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Newsletter

Sustainable ITS

Center for Collaborative Research
The University of Tokyo

Report of the World Congress on ITS, Nagoya, Aichi 2004

Introduction

The 11th World Congress on Intelligent Transfer Systems (ITS) was held in Nagoya in October 2004. The congress is held annually in different cities across Europe, the Asia-Pacific and North America as a forum for international coordination and exchange on ITS-related projects, and also as an opportunity to present the latest ITS research. This, the 11th congress, was organized by Japan ITS World Congress Committee, in cooperation with ITS Japan, Aichi prefecture, and Nagoya city, from 18-24 October 2004 at Port Messe, Nagoya (Nagoya International Exhibition Hall). Conceived with the theme "ITS for Livable Society", it was a large-scale congress focused on how to achieve livable societies through IT&ITS technologies. The main theme was further elaborated in three sub areas: safety, environmental, and comfort issues. The event was aimed at not only specialists but also the general public. The number of registered participants for the congress was 5,794, a record high, and the total number of general visitors to the exhibitions exceeded 60,000, greater than the 50,000 originally expected. The ITS Festival, a World Congress event held in Nagoya city attracted some 600,000 people. Thus the congress received a great deal of attention inside and outside of Japan.

The congress offered a valuable opportunity for us to present our research accomplishments, and we presented four papers* at the Technical Sessions. In addition, an exhibition space named the "Leading Edge Technology Corner," was set up in the exhibition booths for participant universities, as well as companies, governments and countries.

At the congress we exhibited and demonstrated the centerpiece of the Sustainable ITS project: our universal driving simulator, which can imitate real traffic environments through interactive traffic simulation using real scene imagery-a world first. In addition, we demonstrated our two experimental vehicles, and showed off the research achievements of the Sustainable ITS project's participant laboratories and companies, attracting considerable interest. Seven of our ITS project researchers (Suda, Akahane, Kuwahara, Horiguchi, Hasegawa, Ikeuchi and Ohguchi, in order of their presentations) made presentations at the "Leading Edge Technology Session" held at the exhibition venue.

All these activities drew a great deal of attention. The December issue of OHM, a science and technology magazine carried a two-page article based on material gathered at our exhibition, headed, "World state-of-the-art driving simulator presented to public." Reports of our related research work were also well received. For example, "A Study on Sensing System for Running Road Surface Conditions in ITS (the 2ND report)" won the best paper award at the interactive sessions. Our successes at the congress stem from the contributions of many people who have supported this project, so we would like to express our tremendous gratitude to them. In this issue, we will describe our activities at the congress.

* Presentation of papers
(1) Mixed Reality Traffic Experiment Space under Interactive Traffic Environment for ITS Research
(2) Development of a Microscopic Traffic Simulation Model for Interactive Traffic Environment
(3) Image Generation System for Mixed-Reality Traffic Experiment Space
(4) Development of Driver Model Using Driving Simulator with Interactive Traffic Environment

CCR Sustainable ITS Project

The Sustainable ITS Project presented the following exhibits at the World Congress on ITS, Nagoya, Aichi 2004

Exhibition details

- **Panel exhibit**
  Introduction to the project, introduction to participant companies
- **Screening of explanation videos**
  Achievements up to now
- **Demonstration of complex realistic transportation experiment system**
  TS, KAKUMO, DS and IMG
- **Exhibition of experimental vehicles for measurement**
  two vehicles and measuring equipment

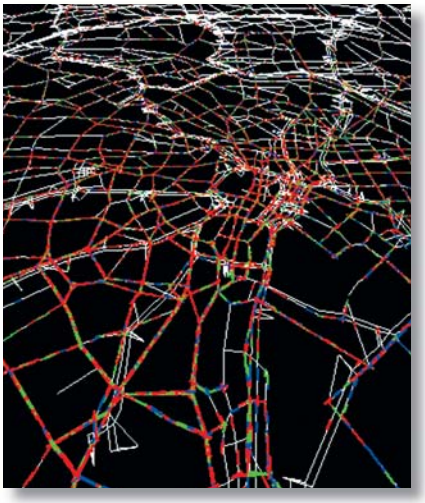
Achievements of the project

The Sustainable ITS project has worked on measurement of human factors related to driving behavior, using the complex realistic transportation experiment system created in the project's first year. The project has also continued working to improve the complex realistic transportation experiment system using the data obtained through such measurement.

