Automotive Systems

1 Next-generation ADAS ECU

1 Development of Next-generation ADAS ECU

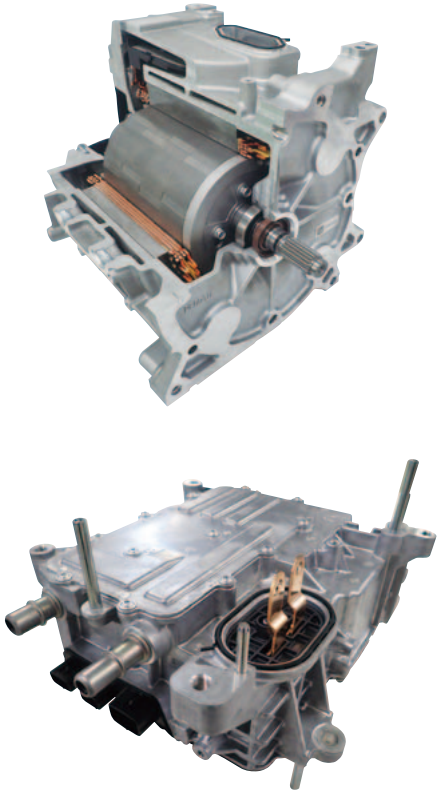
Hitachi has developed a next-generation electronic control unit for advanced driver assistance systems (ADAS ECU) that outperform previous such ECUs. The new ECU is capable of processing large amounts of data at higher speeds, being equipped with a new multi-core central processing unit (CPU) and with added support for Ethernet communications. With software functionality that includes firmware over the air (FOTA) and Controller Area Network (CAN) diagnostic security functions, the ECU provides what is needed to implement new driver assistance techniques.

In the future, Hitachi will continue working to achieve safe and comfortable automotive transportation through capabilities that include security features and the use of FOTA for updating software.
(Hitachi Astemo, Ltd.)

2 Development of Drive Unit Integrating a Motor, Inverter, and Control

As the shift to electric vehicles is accelerating in order to comply with increasingly stringent environmental regulations, Hitachi has developed and mass-produced a drive unit for battery electric vehicles (BEVs) as a system product that integrates the motor, inverter and control.

The motor uses harmonic reduction (HR) winding and ripple reduction (RR) rotor technology developed as torque ripple reduction technology to achieve skewless and low-noise operation. Also, to deliver high output and



2 Motor unit (top) and inverter unit (bottom)

high rotation, the magnets are arranged in V-shape, and the rib structure of the rotor core has been optimized.

The inverter adopting a direct water-cooled double-sided cooled power module achieves a compact size, light weight, and high output. For control, the inverter protection was enhanced by incorporating overvoltage and overcurrent protection control during vehicle slip. In addition, damping control and torque ripple reduction control are used to improve operation at low speeds.

Hitachi will continue to contribute to the realization of a sustainable society and the enhancement of its customers' corporate value by providing environmental, social, and economic value through its advanced mobility solutions that contribute to environmental conservation and improved safety and comfort.
(Hitachi Astemo, Ltd.)

3 CFRP Propeller Shaft from MFW + RTM Manufacturing Process

Hitachi has developed a new structure and manufacturing process for carbon fiber reinforced plastics (CFRP) propeller shafts and achieved a significant weight reduction and cost savings.

The conventional filament winding (FW) manufacturing process wound fiber tow, which leads to a loss in strength due to crossing (crimping) of the fibers due to the back-and-forth motion of FW, requiring considerable manufacturing time.

The new manufacturing process, multi-thread filament winding (MFW), enables carbon fibers to be layered without crossing each other, and the layering (non-crimping) is used to maximize the performance of the carbon fibers. Also, by setting the optimum amount of two types of fibers [polyacrylonitrile (PAN) and pitch-based fibers] that each emphasize tensile strength and elastic properties, the amount of material used was reduced and a significant weight reduction was achieved. In addition, the multi-thread feeding greatly reduced the cycle time compared to the conventional FW and saved the cost.

