The potential impact of electric powertrains on vehicle dynamics, control systems and active safety

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SELF DRIVING CARS?

• The Inspiration - cars that drive themselves and make our lives easier

The Legacy from the 90’s:
• California PATH Program, Automated Highway Systems

• Evolution of the intelligent vehicle

Source: California PATH Program, 1997.

The real-world challenge

- A fully self-driving car must cover **three levels of driving**
- The central level (**tactical** or **maneuvering**) is the most challenging – for an autonomous vehicle this usually includes **path and speed planning** and hence knowledge / prediction of the road and traffic environment


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Electric drives:
- quick response
- precise and accurate control
- bi-directionality
- multiple independent actuators possible
- continuous operation
- ...

Electric drives can be used for:
- Energy recuperation
- Precision speed control
- Yaw moment control using torque vectoring
- ...

Direct Yaw moment Control system (DYC) to improve handling.
Potential of Electric Powertrain

Example, rear-end collision avoidance:

- Automatic Emergency Braking (AEB) reduces relative velocity
- Automatic Emergency Acceleration (AEA) with minor host displacement (2 m) increases reduction

“We want to design automated vehicles that can take any action necessary to avoid an accident.”

“The laws of physics will limit what the car can do, but we think the software should be capable of any possible maneuver within those limits.”

Professor Chris Gerdes
Dynamic Design Lab
Stanford University

Overspeed in curves:
- leads to a path outside the intended path (off-tracking)
- off-tracking may lead to road departure or collisions

Vehicle dynamic control at the limits of human driving

- Understeer compensation using independent four-wheel braking
  - 50kph/steer only
  - 60kph/steer only
  - 60kph/steer + optimal brake intervention

Collision Avoidance (single lane change)
Entry speed 90 km/h

How can we use the driveline?

Open Differential

Locked Differential

Vehicle dynamic control at the limits of human driving

- How can we use the electric powertrain?

- Dynamic Design Lab at Stanford
- Introducing MARTY (Multiple Actuator Research Test bed for Yaw control)
- Autonomous drifting using torque vectoring (and active steering)


Some future research challenges

• Context-sensitive driving support, e.g. for overspeeding in curve:
  — **Blind**: reference curvature command from driver action
  — **Map-sensitive**: mode of intervention from local map
  — **Road-sensitive**: e.g. curvature reference from the driver, local motion relative to the road.
  — **Full autonomy**: switch to full automated path and speed control (all other cases aim to support driver actions)

• Integrated lower control layer based on optimal force distribution (braking, steering traction)
Thanks for your attention!

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