Trajectory Planning and Formation Control for Automated Driving

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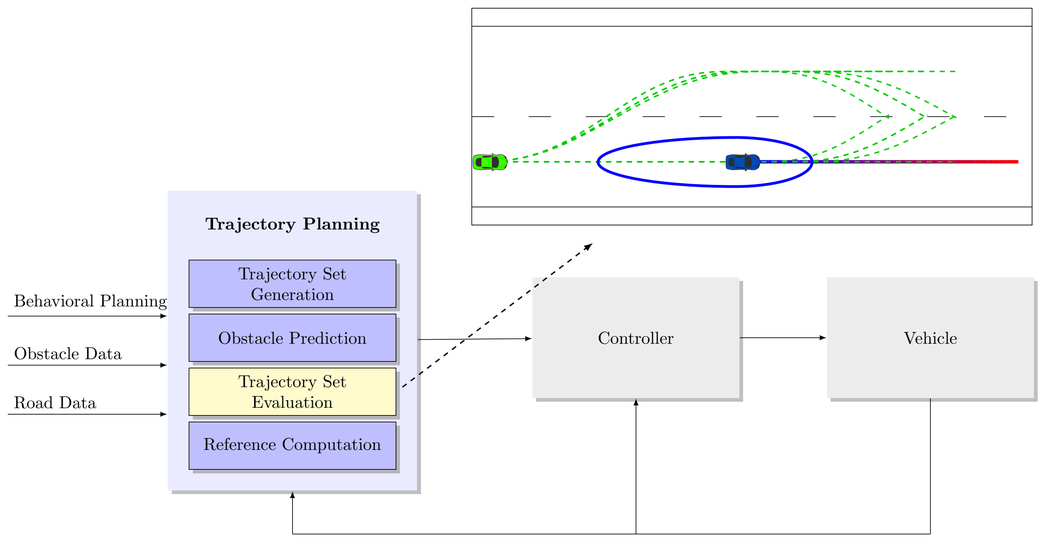
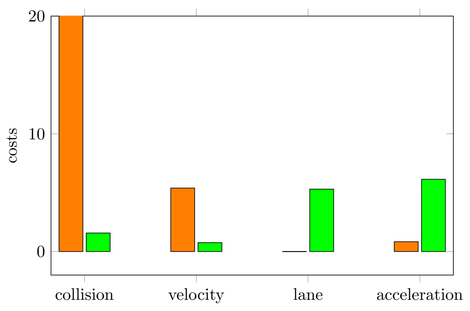
Trajectory Planning



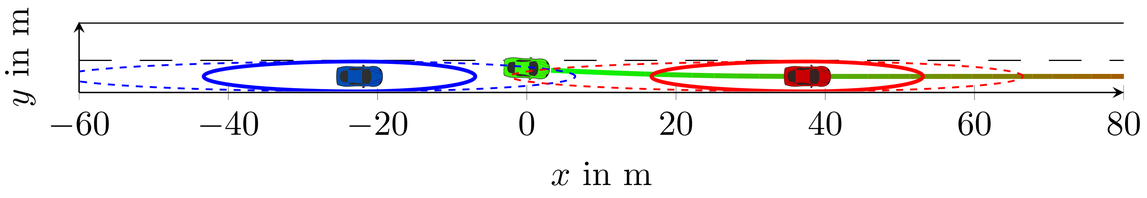
Trajectory Set Evaluation

- Collision avoidance (based on the prediction of other vehicles)
- Tracking of a desired velocity
- Choice of lane (drive on the right-hand lane)
- Comfortable driving (minimum acceleration)



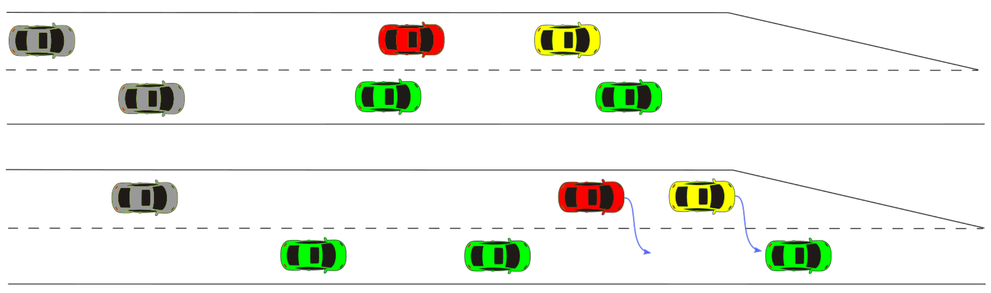
Scenarios

- Automated driving on a single lane
- Passing maneuvers in different scenarios
- Collision avoidance (e.g., obstacles in standstill)
- Merging to a desired lane despite high traffic volume



