FORSCHUNGSINITIATIVE
KO-FAS

Driver Intent Inference Based on Parametric Models

Fahrerabsichtserkennung auf Basis parametrischer Modelle

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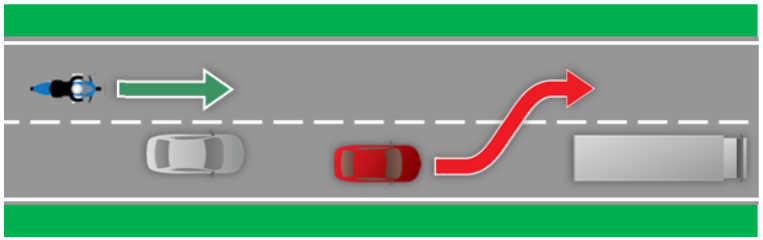
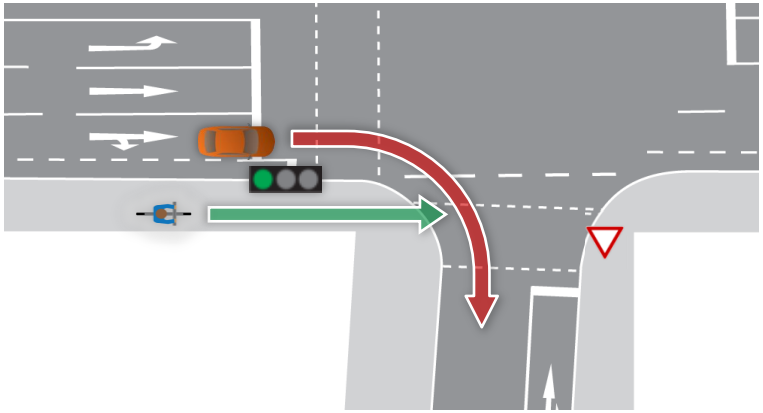
How do Accidents Happen?

1. Driving accidents, e.g. veering off the street.

➔ Numbers decreasing, i. a. thanks to ABS und ESP.

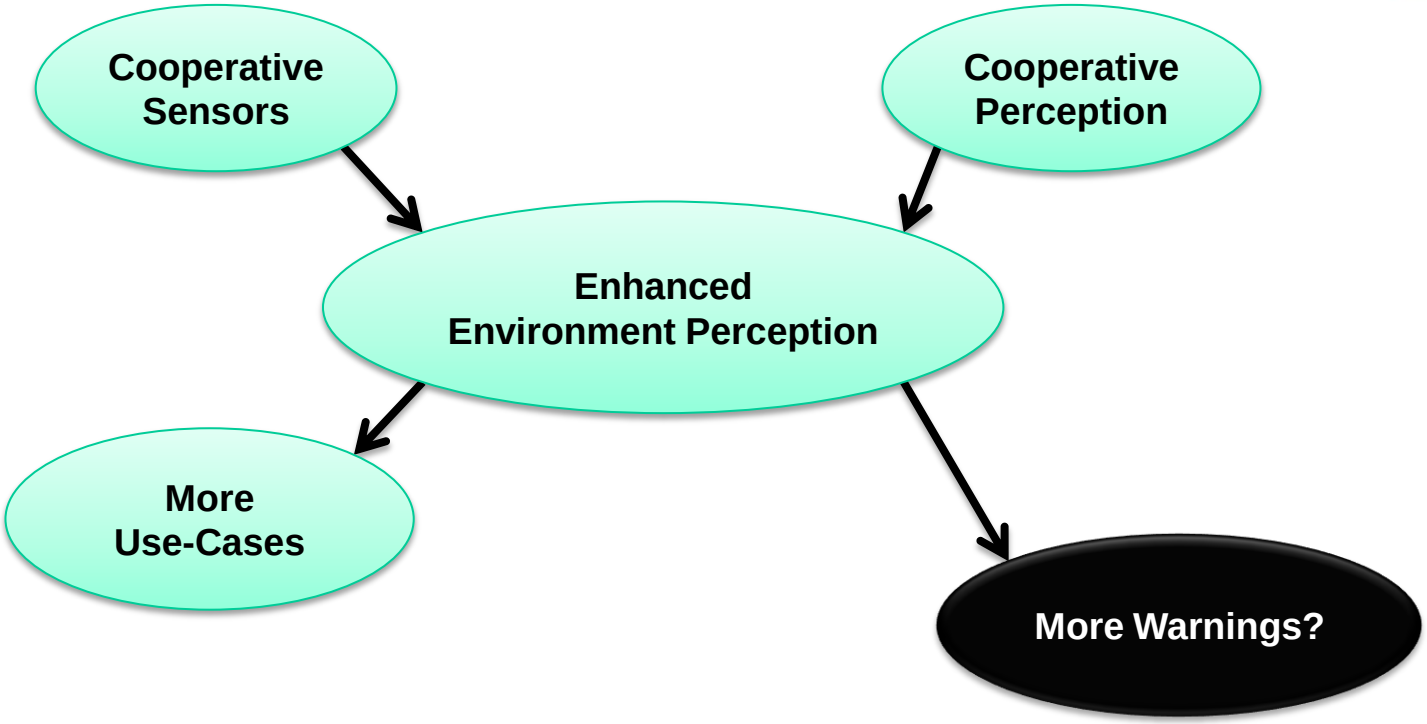
2. Accidents with at least two conflicting traffic participants.





