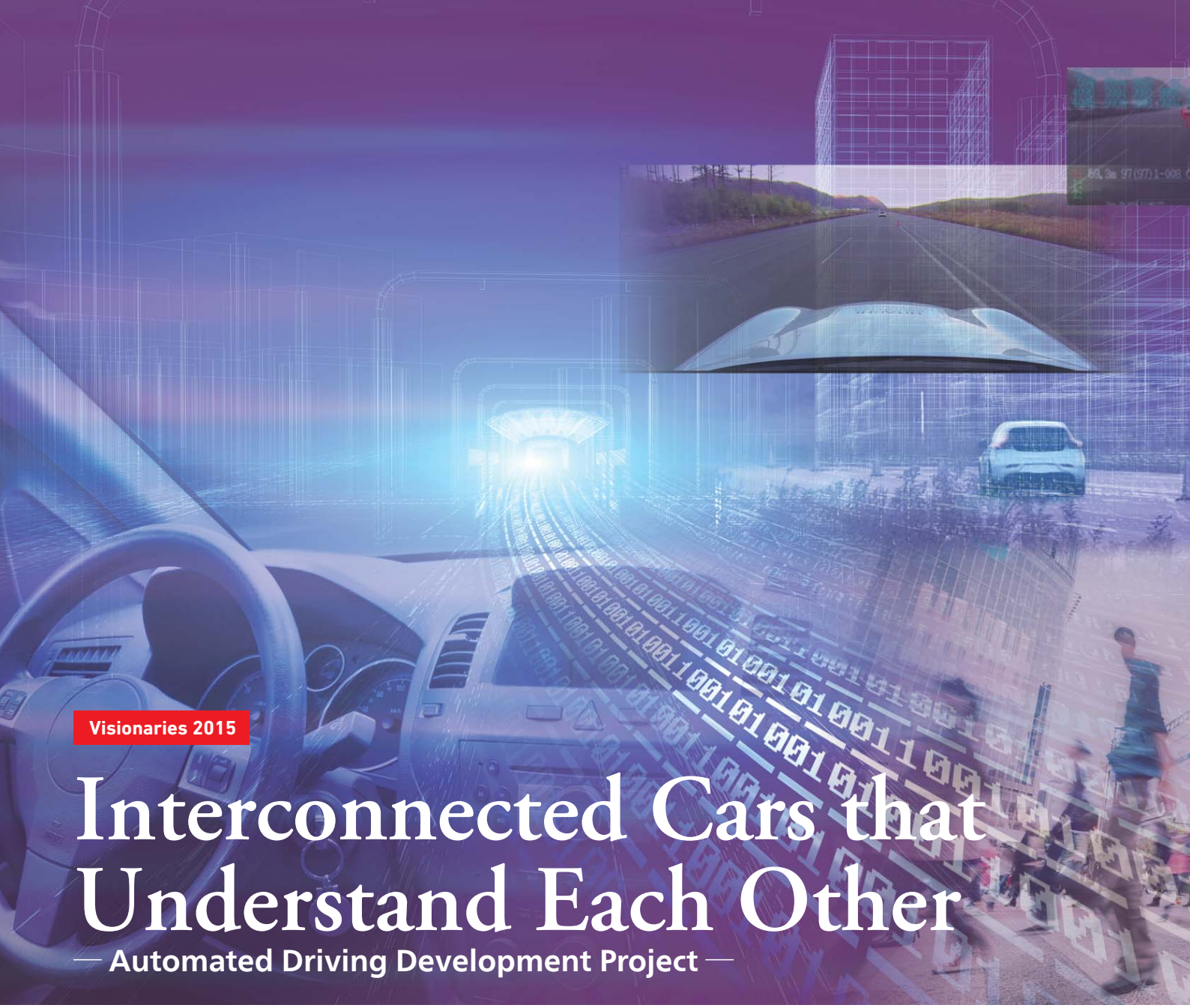


Visionaries 2015

Interconnected Cars that Understand Each Other

— Automated Driving Development Project —

Moves by car makers, suppliers, and others to implement automatic driving are accelerating.
With many years of involvement in automotive technology, Hitachi is working on developments that aim to implement automated driving systems from a variety of angles, including "seeing" and "sensing" as well as driving, cornering, and stopping.
Anticipating integration with the cloud, big data, and other forms of IT, Hitachi is also combining a variety of different technologies.
Automated driving systems are set to forge a new relationship between vehicles and people, and also with the wider world.

