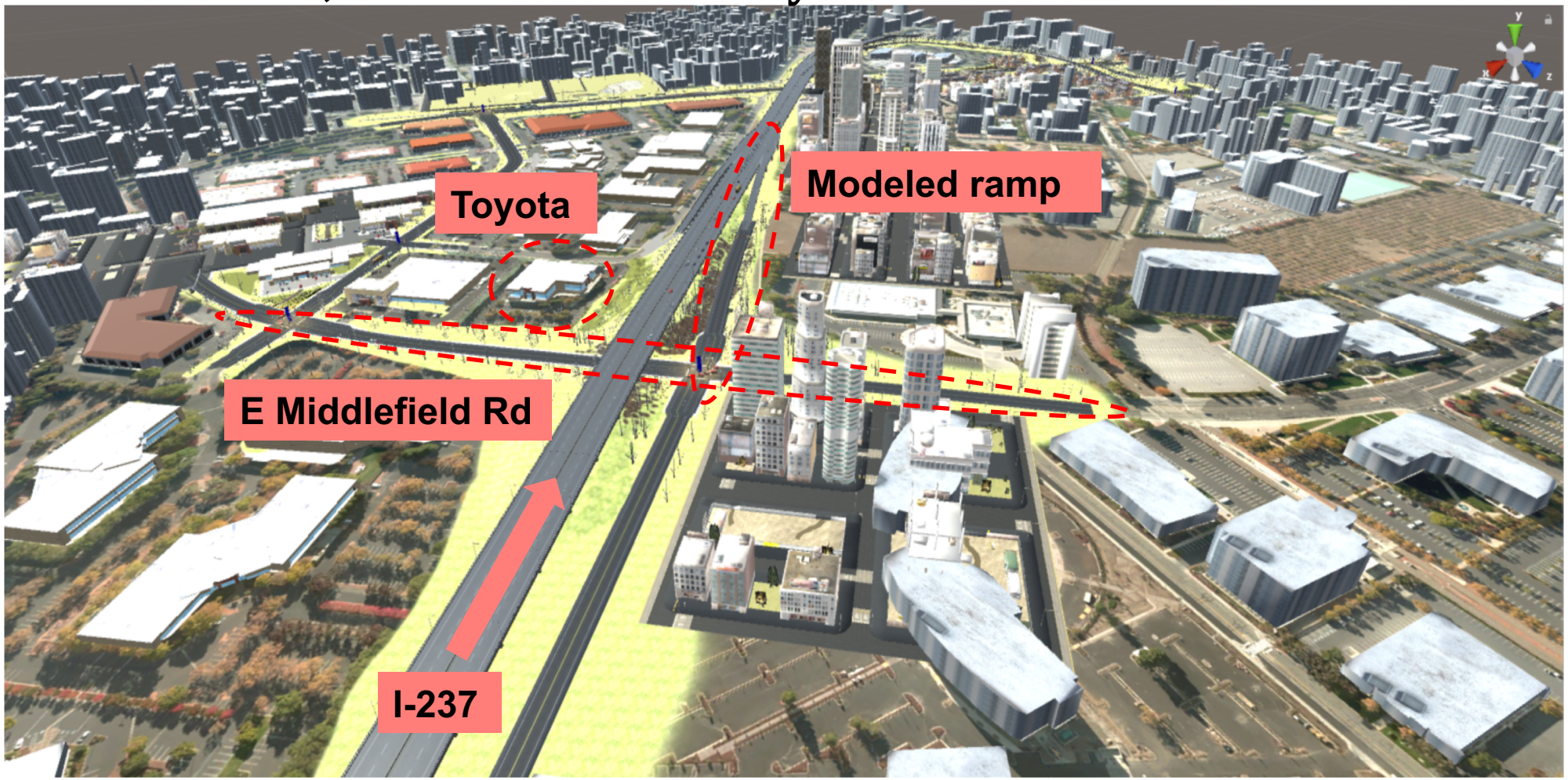
- **Work flow of the proposed system**
  - **Process data: estimated arrival time protocol**
  - **Assign sequence: vehicle sequencing protocol**
  - **Follow the reference vehicle: cooperative motion control algorithm**



(Reference: Wang et al, Cooperative ramp merging system: Agent-based modeling and simulation using game engine, SAE International Journal of Connected and Automated Vehicles, 2019)

