ITS and Telematics in Japan

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Outline

- **Background**
- **In-Vehicle terminals**
  - Car navigation
  - ETC
  - AHS & ASV for safe driving
- **Road Traffic Infrastructure**
- **U Tokyo Research Program**
ITS Key Development Fields in Japan

- Navigation Systems
- Electronic Toll Collection
- Traffic Management
- Road Management
- Safe Driving
- Public Transport
- Pedestrians
Characteristics of Japanese Market

- Navigation
- Driver Service (from 2003)
- Safe Driving Assistance (from 2005)
Information for Drivers

Static Information

Package Media
- Road Map
- City Map, etc.

Dynamic Information

Communication
- Traffic Congestion
- Traffic Accident
- Road Construction
- E-mail, etc.
Communication Infrastructures

- **1st Generation** (1980): PSTN
  - Analog Mobile Phone (High-CAP)
- **2nd Generation** (1990): High Speed Driving
  - Digital Mobile Phone (PDC)
  - i-Mode (PDC Packet)
  - Cordless Phone
- **3rd Generation** (2000): Walking Speed
  - IMT-2000 (Japan W-CDMA)
    - Global Standard
    - Multi-media Capable (64K - 384k - 2Mbps)
  - Wireless ATM
    - Multi-media Capable (up to 12Mbps)
    - 20-40GHz
    - 10 Mbps ATM
- **4th Generation** (2010): Fast Moving Speed
  - FPLMTS
    - 10Mbps
    - High Speed Move

**Data Transfer Rate (bps)**

- PSTN: Stationary (1k)
- Digital Mobile Phone: High Speed Driving (10k)
- IMT-2000: Walking Speed (100k)
- FPLMTS: Fast Moving Speed (1M)

**IMT:** International Mobile Telecommunications
# Roadside-Vehicle Communication

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In-vehicle Terminals
Evolution of In-vehicle Terminal

**Advances in Navigation System**
- Advances in Search Function
- Touch Panel
- Operation and Guide by Voice
- Handy Navigation, etc.

**Mobile Communication**
- VICS
- Interactive Communication via Mobile Phone
- Internet
- Digital Satellite Broadcast
- Information Contents Industry, etc.

**DVD Car Navi**

**AVN, ETC**
- FM Multiplex with Subtitle
- Coordination with TV and Audio Systems
- Display and Operation of Air Conditioner
- On-board Personal Computer

**VICS Navi**

**On-board Camera, HELP**
- Rear Monitor
- Blind Corner Monitor
- Zigzag Driving Detection Function
- Shift Control Coordination

**A Multiplicity of Functions**

**Safety and Comfort**
In-vehicle Terminal
“Car Navigation”
**History of Car Navigation**

- **Navigation Sold in Market**
  - Total: 7.8 Mil.
- **VICS Sold in Market**
  - Total: 2.8 Mil.

- **Car Multimedia**
- **Comm. Navi Internet**
- **AVN DVD D-GPS**
- **VICS Voice Recognition**
- **Detailed City Map Voice Guidance**
- **Route Guidance**
- **Road Map GPS**

- **DVD Qty (Est.)**
- **VICS Qty (Est.)**

- **Units** (000)
  - 1991: 12
  - 1992: 30
  - 1993: 149
  - 1994: 337
  - 1995: 627
  - 1996: 861
  - 1997: 1,010
  - 1998: 1,300
  - 1999: 1,530
  - 2000: 1,950
  - 2001: 1,400

- **Years**
  - 1991
  - 1992
  - 1993
  - 1994
  - 1995
  - 1996
  - 1997
  - 1998
  - 1999
  - 2000
  - 2001
Architecture of Car Navigation System

1. Indication of Self-position
2. Search of Destination (Destination Input)
3. Calculation of Route
4. Guidance to Destination

- GPS
- GPS Antenna
- LCD Monitor
- Navigation Computer
- Speed Sensor
- Map Disc
- DVD-, CD-ROM
DVD Car Navigation Systems
(e-navi: fine sped network)

• WIDE-VGA display
• Gyro, D-GPS, Map-matching
• Voice Control
• Route Search (64 bit bus Risc CPU)
• Destination Search (Address, Tel#)
• Connectivity to VICS, i-mode, HELPNET, ETC

3D Magnified Intersection Map
3D Satellite Map
Vehicle Information & Communication System (VICS)

VICS Center
- Established in ’95 and Started in Apr., ’96.
- Road Traffic Info. In Real Time through Communication Media.
- Media: Radio Beacon, Optical Beacon, FM Multiplex Broadcast

