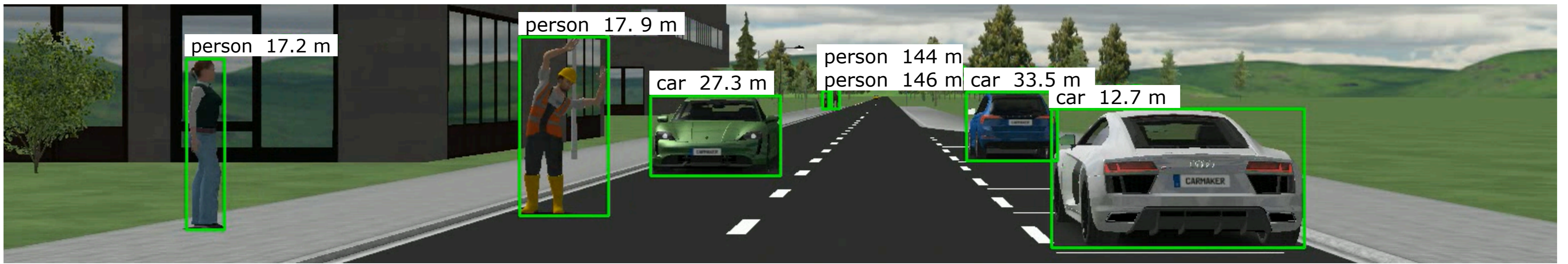


Virtual Testing of ADAS in a Statistically Defined Operational Design Domain

Bc. Vít Mořkovský; Supervisor: Ing. Jiří Novák, Ph.D.



Abstract

Current ADAS testing frameworks, such as those established by Euro NCAP, predominantly assess system performance under idealized operating conditions. This work introduces a virtual testing methodology based on Bayesian optimization for the systematic and efficient identification of safety-critical scenarios. The proposed approach is validated within the IPG CarMaker® environment using a custom-developed Automatic Emergency Braking (AEB) system. The results indicate that the methodology is capable of systematically uncovering safety boundaries under non-ideal and perturbed operating conditions.

Scenario Selection Method

Scenario selection is based on the extended NCAP approach, with an additional fourth layer describing environmental conditions. Virtual testing enables efficient analysis of rare and hard-to-reproduce conditions, such as visibility below 200 m, which occurs only 1% of the time.