The complex realistic transportation experiment system combines a traffic simulator (TS), for simulating traffic over a wide area, a micro traffic simulator (KAKUMO), for simulating the movements of individual vehicles, a driving simulator (DS), for enabling a person to experience driving, and a real time display device (IMG), for displaying the visual driving environment.

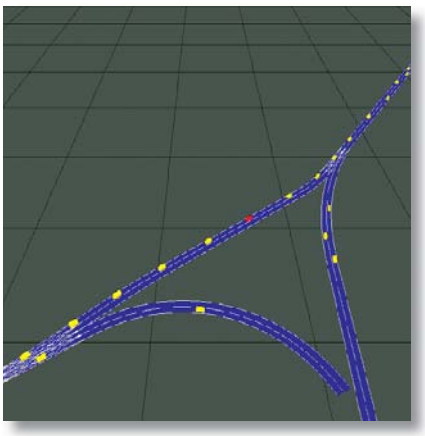
The simulators, controlled using personal computers (PC) connected over a LAN, work together cooperatively. The DS vehicle, which is operated by a driver, and surrounding vehicles, which are controlled by computer, interact with each other to re-create traffic phenomena such as traffic congestion and traffic accidents.

One of the key features in our simulator was our world-first display device (IMG) for reconstructing and displaying driving environments taken from real images recorded in real time. With this technology, a 3D model of the surrounding environment for the DS can be created simply by driving along the actual road in a vehicle equipped with video cameras, and then suitably adjusting the captured images. Previously, to achieve the same results, a huge amount of time and labor was needed to computationally generate 3D models.



▲ TS

▲ IMG



▲ KAKUMO

Exhibition at the World Congress

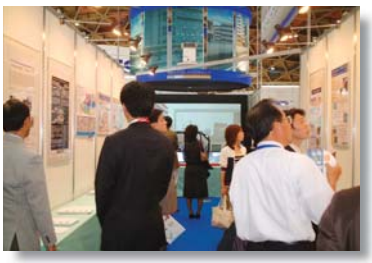
At the World Congress we displayed panels and videos to demonstrate the accomplishments of the project to date. We also had an opportunity to exchange opinions with many people who visited the panel displays, specialists and non-scientists alike.

Along with the panel displays and video presentations, we demonstrated our complex realistic transportation experiment system. This system works through the coordinated operation of several components: a traffic simulator (TS), for simulating traffic over a wide area, a micro traffic simulator (KAKUMO), for simulating the movements of individual vehicles, a driving simulator (DS), for enabling a person to experience driving, and a world-first display device (IMG) that can reconstruct and display driving environments taken from real images recorded in real time. About 200 visitors were able to experience driving on Tokyo's Metropolitan Expressway No. 3 and understand how traffic congestion occurs when a car is stopped on an expressway.

These demonstrations were also screened using two projectors set up beside the exhibition venue to allow the many people who could not directly experience the system to observe how it works.

