Detection of traffic participants and their interactions at urban intersections

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DLR

Content

- Motivation
- Object recognition, classification and tracking
- Detection of critical and atypical situations
- Conclusions & Future Prospects

Content

OptiSiLK – What is it?

- OptiSiLK (Optimierung der Verkehrssicherheit und -Leistung an Kreuzungen verschiedener Verkehre) = (Optimization of traffic safety and performance at intersections of different transport)
- „The project promotes the installation of the major research facility AIM (Application platform Intelligent Mobility) and enables their scientific use and to answer ambitious scientific questions.“
- Research project
  - Funding authority: Ministry for Science and Culture of Lower Saxony
  - Project period: 2011 – 2015
  - Funding volume: 1.25 Mio. Euro
  - Connection of all scientific areas of the DLR Institute of Transportation Systems, i.e. Traffic and transportation management, Railway systems, Automotive)
  - Project structure
    - TP 1000: object and situation detection → today!
    - TP 2000: intersection assistance
    - TP 3000: level-crossing assistance

Initial situation and primary objectives

Left-turning leads to **18 severe injuries per day** in Germany, **every second day someone dies.**

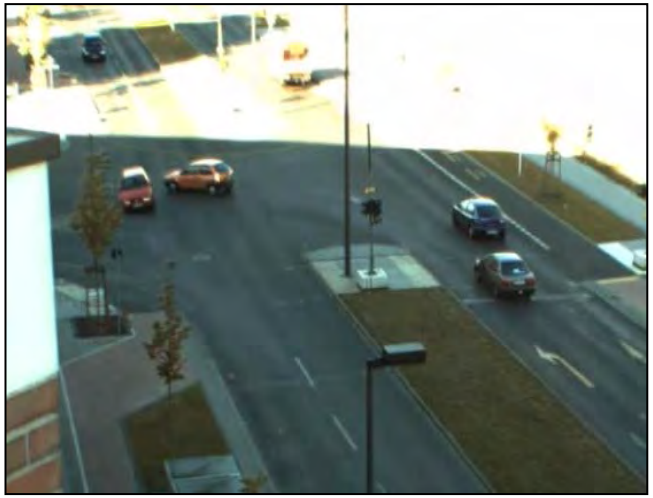
In 2014 about **3,600 people were killed** and more than **60,000 were seriously injured.**

At 45,000 level crossings in Germany, yearly about **200 accidents occur. 25% of them are fatal**.

Objectives: - understand traffic situations at intersections of different traffic modes
- find out the fundamentals to avoid fatalities and severe accidents

