A Safe Driving Support System Based on Distributed Cooperative Edge Computing

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***Abstract*-- We propose a new safe driving support system for car drivers. The proposed method firstly sets up plural sensors inside a car and on a driver's body. These sensors detect the movements and environmental situation of the car, and the driver's vital sign. Next, the system totally analyzes the corrected data and immediately predicts any risks to cause traffic accidents. Then, the system alerts the possible risk to a driver for promoting careful driving and avoiding any accidents. Additionally, the system accumulates and analyzes data acquired from these sensors and gets a new knowledge model for safe driving. We describe the proposed system design, the implementation method, and the preliminary evaluation in this paper.**

I. Introduction

There is a big social demand for reducing traffic accidents caused by human mistakes. There many research activities on the self-driving car technologies and many researchers are actively working in the field. Some of them have already been put into practical use. For example, the automatic braking system may put a brake on a car when it detects a pedestrian or other object around the car. It contributes for reducing traffic accidents by directly controlling the car. We think, however, such automatic control system might reduce the driver's consciousness for taking care of safe driving. The best way to reduce any risks of causing traffic accidents is to let the driver practice for safe driving behaviors.

In this paper, we propose a new safe driving support system for helping the car driver. The system detects some dangerous situations for leading to traffic accidents and conveys attentions to the driver. It uses multiple sensors installed as interiors inside the car and gathers information about car movements and environmental condition. Then, the system analyzes the data and detects any changes from a normal state leading to accidents. Finally, the system notifies the driver of the detected result to raise awareness for safe driving.

Fig. 1 shows the overview of the proposed safe driving support system. We set three monitoring targets for gathering data used in the analysis for danger detection. They are the car movement data, the environmental condition inside the car, and the driver's vital sign. Three separate edge computer nodes are used for independently acquiring these data. The movement sensor node can monitor some situations such as a sudden start, an abrupt stop, and awkward steering wheel operations. The environment sensor node can detect some conditions such as excessive hot or cold temperatures, dirty air, and annoying sounds. The vital sensor node can detect driver's conditions such as a symptom before falling asleep, reduced concentration, and poor physical conditions. The system analyzes the detected conditions and effectively notify the result to the driver. We implemented a prototype system by integrating multiple techniques developed in our previous studies such as a detection method for indoor heat stroke with environment monitoring [1], and a visualization method for the radio wave conditions of wireless networks acquired by multiple observing devices [2] [3].

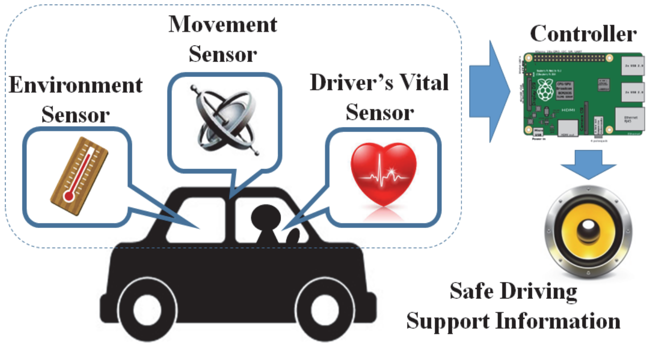

Fig. 1. Overview of proposed safe driving support system.

II. System Design

Fig. 2 shows the components and processing flow diagram of the proposed system. It consists of three edge computing nodes with different sensors used for monitoring the car and the driver, a controller for analyzing the sensing data, and a learning server for training a model for more sophisticated risk assessment. A set of proximity sensors acquire the car motions, a set of non-contact sensors acquire the environment data in the car, and a direct contact sensor acquires the driver's vital information. The in-vehicle controller node processes the data and presents safe driving support information to the driver.

The system has two running modes: a learning mode and a monitoring mode. In the learning mode, the controller uploads all the sensing data (car movements, environmental conditions, and driver's vital sign) to the remote leaning server via a wireless link. Then, the data are used to train a model for detecting some risky status threatening safe driving using a machine learning technique. In the monitoring mode, the controller processes the sensing data for assessing the risk level based on the trained model downloaded from the server.