▲ Front view of the exhibition venue

▲ DS



▲ Panel display view

Ikeuchi Laboratory

The Ikeuchi Laboratory displayed panels on its ITS-related research, including a presentation about its "real space information collection vehicle." At the Nagoya event, the group conducted a demonstration of the first ever driving simulator system utilizing real images, which were displayed on the IMG. The details are as follows:

1. Nine cameras were set up in the experimental vehicle, as shown in the picture, to capture high-resolution images around a 180° view in the forward direction.
2. From these nine different images, a panoramic image of the entire forward direction (180°) is formed, using a method called EPI, for each point along the driving path.
3. Images from any viewpoint can be constructed using these panoramic images.
4. The constructed images are projected onto a virtual wall that appears beside the road. As the vehicle moves these projected images are refreshed continuously. In order to generate left and right hand side scene, we prepare two such virtual walls.
5. In composing the images onto the virtual walls and combining with the conventional driving simulator images, the roads and vehicles between the two walls are generated, using the conventional computer graphics techniques, under the control of the KAKUMO engine, while the background scenes, such as buildings and thee sky, are displayed, using our newly developed techniques, on the two virtual walls. This "real space information collection vehicle" was also displayed at Oasis 21 in central Nagoya City, together with the driving simulator.

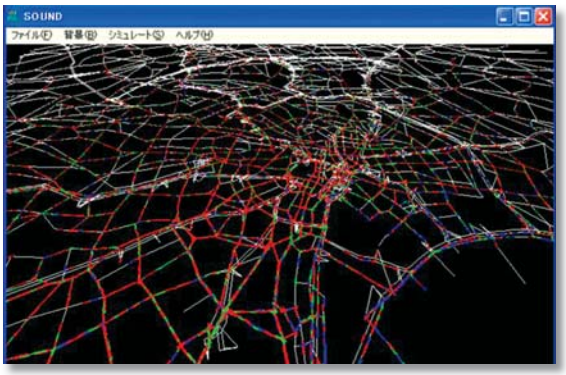
▲ Experimental "real space information collection vehicle" equipped with nine cameras.

Kuwahara Laboratory

For over 10 years the Kuwahara Laboratory has worked continuously on the development of traffic simulation technology as one of the pillars of the Sustainable ITS project. In this exhibition, we demonstrated a wide-area simulation model dubbed SOUND. SOUND can perform simulations of extremely large-scale networks such as the entire Tokyo metropolis, a task that previously could be done only using a static distributed computation system.

We also exhibited an experimental vehicle known as MAESTRO (Measurement vehicle with Advanced Equipment System for TRaffic Operation), which can acquire data on vehicle behavior and driver behavior while driving in actual traffic situations. MAESTRO is equipped with a speedometer, an accelerometer, a rangefinder for measuring the distance between the car and vehicles ahead and behind it, a microwave radar and others. As the car is driven along it can record its own driving parameters and those of surrounding vehicles, as well as the driver's behavior and performance, all in real time.

The MAESTRO demonstration, which showed the way each vehicle moves on the simulation screen, and the wide variety of measuring and monitoring devices including in the system and their complicated wiring drew a great deal of attention from visitors throughout the exhibition.



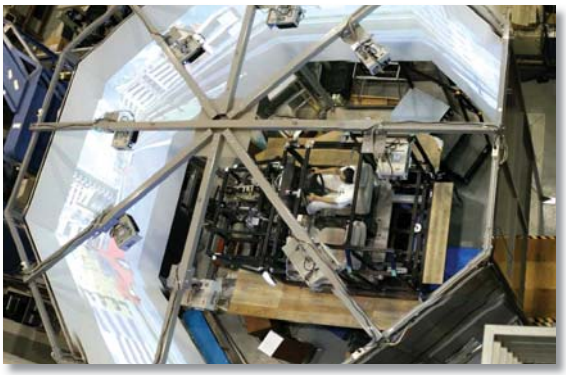
▲ Wide-area traffic simulation（TS）

▲ Experimental vehicle for driving behavior measurement

Suda Laboratory

The Suda Laboratory presented its work related to automotive and ITS systems, focusing on its research on driving simulation and electromagnetic suspension. In fact, the highly versatile universal driving simulator for research was developed by this group. This system is a simulator capable of advanced simulation of driving environments with virtual testing and advanced simulation of vehicle motion using multi-body dynamics. The system enables drivers to experience a strong sense of immersion by virtue of its 360° simulated visual field display and six degrees of freedom vibration. The driver's seat is layout-free so that the simulator can be used not only for automobiles but also for various other research purposes.

