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Construction of an automatic operation system for large dump trucks at a construction site

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Autonomous driving requires vehicle speed control functions and steering control functions, which are the basic functions of automobiles, such as running, turning, and stopping. It also has an obstacle detection function to prevent collision accidents with pedestrians and vehicles. Furthermore, assuming unmanned driving, even if a problem occurs in the vehicle during automatic driving, a fail-safe function and a system management function that comprehensively manages these functions so that the autonomous driving vehicle can control it safely immediately. This paper introduces the autonomous driving system of heavy duty truck for a limited area, which is the first demonstration experiment for Hino Motors using a level 4 equivalent self-driving vehicle, and reports the results obtained by applying the system conducted at the Kawakami Dam Construction Site in Iga City, Mie Prefecture, in collaboration with Obayashi Corporation, which is working on the development of unmanned operation technology for construction machinery.

The system configuration is shown in Fig. 1. It consisted of sensors, a main system control unit and a sub system control unit. The main controller is mainly responsible for the basic functions of the vehicle, and the sub controller is responsible for managing the travel map data, including localization function, failsafe function and GPS Maps. The Electronic brake system can be instructed by each controller. Fig. 2 demonstrates the detail configuration of each sensor. The configuration of each function is also possessed by Fig. 3.

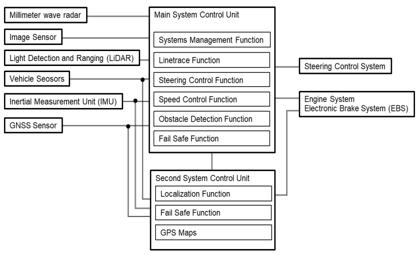

Fig.1 System Configuration

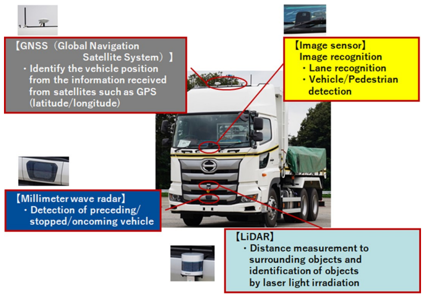

Fig.2 Sensor Configuration

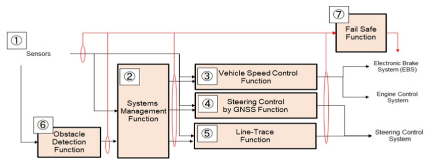

Fig.3 Software Architecture

Based on the scene scenario analysis results, the vehicle states were classified into 10 types, and the transition conditions were clarified by creating state transition diagrams and state transition tables. The goal was to select the state of the self-driving vehicle that suits the situation and to operate as expected. Fig. 4 presented the relationship between the output of the system management function and the vehicle body behavior (vehicle speed) when driving in an actual vehicle using the created system management function. It can be seen that the vehicle is accelerating, running at a constant speed, decelerating, and stopping according to the output of the system management function.

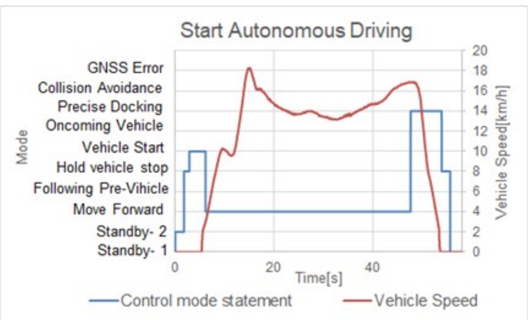

Fig.4 System Management Block Output and Vehicle Speed
(Blue line: Control mode statement, Red line: Vehicle speed)

In this demonstration experiment, it is efficiently to run a course with a total length of 2.4 km including a curve with a narrow lane, while actually transporting aggregates, without the intervention of a monitoring driver. Since the target performance was set as a skilled driver, we received comments from the driver that there was no discomfort in driving.

By evaluating the performance of each autonomous driving technology in the field, it is able to grasp the issues for actual operation by customer. At the same time, thoses issues are identified that Hino Motors should tackle in the future to contribute to the automation of construction sites, including cooperation with construction machinery. Hino will continue to develop self-driving cars that customers can use with peace of mind to solve problems in the logistics industry.