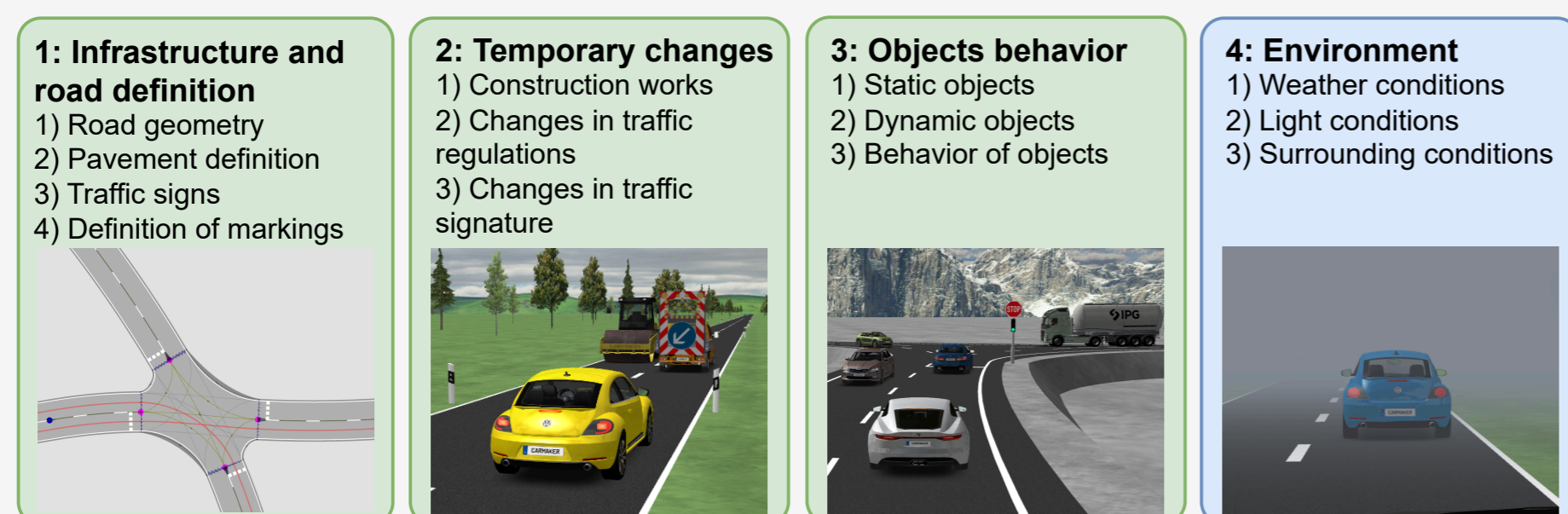


Figure 1.1: Decomposition of ODD parameters to corresponding layers

Adaptive Search for Scenario Generalization

- 1) Test scenario in IPG CarMaker®.
- 2) Evaluate test case and update surrogate model.
- 3) Use the acquisition function to select new scenarios.
- 4) Repeat steps 1 to 3 until satisfactory results are achieved.

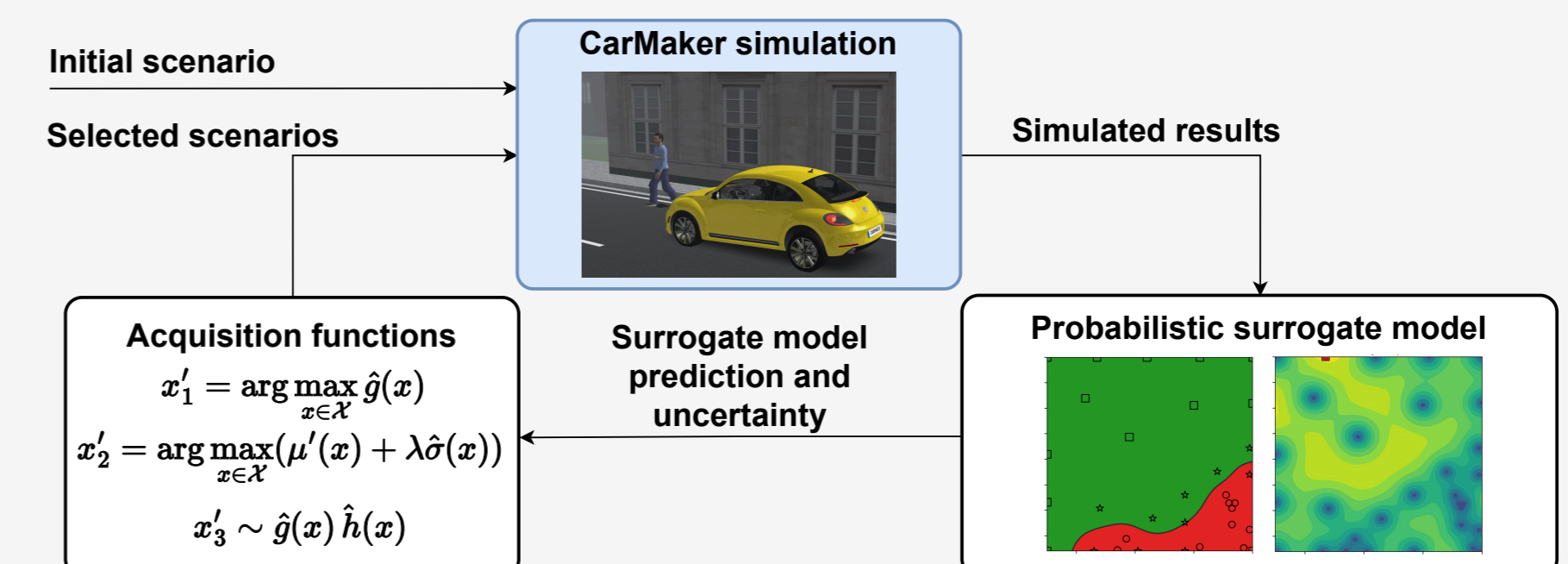


Figure 2.1: Workflow of the adaptive scenario selection method for a single iteration

Emergency Braking System

A simplified camera-based AEB system was developed to validate the proposed approach. All test scenarios were simulated in the IPG CarMaker® environment. The system uses a front-facing.