Also, the resin transfer molding (RTM) manufacturing process and an immediate curing resin has reduced the cycle time to only a few minutes from the several hours required for conventional curing in a curing furnace. The resulting high cycle rate made it possible to cut manufacturing costs. Furthermore, this manufacturing process integrally molds them during injection molding instead of the conventional high-precision serration press-fit control of the metal parts at both ends of the tube, thereby improving the reliability of the fastening parts.
(Hitachi Astemo, Ltd.)

3 CFRP propeller shaft from MFW + RTM manufacturing process

4 New-generation Dual Pinion Assist EPS with Improved Safety and Performance

To meet the growing needs of autonomous driving (AD)/ADAS in recent years and to improve the safety of electric power steering (EPS), Hitachi has completed development and started mass production of the dual pinion assist EPS, which has a redundant structure from electrical signal sensing to motor output. Depending on the level of AD/ADAS functionality that the vehicle has, the system can be selected based on functionality and cost. Also, by optimizing the friction of mechanical parts and implementing a new control logic that enables high response, Hitachi has achieved smoothness and high linearity characteristics that allow the vehicle to be controlled as desired. This new design also enables a 10% reduction in cost and weight compared to the previous system.

Looking forward, Hitachi is committed to meeting the expectations of its customers through high-efficiency development by implementing digital transformation (DX) by using computer-aided engineering/model base engineering (CAE/MBE) for developing safety improvement technology, lighter weight, lower cost designs, and higher steering performance.
(Hitachi Astemo, Ltd.)

4 Dual pinion assist EPS for the Subaru Levorg

5 Built-in semi-active damper structure (left) and the Technology category award received from Toyota Motor Corporation (right)

5 Semi-active Damper with Built-in Control Valve

To meet the need for improved comfort in automobiles, there is a growing demand for semi-active dampers that can be controlled to the optimum damping force at the right time based on the vehicle's motion state. This is what led Hitachi Astemo to develop a semi-active damper in which a built-in control valve is stored inside, which enables superior environmental resistance to chipping and water immersion, for expanding the damper's use from high-end vehicles to trucks and sport utility vehicles (SUVs).

By using a built-in design, the volume was reduced by about 20% and the weight was reduced by about 30%, improving the ease of installation in vehicles. Also, the damping force on the extension and compression sides of the damper can be independently tuned to achieve excellent maneuverability and ride comfort. Production started in April 2021, and in June 2021, Hitachi Astemo was recognized for its technological capabilities by Toyota Motor Corporation in its Technology category award.
(Hitachi Astemo, Ltd.)

6 Front Brake Caliper for BMW Motorrad M 1000 RR Motorcycle

Hitachi developed a front caliper for BMW Motorrad's first M Series M 1000 RR motorcycle that stabilizes braking performance at high speeds.

The cooling performance of the caliper body was improved in order to reduce changes in brake effectiveness due to excessive heat generation at high speeds. The heat-dissipating performance of the caliper body was improved by optimizing the brake fluid capacity inside the caliper body and optimizing the design of the brake fluid lines, while the cooling performance of the piston was improved by using the first mass-produced slit piston that takes into account the heat transfer from the pads and convection around the caliper. These enhancements realized the stabilization of braking effects at high speeds.
(Hitachi Astemo, Ltd.)

6 BMW Motorrad's M 1000 RR (left) and front caliper 3D model (right)

7 Mass Production of the HEIGHTFLEX Ride Height Adjustment Mechanism for Motorcycles

7 HEIGHTFLEX rear cushion

Hitachi started mass production of the electronically equipped ride adjustment (EERA) HEIGHTFLEX. This suspension system improves footing by lowering the vehicle seat height when the vehicle comes to a stop and ride comfort and rough road driving performance by raising the vehicle seat height while traveling. To raise the vehicle body, a self-pumping mechanism has been developed where a pump is driven using the energy of the vehicle body's shaking due to the unevenness of the road surface, which the suspension discards in exchange for heat. The mechanism can also switch between raising, keeping, and lowering the vehicle height with a single solenoid valve. This eliminates the need for auxiliary equipment on the vehicle body to achieve this function at a size roughly equivalent to that of a conventional suspension unit. In addition, this mechanism can maintain the optimal ride height during traveling even when the load changes due to baggage or two people riding through a sensor that detects the suspension stroke.

