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ISSN: 0193-4120 Page No. 4035 - 4044

Design of Autonomous Car Education System by Link and Control Heterogeneous Sensor Integration Module

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Article Info
Volume 83
Page Number: 4035 - 4044
Publication Issue:
March - April 2020

Abstract
Establishment and focus: Recently, with the development of the fourth industrial revolution technology, autonomous driving technology has been recognized as a living space where mobility is secured from simple moving means. In addition, it changes the fundamental concept of automobiles and predicts new industrial paradigm values as well as social, economic and technological changes. Autonomous driving reduces the driver's burden on drivers, thereby increasing production and leisure time in the car. However, there are many obstacles to commercialization of autonomous vehicle technology. Therefore, in this paper, we design a trainer system for autonomous vehicle education.

System: In this paper, we design a trainer system for autonomous vehicle education. For this purpose, we designed the integration module connection and driving part control mechanism of various sensors necessary for autonomous driving car education. In detail, based on the driving part control part based on Arduino, the autonomous vehicle related technologies such as camera image recognition, LIDAR sensor, ultrasonic sensor, laser scanner, GPS sensor, and driving motor are integrally modularized and linked. As autonomous vehicle technology develops, autonomous vehicle technology education and educational trainer system should be developed and developed. Therefore, autonomous driving education system and trainer system can be developed through autonomous driving system designed in this paper.

Article History
Article Received: *24 July 2019*
Revised: *12 September 2019*
Accepted: *15 February 2020*
Publication: *26 March 2020*

Keywords: *Autonomous car education, Sensor control, Sensor integration, Camera image, LIDAR, GPS, Ultrasonic sensor.*

1. Introduction

Autonomous driving technology is changing the fundamental concept of a car from a simple means of transportation to a living space with mobility. These changes foreshadow social, economic and technological transformation as well as new industrial paradigm values. Autonomous driving reduces the burden on drivers and increases the production and leisure time in the car[1,2]. In addition, it is a future core technology that is expected to contribute to improving the quality of life by reducing traffic accidents caused by autonomous driving, streamlining traffic flows, and supplementing the capacity of the disabled, including the disabled and the elderly.

In addition, autonomous driving has led to an increase in travel and in-car content consumption, leading to the growth of the service industry, including digital advertising and Internet sales. In addition, new business planning and model creation can be maximized in the fields of finished cars, core parts, semiconductors, software, and mapping according to ICT technology. With the advent of autonomous cars, accidents caused by driver's immature driving, violent driving and drunk driving will disappear[3,4]. Accordingly, it will be possible to reduce costs related to traffic accidents such as vehicle insurance premiums. The use of autonomous cars will enable more people to use the vehicle, which will increase transportation efficiency. If the person with the current driving ability does not ride, the vehicle cannot be moved.

However, the commercialization of autonomous cars is expected to increase the use of individual vehicles such as the elderly and the disabled. Furthermore, due to the characteristics of autonomous driving, the vehicle is expected to evolve into a new platform space that can do various tasks and activities, not just a means of movement. The use of the display inside the autonomous car will enhance the function of infotainment such as the consumption and search function of various contents such as watching movies[5,6]. As a result, meaningless and exhausting travel time will be changed to a meaningful time to gain new value.

However, despite the positive outlook and astronomical economic value of autonomous vehicles, there are many obstacles to overcome in order for autonomous driving technology to be commercialized. In particular, the development platform for training experts in the field of autonomous vehicle education is insufficient. There is an urgent need to develop an educational trainer system equipped with the basic technology of autonomous vehicles and to utilize them in the field of education[7,8]. In the future society, autonomous cars are emerging as a big topic in the automobile industry, and traditional automakers and leading IT companies are studying autonomous cars. Most companies developing autonomous vehicles now plan to launch fully autonomous vehicles by 2020, and are improving current technologies with the aim of commercializing them in 2035. However, there is no device for training autonomous driving cars. Various studies have been conducted around autonomous vehicles worldwide[9,10]. Therefore, along with the development of ICT technology, education related to autonomous vehicles should be conducted together. However, training and kits related to autonomous vehicles are still incomplete. Therefore, in this paper, we intend to conduct a study to design an educational autonomous vehicle trainer system applying the actual autonomous vehicle functions such as camera image recognition and LIDAR sensor.

