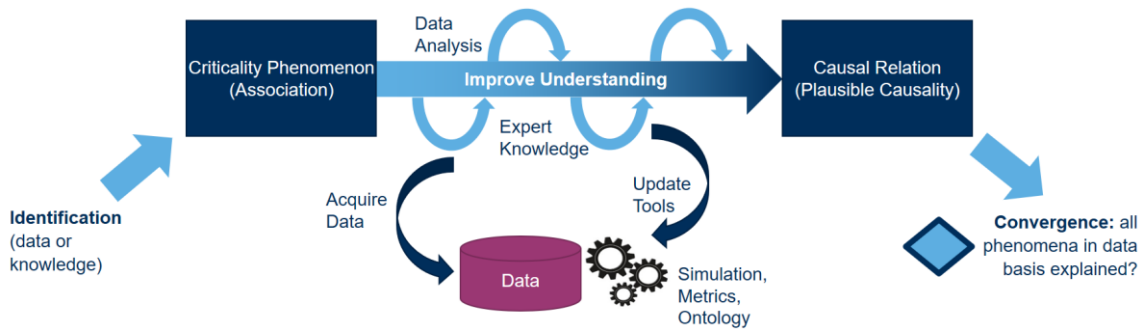


IDENTIFICATION AND ANALYSIS OF CRITICALITY PHENOMENA WITHIN THE GIDAS DATABASE

Basic Concept of the Criticality Analysis – from Association to Causation

Stefan Schoenawa, Volkswagen AG; Christian Neurohr, DLR



Criticality Phenomena (CP) are concrete influencing factors in a scenario that are associated with increased criticality. Therefore, these CP represent abstract classes of danger. The 1st step in a criticality analysis is the identification of CP through knowledge or data. Before moving on to causal analysis, relevance to the traffic system has to be established.

Accident Example featuring 14 CPs:

A car (*Ego*) drives straight in order to cross a junction and overtakes several vehicles waiting to turn left. Ignoring the red traffic light, a pedestrian (*Ped*) enters the lane, emerging from between the waiting vehicles and is caught by *Ego*. Consequently, *Ped* is seriously injured.

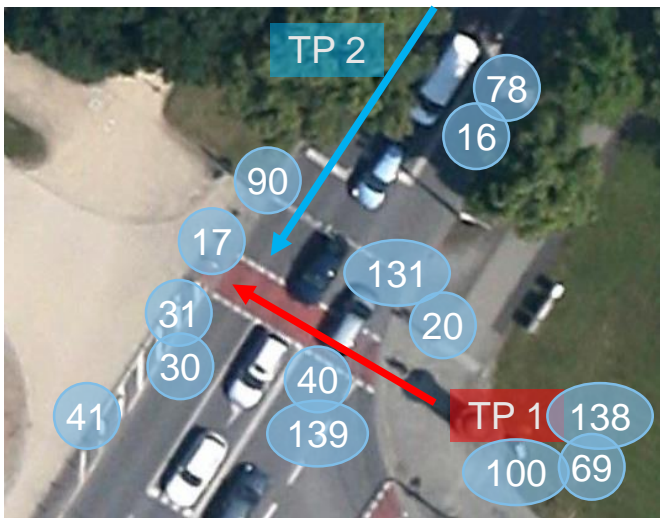


Image: Bird-eye view of the accident example with annotation of the occurred criticality phenomena. Source: [2]

Accident databases provide valuable information about influencing factors in situations of maximal criticality.

In VVMethods, we identified and analyzed a large subset of the **GIDAS database**, consisting of **N=12997** car accidents in urban areas, regarding the presence of CP. A selection of results obtained from **statistical analysis** are provided on the 2nd page.

List of occurred CPs in the Example:

- Intersection^{#41}
- Intersecting Planned Trajectories^{#17}
- Overtaking^{#16} (of Waiting Vehicle^{#78})
- Strong Braking Maneuver of Ego^{#90}
- Subject^{#138} / Pedestrian^{#69} on Road
- Vulnerable Road User with Road Access ^{#100}
- Ped. Crossing^{#40} (Road directly ^{#139})
- Occlusion ^{#131} (Pedestrian^{#20})
- Violating Right of Way^{#31} / Red Light^{#40}



Unity-animated scenario for the accident example featuring 14 CPs. Full video in separate mp4-file. Source: [2]

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Exemplary Results obtained from Statistical Analysis of Urban Accidents in the GIDAS Database regarding the Presence of Criticality Phenomena

- The initial **CP-catalog** contained **166 criticality phenomena** potentially relevant to driving automation
- **116 (of 166) CP could be identified** using the GIDAS query language
- **N=12997 accidents** in GIDAS were checked regarding the presence of these 116 CP
- The resulting **116x12997 binary matrix** was subjected to various statistical analyses

ID	Criticality Phenomenon	Absolute Frequency	Relative Frequency	Projection of Absolute Frequency
#17	Intersecting Planned Trajectories of TPs	7156	55.1%	88305
#31	Non-Ego-TP violating Right of Way	2644	20.3%	32628
#131	Occlusion	2978	22.9%	36746

Table: absolute & relative frequency of three CP featured in the accident example plus projection to the total German accident statistics.