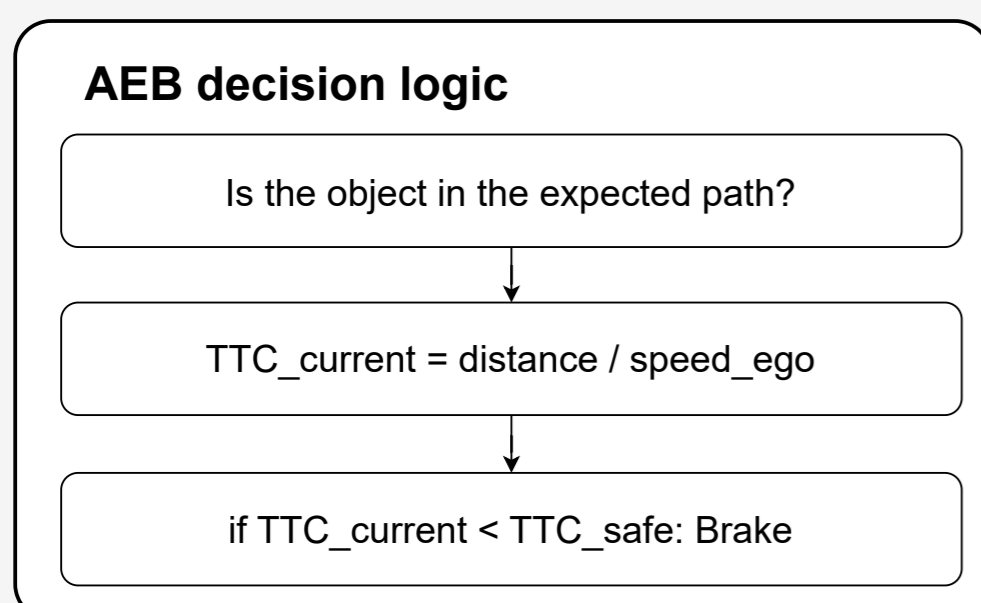


Figure 3.1: Simplified decision logic used for AEB

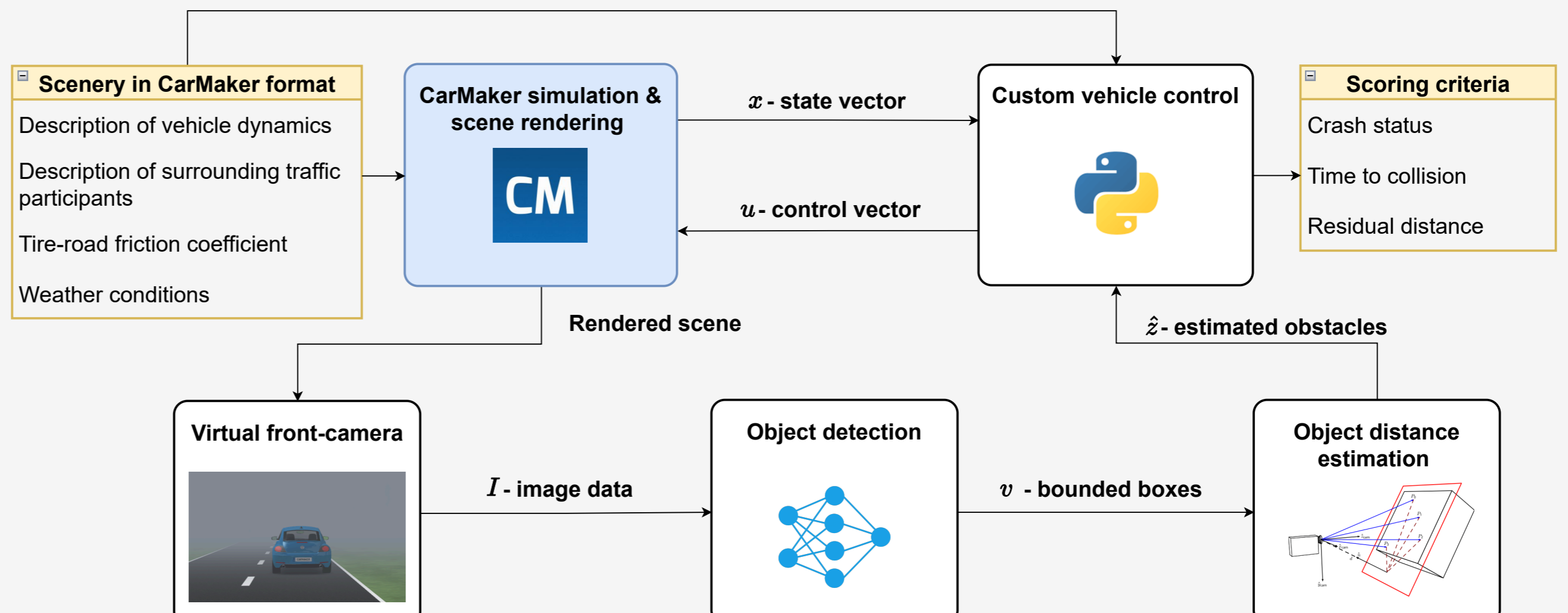


Figure 3.2: Architecture diagram of developed the AEB system in IPG CarMaker®

Main Contributions

- 1) Adaptive search methodology for scenario generation.
- 2) Virtual testing methodology for a camera-based AEB system.
- 3) Validation using the IPG CarMaker® simulation environment.