Therefore, in this paper, we designed a trainer system for autonomous driving car education. To this end, we conducted a study on the design of autonomous driving car training trainer system applying technologies such as overall system control through Arduino, obstacle detection, avoidance and stop based on rider sensor, and sign recognition using camera image recognition.

2. Methods

An autonomous vehicle is a vehicle that can be driven by a vehicle without a driver or passenger. Autonomous Vehicles are organically coupled vehicles with high-performance and high-reliability autonomous driving capabilities. Through this, it is a car that can drive safely without collision based on the concept of driving itself without the driver's involvement, using various information obtained from sensors and recognizing the precise location and surrounding environment of the vehicle[11].

As global autonomous vehicles-related companies select 2020 as the time for commercialization of autonomous vehicles, market research institutes are expected to form a market in full swing by 2020[12]. The Boston Consulting Group (BCG)

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predicted that the market for autonomous vehicles will reach about $ 42 billion by 2025, and will grow to $ 77 billion by 2035. In 2035, autonomous cars are expected to account for 25% of global car sales. Of these, 12 million fully autonomous cars and 18 million partially autonomous cars are expected. IHS Automotive predicts that in 2035, autonomous cars will sell over 10 million units, accounting for about 10% of the automotive market[13,14]. Navigant Research, which is the most optimistic of the autonomous vehicle market, predicts that autonomous vehicle penetration will reach 4% in 2025, 41% in 2030 and 75% in 2035. McKinsey estimated the full-scale commercialization of autonomous vehicles in late 2030, compared to other agencies, and by 2040, more than 75% of US automakers would be autonomous vehicles[15,16]. Fig. 1 shows the market size and sales forecast for autonomous vehicles. The market for autonomous vehicles is $ 1 billion, and the share of full autonomous driving and partial autonomous driving is expected to change gradually. Sales volume is in units of ten thousand units.