Car Navigation
- Road Traffic Info. Displayed by Maps, Diagrams and Characters
- Less-congested Route Guidance by a Triple Media Receiver in 1-DIN Body
VICS Service Coverage

- Tokyo, Chiba, Saitama, Kanagawa,
  Osaka, Aichi, Kyoto, Hyogo, Nagoya
  National Expressway

- Fukuoka, Hiroshima, Miyagi,
  Hokkaido (around Sapporo)
  Shizuoka, Gunma, Okayama,
  Fukushima, Okinawa, Miyazaki,
  Gifu, Mie, Yamaguchi, Ibaragi,
  Hokkaido (around Asahikawa)
  Wakayama, Shiga, Nara, Tochigi,
  Yamanashi

Third Phase: around 2005.
- Niigata, Ishikawa,
  Hokkaido (around Hakodate),
  Kumamoto, Oita, Kagawa, Ehime,
  Saga, Nagasaki, Kagoshima,
  Tokushima, Kochi, Fukui, Toyama,
  Yamagata, Akita, Aomori, Iwate,
  Shimane, Tottori
ATIS / ITGS

Bi-directional Traffic Info. Service

Japan Road & Traffic Information Center

Police Agency Traffic Control Center

Tokyo Metropolitan Expressway Corporation

Kanagawa/Chiba/Saitama Traffic Control Centers

Japan Highway Public Corporation

Traffic Information Service

ATIS/ITGS

Mobile Telephone
In-vehicle Navigation System

Car

Telephone Line
Personal Computer

Office/Center

Telephone Line

Restaurant/Hotel/Gas Station, etc.

ATIS Terminal
i-mode Car Navigation

◆ Route guidance

◆ I-mode functions
  ◆ Transaction
  ◆ News, Weather forecast, Town info
  ◆ Game, Karaoke
  ◆ E-mail ........
IMT-2000 Car Navigation

- Road traffic info. (Congestion, Travel time, etc.)
- Weather Info. (Fog, Snow, Icy road, etc.)
- Parking Info. (Opening hours, Tariff, Availability)
- Reservation (Hotel, Restaurant, etc.)
- Help (Accident, Illness, Theft, etc.)
- E-mail, Internet, Music download

- IMT-2000 Terminal Equipped with GPS Unit.
- Download a Map and Indicate the Present Position.
- Search for POI.
- Route Guidance.
Electronic Toll Collection
Electronic Toll Collection (ETC)

- Reduction of Traffic Jams by Non-stop Automatic Toll Collection
  (35% of Total Jams are at Toll Booth)
- Started Around Chiba Area (Mar. 2000)
- Service Upgrade by Cash-less System...........
- Reduction of Management Cost of Toll Collection

- Toll Collection
- Lane Management
- Vehicle Detection
- Licence Plate Recognition

Core Tech.: Toll Collection / Lane Management / Vehicle Detection / Licence Plate Recognition

Core Tech.: Road to Vehicle Communication Coding / Vehicle Unit / Car Navi.
Operational Section (164 Tollgate)

Planned Section Year 2001 (600 Tollgate).

* 70% of Tollgate in Japan will be Covered by the End of FT 2002 (900 Tollgate)
Deployment of ETC and New ETC/DSRC System

**Led by Government Agency**
- ETC Center
- ERP Center
- SA/PA, Michi-no-Eki Management

**Led by Private Business**
- Server
- Server
- Server

Year 2000
- ETC Terminal
- ETC Terminal Connected with Navi.

Charge Clearance
- Charge Clearance, Provision of Information

ETC/DSRC Dual Terminal
- ASK/QPSK
- ETC/DSRC Dual Terminal Connected with Car Navi.

Simplified Road-side Radio Equipment
- ERP
- Michi-no-Eki, SA/PA
- Gas Station
- Drive Through
- Parking

Led by Government Agency

Led by Private Business
Emergency Report System
Emergency Reporting System (HELP)

Without HELP

Accident Occurs Report Ambulance Arrives at the Scene Arrival at Hospital

Total: 16.3 min.

With HELP

Lung Resuscitation within Two Minutes of an Accident:

90% Chance of Saving the Life.

