Holistic Range Prediction for Electric Vehicles

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"apply & innovate 2014"
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Outline

- Overview: Green Navigation
- Influences on Electric Range
- Simulation Toolchain
- System Integration
- Summary and Outlook
Green Navigation: Project Goals

Reliable range prediction through
- Consideration of route, traffic, vehicle parameters, charging stations, weather forecast, driver behavior
- Adaption of driving strategies and hints for different EV models, load and driver
- Decentralized and local route calculation providers based on a well-defined interface
Green Navigation: Project Goals

- Deterministic characterization of the electric vehicle
- Characterization of driver
- Consideration of 3D map data (slopes, curvature, crossings, charging stations)
- Consideration of weather impact (HVAC, wind, humidity, temperature, solar radiation, etc.)
- **innovative infrastructure to include real-time vehicle data and cloud based service providers**
- **model based development and early simulation using a novel integration and testing platform**
Green Navigation: Project Content

- Application Gateway
- Routing
- Driver Education
- Range Prediction
- Integration and Validation

S. Köhler, 29.09.2014
Green Navigation: Overview Range Prediction

- Vehicle Model
  - HVAC & Thermal Model
  - Static Consumers
  - Vehicle Parameters
- Environment Model
  - Charging Stations
  - Traffic Flow Information
  - 3D Map Data
- Navigation Services
  - Weather Information

Energy Consumption Prediction
Range Estimation

- Driver Model
  - Sensors
  - Driver Identification
Influences: Learning of Driver Influences

- Average deviation from speed limit
- Average accelerator pedal velocity
- Average brake pressure change
- Average time gap between gas and brake pedal usage

3 driver characteristics (Clustering)
Influences: Driver Identification

**Goal: Identification of Driver**
- Selection and improvement of learned driver model
- Adaptation of driving hints according to drivers’ preferences

**Approach**
- Identification via video or depth map image data
- Parameterization of driver model
- Automatic serialization/deserialization of driver model

**Driver Identification**
- Estimation of head attitude based on depth map and color image
- Extraction of silhouette from depth map data
- Identification of driver via SVM
- Driver specific profile and models
Influences: Weather Impact

Identification of significant weather parameters

- Temperature, solar radiation
- Wind velocity and heading
- Ambient pressure
- Sensitivity analysis

Weather data for target area (Karlsruhe-Stuttgart)

- Coverage of 14,000 km² target area (100 x 140 km)
- Cloud based service provider
  - Relevant parameters
  - Accurate temporal and spatial resolution
  - Forecast
  - Well-defined interface
Simulation Toolchain: Validation- and Test-Environment for EV

Validation

Vehicle data

Office (PC/Notebook)

System Experience Platform Mobile

Driving Simulator Stationary

Test Drives
Simulation Toolchain: Validation- and Test-Environment for EV

Parameterization
Visualization
Extended Interfaces
Simulation Toolchain: Vehicle Models

Introduction into Co-Simulation Toolchain

- Measurement model
- Modeling
- Simulation

- Available component models / parameters

- Static consumer
- Driving / operation strategies

Introduction into Co-Simulation Toolchain

Available tools:
- MATLAB
- Simulink
- AVL CRUISE
- CarMaker
Simulation Toolchain: Vehicle Parameterization

Parameterization (batteries, motor, control units)
Simulation Toolchain: Vehicle Parameterization

Vehicle Data Set

Powertrain Model: Electrical

General
- Integration Substeps: 5

Configuration: Parallel Hybrid
- Parallel Hybrid F1

Number of Electric Motors
- Vehicle with 1 Electric Motor
- Vehicle with 2 Electric Motors
- Vehicle with 3 Electric Motors
- Vehicle with 4 Electric Motors

Kind of OpenXWD: With Engine

Gearbox M
- Electric Motor

Motor Model: 1D Look-Up Table

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<th>Rot. speed (rpm)</th>
<th>Torque (Nm)</th>
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Amplification: 1.0

Generator Model: Characteristic Value
- Mechanical power (kW): 20.0
- Maximum torque (Nm): 250.0
- Maximum rot. speed (rpm): 8000.0
- Rot. speed max. torque (rpm): 500.0
Simulation Toolchain: Environment

- IPG CarMaker coupled with
  - Driver model
  - Google Traffic
  - Map Data
  - Weather service provider

- Temperature profile (over route or time)
- Humidity and pressure
- Solar radiation
- Wind velocity and heading
System Integration: Architecture

Display, Control and Configuration via Navi, Android-System
PTV, Bosch services

Onboard Systems for data acquisition and distribution
FZI, CarMedialab

Provisioning of Data
standardized communication channel, security and privacy of data guaranteed
CarMedialab

Processing of Data
services and results are analyzed
Daimler FleetBoard
System Integration: System Experience Platform

Integration of all functions in an Human-in-the-Loop demonstrator
Summary and Outlook

Summary

- Sensitivity analysis
  - weather/driver
- Simulation Toolchain
  - components and parameters
  - environment
- Analysis and abstraction for energy and range prediction
  - Server based (fleet management)
  - Onboard (private transport)
- Specification of architecture and interfaces
  - Integration in Office-Simulation and System Experience Platform
  - Integration in vehicle
  - modular

Future Work

- Test drives for further evaluation and tuning of functions and models
- Focus on driver education
THANK YOU!