From Driving Support to Automated Driving

In 2014, the Japanese cabinet announced that a plan for research and development of automated driving systems would be one of its strategic innovation promotion programs (SIPs). The plan includes a target of achieving fully automated driving by the late 2020s, anticipating benefits in the form of fewer traffic accidents, less congestion, less load on the environment, and mobility assistance for the elderly and others.

The US National Highway Traffic Safety Administration (NHTSA) defines the level of vehicle automation on a scale of zero to four. Already car makers, suppliers, and others in Japan and elsewhere are accelerating research and development into automated driving with the aim of achieving "semi-automated driving" (level 2) by around 2017.

Given this situation, Hitachi launched a project

for the development of automated driving systems in October 2013. Atsushi Kawabata (Board Director and CTO, Hitachi Automotive Systems, Ltd.), who is managing the project, describes it as follows.

"Intermediate technologies that take us some of the way toward automated driving are already part of our daily lives. Driving assistance systems that apply the brakes automatically in an emergency are one example. The project involves the further development of components like these, utilizing the comprehensive capabilities that are Hitachi's strength to drive the work forward."

Hitachi and Fuji Heavy Industries Ltd. have jointly developed the EyeSight driving safety system, which incorporates such functions as automatic emergency braking. EyeSight uses stereo cameras and was first fitted to a Subaru Legacy model released in 2008. The considerable interest this "uncrashable car" attracted is still a fresh memory.

Smart ADAS + IT

Building on this success, Hitachi's aim is to produce an automated driving system that balances the four objectives of fuel economy, time, comfort, and safety. Automated driving using a smart advanced driver assistance system (ADAS), currently under development as a further enhancement of conventional ADASs, provides drivers with benefits such as better fuel economy and earlier arrival times achieved through optimal route selection. Taisetsu Tanimichi (Senior Engineer, Smart ADAS Technology Development Department, Advanced Development Center, Technology Development Division, Hitachi Automotive Systems, Ltd.), project coordinator with responsibility for its execution and direction, explains:

"Hitachi has know-how from supplying a wide range of products, including driving actuators and engine and gearbox control as well as electric power trains, which have a major influence on fuel economy, and the project is taking advantage of this. Furthermore, achieving high-level automated driving will likely require integration between the smart ADAS onboard the vehicle and the trans-

Atsushi Kawabata

Taisetsu Tanimichi

	Control	Practical examples	Traffic monitoring	Responsibility for driving safety
Level 0	Acceleration, steering, and deceleration are always under driver control.	Warning systems only	Driver (continuous)	Driver
Level 1	Vehicle performs either acceleration, steering, or braking (without relieving the driver from driving).	ACC, LKS, and similar functions operate independently.	Driver (continuous)	Driver
Level 2	Under specific conditions, the vehicle performs two or more of following operations: acceleration, steering, and deceleration. [In automated driving mode, the driver is physically relieved from driving (can remove hands from the steering wheel and feet from the pedals).] * The driver is responsible for responding to emergencies.	ACC and LKS operate in tandem, etc.	Driver (continuous)	Driver
Level 3	Under specific conditions, the vehicle performs all three operations: acceleration, steering, and deceleration. * The driver is responsible for responding to emergencies.	Automated driving on designated sections of highway or vehicle-only roads	System (under specific conditions)	System (control can be handed back to the driver with appropriate leeway when the system judges it is unable to continue driving automatically.)
Level 4	The vehicle performs all three operations: acceleration, steering, and braking.		System	System

LKS: lane keeping system

Levels 0 to 4 of driving automation defined by the NHTSA. Similarly, documents from the Autopilot System Study meeting of Japan's Ministry of Land, Infrastructure, Transport and Tourism define automated driving as the vehicle performing two or more of the following operations: acceleration, steering, and braking.

Hiroki Uchiyama

Yoshitaka Uchida

portation infrastructure and other social infrastructure."

