FORSCHUNGSINITIATIVE

KO-FAS

Map-based Probabilistic Path Prediction

Forward Motion Prediction for Vehicle in Traffic Environments

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aufgrund eines Beschlusses des Deutschen Bundestages

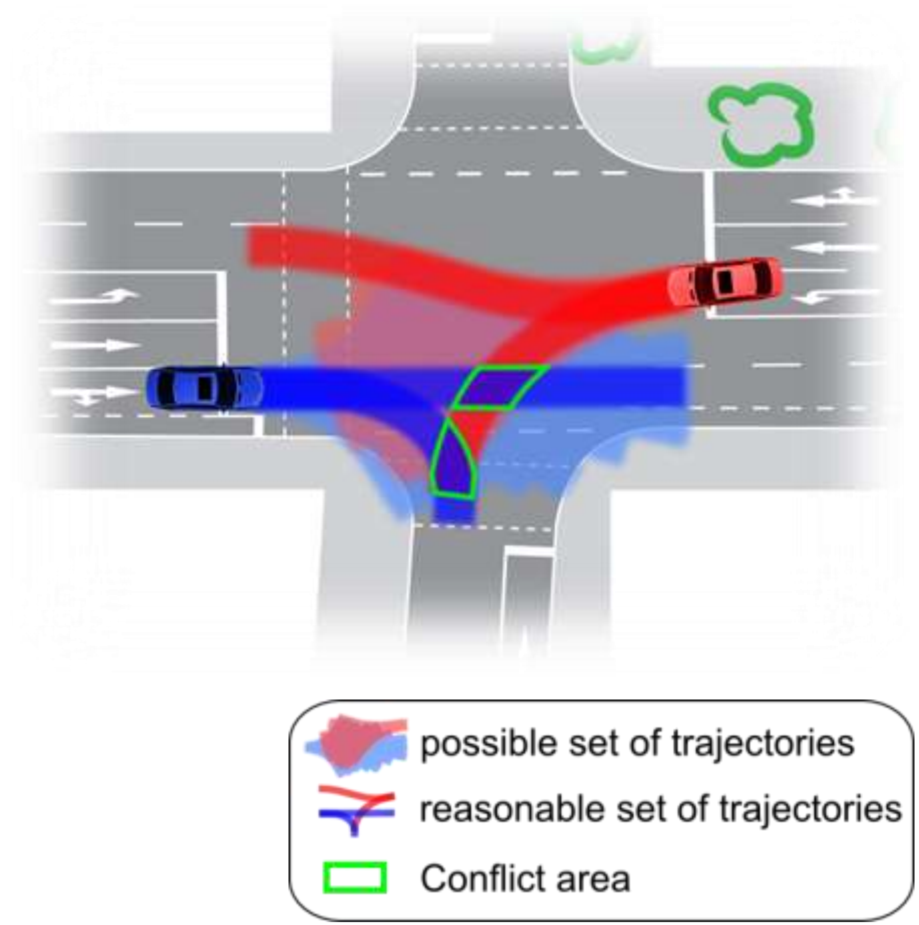
Probabilistic Path Prediction

Motivation

- **Preventive security**
  early recognition of potential collisions

Objectives

- Generate a **set of reasonable future trajectories** for each vehicle
- Find **potential conflict areas** between two vehicles

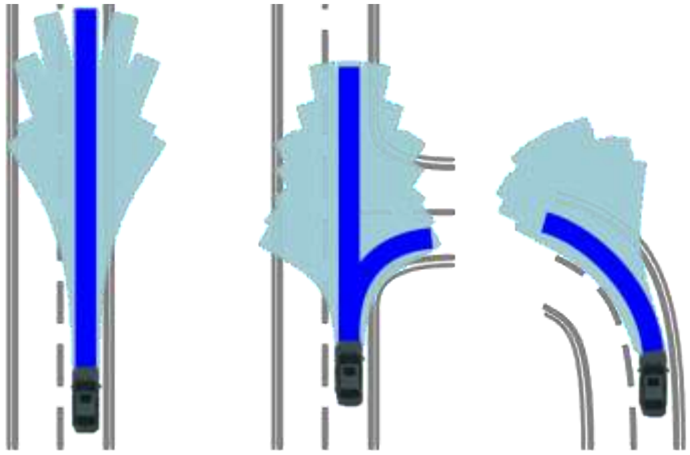


Probabilistic Path Prediction

Challenge

Infinite amount of possible future trajectories, depending on:

- **Current motion state** of vehicle
  (e.g. position, orientation and velocity)
- **Driver intention** to reach destination

