Driving with AI: The Future of Mobility and Transportation

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Overview

- Hitachi – Leaders in Digital Innovation
- Mobility Use Cases
  i. Connected Powertrain
  ii. Ride Comfort Control using AI
  iii. Predictive Maintenance
  iv. Vehicle Occupant Health and Safety Analytics
- Inspiring the Next…..
As a global technology leader, digital innovation is at the heart of everything we do. Hitachi is investing $2.8B over 3 years to build a global leadership in IoT.

- **$88.8B** consolidated revenue*
- **$5.4B** IoT revenue*
- **$3.5B** annual R&D*
- **$2.8B** 3-year IoT R&D*

- **1,400+** strategic alliances
- **119,000** global patents
- **11,000** IoT patents
- **1,000+** subsidiaries
- **335,000** employees

*As of March 31, 2016
The Era of Digital Disruption

Presenting existential threats and transformative opportunities for Fortune 500

Global Mega Trends

- Globalisation
- Aging Populations
- Mass Migration
- Urbanisation
- Sustainability
- Terrorism
- Cyber Crime

Technical Innovation
- Automation
- AI
- Blockchain
- 3D Printing
- Cloud

Creating new markets; breaking down industry boundaries; and disrupting value chains

Society 5.0
- Rail
- Manufacturing and Industry
- Public Service
- Energy
- Automotive
- Financial Service

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Major Trends Disrupting the Automotive Industry

- Light-weighting
- Electrification
- Shared Mobility
- Start-up OEMs
- Fuel Cells
- Connectivity & AI
- Alternative Fuels
- Big Data/Analytics
- New Retail – Direct to Customer
- Intelligent and Automated Vehicles
- Shift to Asia
- Digital Experience
- Low cost brands
- Non-traditional entrants
- Combustion engine advancements
- Digital Experience

Source: Roland Berger
Future of Mobility...

Source: Roland Berger

Shared mobility
- The convergence of high levels of shared mobility and automated driving
  - Automotive 4.0

Shared world
- Sharing proliferates throughout urban and some suburban areas with high acceptance of car/ride sharing services
- Autonomy remains constrained by regulation, cost, technology development and/or consumer acceptance

Today's world
- Shared mobility confined to early adopters in dense urban areas
- Automated driving penetration primarily in flagship premium models

Short-term
- Today to 2020

Mid-term
- 2020-2030

Long-term
- Post 2030
i. Connected Powertrain
Fuel Economy Improvement with Connected Powertrain

Realize eco-friendly propulsion system by creating synergy between powertrain technology AD/ADAS and Connectivity for safety and comfort

AD/ADAS Features
- ACC/AEB (Preceding vehicle recognition)
- Lane keep system (lane recognition)
- Autonomous Driving for highway

AD: Autonomous Driving
ADAS: Advanced Driver Assistance System
ACC: Adaptive Cruise Control
AEB: Autonomous Emergency Braking

Powertrain Control
- E.g. Start & Stop control
  - Opportunity for Start & Stop
    - Sailing stop
    - Coasting stop
    - Idling stop
  - VSP
- Driving Cycle (Acceleration suppression)
- HEV control (Regeneration)

Synergy to create eco-friendly propulsion systems
Connected Powertrain Architecture

Car as a Sensor

HD LDM + V2X + Traffic
Estimating accurate position via HD Map Information
Weather-robust Vision System and Sensor Fusion Architecture

Connected Vehicle

Drive Cycle
Road Grade, Weather, Traffic

Connected Controls

Engine Map

RADAR/LiDAR

Real World Driving

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AI Neural Network Can Reduce Average Fuel Consumption by 10%

**Training Neural Net**
- Extract Features
- Live Traffic

**Drive Cycle Estimation**
- Feature Extraction
- Trip Time
- Avg. Speed
- Congestion Level
- Road Type

**Optimize Supervisory Control**
- Predicted Drive Cycle
- Vehicle Speed (mph)
- Time (Secs)

**Outcomes**
- Emission reduction
- CAFÉ Improvements
- Gas Savings
- Comfort Ride

\[
\min(F(x, u)) = \min \sum \text{fuel_rate}(P_{eng}, \omega_{eng} | P_{driver\_req})
\]
Traffic & Connected Powertrain Co-simulation

- Perform large scale traffic simulation using Real World Driving data
- Evaluate benefit of ‘look-ahead’ controls & calibration for powertrain

Multiple co-simulation platform

Large-scale traffic on Michigan road network

- Traffic Flow
- Vehicle Velocity

FREE FLOW
Traffic Speed

3D vehicle dynamics
ii. Ride Comfort Control using AI
Value of an Autonomous car: Safety + Experience + Comfort

