Technology Megatrends Driving Automotive

1. Vehicle Electrification
2. Autonomous Driving
3. Connected Vehicles

Software everywhere
Software is reshaping the automotive industry

In the future every company will become a software company

Marc Andreessen
Founder of Netscape, Renowned Venture capitalist
Software is reshaping the automotive industry

Software Expertise Is Crucial for the Success of the Mobility Ecosystem

“Software is the oxygen for the mobility ecosystem”

More and more vehicles are being interconnected via software using Continental’s technology. Whereas cars today require more than 100 million lines of software code for their functions, the amount of software required for future functions will increase tenfold. “In the coming years, sales with software will increase tenfold compared to...”

Source: Continental’s 2019 Annual Shareholders’ Meeting
Software is reshaping the automotive industry

Augmenting control with machine learning (BMW)

One Pedal Driving (GM)

Autonomous driving (Voyage)
Models == Understanding
Impact of disruptive trends on us: what we see in the field

- Full vehicle simulation
  - System design and study
  - ADAS/AD virtual drive

Utilize simulation with limited resources
Full vehicle simulation

- Click to 
  - Second
    - Third
      - Fourth
Simulation Integration: Analyses
Atsumitech evaluated FCV system with MathWorks tools

FCV Hydrogen tank with electric components development

- Trade-off study for Hydrogen amount with various driving scenario
- Evaluate the required hydrogen amount while transient changes in pressure and temperature of the hydrogen tank
- Evaluate the effect of energy management, especially efficient use of hydrogen

Source: MathWorks Automotive Conference Japan 2018
Nissan deployed common plant models in the process

- Common Plant model in system requirement study, component and software integration test, and software quality verification
- Test cases are also commonalized through the process
- Fast simulation speed with high accuracy is the key
- Integrated with existing plant model with Powertrain Blockset

Common plant model

To verify the control algorithm, it is important to evaluate software accurately and quickly → Lightweight and high-precision model
- Devices, Transmission and low fidelity vehicle model built with Simulink
- Powertrain Blockset is used for Engine model

Plant model is commonly used for RCP, MIL and HIL
Simulink is Simulation Platform

152 Interfaces to 3rd Party Modeling and Simulation Tools
(as of March 2019)
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- Scaling up embedded software development
  - Agile development
  - System Architecture

Utilize simulation with limited resources

New approach to the new challenge
Agile Values

- **Individuals & Interactions** over **Process and Tools**
- **Customer Collaboration** over **Contract Negotiation**
- **Working Software** over **Comprehensive Documentation**
- **Responding to Change** over **Following a Plan**

“While there is value in the items on the right, we value the items on the left more.”
Volvo cars conducts agile development with Model-Based Design

From planning to experimentation!

This is a software business trend, but we see it as well. Time is valuable and requirements change rapidly.

Small & Fast!!

Integrate hw & sw

New product

MAC 2015, Multi-Domain Simulation for Electrical Propulsion Systems at Volvo Cars. Jonn Lantz, jonn.lantz@volvocars.com
Volvo cars conducts agile development with Model-Based Design

From planning to experimentation!

This is a software development process designed to rapidly change requirements.

New function

MathWorks
AUTOMOTIVE CONFERENCE 2019

Agile 개발 방법과 모델기반 설계

이영준
Linking top-down and bottom-up workflows
Systems engineering

System Composer

Requirements

Components
Requirements

MathWorks AUTOMOTIVE CONFERENCE 2019

Simulink를 이용한 AUTOSAR SW 개발
From Architecture to Design to Testing

류성현
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- Leveraging streaming and stored data
  - Data utilization in Model-Based Design workflow
  - Digital service for new businesses

Utilize simulation with limited resources

New approach to the new challenge

Accelerate development and develop new business
Why Data, Why Now?

▪ Exponential rise in data intake

  Connected vehicles will each generate data every 100 milliseconds while being driven, resulting in more than 10 Petabytes by 2020; Pilot (<3000 vehicles) >18 Terabytes per month being collected

▪ Commoditization of computing
  – Cost of storage drives towards zero
  – Cloud enables massive parallel computing
  – GPU offers computing power at density

▪ Machine learning and deep learning are maturing
  – MATLAB makes them accessible to engineers
Volkswagen Data Lab develops driver recognition algorithms with MATLAB

Develop technology building block for tailoring car features and services to individual
- Need to identify individual drivers based on their driving behavior using collected data

Challenges
- Accuracy despite low training data
- Robustness despite environmental conditions
- Computing time

Data sources
- Logged CAN bus data and travel record

Source: "MATLAB EXPO Germany, June 27, 2017, Munich Germany"
Suzuki motors developed drivability assessment framework with Machine Learning

- Extract features from longitudinal acceleration timeseries of driving behavior and build predictive model for drivability score calculation using Machine Learning
- Optimize vehicle drivability performance by optimizing calibration parameters with Model-Based Calibration approach
Machine learning adoption in new fields

BMW Uses Machine Learning to Detect Oversteering

Challenge
Develop automated software for detecting oversteering, an unsafe condition in which rear tires lose their grip during a turn.

Solution
Use MATLAB to develop, train, and evaluate a variety of supervised machine learning classifier types, including KNN, SVM, and decision trees.

Results
- Oversteering identified with greater than 98% accuracy
- Multiple machine learning classifiers trained automatically
- Code generated and deployed to an ECU for real-time, in-vehicle testing

Link to article

Machine Learning for OBD
Background: On-Board Diagnostics & Boundary

- Separation is needed to minimize:
  - False failure
  - False pass
- Diagnostic should run consistently on:
  - The certification test cycle: FTP75
  - In the field: In Use Monitoring Performance Ratio (IUMPR)
Data utilization in Model-Based Design workflow

- Field Data
- Synthetic Data
- Usage
- Better Algorithms
- Simulated Usage
One example of leveraging simulation for data synthesis

Traditional deep learning workflow

Record → Label → AI model
One example of leveraging simulation for data synthesis

**Traditional deep learning workflow**

- Record
- Label

**Simulation-based workflow**

- Simulate
- Auto-label

AI model
Leveraging MATLAB-Simulink in Building Battery State-of-Health Estimation Pipelines for Electric Vehicles

Challenges

- In the product design phase, battery data is available only under laboratory and limited driving conditions.

Vehicle Simulation Summary

- Electrical
  - Cell models and battery configuration

- Simulation
  - Predicting battery behavior

Simulated Fleet

In electric vehicles, understanding battery State-of-Health (SOH) is critical.
Large Scale Automotive Data Analytics: GM

- OnStar™ Proactive Alert – A new customer care service
  - Alert before failure happens
  - Transform an emergency repair to planned maintenance
  - Enhance ownership experience - a delight to customers

**VEHICLE PROGNOSIS**

**PROGNOSTIC ALGORITHM DEVELOPMENT**

- Physical-model based algorithm generation:
  - Study failure modes - FMEA
  - Model physics of failure
  - Generate fault signatures and failure precursors
  - Develop prognostics algorithm
  - Validate concept on benches and test vehicles

**Big-data based algorithm validation:**

- Collect data from >1M vehicles
- Analyze warranty return parts
- Correlate algorithm outputs with engineering assessment
- Calibrate algorithm parameters
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Simulink is simulation integration platform
Utilize plant models
New capabilities, tools
AI
MATLAB&Simulink integration
MATLAB scalability
Enjoy the conference