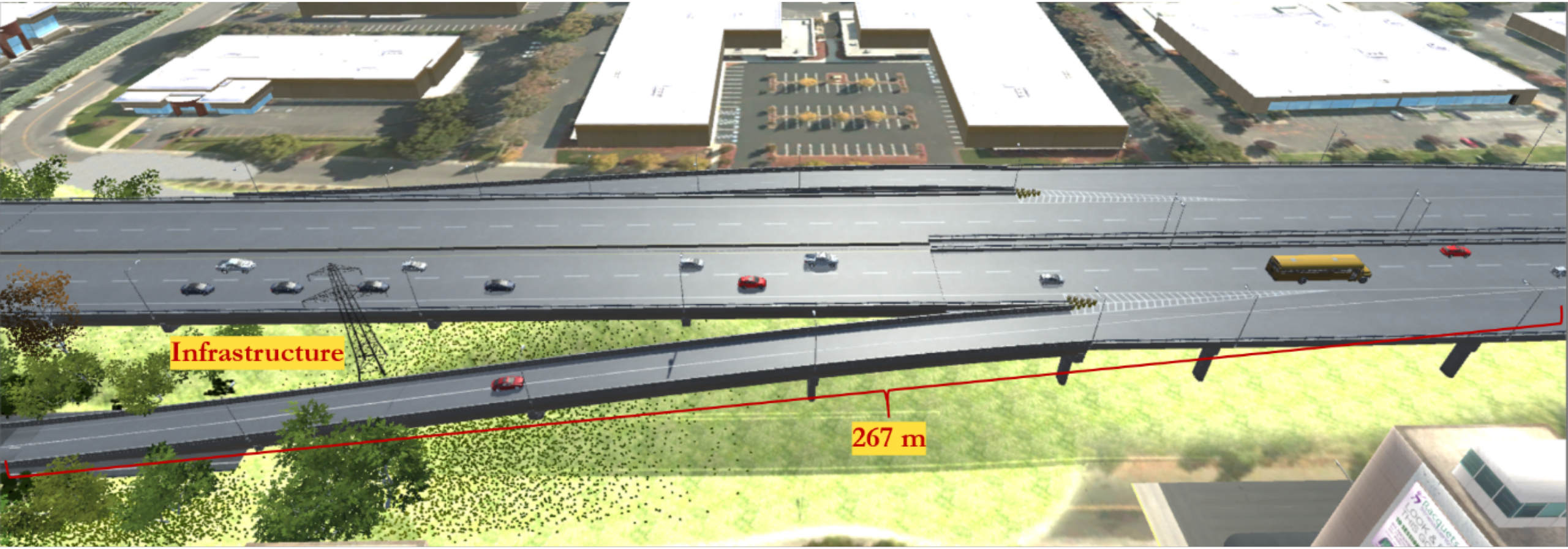
Simulation Environment in Unity

Mountain View, CA modeled in Unity environment



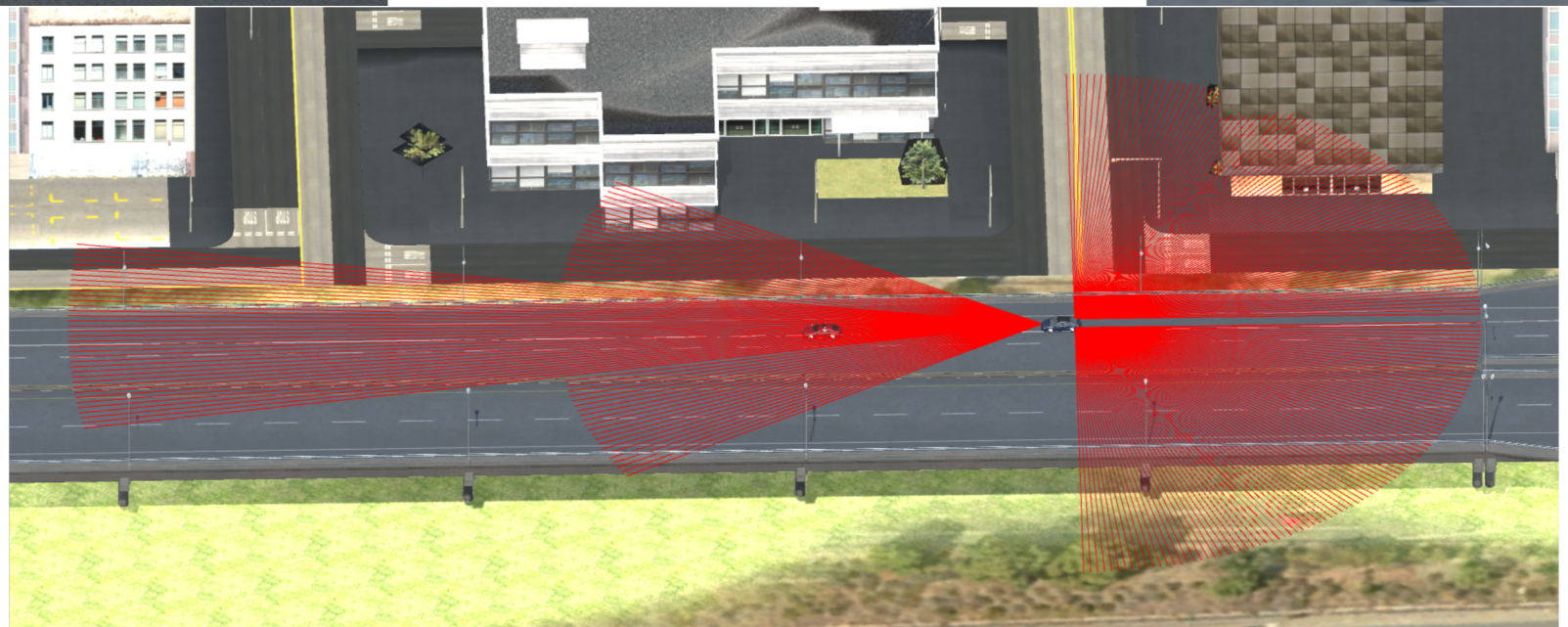
Simulation Environment in Unity