➔ Driver misinformation is the most common cause of accidents!

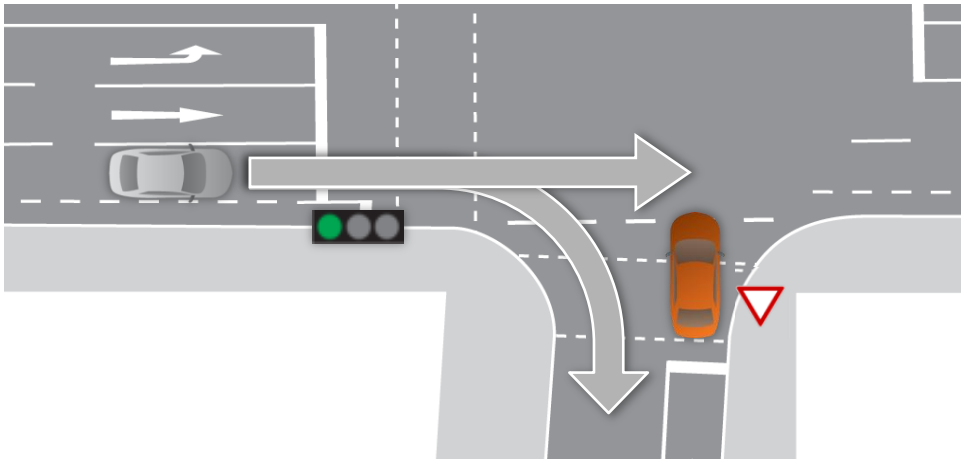
Driver Intent Inference
Motivation



- ➔ Unnessassary warnings need to be avoided.
- ➔ Knowledge of the driver‘s intent is essential to determine the relevance of potential conflicts.

Driver Intent Inference Challenges

Velocity-based right turn prediction



Huge variety of situations:

- Initial conditions
- Driving style
- Intersection geometry
- Surrounding traffic