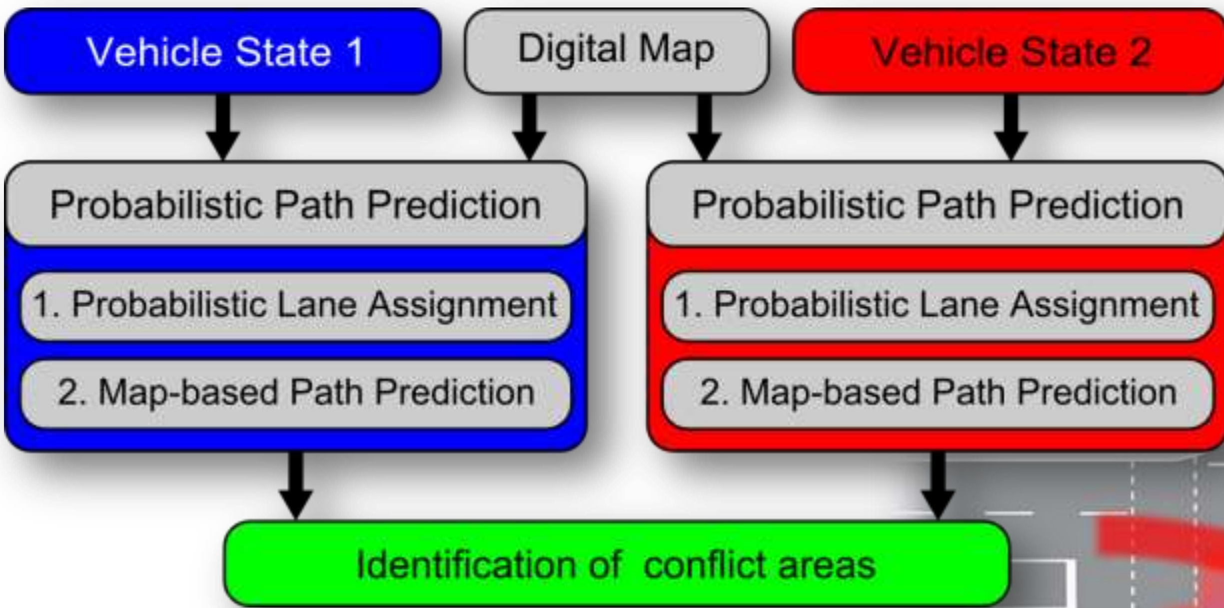


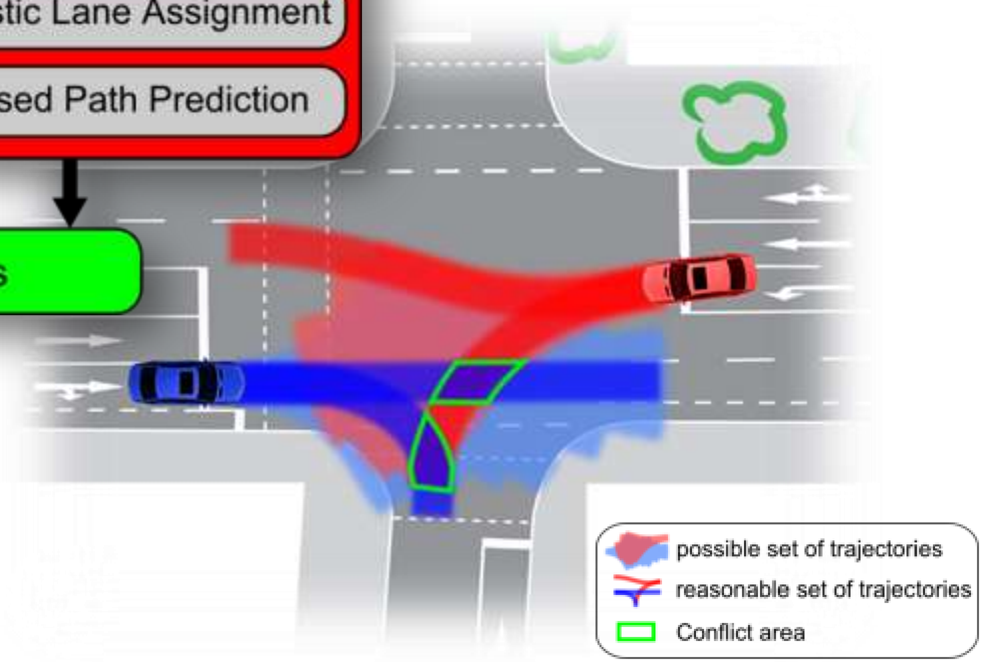
Solution

Use additional information of a digital map

- Vehicle motion is **constrained by the road layout**
- Each traffic lane represents a **possible future motion hypothesis**
- Generate and evaluate a **representative and reasonable set of future trajectories**