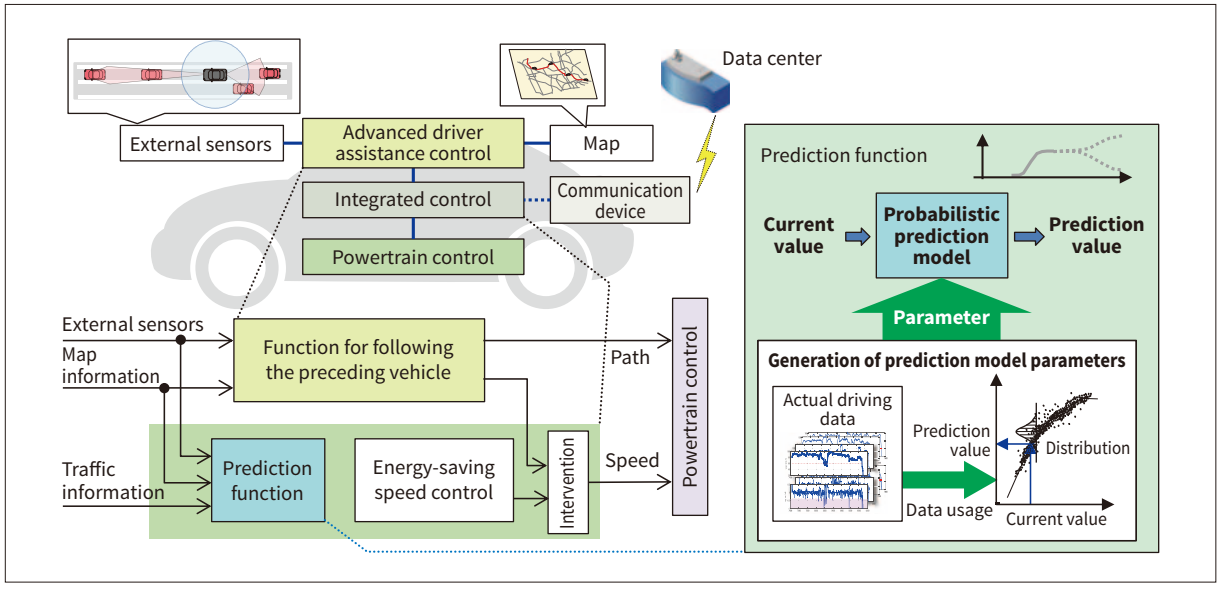
(Hitachi Astemo, Ltd.)

8 Energy-saving Driving Assistant Technology Based on Predictions Using External Information

Energy-saving technologies are essential from the standpoint of preventing global warming, and functions that suppress unnecessary acceleration and deceleration based on the characteristics of the powertrain of a vehicle have gained growing importance. Hitachi has developed a speed control function that suppresses unnecessary acceleration and deceleration and takes into account energy usage by utilizing the function for following the preceding vehicle from the advanced driver assistance system.

In this speed control function, predicting the driving situation is an essential element, and the speed and acceleration of the preceding vehicle is predicted based on the current speed and acceleration of the preceding vehicle and the road information obtained from the map. Then, based on the prediction results, a speed plan is generated to reduce the vehicle energy usage for saving energy. Hitachi used a technique to predict the speed and acceleration by probabilistically modeling the acceleration distribution from actual speed and acceleration data. When this function was evaluated using simulation, it was confirmed that an energy-saving improvement effect of about 4% was obtained in a driving scenario for an urban area.

(Hitachi Astemo, Ltd.)