Ramp modeled in Unity to conduct simulation



Simulation Environment in Unity

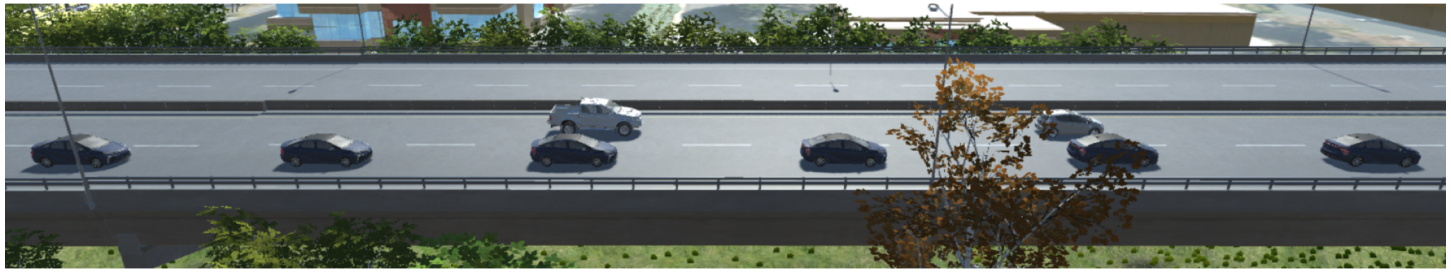
Vehicle modeled in Unity to conduct simulation