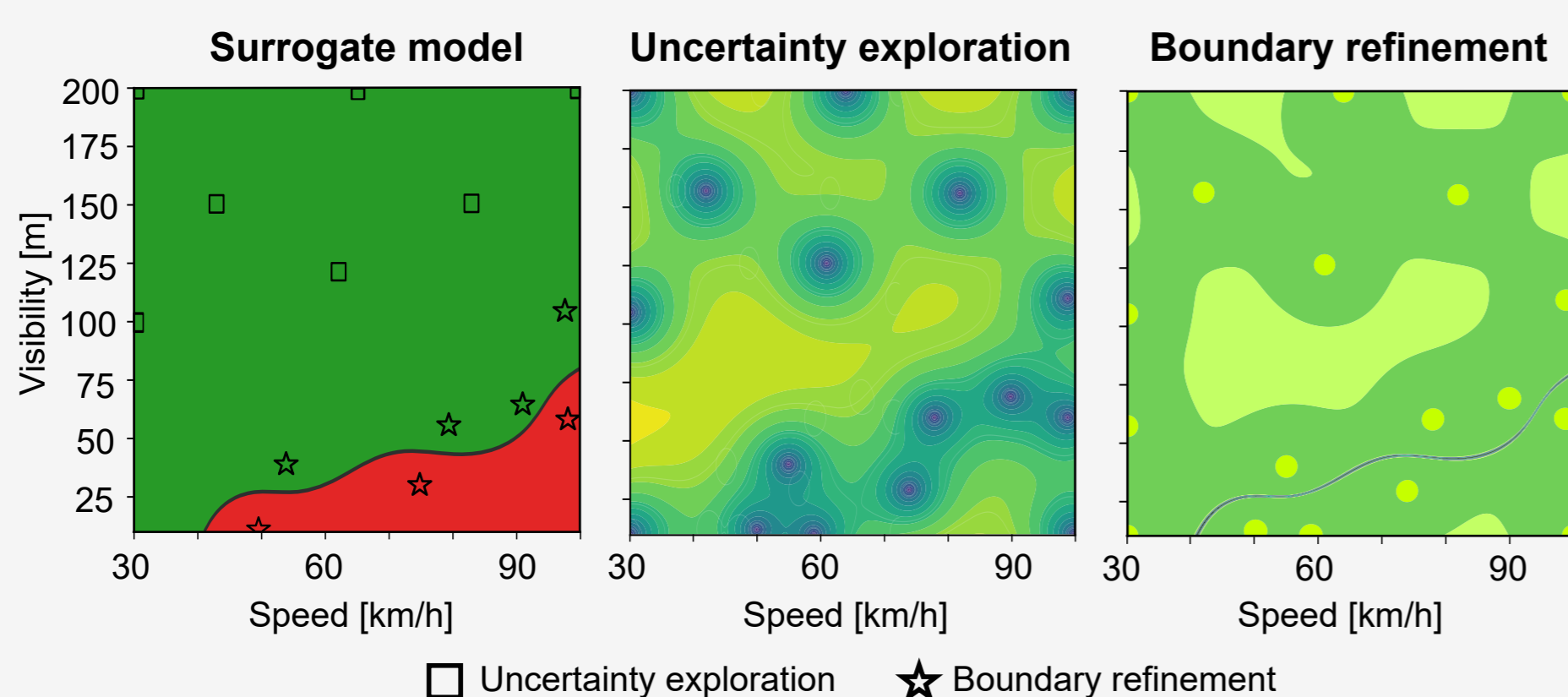


Figure 4.1: Adaptive search of the scenario 2D

Table 4.1: Test summary for AEB (friction 0.3–1.0, visibility 10–200 m, speed 30–100 km/h)

Scenario	Grid-based (512 test)	Adaptive search 2D		Adaptive search 3D	
	Pass rate [%]	Test count reduction [%]	Pass rate [%]	Test count reduction [%]	Pass rate [%]
