Outline of Activities on Automated Driving in Japan

7 July, 2017 in UC Irvine

SoCal-Japan joint workshop on Advanced traffic management & control in the era of connected and autonomous driving

Takashi Oguchi
Professor of "Traffic Management & Control" and Deputy Director of Advanced Mobility Research Center (ITS center), Institute of Industrial Sciences (IIS), the Univ. of Tokyo (UTokyo)
• Introduction of ourselves
  • Japanese delegates
  • University of Tokyo & Institute of Industrial Science
  • Advanced Mobility Research Center & Traffic Eng. Group

• SIP: Cross-Ministerial Innovation Promotion Program in Japan
  • SIP-adus (Innovation of Automated Driving for Universal Services)
  • Next Generation Urban Transport
  • ART (Advanced Rapid Transit)
  • Automated Bus FOT
  • Other FOT's
Japan and Tokyo, ...

**JAPAN**
- population: 127 million
- area: 380 mill. km²

**Tokyo**
- population: 13 million
- area: 2.200 km²

3,000 km
Today's 7 new Japanese delegates from...

**SHIGA (next to KYOTO)**
- Y. Shiomi (Ritsumeikan Univ.)

**MATSUYAMA**
- T. Yoshii
- T. Tsubota (Ehime Univ.)

**TOKYO**
- T. Oguchi
- K. Wada (Univ. of Tokyo)

**TOKYO**
- H. Oneyama
- M. Yanagihara (Tokyo Met. Univ.)

**KOCHI**
- H. Nishiuchi (Kochi Inst. Tech.)
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The University of Tokyo (UTokyo)

- 10 faculties
- 15 graduate schools
- **11 affiliated institutes**

Institute of Industrial Science (IIS)

- Kashiwa
- Hongo
- Komaba
- Haneda Airport
- Narita Airport
- Nishi-Chiba
- Chiba Experiment Station of IIS
Institute of Industrial Science (IIS)

<table>
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<tr>
<th>Professors</th>
<th>Faculty members: 124</th>
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<tr>
<td>Associate Professors</td>
<td>45</td>
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<tr>
<td>Lecturers</td>
<td>8</td>
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### Research Centers

- Advanced Mobility Research Center
- Center for Photonics Electronics Convergence
- Center for Socio-Global Informatics
- Center for Research on Innovative Simulation Software
- Collaborative Research Center for Energy Engineering
- Center for International Research on Integrative Biomedical Systems
- Centre for Interdisciplinary Research on Micro-Nano Methods
- Integrated Research Center for Sustainable Energy and Materials
- International Center for Urban Safety Engineering
- Center for Integrated Underwater Observation Technology

### Graduate Students

- Master’s Program Students (include International Students): 460 (120)
- Doctoral Program Students (include International Students): 260 (145)

### Visiting Research Students of Graduate School

- 12

### Research Students

- 15

### Todai Postdoctoral Research Fellows

- 21

(as of January 1, 2017)
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Advanced Mobility Research Center

abbreviated as "ITS center"

Intelligent Transport Systems
(not Institute of Transportation Studies) ...sorry for confusing name
Advanced Mobility Research Center (ITS center)

Regional ITS Center (for operation)

- Fusion of Elements
- Social/Institutional Researches

Next Generation Transport System with Automated Driving

- Reformation of Infrastructure
- Design of Social System/Institution

Mobility Society Design in Big-data era

Core members
- Info. & Electr.
- Human & Soc.
- Visiting Prof.

Cooperative members
Academia=68, Industry=15, Government= 8
(as of 1, June, 2017)
Examples of the ITS center activities

Driving Simulators

Driving simulator (DS) serves simulated environments of actual vehicle driving for Human, Vehicle, and Traffic Research. This enables to perform experiments such as investigating driving behavior and evaluation of brand-new road infrastructure. Two DSs are installed in Komaba: DS with 6-DOF motion platform and 120-degree field of vision; and DS with 6-DOF motion platform, 1-DOF turntable mechanism, and 360-degree field of vision. Moreover, reality in steering and pedaling operations is being improved. Dynamics of a truck can be simulated, too. Some experiments using the DS are used for evaluating traffic safety measures in actual roads.

