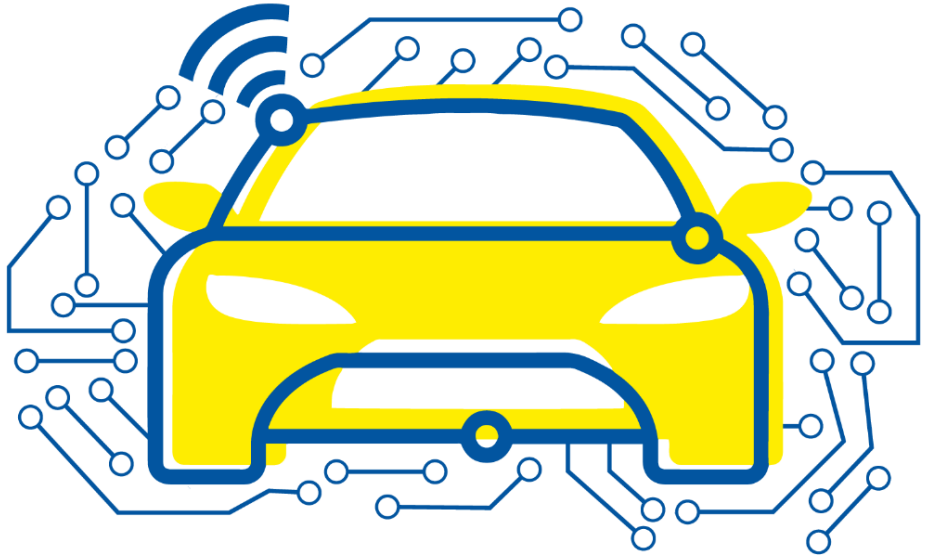
Automated and Connected Driving Challenges

Section 4 – Vehicle Guidance

Vehicle Guidance on Guidance Level Tasks



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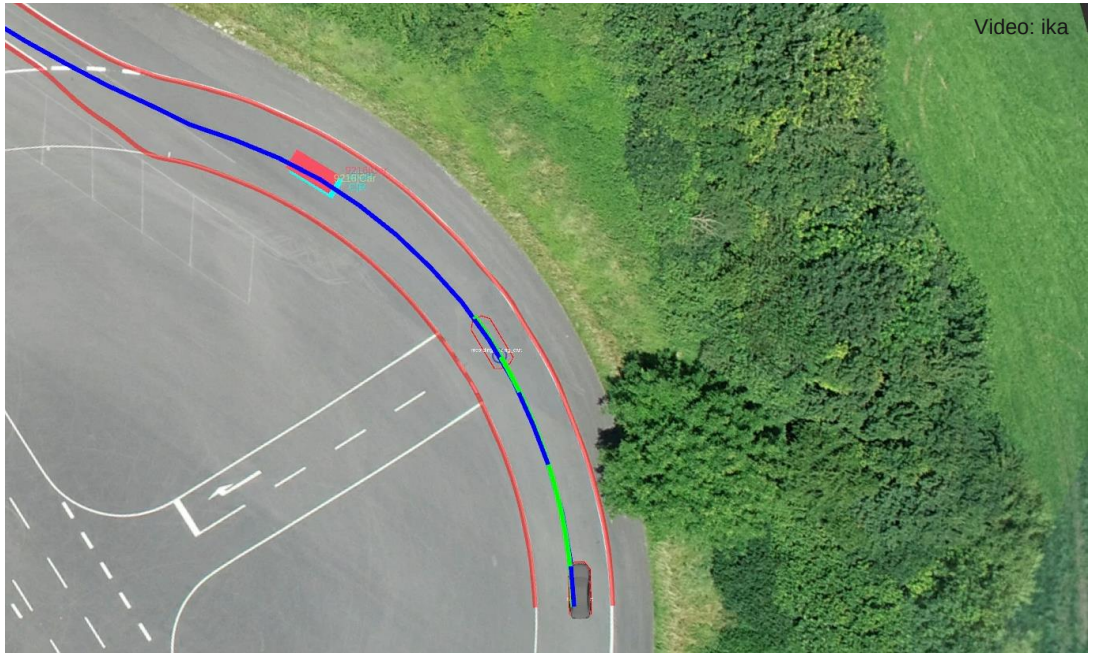
Vehicle Guidance on Guidance Level

Exercise

Assignment: Trajectory-Planning using a direct multiple shooting approach

- Implement the system dynamics model
- Integrate different cost terms regarding:
  - Lateral and longitudinal jerk
  - Steering rate
  - Velocity deviation
  - Dynamic objects
- Using a Closed-Loop-Simulation within the ROS-Framework



Vehicle Guidance on Guidance Level

Exercise 1 – OCP System Definition

1. Define system state
   - $\mathbf{x} = (x \quad y \quad s \quad v \quad a_{long} \quad \psi \quad \delta)^T$
2. Define system controls
   - $\mathbf{u} = (j \quad \alpha)^T$
3. Choose a vehicle model to describe the system dynamics:

Task 1

Kinematic Single-Track-Model

$$\dot{x} = ?$$

$$\dot{y} = ?$$

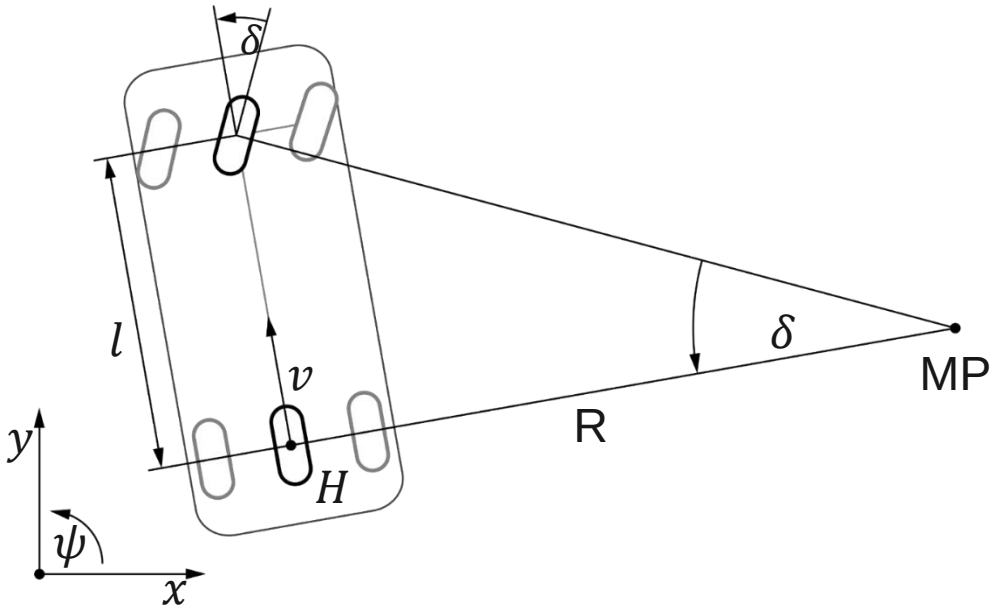
$$\dot{s} = ?$$

$$\dot{v} = ?$$

$$\dot{a}_{long} = ?$$

$$\dot{\psi} = ?$$

$$\dot{\delta} = ?$$



Constraints

$$0 \leq v$$

$$\delta_{min} \leq \delta \leq \delta_{max}$$

$$j_{min} \leq j_{long} \leq j_{max}$$

$$\alpha_{min} \leq \alpha \leq \alpha_{max}$$

$$\|\boldsymbol{a}_{max}\|_2 \geq \|\boldsymbol{a}\|_2, \quad \boldsymbol{a} = (a_{lon}, a_{lat})^T$$

Image: ika, Nietzschmann et al. 2018
Source: Nietzschmann et al. 2018

Vehicle Guidance on Guidance Level

Exercise 2, 3 & 4 – Definition of Cost Function

Cost function

Lateral jerk	$c_{j,lat}(\mathbf{x}(t), \mathbf{u}(t))$
Control variable penalty	$c_j(\mathbf{u}(t)), c_\alpha(\mathbf{u}(t))$
Reference path deviation	$c_p(\mathbf{x}(t))$
Consideration of dynamic objects	$c_{dyn}(\mathbf{x}(t))$
Heading deviation at end point	$h_N(\mathbf{x}(t))$

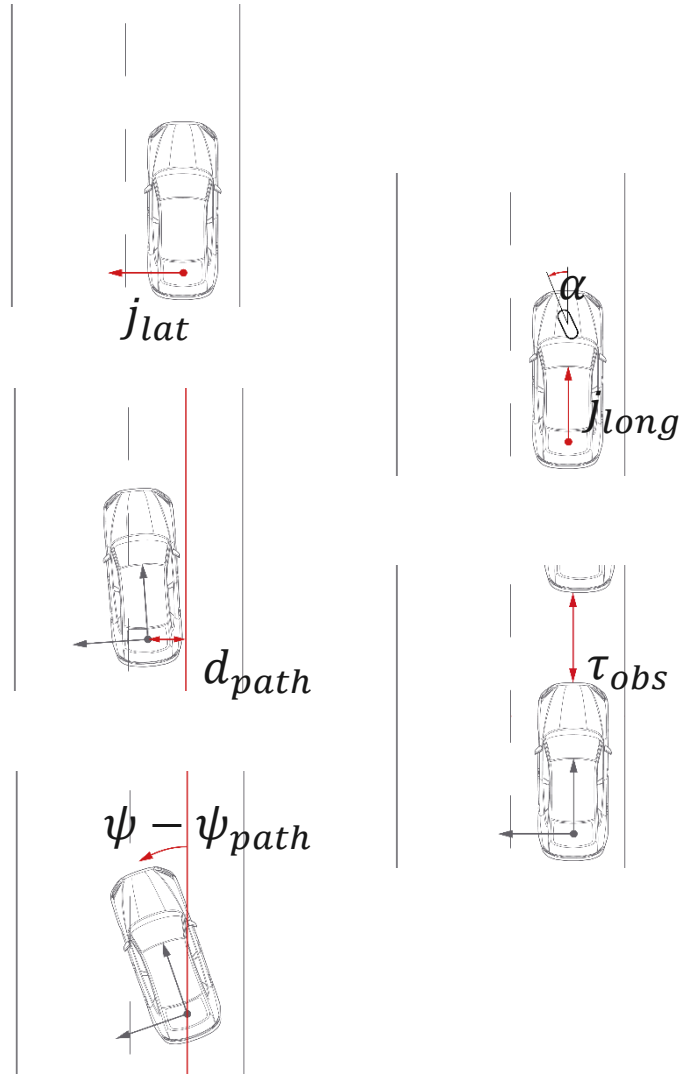
Task 2

Task 4

→ Deviation from reference velocity is propulsive term $c_v(\mathrm{x}(t))$

Task 3

$$\min_{\substack{\mathbf{x}_0,\dots,\mathbf{x}_N \\ \mathbf{u}_0,\dots,\mathbf{u}_{N-1}}} \sum_{k=1}^{N} [w_v c_{v,k}^2 + w_p c_{p,k}^2 + w_j c_{j,k}^2 + \cdots] + w_\psi c_{\psi,N}^2$$



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