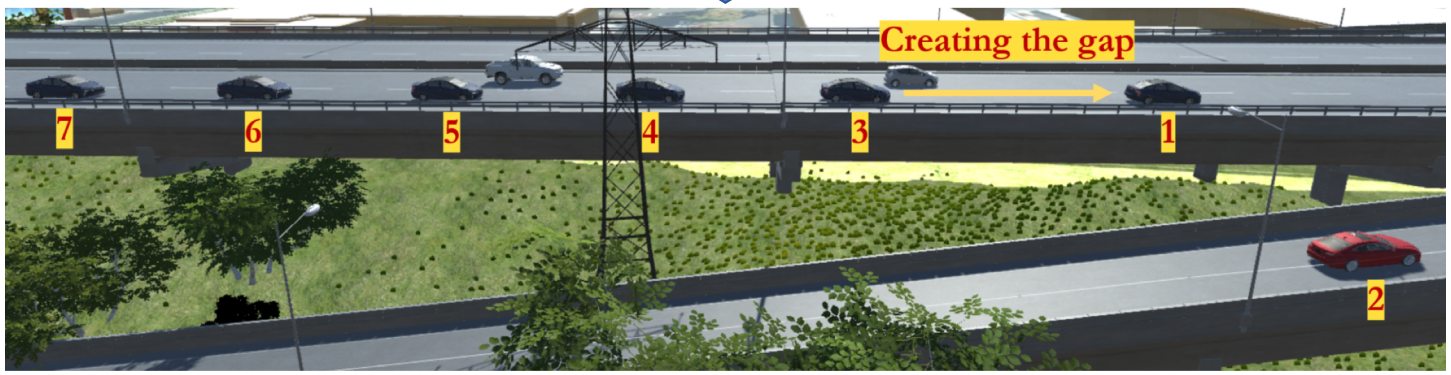


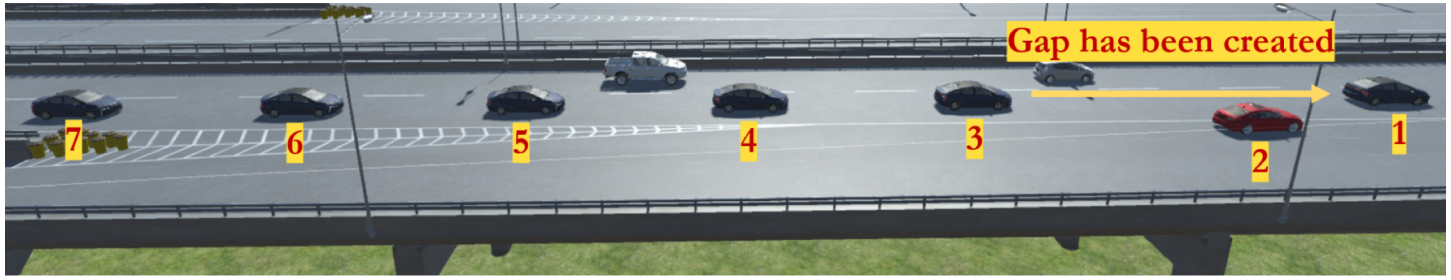
Radar system illustration

Cooperative Merging Simulation in Unity

Cooperative Merging Simulation in Unity







- **Simulation setting:**

1 ramp vehicle, 6 highway vehicles (already formed vehicle string)

- **All algorithm written in Mono scripting API**

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Human-in-the-Loop Simulation Environment

