VERIFICATION
VALIDATION
METHODS

PROJECT of the PEGASUS FAMILY

STRUCTURING THE SCENARIO SPACE USING ABSTRACT SCENARIOS

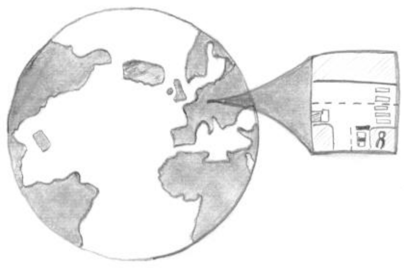
The Scenario Branch within the Criticality Analysis

Martin Butz, Bosch

Motivation and Goals

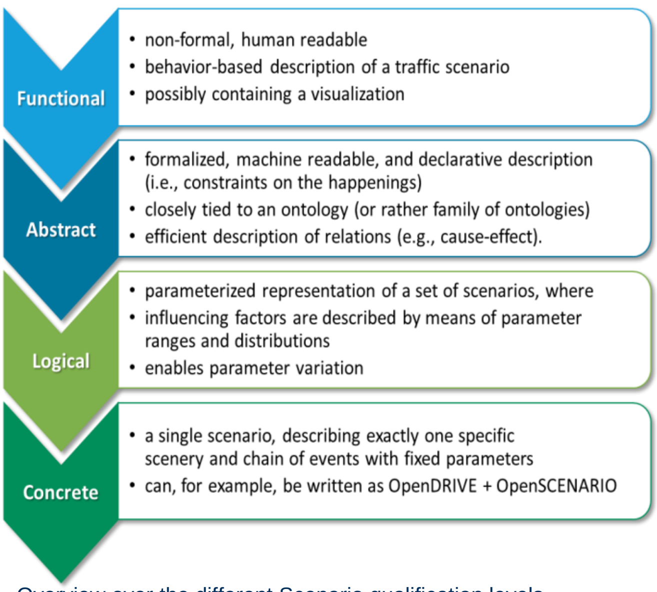
The Criticality Analysis [1] consists of three interacting branches:
The *method branch*, explains the process of deriving causal relations within traffic and how to gather evidence for their plausibility,
the *information branch* covers the management of associated knowledge and data,
the *scenario branch* deals with the classification, abstraction and execution of scenarios.
The execution of scenarios is, e.g., used for the evaluation of a hypothesis of a causality chain in the context of the Criticality Analysis, as well as for execution of test on simulation platforms or in real world driving tests.

The classification of scenarios aims at identifying/creating classes of scenarios based on different properties, e.g., criticality phenomena, relevance of a causal relation, criticality metrics, or desired behavior. An important goal of this classification is to relate scenario classes to the space spanned by the operational design domain (ODD) allowing for an argument of relative coverage there.



This coverage can potentially support the derivation of a definition of done (at a certain point in time) in the iterative workflow of the criticality analysis. This can, e.g., be achieved by comparing the different partitioning of the scenario space derived from behavior with the one derived from causal relations.

Abstract Scenario – Enabler for automation and formal structuring



Overview over the different Scenario qualification levels

We require a notion of an abstract scenario which is not as restricted as the (parametric) logical scenario but is more formal than the functional scenario to allow for the necessary degree of automation.

Additionally, the classification helps in finding the right scenarios in a scenario catalogue or database.

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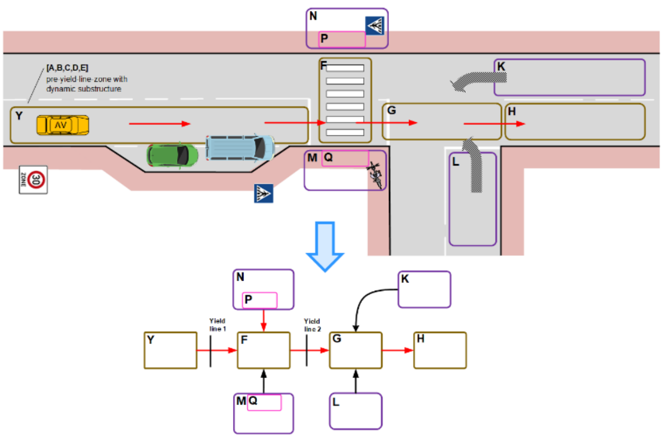
SOCA – SCODE 4 Open Context

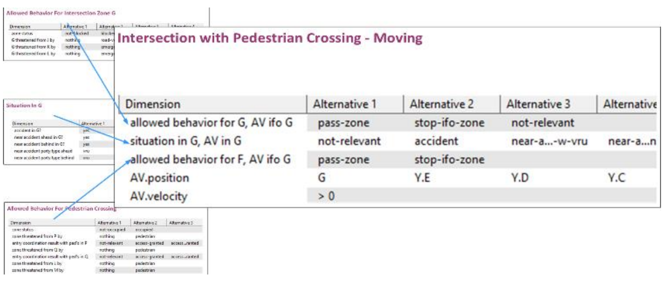
SOCA is a structured and formal approach for domain analysis that is part of the scenario branch. It uses:

An abstraction of road geometry into zones representing relevant traffic flows and ego capabilities. These are driving zones, position zones and threat zones. Zone graphs provide means for arguing equivalence of behaviors across different road layouts and enable structural concatenation.



An exemplary Zone Graph for the Functional Use Case 2 Passing of T-Intersection with Pedestrian Crossing

A behavior analysis, structuring the decision space (a discrete space containing all relevant environmental information) based on the desired/necessary behavior of an AV into finitely many equivalence classes (called modes) of intended AV behavior using morphological boxes, where we use the SCODE-ANALYZER tooling [3].

