Map-based Probabilistic Path Prediction

Forward Motion Prediction for Vehicle in Traffic Environments

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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
• 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

• $\chi^2$-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

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

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

Result at Ko-FAS - Intersection

Example 1:
- Straight drive
Motion prediction with **Extended Kalman Filter (EKF)**

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

- 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
Thank you for your attention