Coordination between vehicle and road, vehicle and vehicle, and pedestrians are important aspects of high-level automated driving. Essential to this is communication based on integration and other links with transportation infrastructure to assist with the acquisition of vehicle, road, and pedestrian information. This synergy with information technology (IT) provides another opportunity for taking advantage of the strengths of Hitachi. Hiroki Uchiyama (Department Manager, Smart ADAS Technology Development Department, Advanced Development Center, Technology Development Division, Hitachi Automotive Systems, Ltd.), who coordinates work on onboard architectures and control maps and communications, makes the following comment:

"Roughly nine million vehicles are produced in Japan each year. This means that the technologies they use must have very high levels of reliability. We are also looking to take technologies that have been proven in automobiles and deploy them in other fields."

Automatic Parking Systems as a Precursor of Things to Come

In October 2014, Hitachi hosted a safety technology presentation in front of about 120 people from 13 Japanese and overseas car makers at the Tokachi test track in Hokkaido where they staged demonstrations that included the unveiling of a smart ADAS that is currently under development.

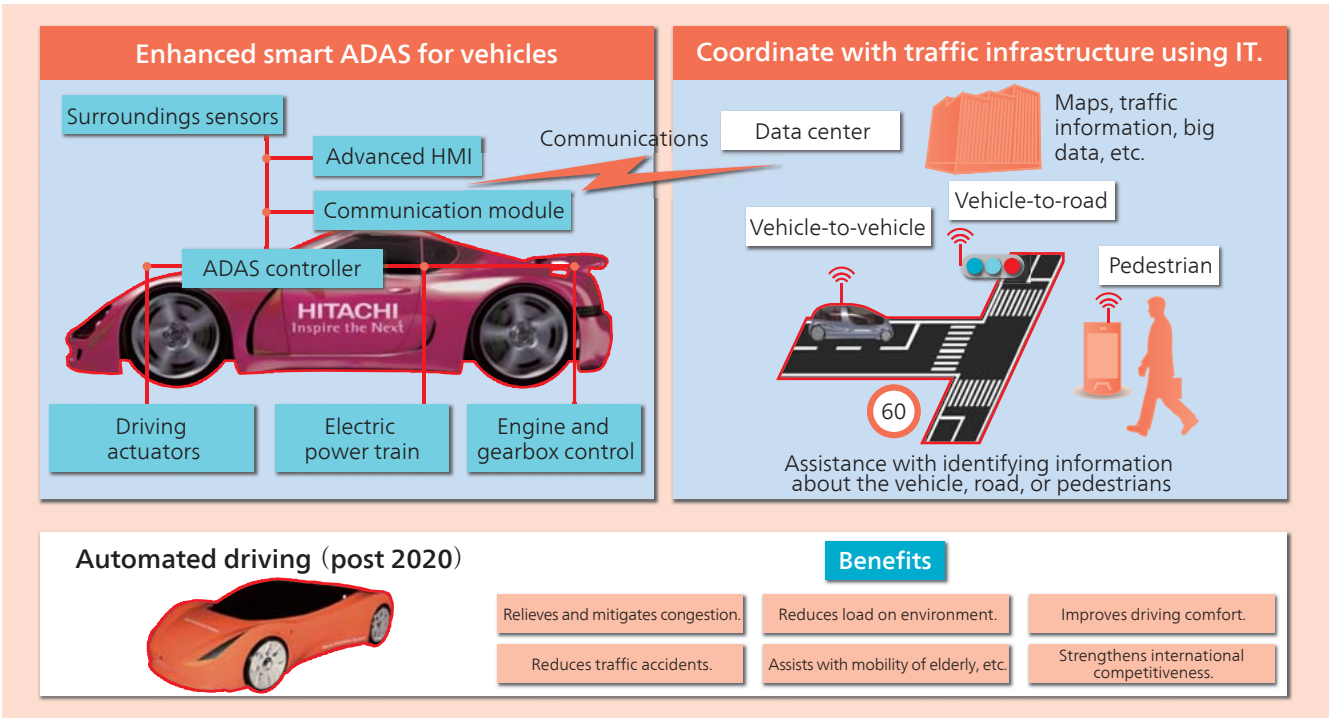
At the demonstration, there was particular interest in the presentation of an automatic parking system intended for commercial release in 2018. This system integrates driving actuators and vehicle control devices with SurroundEye*, a 360° bird's eye camera system developed by Clarion Co., Ltd. The demonstration was based on the scenario of a person suddenly appearing in the path of a reversing vehicle. The audience was fascinated by the movements of the test vehicle, which halted immediately when it detected the manikin used in place of a person, and then resumed its parking maneuver once the manikin was moved out of the way.