Located at Toyota Motor North America, InfoTech Labs, Mountain View, CA

Located at University of California, Riverside

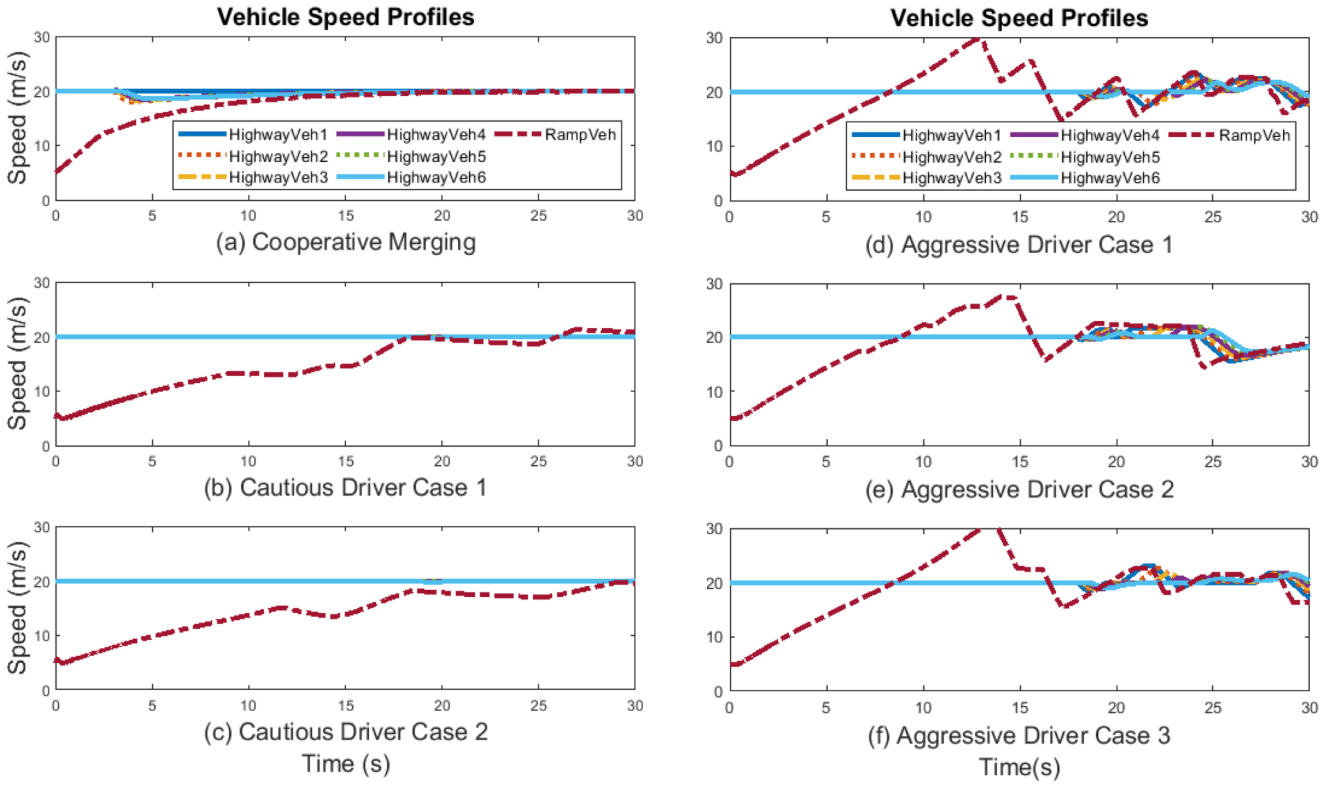
Human-in-the-Loop Simulation as Baseline

Test setting:

- **Control the merging vehicle**
- **No guidance**
- **4 drivers**
- **20 runs**

Cooperative Merging vs Human-in-the-Loop

Reductions in travel time, energy, and pollutant emission



	Travel Time	Energy	HC	CO	CO2	NOx
Cooperative Merging	218.14 s	9153.97 KJ	0.0094 g	1.1737 g	651.287 g	0.0440 g
Human-in-the-loop	233.58 s	9930.56 KJ	0.0200 g	2.8192 g	706.5392 g	0.0759 g
Reduction Percentage	6.61 %	7.82 %	53.00 %	58.37 %	7.82 %	42.03 %

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Driver Speed Assistance for Human-in-the-Loop

Utilize HUD and AR to show suggested speed to the human driver

- Color of HUD varies
  (green < white < red)
- Driver tracking error will be unavoidably generated

Please come to our poster session for more details @ Poster 19, Tuesday, 5:30-7:00 PM