Driver Intent Inference Challenges

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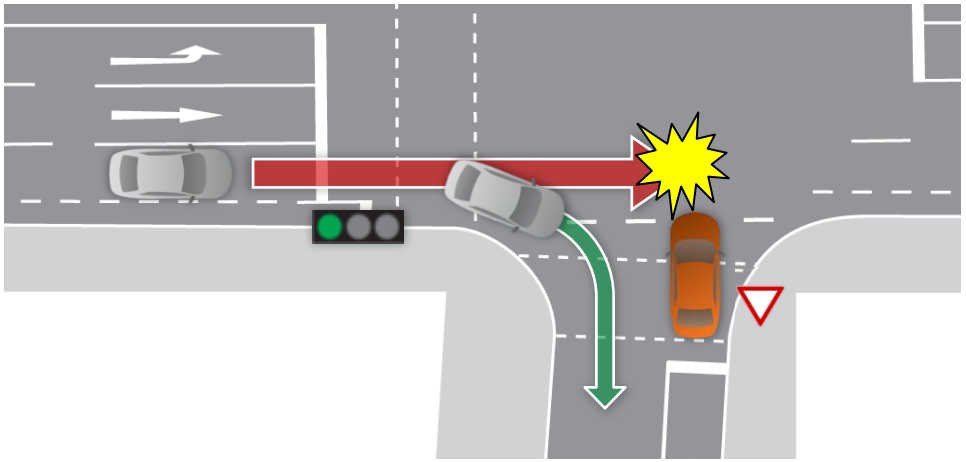
Velocity-based right turn prediction



Huge variety of situations:

- Initial conditions
- Driving style
- Intersection geometry
- Surrounding traffic

➔ Necessity to describe the underlying cause-effect relationships

$$\dot{v} = a\left[1 - \left(\frac{v}{u}\right)^{\delta} - \left(\frac{d^*(v,\Delta v)}{d}\right)^2\right],$$

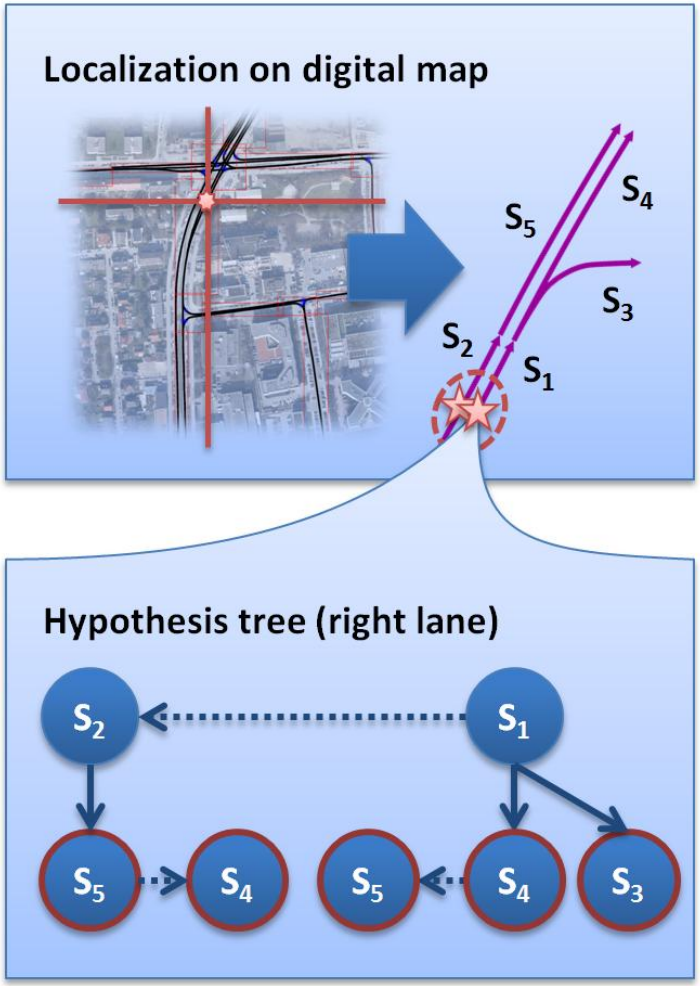
$$d^*(v,\Delta v) = d_0 + T\,v + \frac{v\,\Delta v}{2\sqrt{a\,b}}.$$

Parametric models:

- Natural way to integrate expert knowledge
- Generalize well to arbitrary situations
- Efficient to evaluate

Real World Traffic: Multiple Hypotheses

Self Localization and Hypothesis Tree.



