Virtual risk assessment for the deployment of autonomous shuttles

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FFG

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Motivation

Provide a framework and requirements for using virtual validation as part of a risk assessment for autonomous shuttle deployment

- Embedded into a deployment procedure for autonomous shuttles trails
- Utilizing a model-based testing framework
  - Deriving the necessary requirements of each model
- Showcased for the deployment of an autonomous shuttle in Koppl, Austria

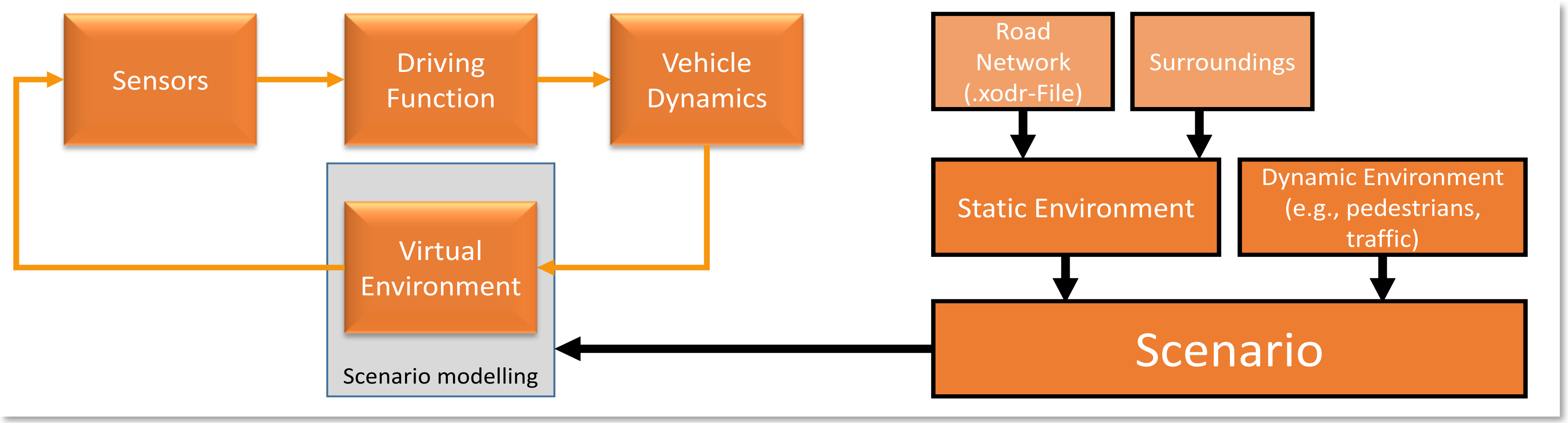
Model-based Testing Framework

General Overview of the Framework Structure

- Reflects the interaction of the vehicles driving function with the environment
  - The vehicles' dynamics and sensors are represented by respective models

Virtual Environment – Scenario Modelling

- The scenarios are executed in the created virtual environment, divided into:
  - static environment
  - dynamic environment



Requirements for Virtual Environments in V&V Procedures

Defines the needed model fidelity for each module of the framework utilized for virtual validation.

V&V Subsystem	Requirements
Static Environment	Road Network: Lanes (e.g., width, curvature), lane markings, pedestrian crossings, sidewalks, junctions, slope, logic road network description
	Surroundings: Objects (e.g., buildings, trees, vegetation, street signs)
Dynamic Environment	Environment (incl. weather, lighting), road users (cars, trucks, pedestrians, bicycles)
Sensor Models	Representation of the used sensor setup of the vehicle in terms of field of view, range (including other effects based on model fidelity)
Vehicle Dynamics	Ability to represent the essential physical effects of the vehicle up to 20 km/h
Driving Function	The framework needs to either: • Reflect the essential automated driving system functionalities of the vehicle • Incorporate the original automated driving systems of the autonomous shuttle

Virtual Environment of Koppl (Austria)