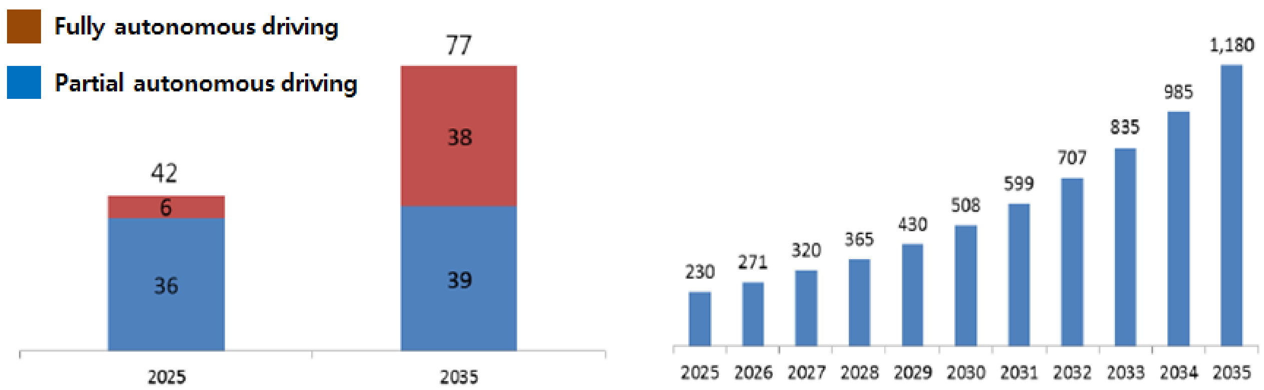

Figure 1. Autonomous vehicle market size and sales volume

The main components of the autonomous vehicle realization are environmental awareness, location and mapping, judgment, control, and interaction (HCI) technologies. In addition, advanced technologies such as artificial intelligence, big data, high-performance processing SW and HW platforms, and sensors are needed for automobiles to recognize and determine their surroundings and operate automatically. Environmental awareness technology recognizes the use of sensors such as radars and cameras, static obstacles (street lights, power poles, etc.), dynamic obstacles (vehicles, pedestrians, etc.), road markings (lanes, stop lines, crosswalks, etc.) and signals. Location recognition and mapping technology uses sensors for GPS / INS / Encoder and other mapping to estimate the absolute and relative position of the car[17]. In the judgment technique, the path to the destination and the obstacle avoidance path are planned. In addition, lane behavior, lane change, left and right turn, overtaking, U-turn, sudden stop, stop parking, and the behavior according to the driving situation is determined. Control technology controls actuators such as steering, speed changes, and gears to drive along a driver-specified route. Interaction (HCI) technology provides warning and information to the driver through the Human Vehicle Interface (HVI) and enters the driver's commands. It also exchanges driving information with infrastructure and surrounding vehicles through V2X (Vehicle To Everything) communication.

Although autonomous driving technology has not yet been defined in international standards, the 5th stage (0 ~ 4) of autonomous driving technology classified by the National Highway Traffic Safety

Administration (NHTSA) and the 6th stage (0 ~ 5) classified by the American Society of Automotive Technology (SAE) Step)[18]. Table 1 shows the technical stage definition and main technical contents of autonomous vehicles according to the American Society of Automotive Engineers (SAE).

Table 1. Autonomous driving car technology based on SAE

STEP	DEFINITION	CONTENTS
Level 0	No Automation	- The driver controls all operations entirely and encourages all dynamic driving
Level 1	Driver Assistance	- Steps in which the vehicle is executed by the steering support system or the acceleration / deceleration support system - Steps for a person to perform all the functions for the dynamic driving of a car
Level 2	Partial Automation	- Steps in which the vehicle is executed by the steering support system or the acceleration / deceleration support system - The driving environment is monitored by the person, and the driver is responsible for the safe driving.
Level 3	Conditional Automation	- The system controls all aspects of the driving operation - If the system calls for the driver's intervention, the driver must control the car appropriately.
Level 4	Hight Automation	-The stage where the system performs all the core control of driving, monitoring of driving environment, and emergency response - The system is not always in control
Level 5	Full Automation	- The system always handles driving in all road conditions and environments

Autonomous car-related companies are aiming to commercialize autonomous cars from 2020 to 2030. To this end, technology is rapidly developing with increasing investment in autonomous driving-related technologies. Various technologies for autonomous driving are being developed, and test driving of autonomous driving cars of Levels 3 to 4 is disclosed, but the technical level for actual commercialization is still insufficient. Currently, autonomous vehicles are completing Level 3, and realize some degree of customer-oriented functions. However, the current level of autonomous driving is limited due to the integration of the driver monitoring system (DMS) application and the HMI-ADAS (intelligent driving assistance system). Recently, Advances Driver Assistance System (ADAS) technology applied to automobiles has been developed into partial autonomous driving technology, which enables the commercialization of autonomous driving cars[19,20].

Currently, partial autonomous driving technologies include Highway One Lane Autonomous Driving System (HDA), Traffic Jam Assist (TJA), Autonomous Emergency Braking System (AEB), and Auto Parking System (APS)), which is expected to expand automobile application by 2020. The addition of automatic lane change and intersection driving technology to the partial autonomous driving technology (4 types) will be the technical basis for commercialization of

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automobiles capable of fully autonomous driving. Since then, the development of artificial intelligence (AI) technology will be the key for autonomous vehicles[21].

In order to succeed in commercializing autonomous vehicles, dynamic maps, V2X, three-dimensional precision maps, user monitoring, and human factor technologies are also required. In addition, artificial intelligence (AI) technology, fault diagnosis and management technology, cloud analysis technology, network security technology, road and infrastructure-related technology, technology for convergence services, etc. are emerging as key technologies for autonomous vehicles. In order to shorten the commercialization time of autonomous cars, low cost LIDAR sensor development, stereo camera technology development, and artificial intelligence technology development are needed. The current sensor system of autonomous vehicles is mainly composed of a LIDAR and a camera, and a LIDAR sensor that can recognize the surrounding environment in 3D by using a laser has not been commercialized due to its high price[22]. Currently, a stereo camera with a long processing time is applied, but it is necessary to develop a stereo camera technology for commercialization of autonomous vehicles in the future. In autonomous driving cars, artificial intelligence technology is applied to object and environment recognition, vehicle control, precise map generation, user voice recognition, and user monitoring.