Yoshitaka Uchida (Manager, Application Development Group, Camera System Development Dept., Camera System Management Department, Clarion Co., Ltd.) explains the significance of this work as follows.

"Automatic parking systems are an important technology for automated driving because parking represents the start point and end point of each vehicle journey. While current systems can sense a region of 3 to 4 m around the vehicle, the new system extends this to between 10 and 20 m."

The image recognition techniques utilized in automatic parking systems hold the key to automated driving. Furthermore, the sensors used to detect the surroundings include infra-red, ultrasound, and radar as well as monocular and stereo cameras, each of which has different characteristics.

* SurroundEye is a registered trademark of Clarion Co., Ltd. in the United States, EU, Australia, and Japan; and is pending trademark registration in China.



Coordination between vehicles and the infrastructure will be essential to achieving automated driving. In this respect, synergies can be expected with IT, which is one of Hitachi' s strengths.

Takeshi Shima (Senior Researcher, SS1 Unit, Department of Smart Systems Research, Hitachi Research Laboratory, Hitachi, Ltd.), who deals with all aspects of image recognition, describes their development plans as follows.

"While sensing capability is important, we also need to be aware of cost when considering commercialization. Accordingly, our first challenge is to determine how much can be achieved using cameras. Of course, cameras have their weaknesses, and therefore we are looking into using a 'sensor fusion' that utilizes the respective advantages of different sensors."

With cameras, there is the risk that they may not be able to reliably sense their surroundings at night or during wet or snowy weather. Accordingly, to ensure safety, Hitachi is working on developments that can cope even with environments that exacerbate uncertainty by utilizing methods such as multiple sensors.

Automated Driving that Feels Natural

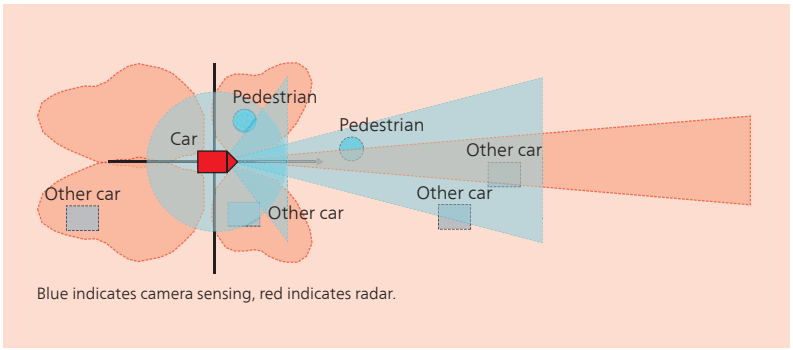
In addition to the ability for vehicles to "see" and "sense," automated driving also requires technologies for driving control that can coordinate these abilities with the vehicle's driving, cornering, and stopping capabilities. Takuya Murakami (Chief Engineer, Vehicle Integrated Control Technology Development Department, Advanced Development Center, Technology Development Division, Hitachi Automotive Systems, Ltd.), who works on automatic parking and vehicle driving control, explains this as follows.

"Along with automatic emergency braking and other collision prevention systems, lane-keeping assist is a vehicle control technique associated with automated driving that is largely complete. We are working on further developments that will 'read' the shape of the road ahead and control the steering accordingly."

A test vehicle has been fitted with a control system that combines adaptive cruise control (ACC) with G-Vectoring Control (GVC), a proprietary Hitachi technology that automatically controls acceleration and deceleration during cornering based on steering wheel position. In a demonstration, which consisted of using ACC (with a stereo camera) to follow the car ahead, and then using GVC to control the vehicle as it entered a corner at a speed of 70 to 80 km/h, the vehicle exhibited the same smooth cornering you would expect from an experienced driver.

Mr. Murakami notes that, "It is not uncommon to feel disconcerted when traveling as a passenger in a car driven by someone else. For automated driving at level 2 or 3, vehicle control needs to be good enough to avoid this."

The next step is to combine these individual technologies for the purpose of changing, merging, or diverging lanes on a highway. Beyond that lies the realm of level 3, which is close to fully automated driving.