Sensing Vehicles

Sensing vehicles are developed for collecting various real-world data while running on the field. ARGUS equips omnidirectional cameras, laser range scanner, etc. and can acquire 3D geometry and photometric attributes of surrounding structures such as buildings and roads, which is applied for virtual city modeling and driving-view rendering based on real image.

MASTRO II can measure location, speed, acceleration, and direction of the experimental vehicle itself with relative positioning of the following vehicle, which is applied for analyzing behaviors of vehicles and drivers under various traffic conditions.

Acoustic Laboratory

To evaluate the psycho-acoustical influence of an acoustical environment on human, “6-channel recording/reproduction system” is constructed in an anechoic room. The 3D sound field simulation technique can realize natural aural impression in the acoustic laboratory equipped with 4ch reproduction system, using directional data received through a 6ch microphone system or obtained by numerical analysis.

Traffic Simulation Models (TS)

Traffic simulators (TS) of different scales are being developed. By constructing virtual driving environment with richer reality, various ITS technologies and policies can be simulated and evaluated with high accuracy.

SOUND: A network traffic simulator, covering a wide network including expressways, while vehicles are considered individually.

AVENUE: A street-level traffic simulator, based on the detailed maneuvers of individual vehicles, such as lane changing at an intersection. Used for evaluating traffic operation strategies, reducing congestion on streets, etc.

KAKUMO: A micro traffic simulator, connecting TS and DS. It fills the gap of spatiotemporal resolution between TS and DS by calculating driver’s behavior and vehicle dynamics of hundreds of vehicles around the test driver in DS. Simultaneously, the behavior of the test driver in DS is reflected to TS, and then the movements of surrounding vehicles and the traffic condition change interactively.

Societal Implementation of Automated Driving

In recent years, interest in automated driving technology is heightened around the world. To realize the technology, it is necessary to consider about the ecosystem. Social acceptability that is compatible with the social system is necessary. We promote to establish the comprehensive ecosystem related to automated driving.

Kashiwa ITS FOT Model City

Kashiwa City is one of ITS FOT model cities designed by the government, where our center is leading R&D on ITS especially with some field studies, concerning public transport use, advanced mobility, etc. In the recent project, we built a social feedback system to make regional citizens be aware of CO2 emissions and to promote their eco-friendly travel behavior, by estimating regional traffic situation using ICT and presenting them with an easy-to-understand contents through web. The results of the field experiment proved the possibility of roughly 8% reduction of CO2 emission.
Chiba Experiment Station: moved to Kashiwa: April 2017

- Kashiwa
- Hongo
- Komaba
- Narita Airport (NRT)
- Haneda Airport (HND)
ITS R&R Experiment Field (Chiba Experiment Station)

- DS for Large Vehicle
- Proving Ground
- Traffic Lights
- Automated bus Development
- Chiba Test Track 2.0
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SIP (Cross-Ministerial Strategic Innovation Promotion Program)

- Intensive R&D program
  - promote 5-years R&D (FY2014-2018)
  - enhancing cross-ministerial cooperation

- 11 research themes
  From societal issues such as Energy, Next-Generation Infrastructures and Local Resources, including R&D for Automated Driving

- Leadership and total Budget
  CSTI appointed Program Directors and allocates the budget every year for each research theme*.

* 50 billion JPY in total per year
  = (approx.) USD 500 Million
  65% for SIP 11 themes
  35% for medical R&D

-Governance Structure-

Council for Science, Technology and Innovation

Governing Board

PD (Program Director)

Promoting committee
- PD (chair)
- Related ministries, Management agencies, Experts from academia and public sector

Management Agency (Funding Agency)

Research organizations
- Universities, Corporations, Research institutes, etc.