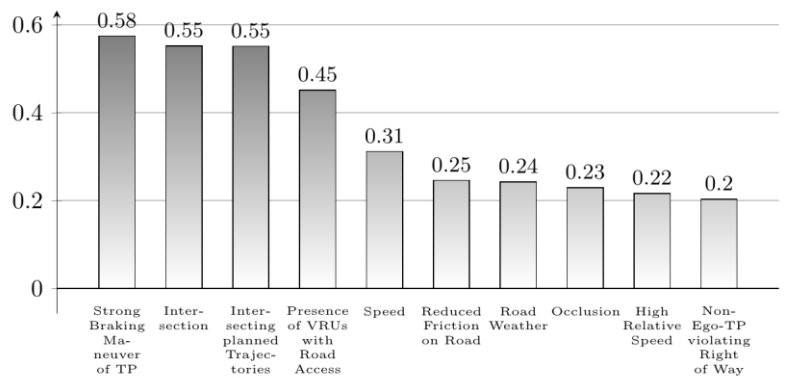


Figure: top ten most frequent CP for urban accidents with car involvement in the GIDAS database.

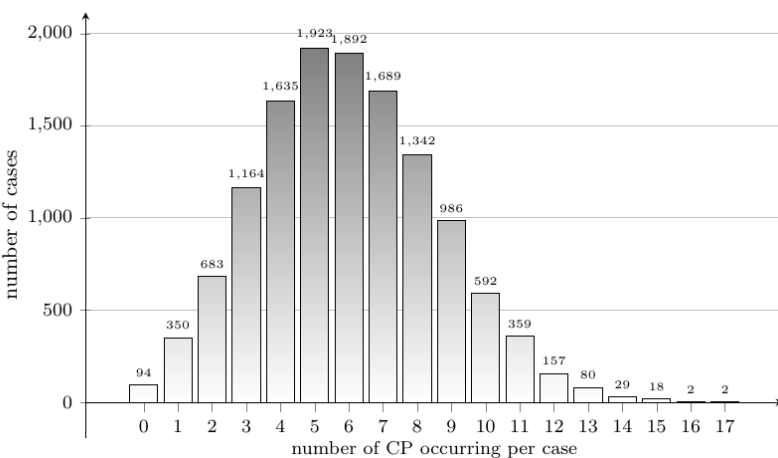


Figure: distribution of the number of CP occurring per case for urban accidents with car involvement in the GIDAS database.

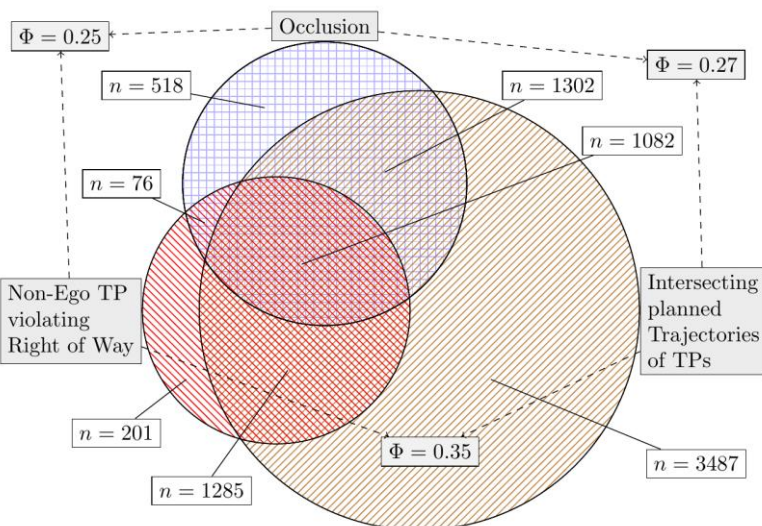


Figure: Venn diagram showing the absolute case numbers in the dataset for different combinations of three criticality phenomena as well as the pairwise Φ -coefficients as a correlation measure between them.

- **Absolute and relative frequency** in the urban data set for each CP, including
 - projection to total German accident statistics,
 - can be used for relevance estimation of CP
- **Distribution of the number of occurring CP** per accident suggests **multi-causality**
- Absolute frequencies of **n-wise combinations** of CP can be considered
- **Φ -coefficient** as pairwise correlation measure for binary variables hints at common causal factors
- **Results will be published as a journal paper** between DLR, VW & VUFO

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References

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Literature:

[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] VUFO, GIDAS-PCM database, Dresden (2021)

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