We also performed studies on measurement of road surface conditions and on vehicle motion control using electromagnetic suspension. In this area, we are looking to develop driving environment recognition technology using sensor integration for measuring road surface conditions in real time. These include measurement of the road surface friction coefficient based on tire vibration measured using electromagnetic suspension, and road surface water quantity, measured using Albedo sensors.



▲ Universal driving simulator for research

▲ Electromagnetic suspension for measuring road surface conditions

Presentations

Takayuki Taguchi [Suda Laboratory]

Development of Driver Model Using Driving Simulator with Interactive Traffic Environment

To improve the driver model, the Sustainable ITS project developed a driving simulator with a vibration device attached as a research platform for analysis of driver behavior. We named it the Universal Driving Simulator for Human, Vehicle and Traffic Research. Improved measurement of human factors to allow is needed for more effective analysis of driver behavior, as the traffic environments targeted by research are getting more and more complicated. There is also a need to improve the sense of realism of driving simulators. However, these aspects are still not the only concerns. A driving simulator is required that can be used for a diversity of experiments.

In response to this need, we developed a screen with a 360˚ viewing angle, which offers a greatly improved sense of visual reality. This system can also reproduce traffic congestion on expressways and in complicated traffic environments in urban areas, and it provides an environment that allows visual inspection in all directions. The sense of audio reality has also been improved by implementing 5.1 channel surround sound. Hereafter, we hope to improve the audio experience further by controlling the direction of the sounds. The system utilizes an AC servo motor mechanism for generating a steering reactive force. This offers smoother torque control and enables any model of steering reactive force to be reproduced. In addition, by capturing the driver's facial expression and behavior using a 16-way split HDD, and storing this as image data, post-simulation questionnaire surveys can be performed more effectively. The system also features a layout-free driver's seat made with an aluminum frame. This feature not only improves the sense of reality but will also enable various experiments to be conducted in the future. We are now planning to use this driving simulator to research driver models in complicated traffic environments.

Makoto Furukawa [Chodai Co., Ltd.]

Development of a Microscopic Traffic Simulation Model for Interactive Traffic Environment

The presentation consists of three components:

1 **An outline of the Sustainable ITS project** 2 **An outline of VEL** 3 **An outline of KAKUMO**

This paper overviews the project, how this project is a collaborative effort involving industry, government and academia, with contributions across a number of different fields of research, and pointed out that the project aims to advance applied ITS research by undertaking studies in three phases, repeatedly taking into account feedback from the research. In the next section, the significance of the development of VEL, composed of a TS and a DS, and KAKUMO.developed with the aim of absorbing the differences in specification between TS and DS for analyzing human factors were presented.

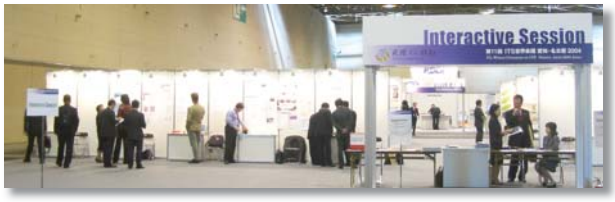
-Finally, our plans to provide KAKUMO with the capability to manage vehicle information, and to perform simulations using a three-stage driver model, embodying cognition, judgment and operation, as these features are important to the role of KAKUMO was reported Our goal is to provide KAKUMO with a simple Vehicle Dynamics system to reproduce the driving trail of vehicles more realistically.