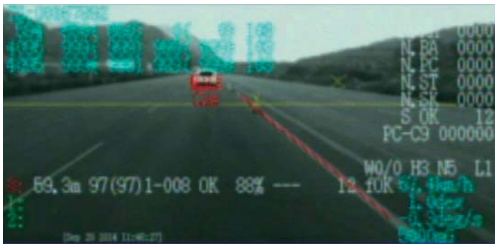


Concept of sensor fusion. There is a need to study how to combine the benefits of different techniques.

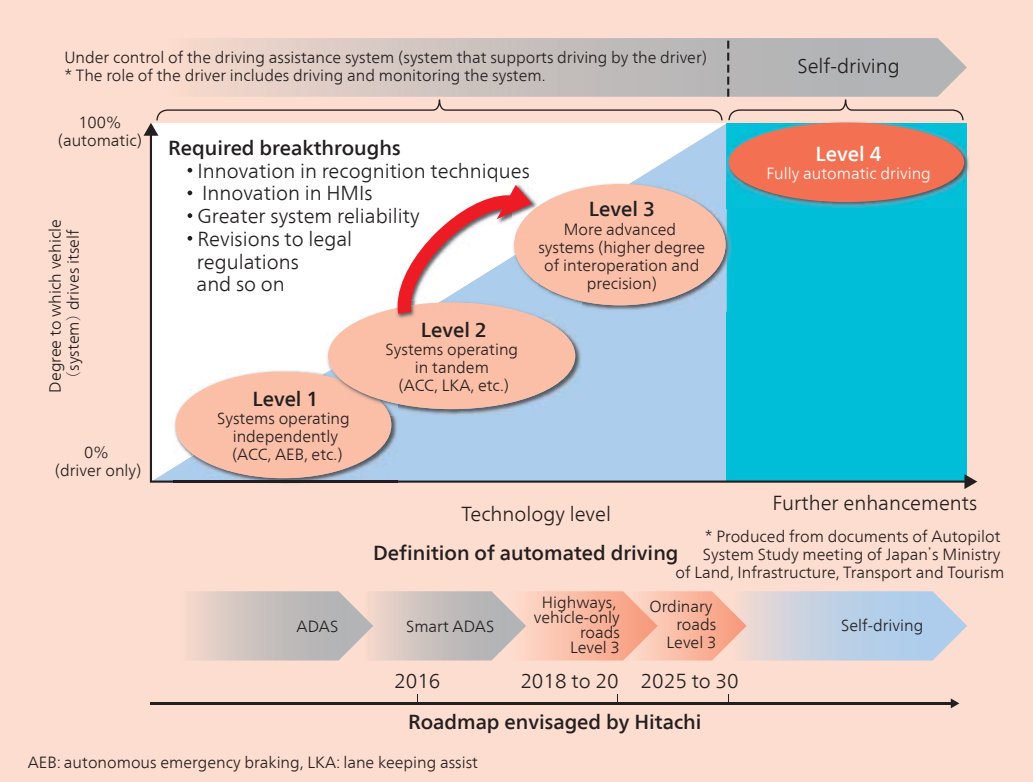

Takeshi Shima


Takuya Murakami


Demonstration of automatic parking system at Tokachi test track. The system incorporates technologies essential to automated driving.


A demonstration of ACC using only small stereo cameras. Delicate control of the vehicle is needed to prevent the operation from feeling unnatural to people in the car.



Hitachi is working on a project targeting automated driving at levels 1 to 3. A number of technically challenging hurdles separate levels 2 and 3.

Challenges on the Way to Fully Automated Driving

Between automated driving on a highway and unrestricted automated driving lie a number of difficult technical hurdles. Hitachi is working on research aimed at fully automated driving in the future. Atsushi Yokoyama (Senior Researcher, Green Mobility Research Department, Information and Control Systems Research Center, Hitachi Research Laboratory, Hitachi, Ltd.), who is engaged in leading-edge research and development in this field, describes the difficulties as follows.

"When we look at operating under all the different road environments, we see that the self-driving vehicle will need to interpret not only unexpected obstacles but also complex traffic rules in the same way as a human driver. Accordingly, various technologies for recognition, decision-making, and driving need to work at a level that is an order of magnitude higher than on a highway. In the case of recognition, along with the obvious need to be able to identify pedestrians, there is also a requirement to predict their behavior and use this as a basis for on-the-spot control of the engine, brakes, and steering."