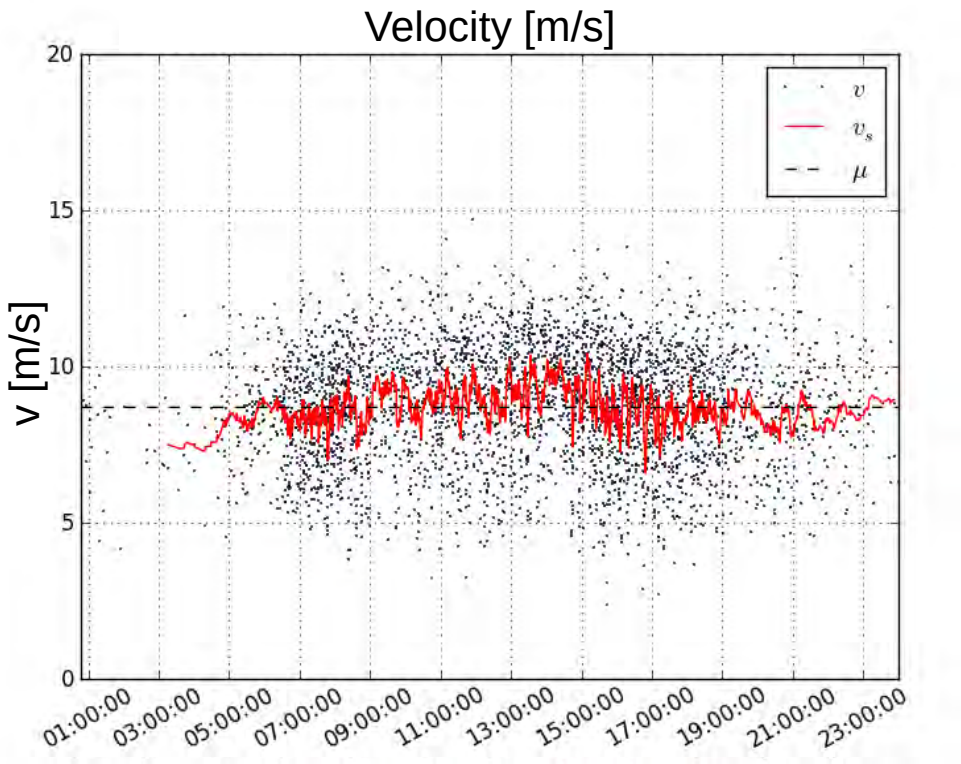
Motivation

- A fully-automated traffic detection system is necessary to get and analyze functional correlations between critical situations and accidents.
- Problem: heavily occluding objects merge optically, which requires an increasing technical effort (e.g. redundancy by others sensors, etc.).
- Thus, we focused on the development of an algorithm to detect traffic in a wide-area manner to compensate occlusions.
- Further, we determined atypical and critical situations
- Tested at the AIM research level-crossing in Bienrode (Brunswick)



Some traffic characteristics of the research level-crossing

- Average daily traffic
  - →Wenden: 4500 Veh/24h
  - →Brunswick: 4580 Veh/24
- Average net timegap
  - →Wenden: Δt = 19 s
  - →Brunswick: Δt = 21 s
- Average speed
  - →Wenden: v = 32 km/h
  - →Brunswick: v = 34 km/h



Content

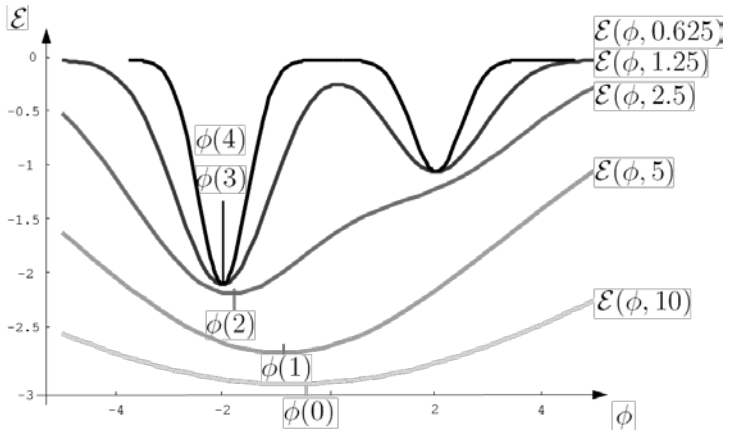
Object detection, classification and tracking

Motivation

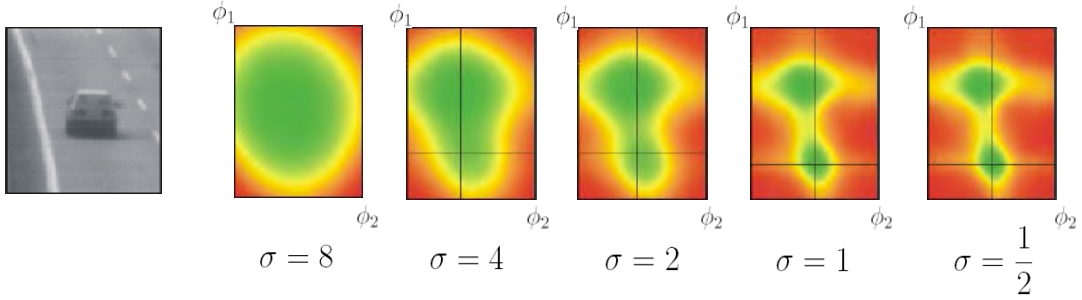
- Compensation of occlusions for traffic safety related investigations and analyses

Approach: Robust regression

- Transformation of an image sequence in a cost function. Its minima represent the motion hypotheses of the traffic objects
- Determination and tracking of the minima, even if the motion hypothesis is not dominant.