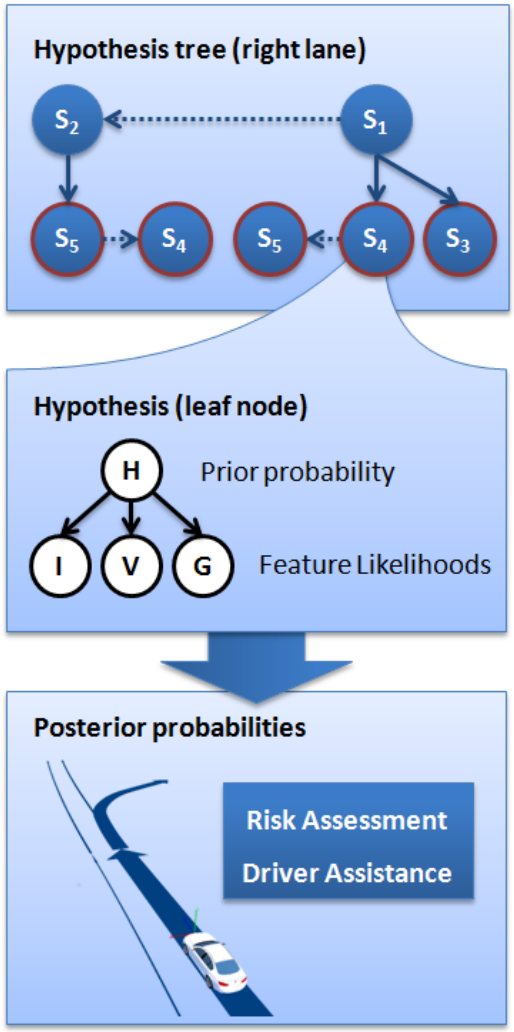
Digital map

- Database of distinct lane segments represented by their centerlines.
- For efficient map-matching, lane centerlines are modeled as circular arc splines.

Hypothesis tree

- Directed acyclic graph.
- Horizontal neighbours represent lane change maneuvers (one per lane segment only).
- Each leaf node represents a unique path through the intersection.

Path Probabilities



Prior probability:

- Lane assignment based on lateral deviation.
- Lane change probabilities based on remaining segment length.

Investigated features:

- Velocity profile
- Indicator activation
- Gaze direction

Posterior probability:

$$P(H|O) = \frac{\prod_i P(O_i|H)}{P(O)} P(H)$$

Feature Likelihoods

Normalizing Constant

Prior Probability

Velocity Feature

Intelligent Driver Model.

$$\dot{v} = a\left[1 - \left(\frac{v}{u}\right)^{\delta} - \left(\frac{d^*(v,\Delta v)}{d}\right)^2\right],$$

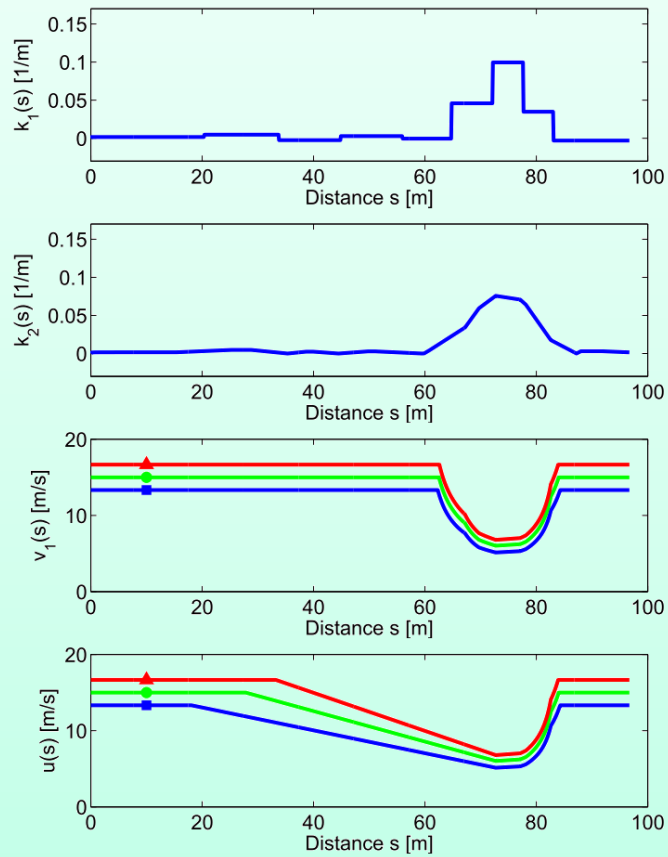
$$d^*(v,\Delta v) = d_0 + T\,v + \frac{v\,\Delta v}{2\sqrt{a\,b}}.$$