The project has improved recognition performance through advances in sensing technologies that primarily involve cameras. For decision-making, meanwhile, the basis is provided by using a local dynamic map (LDM), a technology on which the laboratory has already started working.

Atsushi Yokoyama

An LDM is a database consisting of precise map data overlaid with information about surrounding vehicles, road conditions, traffic conditions, the weather, and so on. When using an LDM, automated driving is performed by utilizing communication information (communications between vehicles and between vehicles and the road) as well as sensing information.

As the range of times and situations in which automated driving is possible increases, interaction between the driver and the system also becomes more important. This is because it is necessary to switch from automated to manual driving to hand control back to the driver when the system judges that it cannot continue to drive automatically. By extending cockpit technologies, Hitachi is making it possible for the driver to smoothly take over the driving actions that the vehicle is about to perform.

As Mr. Yokoyama said, "Since assistance is needed for both driving and awareness, interaction with humans will come to have an important role as a step toward fully automated driving. In particular, because control at the level of milliseconds becomes necessary as vehicle speed increases, advanced technology is essential."

Hitachi is developing human-machine interfaces (HMIs) that will be essential to automated driving, and Mr. Yokoyama believes that utilizing advanced artificial intelligence for a deeper understanding of people will be needed in the future.

Forging New Relationships between Vehicles, People, and Society

Hope for Wider Scope of Driving Assistance Systems


Hiroshi Mouri

Hiroshi Mouri (Professor, Division of Advanced Mechanical Systems Engineering, Institute of Engineering, Tokyo University of Agriculture and Technology) works on important vehicle control algorithms for automated driving, driving assistance, and other systems. His relationship with Hitachi Automotive Systems, Ltd. includes joint research.

"Automated driving can be seen as a revolutionary development for overcoming the societal problems associated with automobiles such as traffic accidents and environmental degradation. However, because there are problems associated with automated driving, such as security and who is responsible in the event of an incident, there will likely be a need for things like determining standards and establishing the legal framework before it can become a reality. On the other hand, as things currently stand, it remains a serious technical challenge even for vehicles to identify their own position with a high level of accuracy, or to read the traffic conditions as they go and drive accordingly, the way an experienced driver would.

Nevertheless, the prospect of a 'super aging society' means there is a growing demand for safe and convenient means of transportation, with automated driving clearly being one of the key technologies. However, before fully automated driving becomes a reality, I believe that the wider adoption of driving assistance systems that reduce the psychological and physiological burden on drivers is important.

A strength of Hitachi is that it can configure complete systems by combining stereo camera sensors with actuators, electric power trains, and other components, and I believe it has the capabilities to compete with major overseas suppliers. I am looking at safe and secure driving assistance systems that draw on these capabilities, as well as the research and development of automated driving systems for use in the future.

While Japan's automotive industry is behind Europe and the USA when it comes to collaboration between industry and academia, speaking as an academic, it is my hope that there will be more activity in the future in the area of personnel exchanges, such as internships and guest engineers, and in joint research and development. As a leading Japanese corporation, I look forward to Hitachi taking the initiative in this field also."

Mitsuhide Sasaki (Department Manager, Vehicle Integrated Control Technology Development Department, Advanced Development Center, Technology Development Division, Hitachi Automotive Systems, Ltd.), who manages these developments and projects, expresses his resolve as follows.

"If we are to ensure that the elderly and other vulnerable users of transportation are able to drive vehicles with confidence, then I believe we will need to work on the research and development of automated driving. Although we are only just getting started, we intend to overcome the difficult obstacles one step at a time."

It is believed that the successful realization of automated driving will dramatically reduce traffic accidents by eliminating driving mistakes and other forms of human error. Another aspect worth considering is that of linking cars to information from the outside world. It is clear that vehicles will be connected to extensive cloud networks, with a steady stream of new services emerging that analyze the resulting big data.

As Mr. Kawabata says, "Along with being an innovative technology for preventive safety, automated driving also adds value to vehicles. That is, it creates new value for vehicles, people, and society, and the realization of a richer world."

This will be a world in which vehicles and drivers, vehicles and other vehicles, and vehicles and their surrounding environments will be interconnected and able to co-exist harmoniously. Once such an outcome has been achieved, it may result in a major change in how people think about cars.


Mitsuhide Sasaki