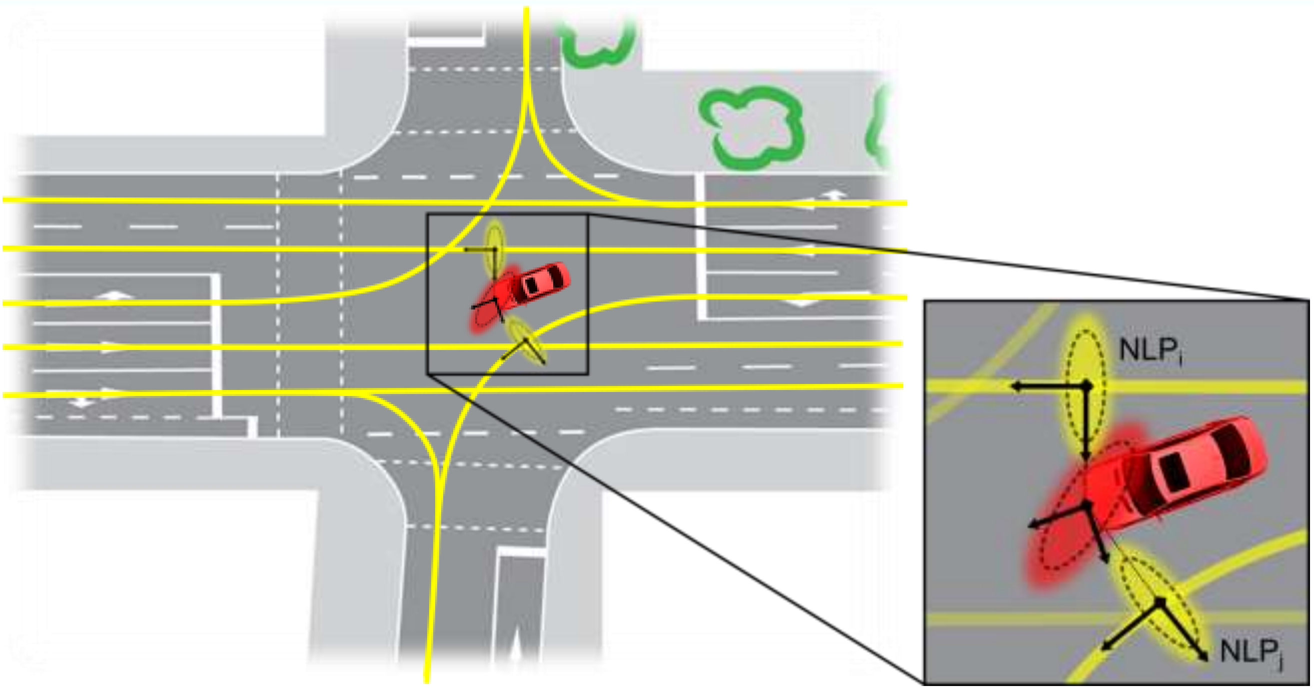
System Design





- **Digital Map**
  SICK, Roland Krzikalla
- **Vehicle State Fusion**
  Uni. Ulm - DriveU Institut, Florian Seeliger

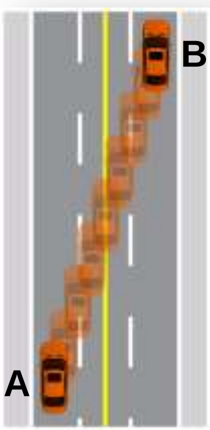
Model of Lane Information from the Digital Map

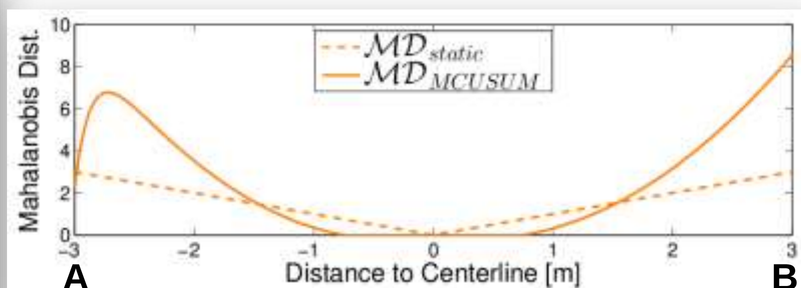


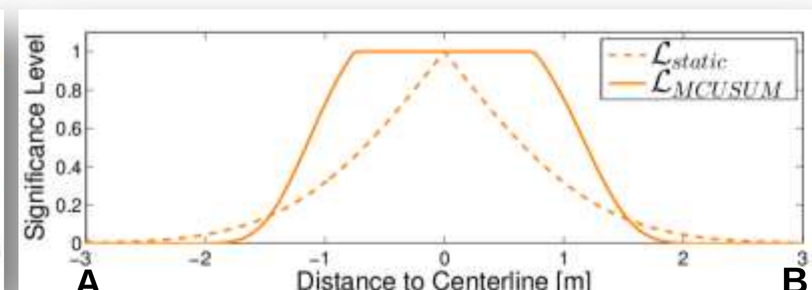
- Each lane is represented by its corresponding **Center-Line (CL)**
- Stochastic state vector at **Nearest Lane Point (NLP)** to vehicle position
  - State variables: **position, orientation and average (desired) speed** at NLP
  - Probabilistic model due to the uncertainties of the estimated lane state vector

Probabilistic Lane Assignment

- **Distance measure** based on Mahalanobis Distance (MD) of the **stochastic residual** between vehicle and NLP state vectors
- χ^2-test of squared MD leads to the **significance level ($\mathcal{L}$)** of the lane hypothesis
- **Modified multivariate cumulative sum (MCUSUM) algorithm*** to consider the **time evolution** of the distance measure