Principle of the determination of motion hypotheses

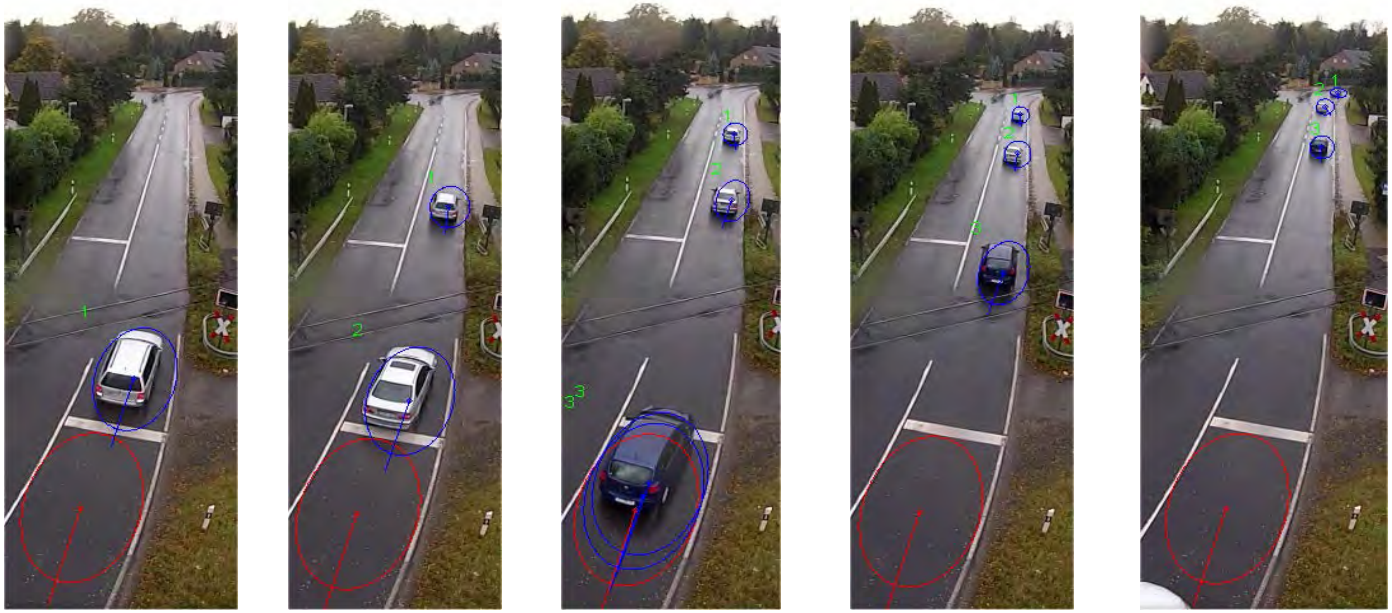


Tracking of motion hypotheses in parameter domain

Object detection, classification and tracking

Results

- Tracking of traffic participants at the AIM research level-crossing up to 120m in comparison to about 80m of a state-of-the-art system
- Coping of occlusions of up to 90%



Tracking sequence at AIM research level-crossing in Bienrode

Object detection, classification and tracking

Comparison of the accuracy of the trajectories of the implemented systems algorithms at the level-crossing

State-of-the-art implementation

Novel implementation

Parameters	State-of-the-art implementation	Novel implementation
Average value | standard deviation | median (evaluation of the „common“ areas)	3.37 m | 1.69 m | 3.12 m	2.36 m | 2.46 m | 1.70 m
Average value | standard deviation | median (Total evaluation)	3.50 m | 2.31 m | 3.03 m	3.45 m | 3.18 m | 2.44 m