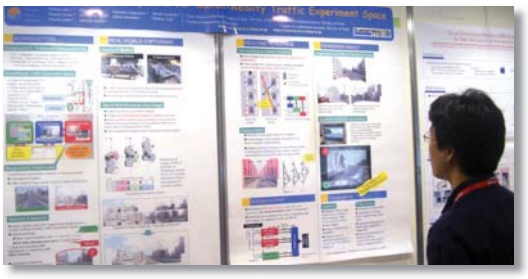
At the time of the presentation, some of the items were of course still in the planning stages. Nonetheless, we believe that it was very worthwhile to present the aims and particular features of the project.

Sessions

Interactive Session

This was the first interactive session held at a World Congress on ITS. The idea was to allow session presenters and participants to talk interactively. Specialists, serving as moderators, would move around and observe all the presentations. As a moderator visited a session, the presenter would give an explanation of several minutes, and have a couple of question/answers interactions. This provides opperatunities to presentors, usually young researchers, to be able to directly talk to world reknown experts in their fields. At the Sustainable ITS Project we offered two presentations: one summarized the project overall, and the other covered some of the details of our IMG. These interactive sessions provided an opportunity for half-day presentations, but unfortunately not many people took advantage of them, except in the breaks between oral sessions, since the oral presentations were held at the same time. However, all the presentations were well received as they included explanations of the project along with demonstrations at the exhibition venue.





Development of a Time and Space Continuous Observation Vehicle with Inter-vehicle Interaction.

[Prof. Hirokazu Akahane, Chiba Institute of Technology]

The Virtual Experiment Laboratory (VEL) provides an environment in which people can actually drive using a driving simulator in a virtual traffic environment utilizing real-world data. We are developing an observation vehicle to provide measurement data relating to microscopic driving behavior of vehicles to the VEL.

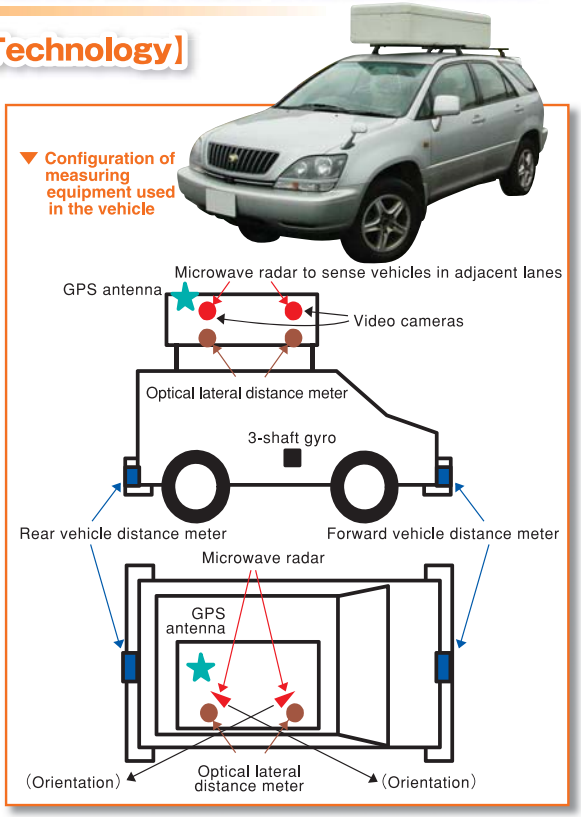
The observation vehicle is fitted with a RTK-GPS receiver, 3-shaft gyro acceleration meter, rotary encoder for measuring its own behavior, laser inter-vehicle distance meter, optical lateral distance meter, and microwave radar for measuring the behavior of surrounding vehicles.

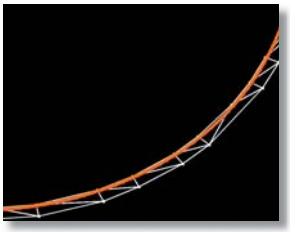
The measurementdata obtained from the various sensors is stored on a PC in the vehicle at a frequency of 30 Hz, along with a high-accuracy time code generated from a GPS signal. Image data captured by a digital video camera mounted on the roof for filming surrounding vehicles is also recorded. The measurement data from each sensor includes random errors and bias. The measurement data need to be integrated with the results of observations conducted on the driving behavior of specific vehicles using a different method. Furthermore, whenever a GPS signal cannot be received well, for example inside tunnels and in areas with sound barriers, some of the GPS measurement data will be missed. The missing data must therefore be interpolated from other measurements.