Expected Acceleration

Observed Acceleration

Feature Likelihood

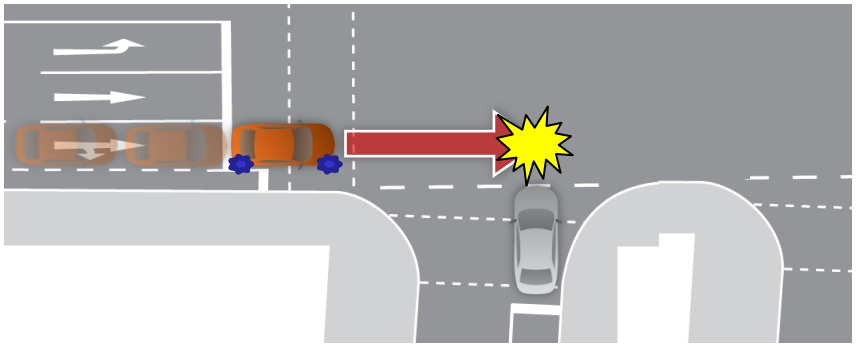
Turn Related Deceleration.



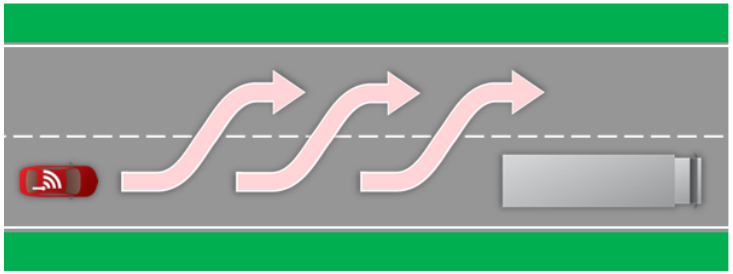
Velocity-Based Right Turn Prediction

Indicator Feature

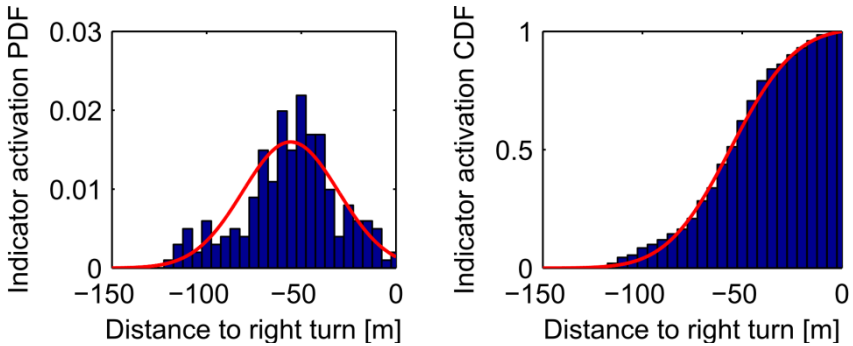
Multiple explainations for right turn signal.



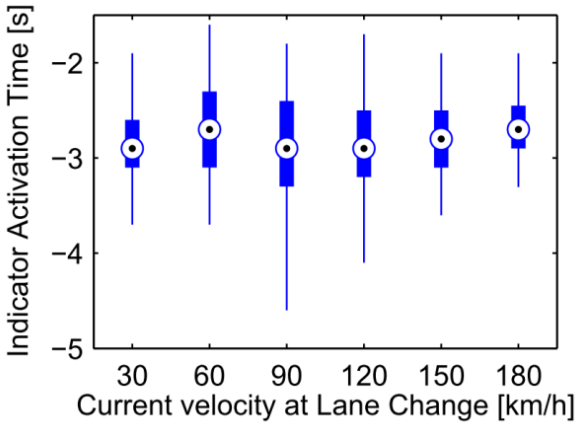
Exact time of lane changes.