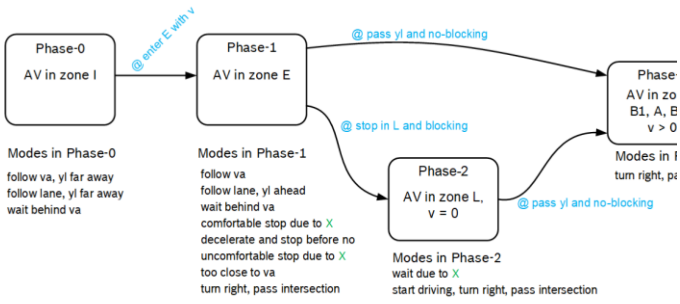


A simple exemplary set of Zwicky Boxes for the above Functional Use Case 2. The decision on why a zone is passable or non-passable (e.g., Row 1) can be represented in a Zwicky box as well

We associate Zwicky boxes to zones to enable reuse. The analysis of higher-level elements (e.g., crossing) embeds modes of subspaces (e.g., pedestrian crossing). These modes constitute equivalence classes. This partitioning can be used for arguing coverage of the described discrete decision space.

From Situation to Scenario

The SOCA analysis is based on a situational (i.e., timeless) view. To add (logical) time, we derive phase graphs from the formal model. These phase graphs contain a natural sequence of the driving zones based on the intention of the AV in the situation.



Cutout of the phase graph derived from the above model

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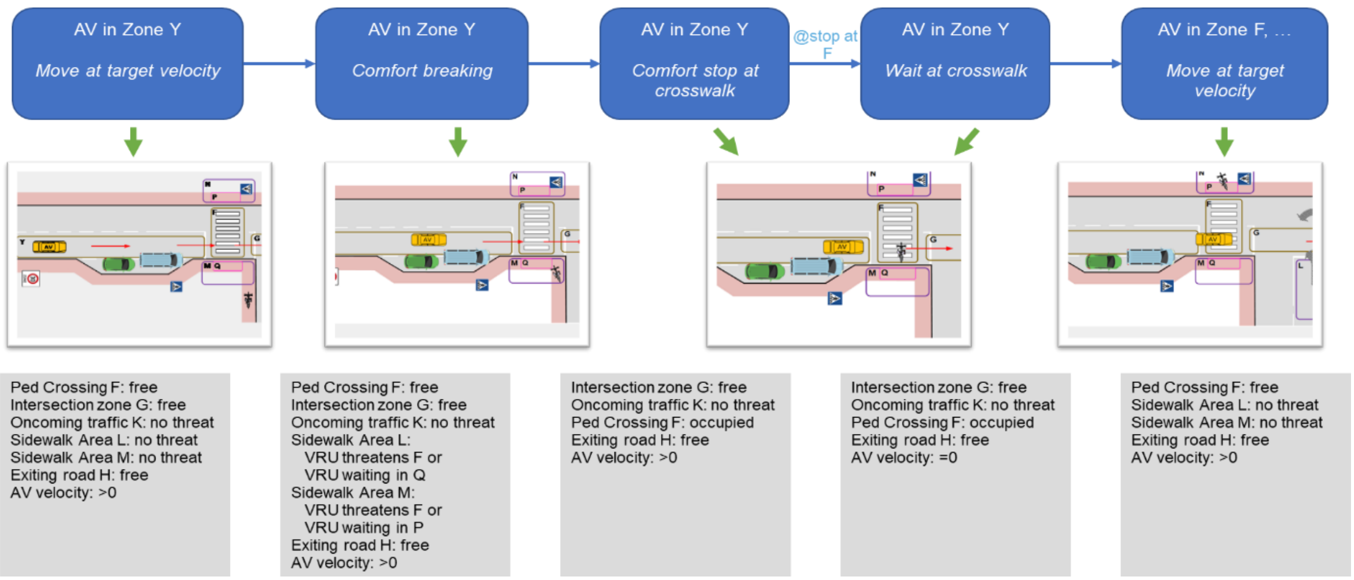
From Situation to Scenario …

These phase graphs are subsequently used to derive abstract scenarios by computing sequences of scenes from the model. This derivation allows to argue coverage of the scenario space w.r.t. the space spanned by the phase graph.



A trace through the phase graph of the above model, corresponding to the Functional Use Case 2.

Outlook – Downstream from an Abstract Scenario

Going forward the abstract scenario description needs to support the derivation logical and concrete scenarios to be used for example in a simulation environment, real world drive descriptions, as well as for the evaluation and classification of real-world driving data.

Furthermore, the abstract scenario is intended to create a “bridge” between the open world in form of an operational design domain, the criticality inducing phenomena and their related causal relations. One of the key features with respect to identifying the right abstraction will be the efficient and suitable handling of the underlying combinatorial complexity.

References

[1] C. Neurohr, L. Westhofen, M. Butz, M. H. Bollmann, U. Eberle, R. Galbas, “Criticality Analysis for the Verification and Validation of Automated Vehicles“, IEEE Access 9 (2021) 18016–18041. doi:10.1109/ACCESS.2021.3053159.

[2] M. Butz et al., “SOCA: Domain Analysis for Highly Automated Driving Systems”, presented at the 2020 IEEE 23rd International Conference on Intelligent Transportation Systems (ITSC), Sep. 2020. doi:10.1109/ITSC45102.2020.9294438.

[3] ETAS GmbH, “SCODE-ANALYZER,” https://www.etas.com/en/products/scode.php.

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