Trends and Challenges in AI and IoT for Connected Automated Driving

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Outline

• Who we are
• Deep Learning
• Cloud-assisted Control
• IoT / EU AUTOPilot
• Key Challenges
NEC Group Overview

- Established July 17, 1899
  98,726 Employees as of March 2016

- Business activities in over 168 countries through 237 branches

- 5 R&D Labs: JP, US, DE, SG, CN

- Transportation Business includes public transport solutions, traffic management, automotive computer vision and deep learning, Logistics and fleets solutions

USD 25 Billion in FY15 sales
Our ICTs Map (2015-16)

**Data Science**
- **Visualization**
  - No. 1\(^*1\)
  - Face recognition
  - GLVQ (Quantifying General Learning Vector)
  - Self-learning super resolution
  - Crowd behavior analysis
  - Object Fingerprint
  - Optical Vibration Sensing
  - Speech recognition
  - Emotion recognition

- **Analysis**
  - Only 1
  - Invariant analysis
  - Heterogeneous mixture learning
  - Scent analysis
  - No. 1\(^*3\)
  - Textual Entailment Recognition
  - High speed
  - RAPID machine learning (deep learning)
  - Profiling Across Spatio-Temporal Data

- **Control/Guidance**
  - Only 1
  - Autonomous and Adaptive Control
  - Predictive Robust Optimization Framework

**ICT Platform**
- **Computing**
  - No. 1\(^*4\)
  - Vector computing
  - First in the world
  - I/O virtualization (ExpEther)
  - Only 1
  - NanoBridge\(^6\)
  - First in the world
  - Phase change cooling
  - Only 1
  - CWB\(^*5\)

- **Networking**
  - Only 1
  - Applicable rate control
  - SDN/NFV

- **Security**
  - High speed
  - Authenticated encryption
  - First in the world
  - Secure computing
  - Only 1
  - Automated Security Intelligence
  - Integrated access control

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\(^*1\) Ranked 1st three consecutive times in task assessment as sponsored by National Institute of Standards and Technology (NIST) of the U.S.

\(^*2\) As of November 2015 based on research by NEC

\(^*3\) Ranked 1st in task assessment as sponsored by National Institute of Standards and Technology (NIST) of the U.S. (2012)

\(^*4\) As of November 2013 based on research by NEC

\(^*5\) CyberWorkBench

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Deep Learning

• **Object Recognition: Solved**
  - CNNs beat other approaches (and humans)

• **Scene Recognition: Hot**
  - Train CNNs on a codebook of situations and map current scene to reference scenes
  - Longer prediction horizon than current rule-based approaches

• **End-to-end Learning: Future?**
  - Get rid of semantic abstraction, path planning and control as a whole
  - Plug CNNs between sensors and vehicle controls. Train with e.g. simulators

<table>
<thead>
<tr>
<th>Team</th>
<th>Method</th>
<th>Accuracy</th>
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<td>sermanet</td>
<td>EBLearn 2LConvNet ms 108-108 + 100-feats CF classifier + No color</td>
<td>99.17%</td>
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<td>IDSIA</td>
<td>cnn_hog3</td>
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*Source: Sermanet et al., Traffic Sign Recognition with Multi-Scale Convolutional Networks, 2011*

*Source: End to End Learning for Self-Driving Cars, NVIDIA, 2016*
Cloud-assisted Motion Planning

- ICT Enablers
  - Scalable space search motion planning (RRT family)
  - Low-latency short-range communication (ITS-G5)
  - Image based localization (cooperative SLAM)

Source: NEC Labs Europe 2016
Evaluate network performance needs

Create IoT and cloud based service platforms

Define a vehicle IoT platform

Evaluate network performance needs

Involve IoT sensors
IoT Key Features for CAD

- OMA NGSI API (100 OASC cities)
- Brokering and Discovery (FIWARE)
- Hierarchical/Mesh-up Federation (NEC Contribution to FIWARE)
- Contextualized pub/sub (ETSI ISG CIM)
- Semantic Interoperability (building on oneM2M)
- Cloud-edge Orchestration
- Edge and network optimization
6 pilot sites

Brainport, NL
- Automated Valet Parking
- Highway pilot
- Platooning

Tampere, FI
- Automated Valet Parking
- Urban Driving

Versailles, FR
- Automated Valet Parking
- Urban Driving
- Platooning

Daejeon, KR
- Urban Driving

Vigo, SP
- Urban Driving
- Automated Valet Parking

Livorno, IT
- Urban Driving
- Highway pilot
Key Challenges for CAD

Technical
• Lack of open reference repositories for benchmarking
• Testing becomes a huge burden. Shift testing to training?
• Security beyond authentication, integrity and encryption. Verifiable computing? Blockchain?

Non-Technical
• Adequate campaigns
• Lack of Venture Capital
• Network externalities in cooperative systems
**ITS-G5/DSRC V2X**

- **Status**
  - European stack completed by ETSI
  - 15+ years of R&D, trials, pilots

- **Features**
  - OCB 802.11, low latency, no infra
  - Multi-hop uni- and geo-cast
  - Network congestion, utilization limits

- **Deployment**
  - Difficult business case (externalities)
  - Only through mandate (NHTSA)

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**Cellular V2X**

- **Status**
  - 3-4G trials in last ~8 years
  - Cellular V2X Part of LTE-A Pro in Rel14 (March 2017)
  - Evolution towards Rel-15 5G (2020)

- **Features**
  - ProSe PC5 = direct communication
  - Controlled resources (slicing) to throttle bandwidth and latency

- **Deployment**
  - Business case through MNO services
  - Some inter-operator externalities
  - Consumer internet drives roll-out