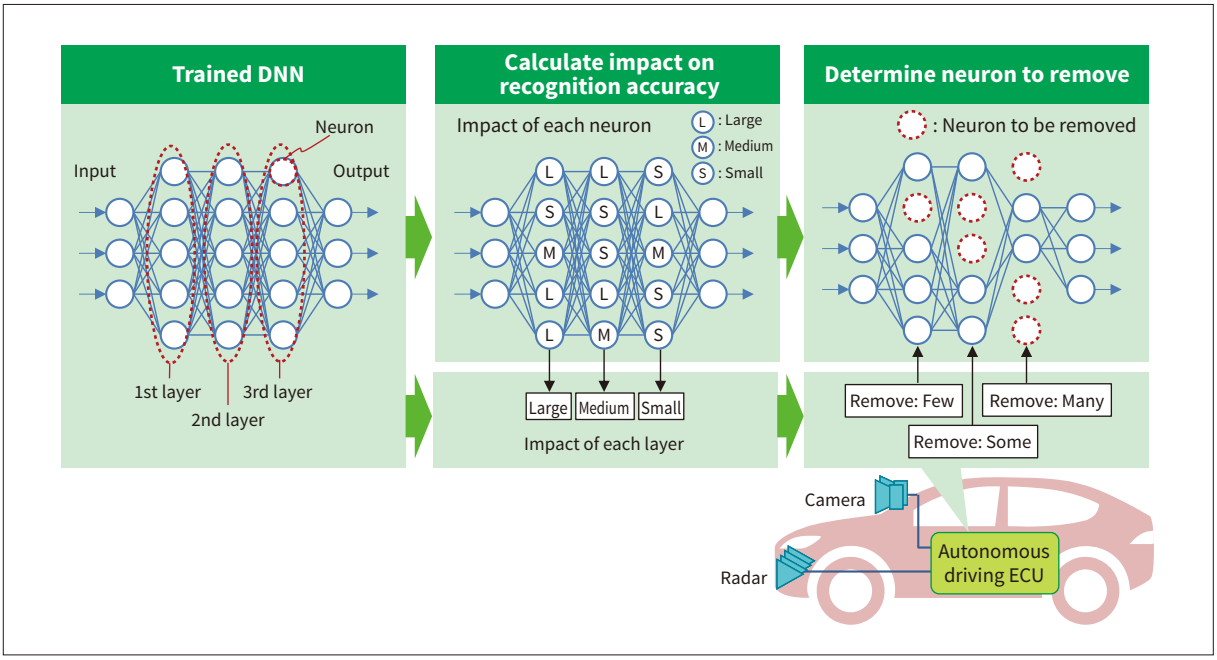
8 Overview of energy-saving driving support system based on predictions from external information

9 Computation Reduction Technology for In-vehicle Usage of Deep Neural Network

With the recent advances in autonomous driving technology, there is a growing need to achieve a high level of autonomous driving, including usage in complex environmental conditions such as ordinary roads and Level 3 on highways. Autonomous driving requires highly accurate peripheral recognition using deep neural networks (DNNs), but DNNs generally tend to require extensive amounts of computations. To address this issue, Hitachi has been developing technology that reduces the computational complexity of DNNs to the extent that they can be installed in autonomous driving ECUs.

One method to reduce the amount of computations in DNNs is to reduce the number of neurons, which are the building blocks of DNNs, however the recognition accuracy may be significantly degraded depending on the neurons selected. Then, Hitachi analyzed the impact of each neuron on the recognition accuracy and aggregated them in layers to calculate the impact of each layer. In this way, the neurons were adjusted so that many of the neurons in layers with low impact on recognition accuracy were removed, and the neurons in layers with high impact on recognition accuracy were mostly retained.

By applying this technique, neurons to remove could be selected only in 30 minutes, which used to take about 20 days to decide, for example. Hitachi will continue to investigate how to implement DNN processing with low load and low power, aiming at early practical applications. (Hitachi Astemo, Ltd.)



9 Processing flow from DNN computation reduction to use in autonomous driving ECUs