In view of this, we applied a Kalman filter to perform integrated smoothing of the measurement data, resulting in a least-squares estimate of the driving path. The algorithm used features a 30-dimensional state equation and a 30-dimensional measurement equation for translational motion and rotational motion of the observation vehicle.

We are also developing a method to estimate the relative positions of the observation vehicle and the escort vehicle by automatically obtaining the screen coordinates of the number plate. This is achieved by image processing of recorded data of the escort vehicle, followed by application of a projection conversion formula. We take these estimate values as inputs for the Kalman smoothing filter, and then perform a least squares estimate of the driving behavior by combining information from the observation vehicle and the escort vehicle.

▼ Configuration of measuring equipment used in the vehicle





▲ Estimate of vehicle position

▲ Video image from the driving behavior measurement experiment vehicle

Why Traffic Congestion on Expressways occur?

[Assoc.Prof.Takashi Ohguchi, Tokyo Metropolitan University]

Traffic congestion occurs frequently in the middle of expressway, well away from any exits or tollgates. Often the causes of this relate to a driving behavior characteristic of individuals known as "following," which occurs in areas where the road slope changes from descent to ascent (sag).

In order to elucidate the detailed mechanism of this phenomenon, we conduct driving experiments using an experimental vehicle with advanced position identification technology, targeting the areas and times when the traffic congestion occurs. We also need to collect actual time and space paths of many vehicles by roadside video observation, to analyze distribution of the driver characteristics.

In addition, we can use a driving simulator to investigate the differences in behavior characteristics among test subjects under the same conditions, and to study traffic changes under different slope conditions. Integrated experiments and data collection using features of all three tools-an experimental vehicle, roadside video observation and a driving simulator-is the key to elucidating the mechanism of traffic congestion on expressways.

Ubiquitous ITS platform, EUPITS
[Prof.Takaaki Hasegawa, Saitama University]

Instead of constructing an ITS as an exclusive system, the Hasegawa Laboratory at Saitama University is proposing the creation of an ITS that functions as an application on the Ubiquitous ITS platform, EUPITS (Evolutional Ubiquitous Platform for ITS), which takes into account migration and is in constant evolution.

The EUPITS that we propose (refer to Fig. 1), consists of a Human Machine Interface (HMI) sub-platform and a Map Information sub-platform, as well as telecommunications and positioning sub-platforms. Furthermore, we are also proposing adoption of the Liver ITS Platform (LIP) (refer to Fig. 2 and Fig. 3) that supports movement of pedestrians and objects, as well as economic activities. Our work aims to realize a new kind of ITS for creating elemental technology to support these platforms, and ITS applications to be used on various sub-platforms and platforms.

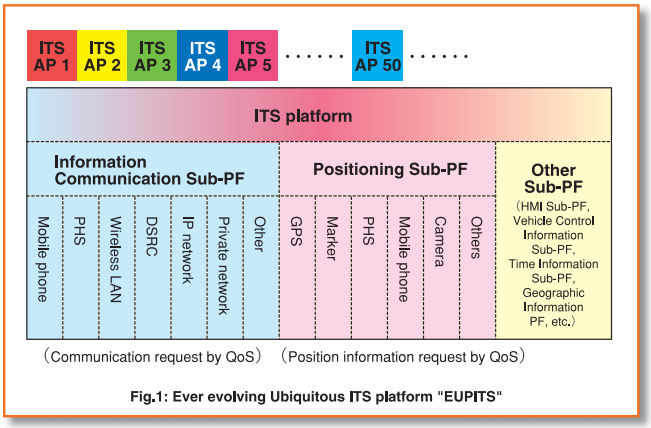


Fig.1: Ever evolving Ubiquitous ITS platform "EUPITS"