Total: 7.3 min.
HELP architecture

Emergency Report Center

Emergency Vehicle Support

110
Police Dept

119
Fire Dept.

Road Service

Accident Position

Rescue

Cellular Telephone

GPS

Vehicle Unit

Automatic Report

Manual Report
HELP Terminal

Primary Battery
PDC Module

Proc Button, Microphone, Indicator

Accident

Battery
Navigation System
Air-Bag

Manual Report
Crash Information
Location Information
Power

HELP Terminal
TEL Antenna
HELP Terminal
(Option for Navigation System)

Car Navigation System
- LCD monitor
- Speaker for Voice Guidance
- Microphone for Voice Recognition

Mobile Communication Unit
- Modem
- Hands-free Set
- CD-ROM for HELP Function
- CD-ROM for MONET, i-mode Function
- CD-ROM
- Dedicated Map DVD
- Emergency Button
- Browser Software (Smart Media)

Replace with Standard Map DVD
In-vehicle Terminal Assistance for Safe Driving
AHS: Advanced Cruise-Assist Highway System

By AHS Research Association

2000  Proving Test Program “Smart Cruise 21”

2003  Start Installation of “Smart Cruise 21”

2010  Establishment of 150,000 km long “Information Highway” Optical Fiber Network.

2015  Realization of “Smart Way”
Smart Cruise 21

- Maintaining Headway
- Prevention of Collisions with Obstacles
- Prevention of Lane Departure
- Prevention of Overshooting on Curve
- Prevention of Crossing Collisions
- Prevention of Collision with Pedestrian
- Prevention of Right Turn Collisions
ASV: Advanced Safety Vehicle

- **Blind Spot Assist** (Parking Assist, Blind Corner Monitor): Synthesize Several Images and Provide Wide Angle Image
- **Visibility Enhancement** (Night Vision): Obstacle Detection Using Infrared/Visible Camera and Warning System
- **Reduction in Driving Operation**: (Look Off Detection, Stop & Go). Assist Using Camera Image, Radar, Lane-Marker
On-board Monitoring Camera

Rear view camera

- Resin Housing Case
- Taken on photo

108° wide angle back view

Front lateral view camera

- Metal Housing Case
- From dealer’s option manual

44° normal angle side view
Road Traffic Infrastructure
Evolution of Road Traffic Infrastructure

Advances in Functions
- Collection of Traffic Info.
- Collection of Weather Info.
- Processing of Traffic Info.
- Provision of Traffic Info.
- Control of Traffic Signal

Mobile Communication
- Beacon
- FM Multiplex Broadcasting
- Mobile Phone
- Internet
- Digital Broadcasting

ETC
- Road Pricing
- Dynamic Route Guidance
- Priority Passing for Public Transport
- Support for Emergency Vehicle
- Decrease of Pollution

Traffic Control System
Road Information System

- Emergency Report
- Anti-Theft, Trace
- Traveling Support Road
- Support for Pedestrian

Safety / Comfort

Diversity of Functions
**Police Traffic Management System**

### Information Collection
- AVI Sensor: 2,200
- Ultrasonic Sensor: 120,000
- Optical Beacon: 36,000
- Traffic Flow Measurement: 2,050

### Information Processing
- Traffic Control Center (Processing System)

### Traffic Control
- Traffic Signal
- Multi-Pattern Display
- Free-Pattern Display
- Road-Side Communication
- Police Traffic Management System
- Inside Controlling Area: 57,000

### Information Provision
- Traffic Control Center
- 170 Cities

- 2,700
- 810
- 90
Incident Detection System

- Image Recording Device
- Control Processing Device
- Device for Detecting Unforeseen Occurrences
- CCD Camera
- Display Board
  Provide Information to the Following Vehicle

System is Controlled by Images from Each Camera
AVI (Automatic Vehicle Identifier) System

AVI: Automatic Vehicle Identifier

AVI Central Unit

- Prepare Travel Time Information
- Prepare Clustering Information
- Prepare OD Information

Travel Time Information Board

Image Recognition

License Plate

AVI Terminal Unit (Point A)

License Plate

AVI Terminal Unit (Point B)

Recognition Unit

Sensor Camera

Camera

Flash

Measured Travel Time
Bus Locating System

- Central Data Collecting Station Analyzes Bus Transit Information Supplied through MCA Control Station.
- Central Data Providing Station Delivers Bus Operation Status/Approaching Information to Each Bus Stop through MCA Control Station.

**Center System**

- Host Computers
- Location Monitoring Servers
- Operation Status Displays
- Data Authoring Systems
- Data Collecting Station
- Data Providing Station
- Voice Command Station
- Bus Approach Indicator

Digital MCA Control Station

Electromagnetic Induction Effect Creates a Signal Each Time Buses Pass by.