Generated based on a OpenDRIVE-File

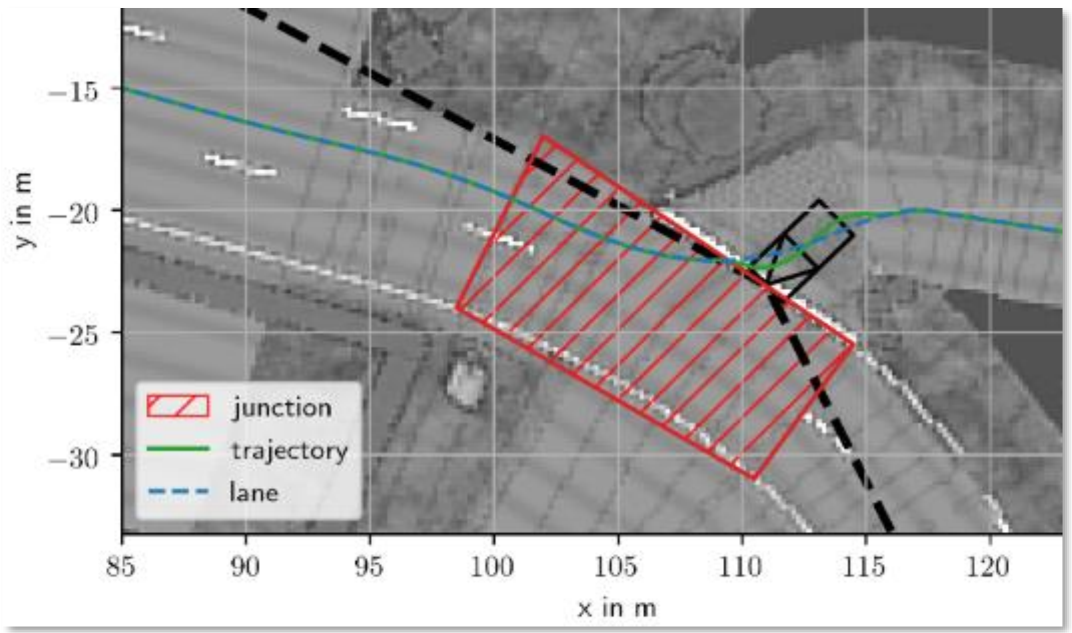
- Derived by partners of the Digibus® Austria project

Generation of a 3D-model and integration in CARLA[1]

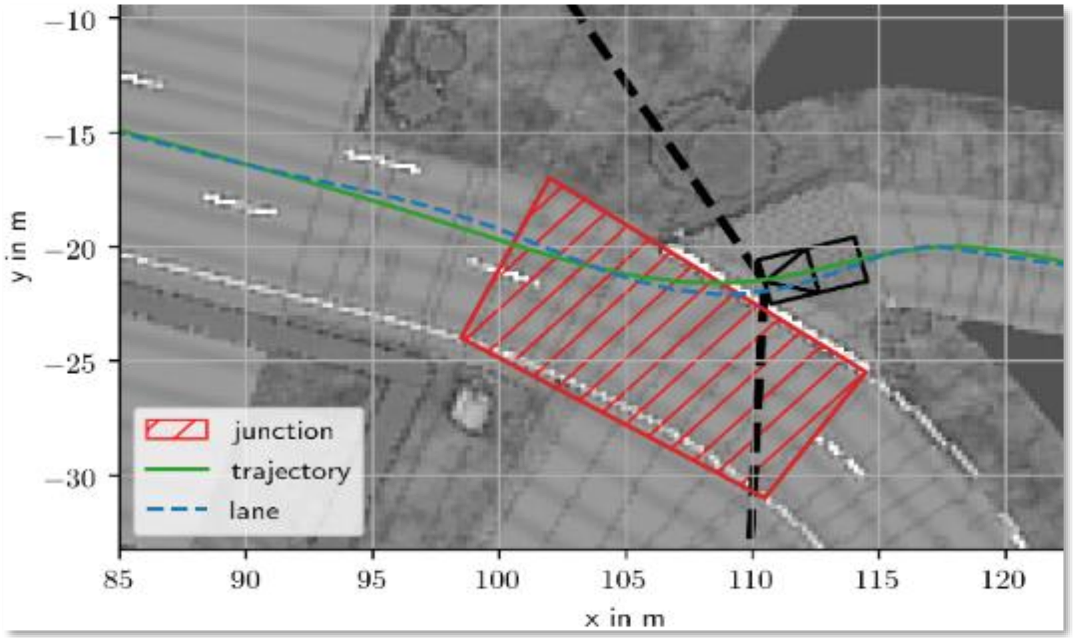
- Including all necessary elements from the static environment

[1] http://carla.org/

Comparison of Potential Autonomous Shuttle Paths



Case 1	Optimal field of view for the proposed path
Optimized for:	Orientation at the stopping point φ_{stop}
Boundary conditions:	Path curvature $\kappa < 0.35\, m^{-1}$
	Distance to opposite lane $t_{safe} \geq 0.26\, m$
Needed time to clear the junction: **15.82 s**	



Case 2	Minimized curvature of the proposed path
Optimized for:	Path curvature $std(\kappa)$
Boundary conditions:	Distance to the roadside/ opposite lane: $\lvert t_{safe} \rvert \geq 0.26\, m$
Needed time to clear the junction: **9.81 s**	

Trade-off between optimal field of view and time to clear the junction!

Conclusion & Outlook

Conclusion

Derivation of requirements for virtual validation of autonomous shuttles

- Regarding the necessary model fidelity

Embedding this into a general procedure for the risk assessment of autonomous shuttle deployments

Example:

- Optimizing the trajectory of the shuttle based on different boundary conditions
  - Enabled by the created virtual validation framework

Outlook

Extend the framework to further integrate different KPIs

- Based on urban use cases (including junctions, traffic lights and various traffic participants)

Integrate models with higher fidelity for advanced use cases

- Extend the capabilities of scenario execution (e.g. integrate different models for trajectory following)

Integrate optimized trajectories in the real shuttle

THE CONVERSATION CONTINUES

ERTICO

THE MOBILITY R-EVOLUTION

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VIRTUAL ITS EUROPEAN CONGRESS

virtual vehicle

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