▲ Evolutional Ubiquitous Platform for ITS (EUPITS)

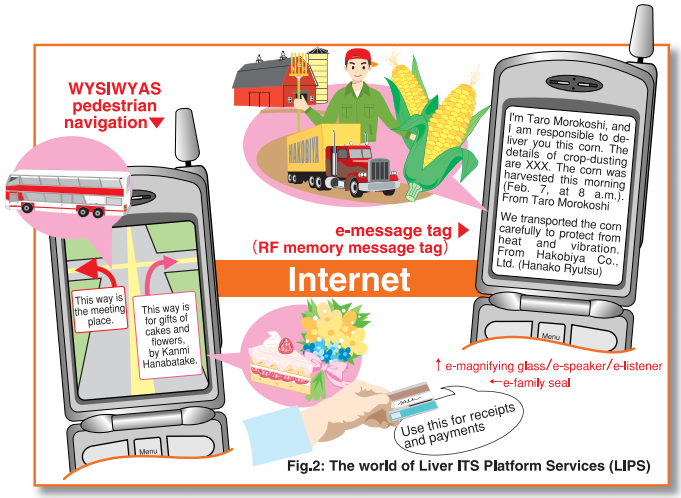


Fig.2: The world of Liver ITS Platform Services (LIPS)

▲ The world of Liver ITS Platform (LIP)

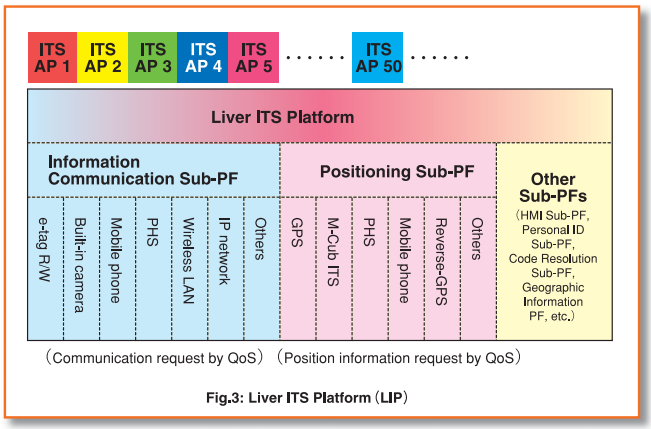


Fig.3: Liver ITS Platform (LIP)

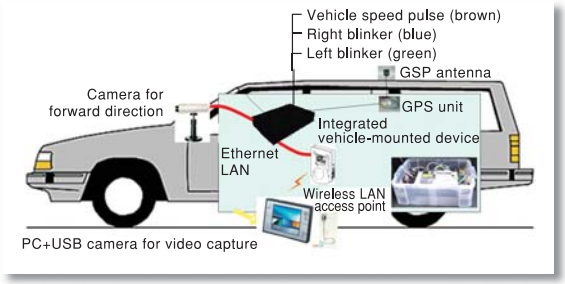
▲ Liver ITS Platform (LIP)

Use of a Probe Information Processing System
[Mr. Ryota Horiguchi, researcher, ITL]

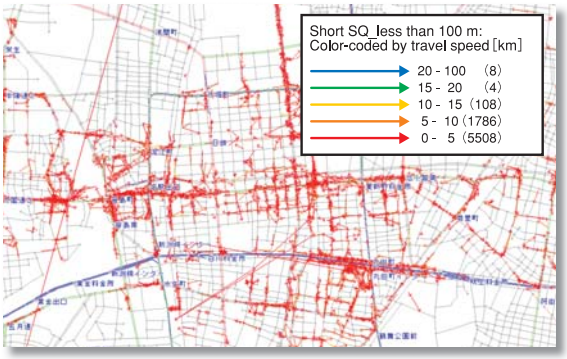
Since I joined this project at the Japan Automobile Research Institute in 2000, I have been working on experiments to demonstrate a probe information processing system for an integrated vehicle-mounted device.