Right turn indicator activation distances:

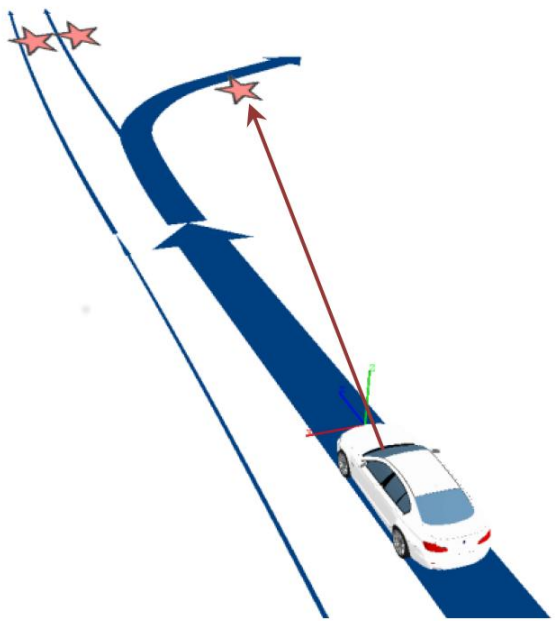


Lane change indicator activation time:

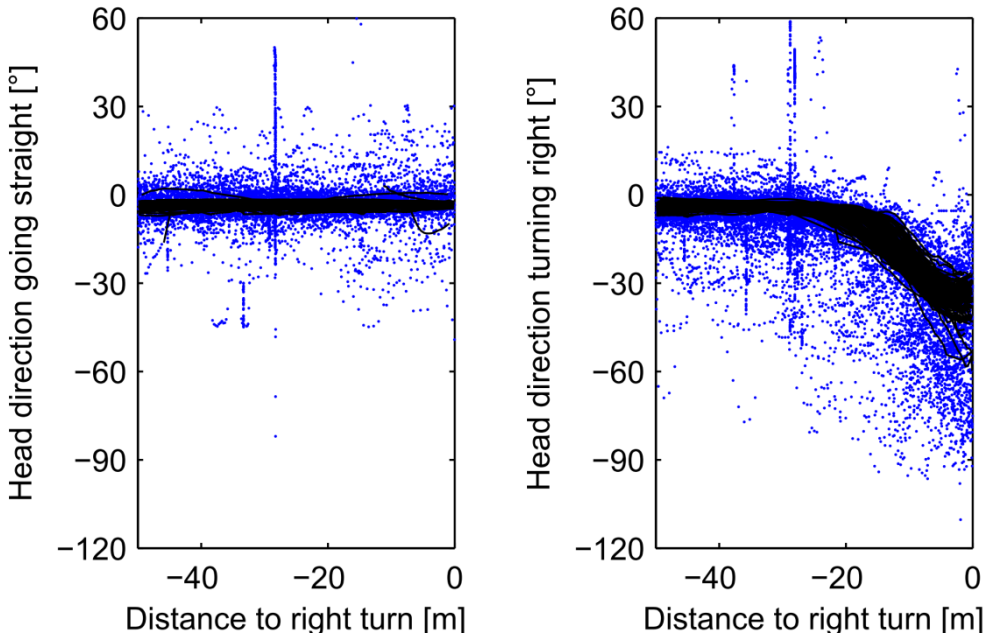


Gaze Direction Feature

Expected gaze points:



Expected vs. observed head direction:



➔ **Model can be used to evaluate arbitrary hypotheses!**

Right Turn Prediction: 12 Drivers, 5 Intersections, 400 Crossings

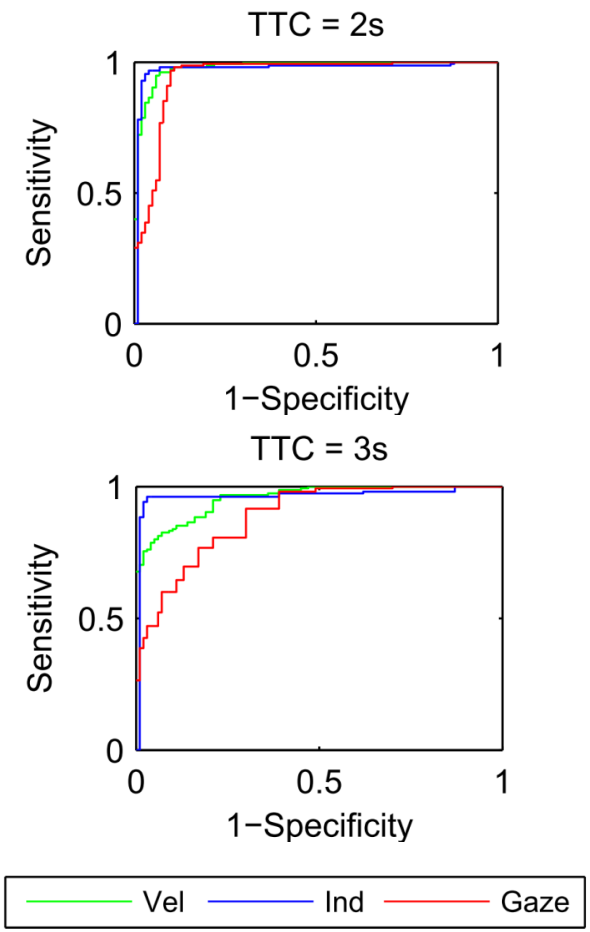


TABLE III

CLASSIFICATION RESULTS AT $TTC = 3\,\mathrm{s}$.

Ind	Vel	Gaze	Sensitivity	Specificity
-	-	-	0.56	0.69
-	-	+	0.92	0.71
-	+	-	0.97	0.70
-	+	+	0.98	0.74
+	-	-	0.96	0.98
+	-	+	0.96	0.98
+	+	-	0.97	0.98
+	+	+	0.97	0.97
0	-	-	0.15	1.00
0	-	+	0.19	1.00
0	+	-	0.67	1.00
0	+	+	0.75	0.99

➔ **Good classification performance even with implausible observation of the indicator feature!**

Conlusion and Outlook

Major achievements

- Prediction of entire paths rather than single maneuvers.
- Interaction with preceding vehicles taken into account.
- Driver intent inference for other traffic participants.

Ongoing work

- Add mirror glances to the driver gaze direction model.
- Driver situation awareness: Provide warnings only when neccessary.
- Evaluation of lane change prediction.

References

[1] M. Liebner, C. Ruhhammer, F. Klanner, C.Stiller, “Generic Driver Intent Inference based on Parametric Models”, IEEE Intelligent Transportation Systems Conference, The Hague, The Netherlands, Oct. 2013.

[2] M. Liebner, F. Klanner, and C. Stiller, “Active Safety for Vulnerable Road Users based on Smartphone Position Data” in IEEE Intelligent Vehicles Symposium, Golden Coast, 2013.

[3] M. Liebner, F. Klanner, M. Baumann, C. Ruhhammer, and C. Stiller, “Velocity-Based Driver Intent Inference at Urban Intersections in the Presence of Preceding Vehicles,” IEEE Intelligent Transportation Systems Magazine, May 2013.

[4] F. Klanner, R. Rasshofer, M. Liebner, A. Rauch, F. Schwarz, „Eine neue Dimension der Fahrzeugsicherheit“, Elektronik Automotive, Oct. 2012.

[5] M. Liebner, F. Klanner, and C. Stiller, “Der Fahrer im Mittelpunkt – Eye-Tracking als Schlüssel zum mitdenkenden Fahrzeug?” in 8. Workshop Fahrerassistenzsysteme Walting, 2012, pp. 87–96.

[6] M. Liebner, M. Baumann, F. Klanner, and C. Stiller, “Driver Intent Inference at Urban Intersections using the Intelligent Driver Model,” in IEEE Intelligent Vehicles Symposium, Alcala de Henares, Spain, June 2012, pp. 1162–1167, (best paper award).

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