Content

Detection of critical and atypical situations at the research level-crossing

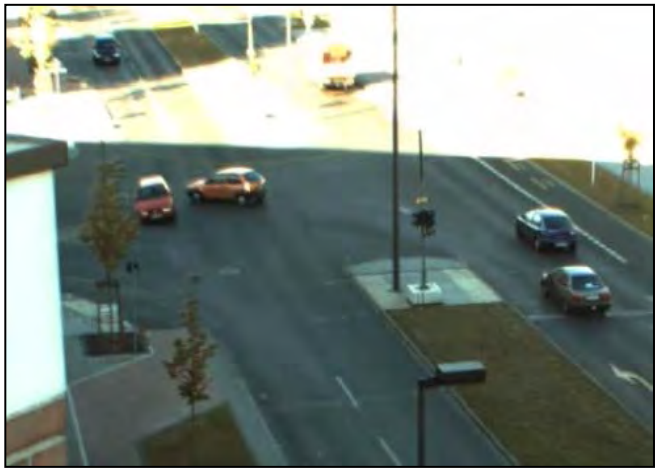
Atypical are situations that diverge from normal situations and are normally uncritical (U-turns, wiggly lines, etc.).

In OptiSiLK two methods developed and compared

- **Self Organizing Feature Map (SOFM)**
- **Probability Density Map (PDMap)**

Critical situations are situations, in which interacting traffic participants are timely and spatially near to each other (e.g. rear-end approaching at high speeds, intensive braking, etc.).

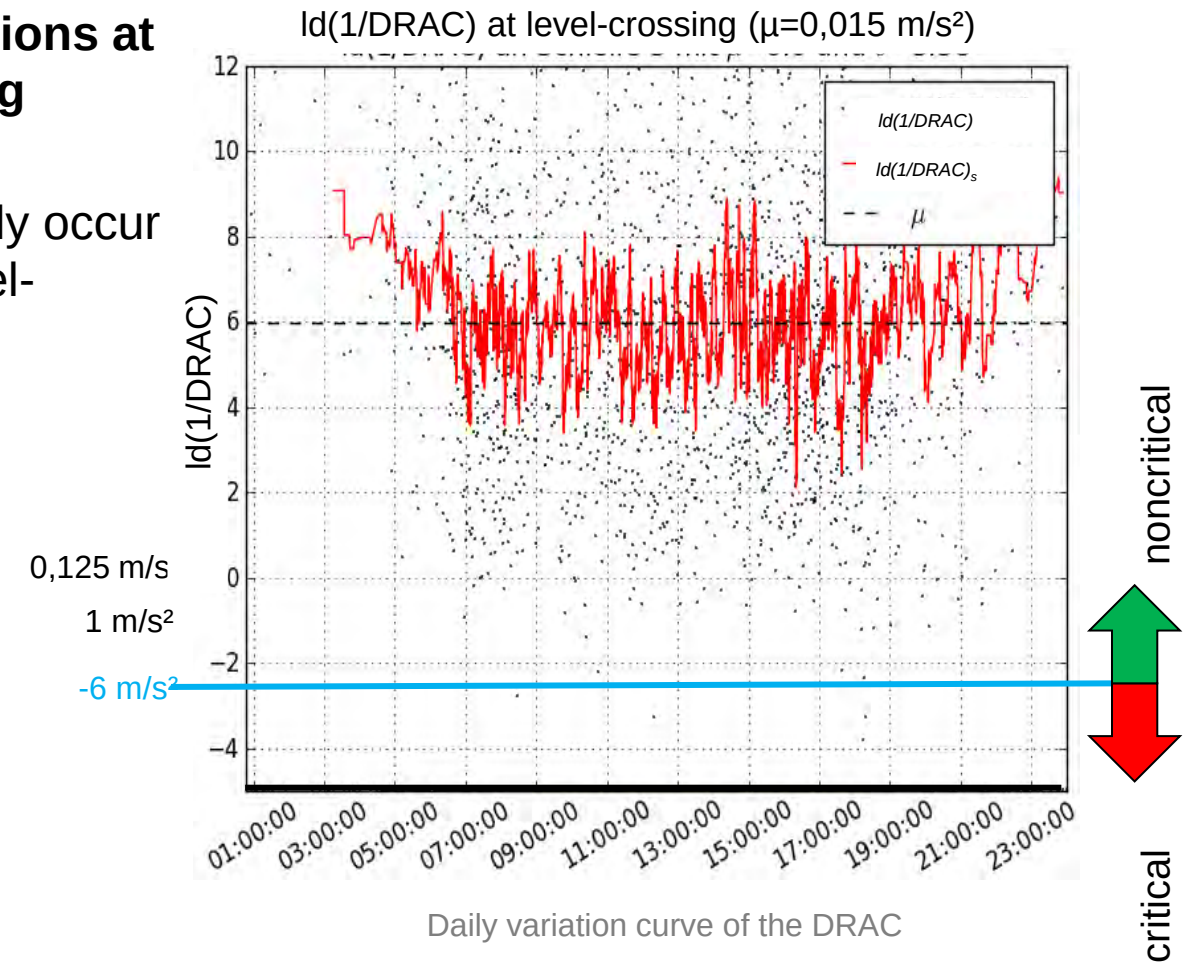
In OptiSiLK critical situations were quantified by determining parameters of the traffic conflict technique (TCT)