This integrated vehicle-mounted device is a server fitted in a vehicle and connected to the Internet via IPv6. It includes functions to collect vehicle-related information, such as GPS data, vehicle speed, indicator and camera states, and to process this information and transmit it to a data center.

Within this project my main focus is the study of a processing function for extracting effective data with the vehicle-mounted device so that only useful data is sent to the data center, thereby increasing efficiency. In the 2004 university year, I developed algorithms for extracting traffic congestion driving patterns and for detecting abnormal traffic congestion information using statistical information. I presented some of this research at the ITS World Congress in October last year.



▲ Configuration of the integrated vehicle-mounted device probe



▲ Distribution of traffic congestion patterns, extracted by probe experiment

Towards the final university years

CCR's "Sustainable ITS" project is now more than halfway through its planned lifetime.
Here we offer an outline of our current plans for the project.

(1) Generating environmental data for DS

3D data describing roads and surrounding structures is needed for motion and image displays in DS devices. In order to provide more flexibility for the growing diversity of research on ITS applications, we are planning to develop new methods to more efficiently generate these environmental data.

(2) Correction and display checking of KAKUMO

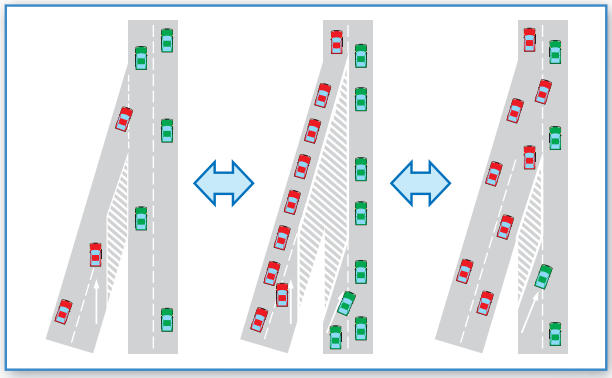
We aim to improve several KAKUMO programs to link better with our DS and TS. Some applications, for example, need different models for porting of driving behavior. Thus, we intend to enhance KAKUMO so that these models can be more easily ported. Another aim is to improve KAKUMO so that vehicle heading directions are more accurately taken into account. We will also correct defective operations at link boundaries.

(3) Verification of DS and KAKUMO

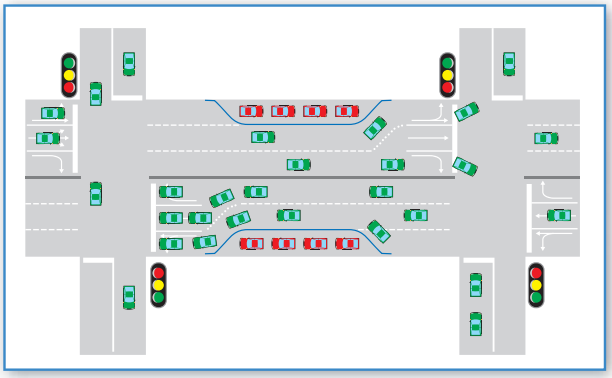
Using experimental vehicles and real data obtained by video observation, we plan to verify basic driving behavior models that are ported in KAKUMO. On the DS side, we will verify the sense of speed and acceleration that test subjects experience, and will also verify the subject's recognition of symbols and information panels displayed on screen.

(4) Various applications

In the ITS application research of Stage 3, we will analyze various applications using this system. Before this, however, we will investigate effective variable-lane markings for sags, and diverging and converging sections of expressways. We will also study how to effectively convey traffic information, and how to better process traffic at general road intersections.



▲ Image of converging point variable-channelization



▲ Image of road parking management between intersections

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