Established for each project

Chair: Prime Minister
## SIP (Cross-Ministerial Strategic Innovation Promotion Program)

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<tr>
<th>Societal Issues</th>
<th>Themes</th>
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<td><strong>Energy</strong></td>
<td>Innovative combustion technology</td>
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<tr>
<td></td>
<td>Next-generation power electronics</td>
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<tr>
<td></td>
<td>Innovative structural materials</td>
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<td></td>
<td>Energy carrier</td>
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<td></td>
<td>Next-generation ocean resources development technologies</td>
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<td><strong>Next-Generation Infrastructures</strong></td>
<td><strong>Automated Driving System</strong></td>
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<tr>
<td></td>
<td>Technologies for maintenance/upgrading/management of infrastructures</td>
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<td></td>
<td>Reinforcement of resilient function for preventing and mitigating disasters</td>
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<td>Cyber-Security for Critical Infrastructure</td>
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<tr>
<td><strong>Local Resources</strong></td>
<td>Technologies for creating next-generation agriculture, forestry and fisheries</td>
</tr>
<tr>
<td></td>
<td>Innovative design/manufacturing technologies</td>
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"Automated Driving System" in SIP

SIP-adus

(Innovation of Automated Driving for Universal Services)

- Intensive R&D program supporting development of future advanced Automated Driving System
- Industry-academia-government collaboration
- Budget for SIP-adus: JPY 2.7 Billion (FY2016) = (approx.) USD 27 Million

Program Director (PD)
CSTO (Chief Safety Technology Officer) Secretary, Toyota Motor Coop.
Goal and Exit Strategy of SIP-adus

1. Ensuring safety and traffic jam reduction on the road

2. Development and deployment of Automated Driving System

3. Realization of advanced next generation public bus service especially for elderly and handicapped users (Advanced Rapid Transit: ART)
Technologies for Automated Driving

On-board Technologies

- Perception
- Decision
- Operation

HMI

- Coordination

Platform

- Security, Simulation, Shared database, etc.

Precise 3D digital map

V to X

GNSS

Camera

Lider

Rader

Built-in sensors

Human Machine Interface
Major development theme of SIP-adus

[II] Development and verification of automated driving systems

1. Traffic fatality reduction effect estimation method & national shared data base
2. Micro and Micro data analysis and simulation technology
3. Local traffic CO2 emission visualization technology

[III] International cooperation

1. Shared Research facility
2. Social Acceptance
3. Package export organization

[IV] Deployment for next generation urban transport

1. Local Traffic Management Enhancement
2. Next Generation transport system
3. Accessibility Improvement

[V] Large scale experiment

Area of cooperation = focus of SIP program
SIP-adus R&D activities are reviewed in the Promoting Committee. Currently, 3 Working Groups and 2 Task Forces have been established to cover wide variety of the topics.

**SIP-adus Promoting Committee**

- **System Implementation WG**
  - Chief: Inagaki (Tsukuba Univ.)
  - Dynamic map (precise 3D digital map with information changing over time)
  - Micro and macro data analysis and simulation technology
  - Prediction based on information from ITS
  - Sensing capability enhancement
  - Human Factors
  - System security

- **International cooperation WG**
  - Chief: Amano (ITS Japan)
  - Open research facility
  - Social acceptance

- **Next Generation Urban Transport WG**
  - Chief: Oguchi (UTokyo)
  - Local traffic management enhancement
  - Next-generation public road transport system
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Missions of **Next Generation Urban Transport WG**

For "Ensuring **safety** and **traffic jam reduction** on the road" ...

- Enhancement of **surface public transport (PT) function** for ensuring safety of vulnerable users (disabled & aged)
  - Increased **level & quality of services** of PT
  - ART: Advanced **Rapid** Transit ← BRT
    - automated pull-over control (**precise docking**) *
    - smooth & comfortable **vehicle control** *
    - priority service for public transit (**PTPS**)  
    - seamless **fare-payment, quick & safe boarding for wheel-chairs**
    - integrated services with seamless & stress-free **connections**
    - universal **information provision** service including vulnerable users
- Showcase for **Olympic/Paralympic Games 2020 Tokyo**
  - travel demand concentration prediction; including congestion avoidance campaign
  - to promote ART in other urban areas in Japan, and abroad !!
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Next Generation Urban Transport: concept of ART

Advanced PTPS (Public Transportation Priority System)
- Rapid and On-time operation

Advanced operation system with automated control systems
- Seamless and stress free connection