Detection of critical and atypical situations at the research level-crossing

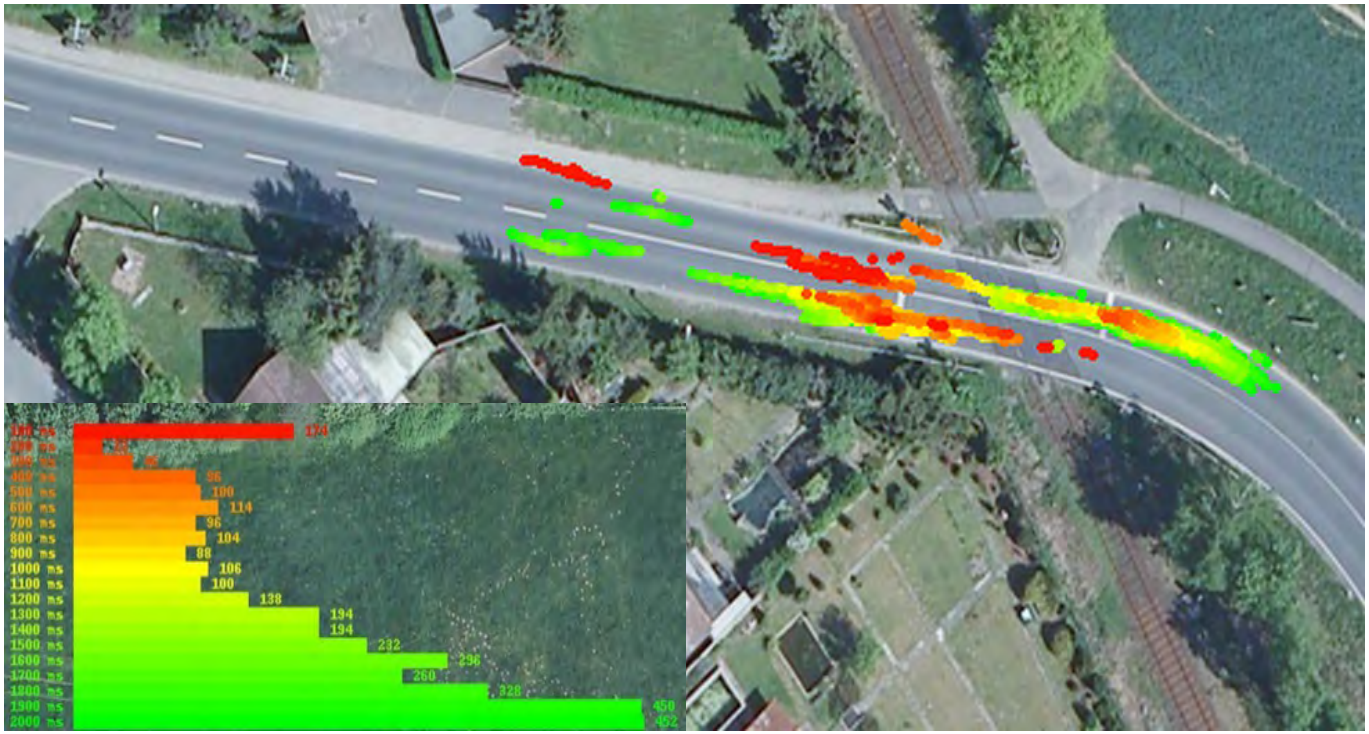
Critical and atypical situations at the research level-crossing

