Virtual testing of autonomous vehicles

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Who are Claytex?

• Model-based engineering analysis consultancy
  – Innovators in CAE process
  – Leading the way on zero-prototype development
  – Specialists in high-fidelity real-time simulation
  – Users of Dymola and Modelica since 1999

• Provider of software solutions for systems engineering
  – Dymola distributors since 2003
  – Dassault Systemes partner since 2008
    • 3DEXPERIENCE, Reqtify, ControlBuild, AUTOSAR Builder
  – rFpro system integrator and distributor since 2009

• Modelica library and FMI tool developers
• Dassault Systemes Certified Education Partner
• Offices in the UK, USA and South Africa
• Major customers include Automotive OEM’s, suppliers and Motorsport teams (Formula 1, NASCAR, Indycar)
Autonomous Vehicles Are Coming!

The government wants to see fully self-driving cars on the UK roads by 2021.

Baidu’s Chief Scientist expects large number of self-driving cars on the road by 2019

In an interview session, Andrew Ng, the chief scientist of the Chinese search engine Baidu expects that a large number of self-driving self-driving cars will be on the road within three years, and that mass production will be in full swing by 2021.

(Source: Quora, 2016-08-16, Digital Trends, 2016-05-24)

Audi to introduce self-driving cars

Scott Keogh, Head of Group Technology at Audi, has said that the company’s autonomous driving technologies would be ready by 2021.

(Source: IEEE, 2016-05-10)

GM: Autonomous cars could be deployed by 2022

General Motor’s head of foresight and trends Richard Spero of Detroit that most industry participants now think that autonomous cars could be deployed by 2020 or sooner.

(Source: Wall Street Journal, 2016-05-10)

Fully autonomous vehicles will be on the road before 2022, says NVIDIA CEO

The CEO of the chipmaker NVIDIA, Jensen Huang, said that “it will take no more than four years to have fully autonomous cars on the road.” This refers to actual cars driving on the road (not just car models being ready technically) and assumes that the key legal issues will also have been resolved.

(Source: Reuters, 2017-10-26)
How do we prove the AI is safe?

• Research has been carried out to determine the amount of testing required to prove autonomous vehicles are safer than human drivers
• Each software/hardware release will have to be validated
Testing autonomous vehicles

Simulation
- Huge number of scenarios can be considered
- Full control of virtual environment: traffic, pedestrians, weather, etc.

Proving Grounds
- Recreate critical scenarios
- Limited control of the environment
  - Robot controlled targets
  - Pedestrian targets
  - No control of weather and light

Field Tests
- Investigation of real driving situations
- No control of the environment
Simulation based development and testing

• rFpro delivers high fidelity representations of real world locations
• Define traffic, pedestrians, cyclists, traffic lights, etc.
• Control weather and lighting
• Open architecture to plugin vehicle models, sensor models and connect to other tools
Testing entire toolchain

- rFpro
- Validate vs Ground truth
- Control systems
- Sensor model
- Algorithms
- Vehicle physics
- HUMAN TEST DRIVER
Control weather conditions
Control the lighting conditions
Sensor feeds

- Apply effects to replicate what the sensors see
  - Lens distortion effects
  - Dirt
- Interpret the environment as range information
Validate algorithms

- Semantic segmentation of the environment
  - Access full object list
- Render the scene with each object type using a unique colour
- Accurate models of real world locations available
  - Proving grounds
  - Public roads
  - Race tracks
Vehicle physics model

- Multi-domain modelling and simulation of complex dynamic systems
- Component orientated modelling
  - Components represent physical parts: valves, gears, motor
  - Connections between parts describe the physical connection (mechanical, electrical, thermal, signal, etc.)
- Built on open standards of Modelica and FMI
  - Modelica is the modelling language
  - FMI is an open standard for model exchange
Vehicle Systems Modelling and Analysis

- Suite of Modelica libraries for Vehicle Systems Modelling and Analysis
- Core platform enables performance, fuel economy and energy analysis
  - Drive cycle simulation
- Application specific extensions provide detailed models across many areas
  - Engines, powertrain, vehicle dynamics, driver-in-the-loop
- Used for modelling conventional, hybrid and electric vehicles
- Real-time capable
- Integrates with rFpro
Summary

- Simulation will be an essential part of the development and testing of autonomous vehicles.
- Your tools need to provide:
  - detailed models of the environment
  - open API to allow sensor models to access details about the environment
  - support for HIL to include the real controller
  - vehicle physics model
Thank You

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