Cooperative Driving

Merging at Lane Reduction



1. Adaptation of velocity by a Formation Controller
2. Lane change via Trajectory Planning (with adapted velocity)

Car-2-Car Communication

No C2C

- Adaptive Cruise Control (ACC) (large inter-vehicle spacings)
- Predicition of other vehicles
- Lane reduction = traffic jam ?
- Advantage: no wrong information
- Disadvantage: limited efficiency

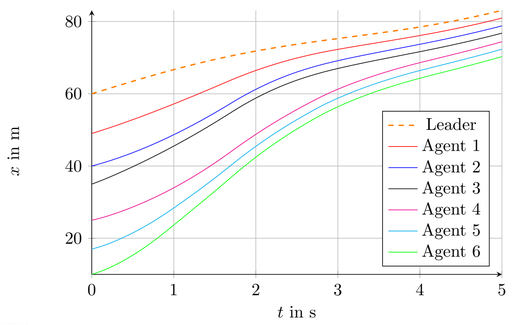
With C2C

- Cooperative ACC (small inter-vehicle spacings)
- Exchange of intentions
- Cooperative merging
- Advantage: efficient maneuvers
- Disadvantage: time-delays/attacks/...

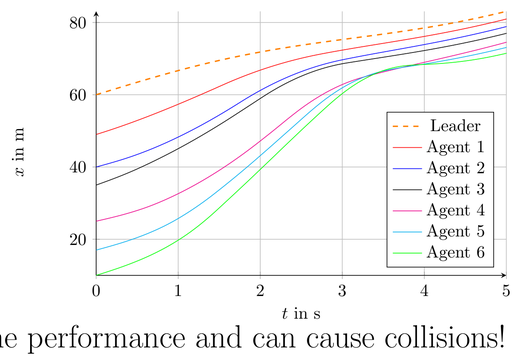
Networked Control Systems

First Order Sliding Mode Controller with small initial spacing errors using feed-forward: acceleration of the preceding vehicle is communicated

Perfect communication:



Delayed communication ($\tau = 0.25\,\mathrm{s}$):

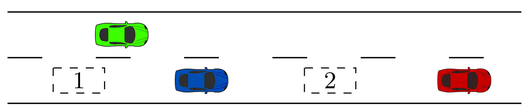


Time-delays and packet dropouts degrade the performance and can cause collisions! Moreover, large initial spacing errors can not be handled.

Formation Control with Non-Zero Initial Spacing Errors

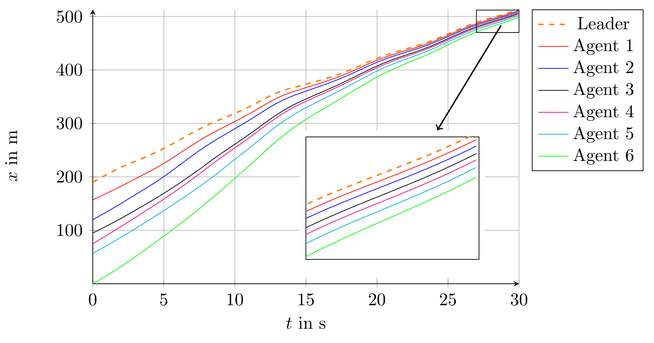
- Adaptation of the velocity
- Consideration of String Stability:
  - large number of vehicles
  - collisionfree (positions)
  - applicable (accelerations)
- Without communication

- **Reaching the formation**
- Keeping the formation
  - velocity-dependent distance ✓
  - **constant distance**
    - string stable without C2C **?**
- **Sliding Mode Control**



Predecessor Selection based on

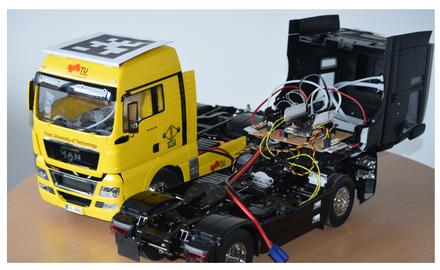
- lane
- relative velocity
- relative position



Main Contribution

- adaptive time-headway for non-zero initial spacing errors
- string stability for constant distance spacing without C2C

Application to Model Trucks

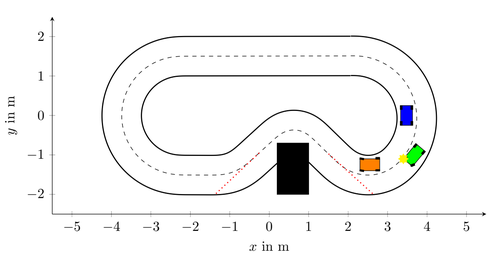


Data:

- Trucks (1:14) with Beagle Bone Board
- Position tracking via webcams ("GPS")
- Implementation of assistance systems
- Real-time capability

Szenarios:

- Longitudinal and lateral trajectory tracking
- Lane change
- Collision avoidance
- Cooperative merging (no C2C)



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