The controller calculates the risk level by processing the sensing data received from the edge nodes. There are three ways for calculating the risk level. The first method is a simple one by judging whether a raw datum such as temperature and humidity exceeds a normal range threshold or not. The second one is a rule-based method. It determines the level by processing a combination of sensor data using

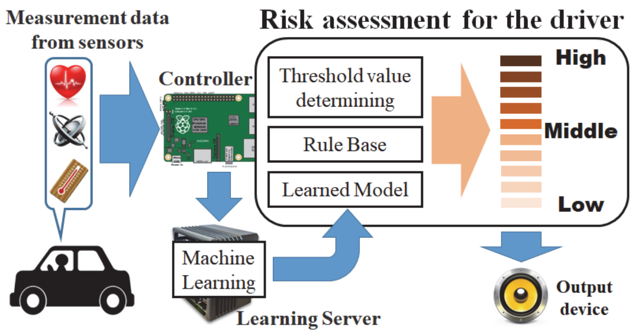

Fig. 2. System components and processing flow.

predefined rule sets. The third method is to use a trained model. Machine learning leads to produce a new rule set by analyzing the aggregated data sets. Processing the datasets using a trained new rule enables the controller to make appropriate risk assessments.

The learning server takes the sensing data received from the controller and generates the trained model. There are several ways for training the model, but we are now gathering effective data sets used for the training. We are planning to train the model using RNN (Recurrent Neural Network) because the data sets describe time series information.

Table 1. Monitoring nodes with their sensor types.

Monitoring node	Sensor type
Car motion node	3-axis accelerometer
	3-axis compass
	3-axis gyroscope
Environment node	Temperature
	Humidity
	Light-dependent
	Sound intensity
	Distance
Driver node	Heart rate

III. System Implementation

The system uses three edge computer nodes installed in the car for collecting different sensing data. The user can independently install each node in a location suitable for obtaining the information. They can communicate with each other via a wireless link.

Table 1 shows the three monitoring nodes with their built-in sensor modules. The car motion node uses a Raspberry Pi board with an onboard sensor called Sense Hat for monitoring car movements. The Sense Hat device is an add-on type sensor connected via a GPIO interface of the Raspberry Pi board. It can detect the car movements by using a built-in 9-axis sensor consisting of a gyro sensor, an acceleration sensor, and a magnetic sensor. It also has additional built-in sensors such as a temperature sensor, a humidity sensor, and an atmospheric pressure sensor.

The environment node monitors the in-vehicle conditions using a Raspberry Pi board with "Grove System" sensors marketed by Seeed Studio. The Grove System enables to easily customize the sensing node by selecting a set of necessary sensor modules and simply inserting to connectors of a prototyping board. Then, the board can be connected to the Raspberry Pi via its GPIO interface. The node consists of sensing modules including a temperature sensor, a humidity sensor, a light sensor, a sound sensor, and an ultrasonic distance sensor.

The driver node monitors the driver's vital information by using a wristwatch-like sensor. Although some methods for measuring the heart rate, respiration, and skin surface temperature of the subject using non-contact sensors are available, we adopted a wristwatch type sensor for obtaining the vital information because of its low price yet high reliability. We use an activity meter marketed by Fitbit. It can continuously monitor the heart rate and arm movements with a 3-axis acceleration of the driver during driving.

IV. Preliminary Evaluation

We conducted a preliminary evaluation for simultaneously acquiring all the sensor information using the three edge computing nodes mentioned in the previous chapter. As a result, five sensing data (temperature, humidity, light, sound, and distance) and nine sensing data (3-axis gyroscope, 3-axis accelerometer, and 3-axis compass) related to an in-vehicle environment as well as a driver's vital sign can successfully be obtained at the same time.

Additionally, a simple model for identifying a risky situation trained by machine learning was also created using the acquired 15 kinds of sensing data. We tried to download the trained model from the server to the controller and confirmed the controller worked with the model and correctly presented the result to the driver. We also checked the communication between the edge nodes and the controller was working well via a wireless link without the server.

V. Conclusions

We proposed a safe driving support system using multiple edge computing nodes. We developed a prototype system and verified it was working. Three sets of edge computing nodes equipped with different sensors are able to monitor in-vehicle conditions and a driver's vital sign. It is able to acquire 15 kinds of sensing data simultaneously. The controller processes the data and provides safe driving support information in real time to the driver. We are working on implementing a mechanism to generate a trained model by uploading the data to the learning server for training. We can add some additional information about that part in the final paper.

Reference

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