Distance Measure

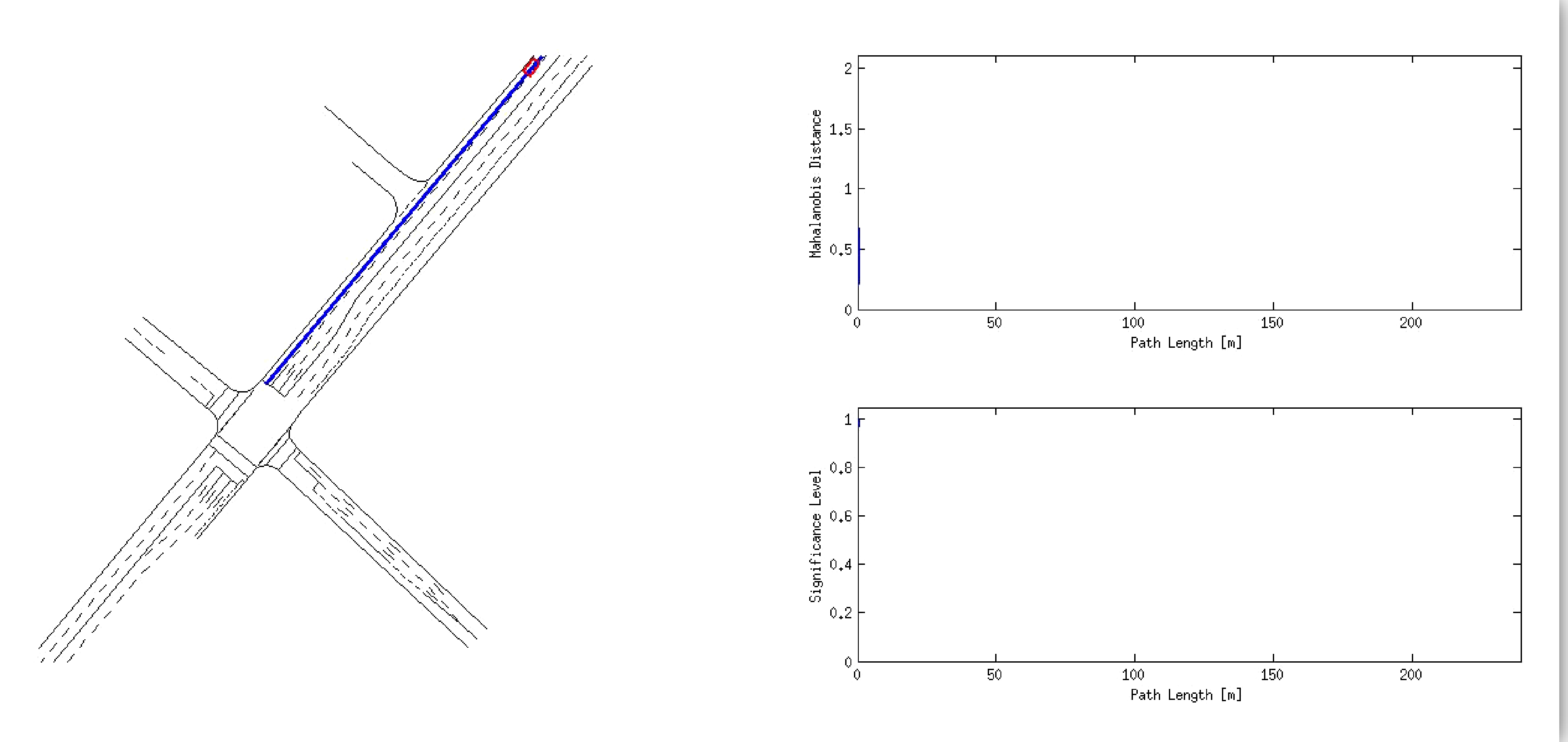
$$\mathcal{L} := \Pr\{\chi^2 > MD^2\} = \int_{MD^2}^{\infty} p_{\chi^2}(\xi)\, d\xi$$

* [Yi Dai, Yunzhao Luo, Zhonghua Li, Zhaojun Wang: *A New Adaptive CUSUM Control Chart for Detecting the Multivariate Process Mean*]

Result at Ko-FAS - Intersection

Example 1:

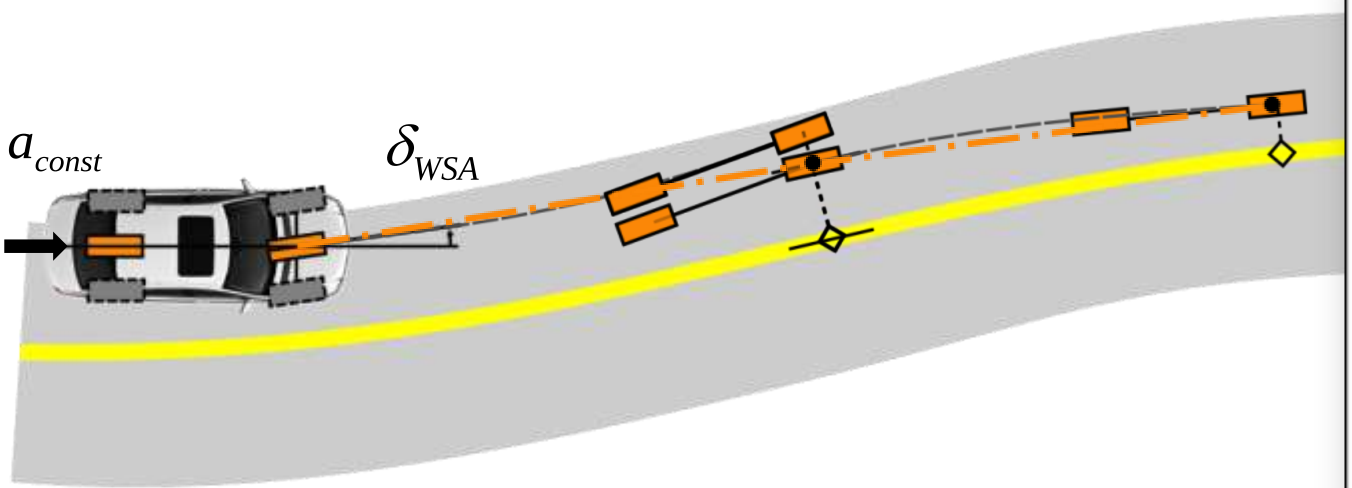
- Straight drive

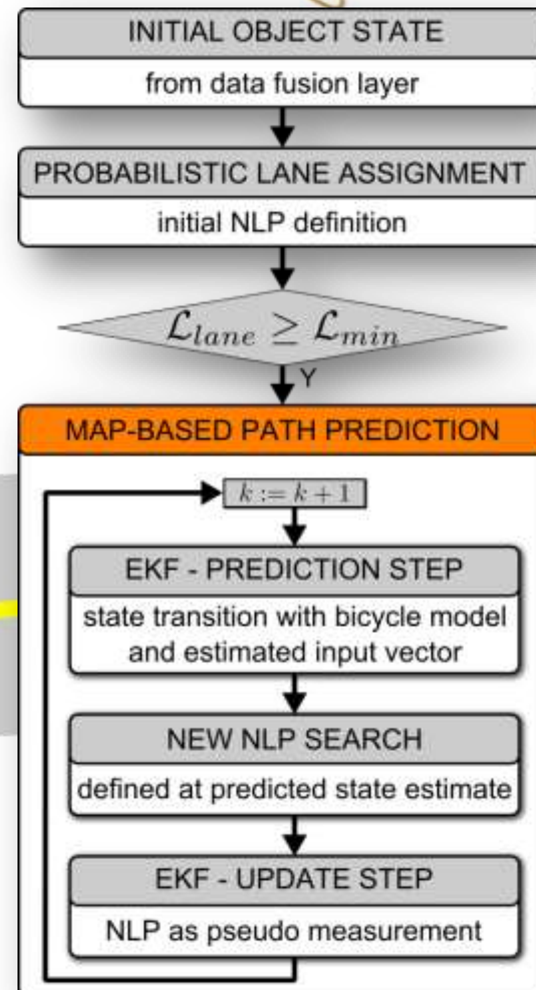


Map-based Path Prediction

Motion prediction with **Extended Kalman Filter (EKF)**

- Consider additional information in system model
- Kinematic **bicycle model** with constant acceleration assumption





Map-based Path Prediction

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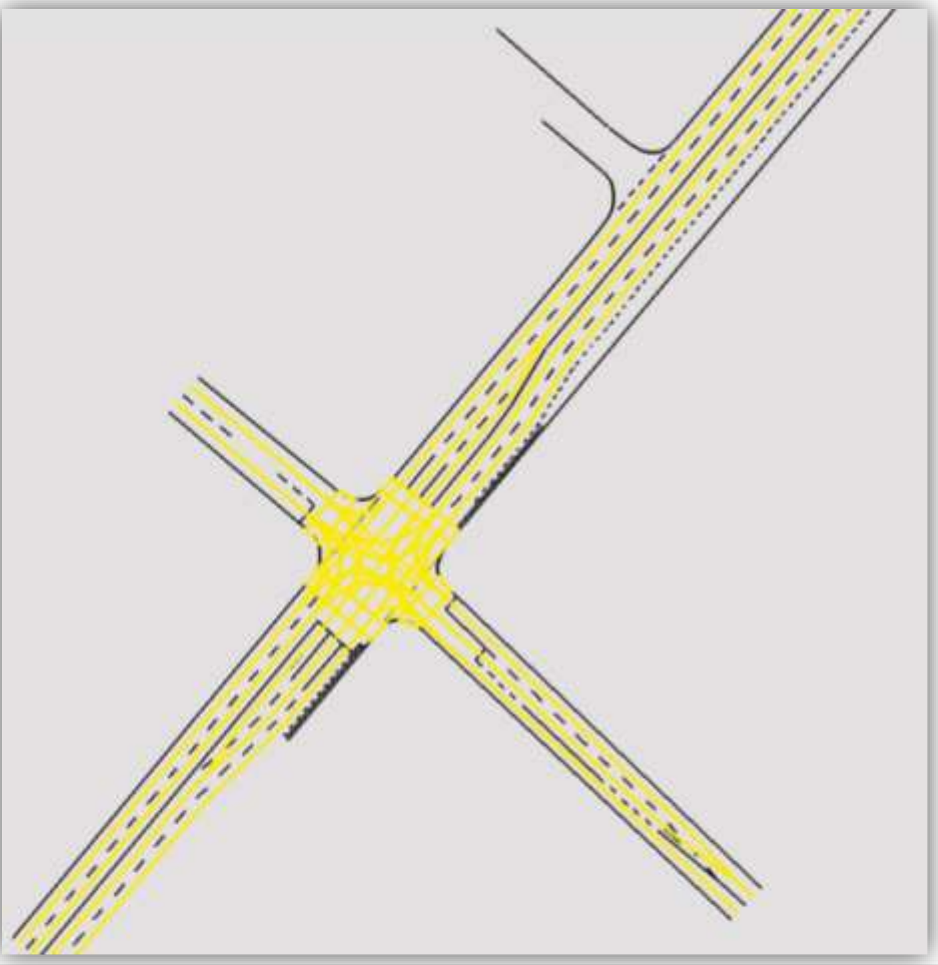
Result at Ko-FAS – Intersection