Bus Approach Indicator Shows the Bus Location with a Flashing Light.
Taxi Dispatching System

Management Efficiency
Reduction of Driver’s Stress
Customer Service Improvement
Social Benefits

Optimum Dispatching
Automatic Dispatching
Operation Record Management
Customer Management

Closest Taxi Searching
Destination Route Searching

Incident Information

Character/Voice Map display

Taxi Radio

Management Efficiency
Reduction of Driver’s Stress
Customer Service Improvement
Social Benefits

Optimum Dispatching
Automatic Dispatching
Operation Record Management
Customer Management

Closest Taxi Searching
Destination Route Searching

Incident Information

Character/Voice Map display

Taxi Radio
Fleet Operation Management System

- By Using MCA Radio Communication, an Office Display Indicates the Fleet Location and Status.
- Computer Finds the Customer’s Location from Their Name or Telephone Number and Indicates on the Display.
- Customer Information is Provided to a Delivery Truck Closest to the Customer.

Option:
Registered Condition Selector

System Specifications (Capability)

Connectable Stations: 2 Control Stations/system
Max. Vehicles: 200 Vehicles/System
Number of Zone: 16 Zones/System
Customer Listing: 20,000 Customers/System
Number of Registered Conditions: 99 Items /System
Pre-registered messages: 10 Messages/Control Station

(Note) Car Navigation Unit can be used as the Mobile Radio Unit.
U Tokyo Research Program

◆ **Information gathering**
  – Recognition of vehicle in infrared images
  – Land mark recognition
  – Event recognition at intersection

◆ **Information display**
  – Modeling environmental map through vision
  – Visualization of arbitrary views for driver
Recognition of vehicles
(in Infrared Images)

Previous methods
• Detection; not recognition
• Vehicle class by size

Eigen-window method
• Recognize vehicle without reading number plates
• Possible under occlusion
• No need to segmentation
Eigen-window method

Training images

Eigen space

voting

Recognition results

Input images

Car-A

Voting space: Pos x Model#
Event recognition

TV camera

Surugadai

NTT Optical fiber line

Sakauchi Lab

Local analysis

monitoring

application

Event DB
Event recognition

Illegal parking

Stopping
Tracking

Current frame

Next frame (Middle situation)

Move Blocks based on Estimated motion vector

Adaptive algorithm

Next frame

Delete

Extend

Adapting to new formation
Feature Extraction

Motion vectors  Normalization  Indexing
Accident Models in HMM

- **Bumping**
  - Close in
  - Buses
  - Close in
  - 0 1 2

- **Tandem**
  - Close in
  - Buses
  - Close in
  - 0 1

- **Passing**
  - Close in
  - Buses
  - Close in
  - 0 1 2

- **Impact**
  - Buses
  - Close in
  - 3 0

- **Repulsion**
  - Buses
  - 8

- **Stop**
  - Buses
  - 2 0

- **Restart**
  - Buses
  - 8

- **Overlap**
  - Buses
  - 3

- **Pass**
  - Buses
  - 2
Accident recognition

Yokohama-harajuku AHS
Accident recognition
Modeling Urban Scene

1. Image base rendering
2. Model base rendering
3. Augmentation

Omni camera

Moving Direction
Data Acquisition Vehicle
Outline

- Acquiring omni-images along a path

- Generate another images along a different path
Basic idea

Image capturing

Panoramic image

Perspective images
2D image from light field

Synthesize image
Synthesize Sequence
(Changing lanes)
Synthesize Sequence
(Rotation)
Merits

- Image sequence different from acquired one
Constructing 3D Map

- Omni image acquisition
- 3D digital map by Omni analysis
- Texture mapping
Omni Spatio-temporal Image
Cross-section (an elliptic curve)
Digital Map

- Depth info +

- Correspondence between map and image
Cross-section (a radius line)

Panorama image
3D Map
Virtual Surugadai intersection

- Current situation into virtual world
- Warning to drivers
Outline

- Tracking vehicles
- Combine VR vehicles with the VR Surugadai
- Generate arbitrary views with transparent building
Tracking
Making paths to run

- Projecting detected coordinates onto the virtual world coordinate
- Making paths to run by connecting them
Transparent buildings with vehicles
Modeling from Reality

Real Object

Modeling from Reality

VR Image
U Tokyo Program

◆ **Information gathering**
  – Vehicle recognition based on Eigen window
  – Event recognition based HMM

◆ **Information display**
  – Virtual Surugadai intersection
  – Modeling urban scene using Omni images
Summary

◆ Background
◆ In-Vehicle terminals
  – Car navigation
  – ETC
  – AHS & ASV for safe driving
◆ Road Traffic Infrastructure
◆ U Tokyo Program