Vehicle-2-X Communication to Enable Autonomous Driving Systems

Motivation

- Most autonomous vehicles are based on perception subsystem (on-board sensors, e.g., camera, radar, lidar and GPS) and control subsystem
- Approach imposes some drawbacks:
  - Limited perception range and accuracy of on-board sensors
  - Complex integration (high cost) of sensors into current vehicles
- V2X communication allows the exchange of information among nearby autonomous vehicles by means of ad hoc networking
- Cooperative Autonomous Driving Systems (C-ADS) combine vehicular communication and autonomous driving to enable two key features:

Cooperative Sensing

- Increases sensing range of autonomous vehicles
- Allows cars to “see” behind obstacles and around corners

Cooperative Maneuvering

- Allows a group of autonomous vehicles to drive coordinately
- Enhances the safety and efficiency of maneuvers

Performance Evaluation of Convoy Communications

- Use of coupled vehicle and network simulation framework
- Simulation scenario:
  - Convoy of 6 to 32 cooperative autonomous vehicles driving on a highway
  - Propagation model: multi-slope log-distance with Nakagami fading
  - Transmission power and data rate from IEEE 802.11 OCB / ITS-G5
  - Average results of 10 simulation runs with 95% confidence intervals
- Main results:
  - Node coverage ratio (reliability) of the convoy communications is lower in large convoys, unless the interval between transmissions of convoy messages is increased
  - Communication delay of convoy messages increases with convoy size and message frequency
  - Trade-off between node coverage ratio and communication delay of convoy messages

Selected Publications


Testing Environments for V2X Communications

- Bidirectionally-coupled vehicle and network simulation framework
  - Webots: vehicle simulator with highly realistic vehicle dynamics
  - ns-3: network simulator with accurate V2X network model
  - Simultaneous execution of both simulators and information exchange via a communication plugin
  - Study impact of V2X communication on the maneuvering performance of C-ADS

- Hardware testing with Cohda MK5 on-board units
  - Dual IEEE 802.11 radios, processor running V2X software stack and GNSS
  - Protocol stack for cooperative automated driving developed in AutoNet2030 project
  - PXI channel emulator allows a higher realism
  - Planned field trials on actual vehicles driving in a circuit

Convoys of Autonomous Vehicles

- Fast and reliable communication to support autonomous driving, in particular for convoys of autonomous vehicles:
  - Groups of autonomous cooperative vehicles in line
  - Maintain close distance and travel to a common destination
  - Fully distributed control mechanism
- Periodic transmission of single-hop broadcast convoy messages allows convoy vehicles to maneuver cooperatively:
  - Vehicles exchange position, speed, heading and maneuver intentions
  - Each vehicle controller uses this information to steer the vehicle appropriately
- Convoy vehicles are subdivided into groups:
  - Convoy vehicle: vehicle that leads the convoy
  - Convoy messages: messages exchanged within a convoy

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