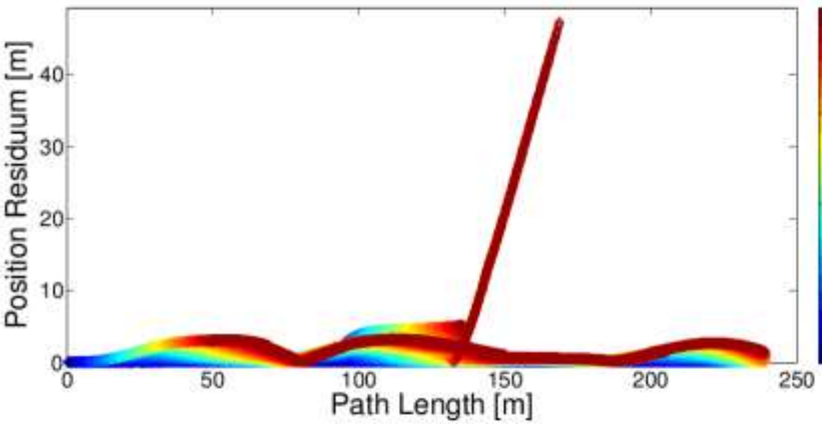


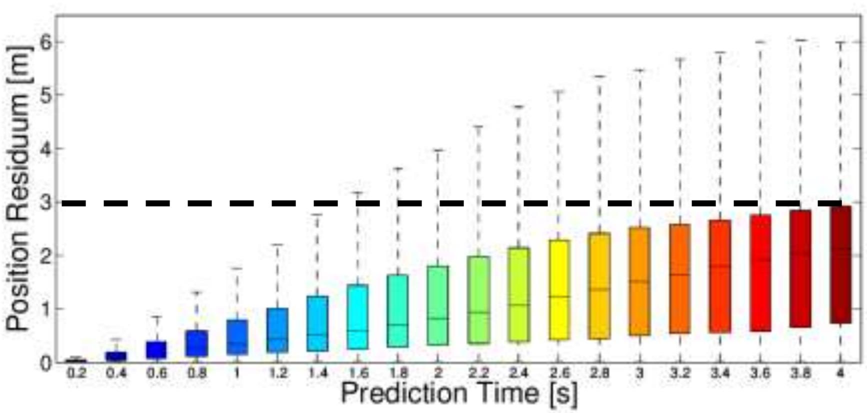
Example 1:
- Straight drive

Prediction parameter:
Time horizon: 4 s
Time interval: 0.2 s

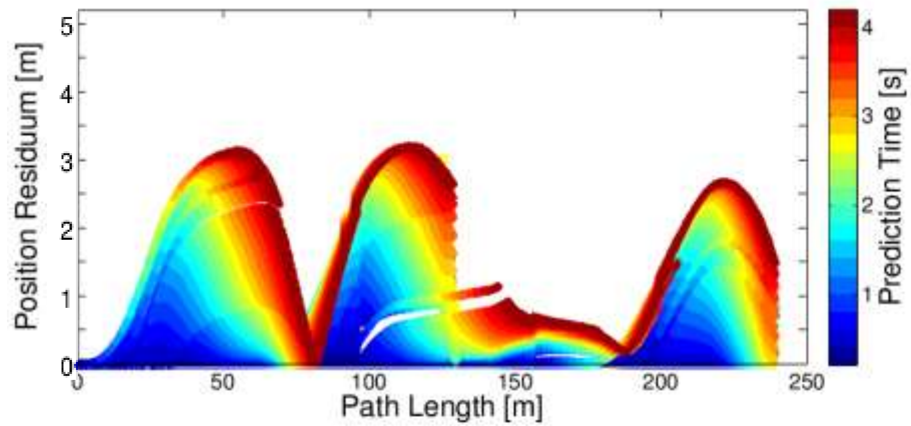
Map-based Path Prediction