Automated acceleration control
- Smooth & Comfortable ride

Automated pull-over control
- Accessibility
- Short time and Safety boarding

Advanced Driver Assistance
- Traffic accidents prevention
- Driver burden reduction

Universal built-in seats
Contactless electronic charging
- Cabin Safety and Convenience

Cooperative ACC
- Traffic congestion/CO2 reduction
Research topics on ART

- **ART Information System**
  - ART Information center
  - Congestion Estimation
  - Central Info. management agent
  - Peds convenience & safety support
  - Advanced PICS
  - Rapidness establishment w/A-PTPS

- **ART vehicle development**
  - Sensing & control for ART precise docking
  - Control & actuator for ART precise docking
  - Advanced PTPS on-board system
  - ART boarding service assistance

- **Advanced PTPS Infrastructure**
  - Info. sharing w/bus location

- **Digital signage**
  - On board personal agent

**ART Information System**

**Central Info. management agent**

**Advanced PICS**

**Rapidness establishment w/A-PTPS**

**On board personal agent**

**ART vehicle development**

**Advanced PTPS on-board system**

**ART boarding service assistance**
Automatic precise docking

Dangerous gap between bus & platform for wheel-chairs & blindness.

Docking technology to fill the Gap
ART Information center

Core information for ART operation

Safe, Secure, pleasant movement

Open data Info.
Congestion opr. status
travel time
transfer info.
platform info.

ART Info. Center
Info. provision
Info. distr.

location
congestion
opr. status
travel time
related info.

Transferability

Railway Co.
Road Authority/Co.
Bus Oper. Co.

App service Co.
other org.
Public Transport Priority System PTPS
ART Rapidness
Bus lines
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1st Automated Bus FOT in Okinawa

Press released on 26 Dec., 2016: announced that FOT held in Okinawa in March 2017

Surface Street
Nanjo-city, Azama-Sansan beach

Automation introduced to Small Bus

speed, steering | no brake
almost no disturbance
parked vehicle
1st FOT in Okinawa (March): Automated bypassing a stopping vehicle
1st FOT in Okinawa (March): Precise docking to a bus stop
自動運転バスについて

今回の実証実験で使用する車両は、既存のバスに先進モビリティ株式会社が開発した装置を取り付け、自動制御が可能な車両に改造しました。また安全対策の車両監視システム、乗客への情報提供をおこなうバス車内の表示装置をSBドライブ株式会社が開発しました。

自動運転バス構成
実験車両
○車種:小型バス「日野リエッセ」
○定員:12人程度
○全長:699cm×全幅:208cm
○エンジン:ディーゼルエンジン○排気量:4.72L

自動運転機能
自動運転制御項目
走行ルートに沿ったハンドルとアクセルの自動制御（ブレーキ制御は除く）
○目標軌跡座標テーブルとRTK-GPSによる車線維持制御
○バス停でのライダーによる正着制御
○障害物認識（停止車両等）と自動車線変更制御
○信号スプリット機能による速度制御

運行サービスシステム
車線維持制御
○GPS位置情報による操舵制御

より良い自動運転システムを開発するため、乗客となる皆様の声をお聴かせいただけますと幸いです。アンケートにご協力いただきますよう、よろしくお願いいたします。

ライダーとディープラーニング画像認識による車両および歩行者認識

- 2nd FOT at Ishigaki in Okinawa (press released June, 2017)
- Mainly Social acceptance survey

Ishigaki Island: total course length 16km

speed, steering | no brake
traffic lights, moderate traffic volume
2\textsuperscript{nd} FOT at Ishigaki in Okinawa: traffic environment
3rd FOT plan in Nov. 2017, with O-ART committee

- Okinawa prefecture: the worst congested capital cities → establish "Roadmap towards new traffic environment"
  - 6 urgent challenges
    - (one of the challenges) dedicated bus intro.

"O-ART committee" starts: ART will be introduced to the tranck routes (Nat'l route #58)
Other FOT's

FY 2017 -2018: Large-Scaled Comprehensive Field Operational Tests

at; Expressway, Tokyo-waterfront "Odaiba", JTown, ...

- Dynamic Map validation

- HMI (Human Machine Interface) test