- Critical situations frequently occur on or directly after the level-crossing



Daily variation curve of the DRAC

Detection of critical and atypical situations at the research level-crossing



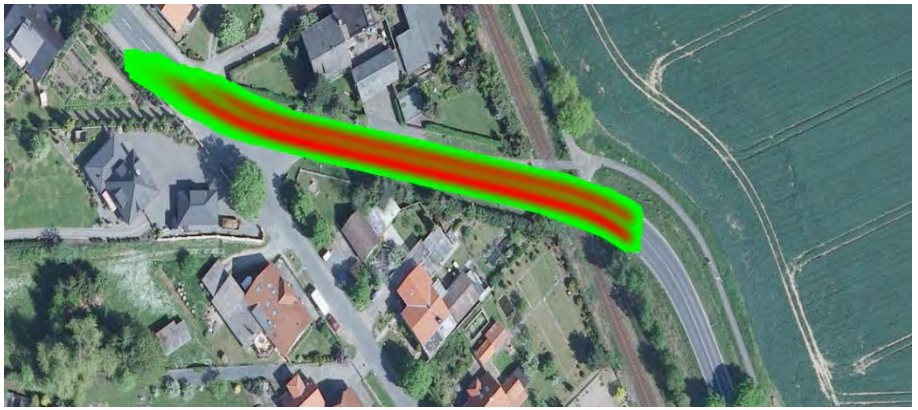
Critical situations at the AIM research level-crossing in Bienrode

Detection of critical and atypical situations at the research level-crossing

Critical and atypical situations at the research level-crossing

- Critical situations frequently occur on or directly after the level-crossing

- Atypical situations were automatically classified as follows
  - stopping
  - overtaking
  - Intensive braking and accelerating
  - Inadequate speed
  - (channels and trenches in the road)



PDMap of the positions for both directions

PDMap of the velocities for both directions

Detection of critical and atypical situations at the research level-crossing

Example of an automatically detected atypical situation at the research level-crossing