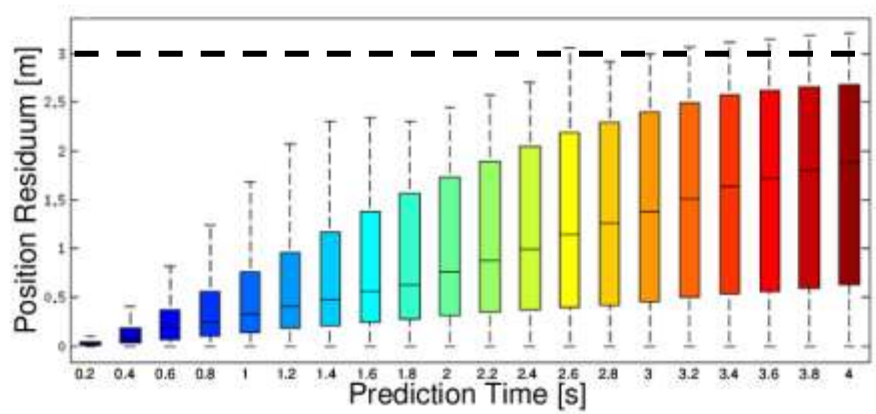
All relevant lane hypotheses





Only used lane hypotheses





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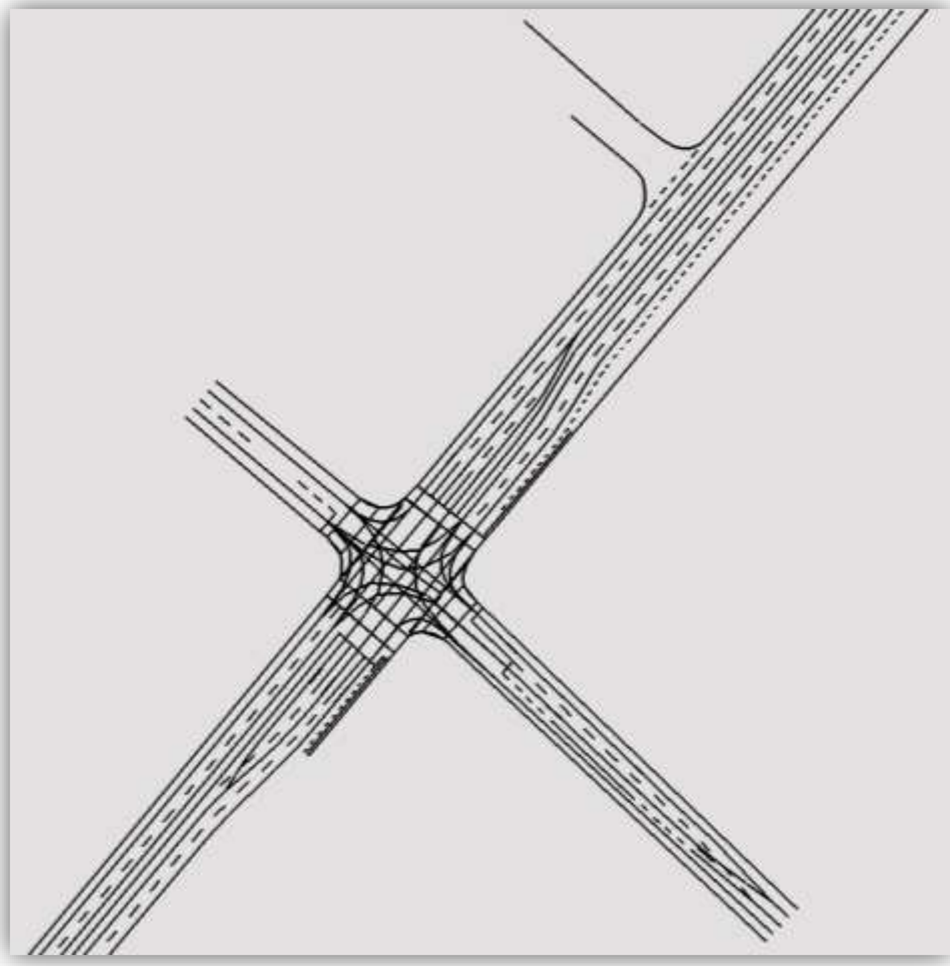
Result at Ko-FAS – Intersection