Car-to-Car	77.34	54.69	77.85	91.6	80.57
Car-to-Pedestr.	76.76	63.67	80.05	91.6	79.15
Car-to-Bicycle	79.10	63.67	82.80	90.8	79.64

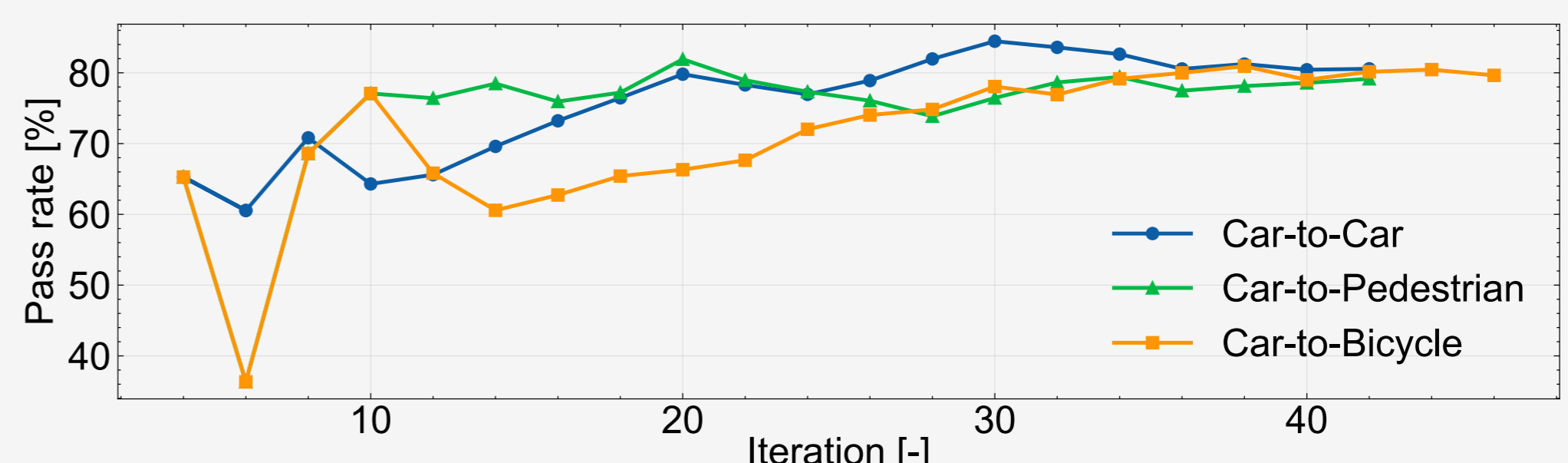


Figure 4.2: Evolution of predicted pass ratio during adaptive scenario selection in 3D