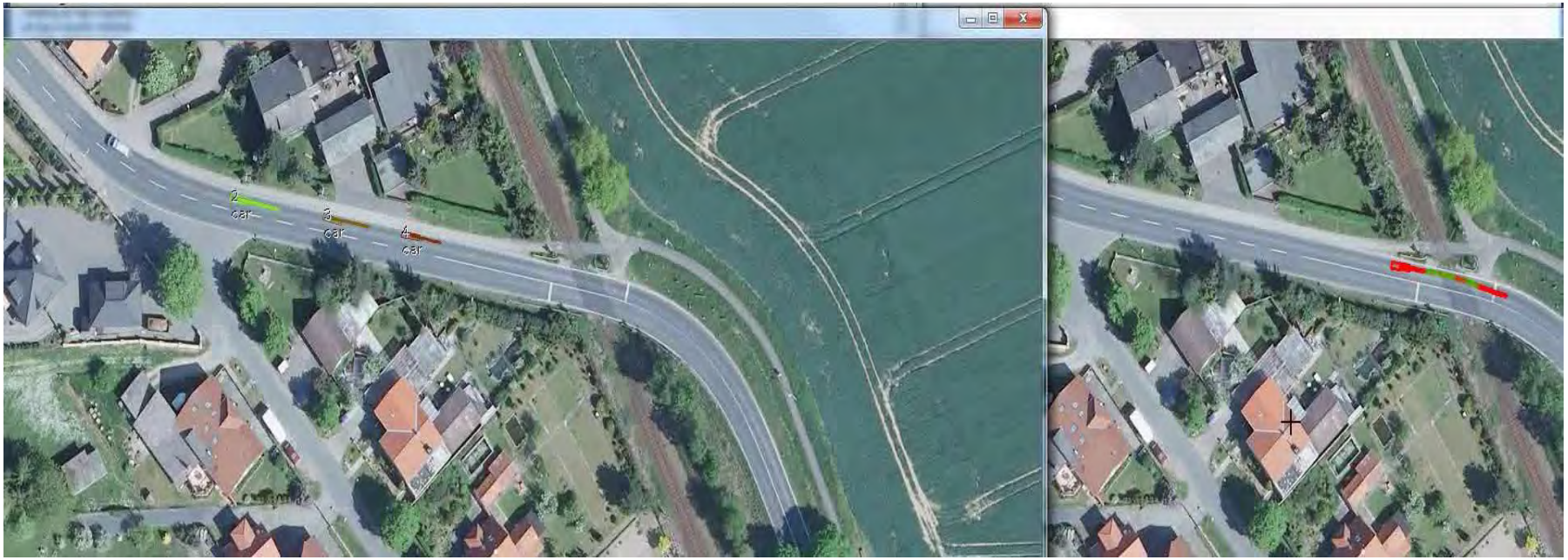
- Overtaking situation

- Computation of normal values of
  - position
  - velocity
  - direction of travel
  - acceleration
- These values are combined to a total normality value within [0;1]

Overtaking situation

Detection of critical and atypical situations at the research level-crossing

Example of an automatically detected atypical situation at the research level-crossing



Automatic determination of atypical situations at the AIM research level-crossing in Bienrode (normal Situations: green, atypical situations: red)

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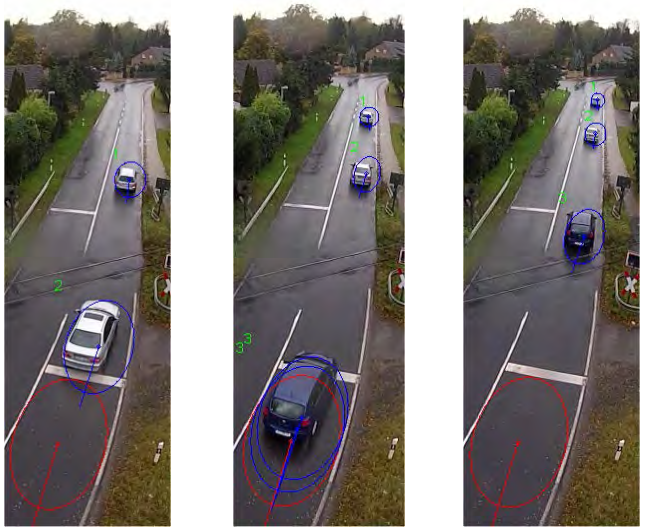
Conclusions & Future Prospects

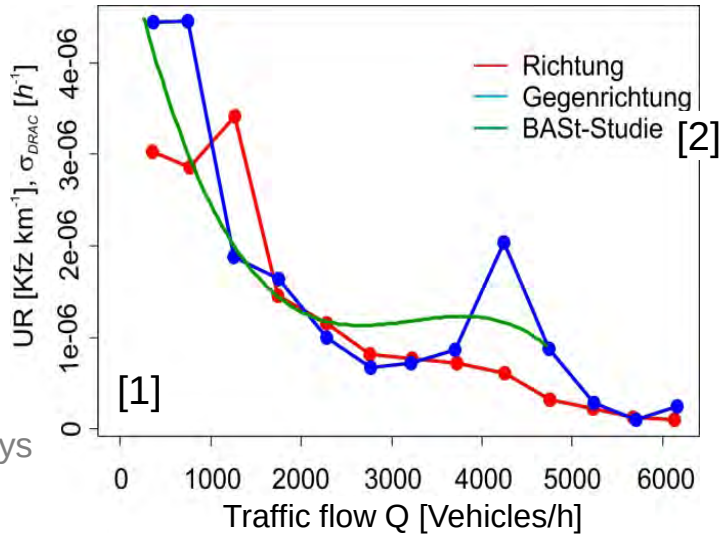


Conclusions

- Development of a robust method for wide-area traffic detection, classification and tracking of up to 120m
- Development and testing of several methods to measure atypical and critical traffic situations

Future Prospects

- Further development and extension of the robust method for wide-area traffic detection, classification and tracking at the AIM research intersection in Brunswick
- Analysis of the correlation between accidents and near accidents



[1] Biemann et al. 2014. Traffic safety versus traffic flow on freeways – an empirical analysis. 27th ICTCT Workshop in Karlsruhe, 2014
[2] Pöppel-Decker et al. 2003. Basics of line-based traffic accident analysis on Germany's freeways, reports of the Bundesanstalt für Straßenwesen, Band M 153, Bergisch-Gladbach. (In German)

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