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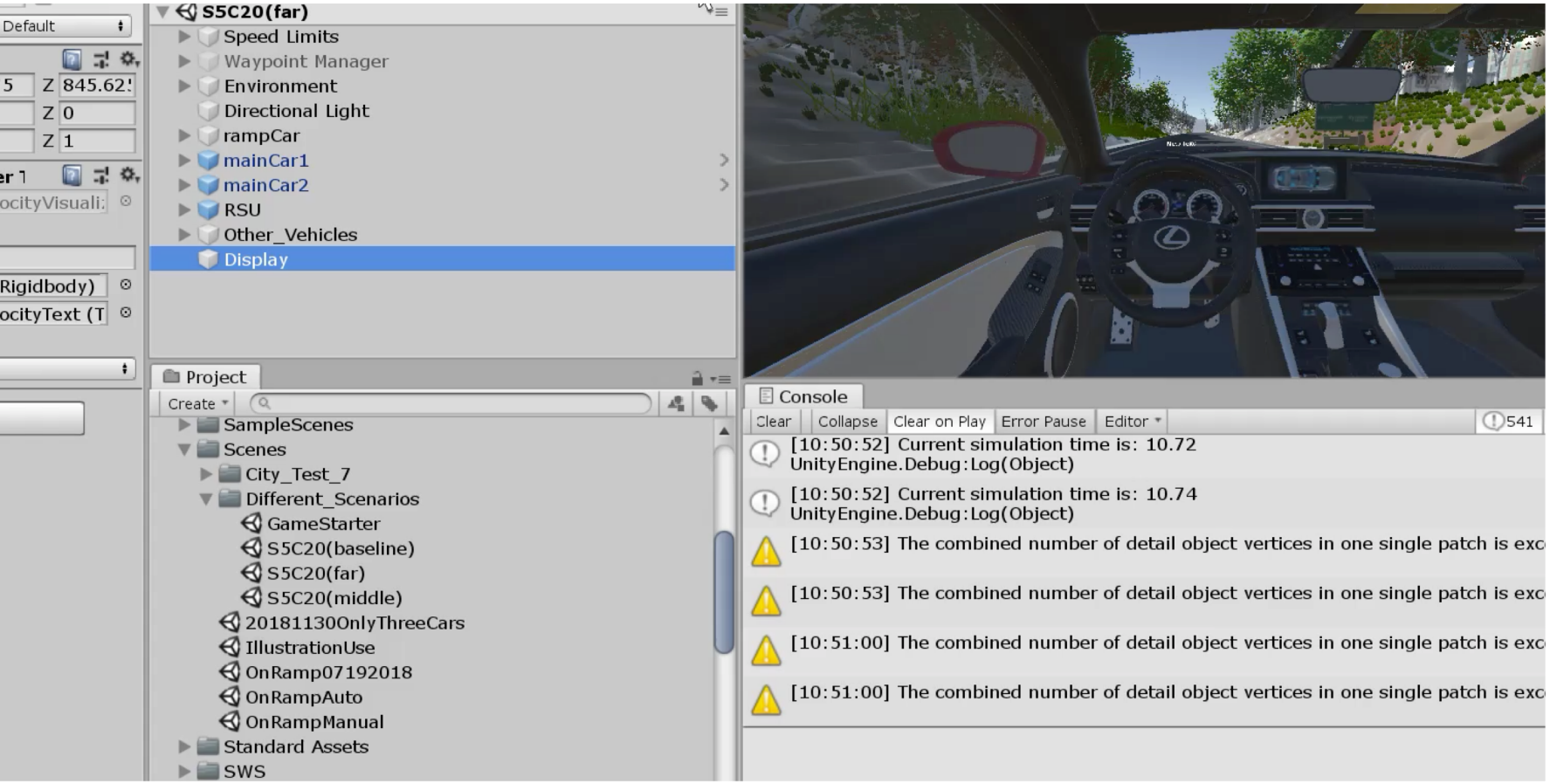

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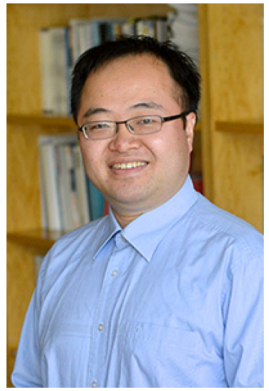
Acknowledgement

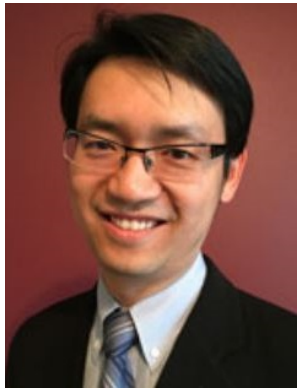
Ziran Wang
Ph.D. Graduate

Xishun Liao
Ph.D. Student

Chao Wang
Ph.D. Candidate



Guoyuan Wu
Adjunct Professor



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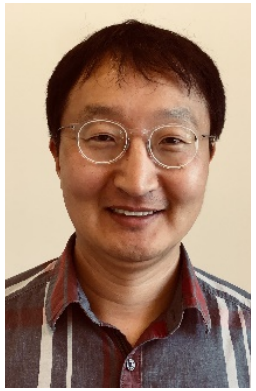

Kyungtae Han
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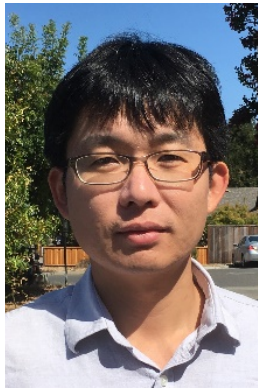

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