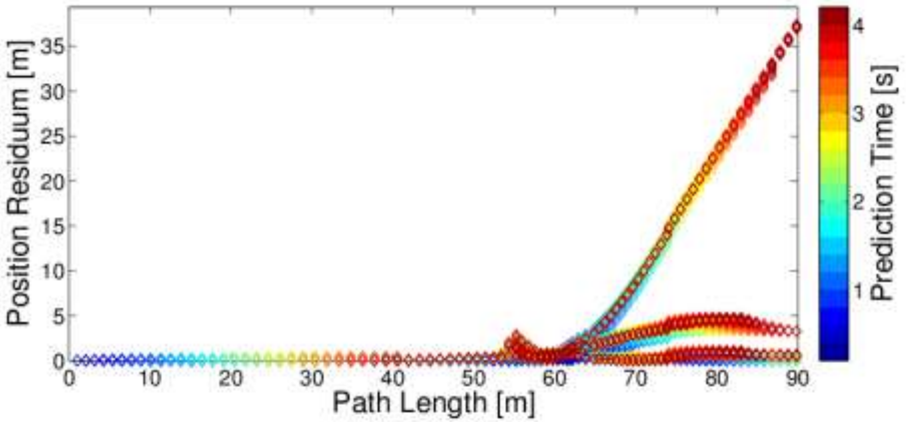


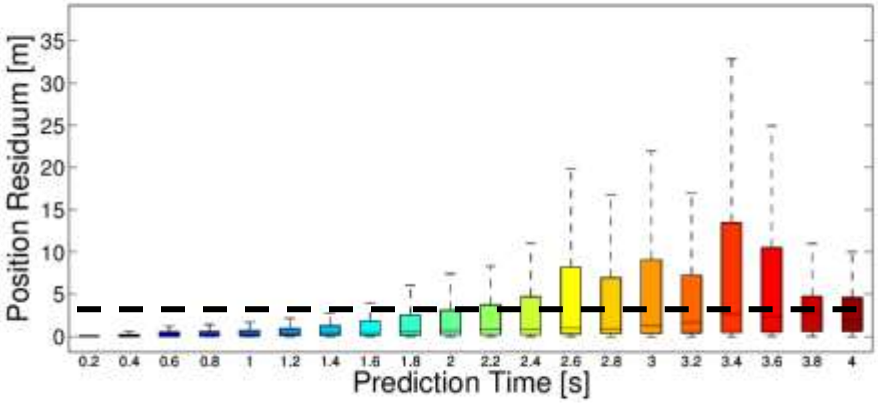
Example 2:
- Right turn maneuver

Prediction parameter:
Time horizon: 4 s
Time interval: 0.2 s

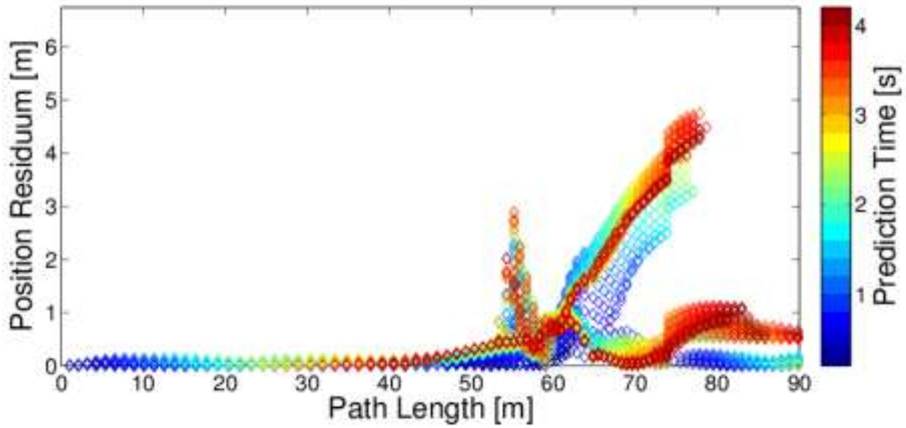
Map-based Path Prediction

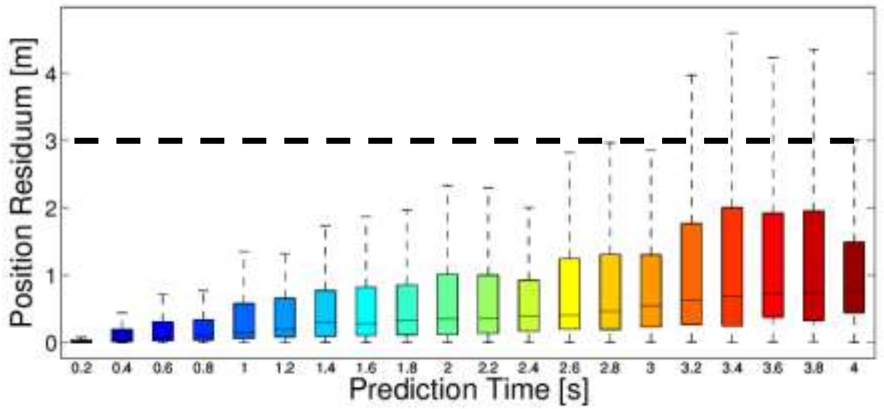
All relevant lane hypotheses





Only used lane hypotheses





Conclusion

Conclusion

- Incorporating **additional information from a digital map** into the motion prediction process
- Decrease the number of possible maneuvers to a **set of reasonable future trajectories**
- Provides an **efficient method** for long-term motion prediction

Future Perspectives

- Behavior prediction in case of **interactions with other traffic participants** and surrounding **infrastructure**

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Thank you for your attention