Safety
- Ex: Driver Assist Technology

Drive Experience
- Ex: Configurable seats

Ride Comfort
- Ex: Semi-Active Dampers

Our AI based approach for Enhanced Ride Comfort

Maps/Traffic + Road Topology + AI – Machine Learning = Sensing Technology Fusion coupled with AI

Safe, Smooth & Comfortable Ride
Ride Comfort Solution:

**Pitching** – Acceleration/Deceleration

**Yaw / Roll** – Turns & Curved Roads
Development of AI Platform

Level 3 – Event Based Profile
- Turning Rate
- Engine Load
- G-force
- Machine Learning
- Traffic Pattern
- Braking Pattern
- Engine Op. Pattern

Level 2 + Machine Learning

Level 2 – Vehicle Profile
- Accel.
- Braking
- Turning
- Vehicle Intelligence Algorithm
- Turning Rate
- Engine Load
- G-force

Level 1 + Vehicle Intelligence

Level 1 – Driver Signature
- GPS
- G-Sensor
- OBD2
- Data Analytics
- Accel.
- Braking
- Turning

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System Architecture – Turn Prediction

**Input**
- GPS
- OBD
- Accel/Gyro

**Approach**
- Feature Extraction
- Model Training/Test
- Speed
- Calculate G-Force
- Gyro_Z
- Polish Features
- Calculate G-Force
- GPS Heading
- Trained Model

**Output**
- Identify Driver
- Drive Mode
- Predict Turn
Road Tests – Drive Model & Turn Prediction
iii. Predictive Maintenance
Need for Predictive Maintenance – Background

Proactive and predictive maintenance approach are needed to minimize warranty and service related expense for next generation mobility:

- Reactive maintenance approach no longer relevant/applicable in this landscape
- Need Proactive and Predictive maintenance
- Use-case of a shock absorber to emphasize the predictive maintenance benefits for reducing warranty costs

Source: WarrantyWeek
Predictive Maintenance Architecture

IoT Architecture with Edge Analytics to Collect, Process, Analyze & enable Decision Making Capability through Cloud Infrastructure

Our Core Area of Expertise

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Results Visualization – Miles to Failure Prediction

Potential Reduction in Component Life

Length

Load Fx

Load Fy

Suspension Assembly

A-Bracket

Piston, Rod

Loading Region

B-Bracket

Damper Length (L)

Damage Index threshold

Expected Life

Potential Reduction in Component Life

Revised Expected Life

Lifetime Prediction

Damage A-Bracket

Damage Piston Rod

Damage B-Bracket

Fatigue Indexes

Damage Index

Miles driven

0 10000 20000 30000 40000 50000

0.0 0.2 0.4 0.6 0.8 1.0

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iv. Vehicle Occupant Health and Safety Analytics
Overview – Vehicle Occupant Health and Safety

**Background and Value**

- Market projections $7.74B by 2020

**Requirements and Challenges**

- Effective distraction monitoring
- Remote health monitoring
- Estimate driver fatigue level

**Our Key Differentiation**

- Breath Alcohol Detection
- Facial state recognition
- Fusion of physiological sensors and vision system
- On-going field trials in the US
Breath Alcohol Detection System

Drunk Driving Accounts for 30% of Total Deaths in USA


Facial recognition demo

Occupant Psychophysiological State Monitoring

In-vehicle sensor fusion

Cloud Platform

Real-Time Data Usage by Service Provider

Current System Architecture

<table>
<thead>
<tr>
<th>Input</th>
<th>System</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camera</td>
<td>Emotional stress detection using Facial expression</td>
<td>Emotion</td>
</tr>
<tr>
<td></td>
<td>Fatigue estimation using Physiological signals</td>
<td>Distraction</td>
</tr>
<tr>
<td>Physiological/Body Sensors</td>
<td>Driver state estimation using Dynamic Expert System</td>
<td>Drowsiness</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fatigue</td>
</tr>
</tbody>
</table>
Field Tests – Occupant Psychophysiological State Monitoring

Experimental Setup

Sample Experimental Results of Subjects Heart and Respiration Rate

Real-Time Pulse & Respiration Monitoring

Real-Time Driver’s Facial State Monitoring System
Inspiring the Next…
Innovation and IoT are in our DNA
Hitachi’s Unique Value Proposition

Leap-frogging competitors through collaborative co-creation

Embed Hitachi’s IT x OT Experience

OT asset

IT asset

Connectivity

Core

Foundry

Security

AI/Analytics

Studio

Edge

Business data

Machine data

Human data

OT x Market Disruption

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Inspiring the Digital Transformation

Unparalleled OT + IT + IoT Expertise
Accelerates time to value

Social Innovation
Solutions that benefit business and society

Flexible Business Models
Focused on delivering value
Thank You!
Visit us at the ‘Smart Transportation’ Exhibit…
Questions....
NEXT
2017
LEAD WHAT’S NEXT