3. System Design

As autonomous cars are expected to become a core area of the future society, related industries are focusing on the development of core technologies for autonomous vehicles. However, education and training for the development of technology are the prerequisites for developing the core technology of autonomous vehicles. In other words, designing and developing an education and training system for realizing autonomous vehicle technology, securing reliability and optimizing the system should be carried out first.

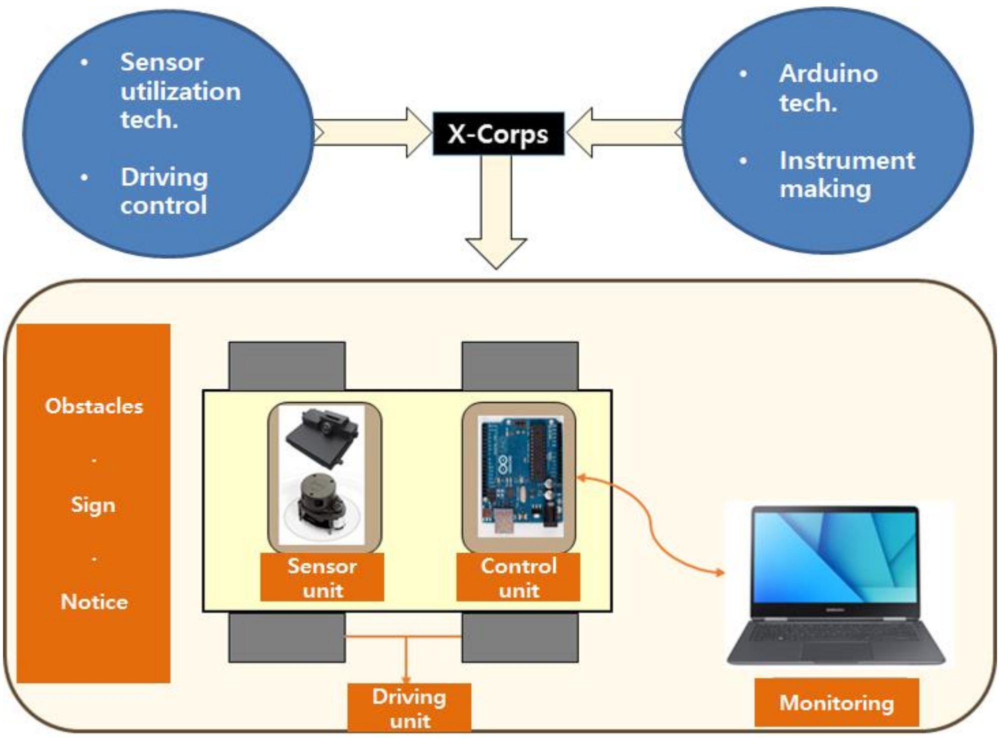

Figure 2. Autonomous driving car education system diagram

Therefore, in this paper, we designed a trainer system for autonomous driving car education. To this end, we conducted a study on the design of autonomous driving car training trainer system applying technologies such as overall system control through Arduino, obstacle detection, avoidance and stop based on rider sensor, and sign recognition using camera image recognition. Fig. 2 shows the design of the integrated module linkage and drive control mechanism of various sensors for autonomous vehicle training.

In the system design for autonomous driving car education, the key technologies are control of driver, obstacle avoidance using LIDAR sensor, and sign recognition. First, the main control module contains the Arduino as a CPU and is fastened to the PCB board for replacement with other control modules. In addition, it is designed to be driven by receiving operating power for each CPU type from the PCB board. The driver control is the programming Sauce Code of the control board using ATmega main chip, and is developed by applying the software that provides various configurations for applying to various ATmega autonomous driving control boards.

Second, we designed the obstacle detection and avoidance education system using LIDAR sensor. Obstacles are recognized by merging 3D point cloud data acquired through LIDAR and 2D images obtained from camera. The LIDAR sensor is a technology that can shoot a laser at a target and detect the distance to the object, direction, speed, temperature and concentration characteristics. LIDAR sensors typically take advantage of lasers that can generate pulsed signals with high energy densities and short periods. In addition, the laser technology is used for more precise physical property observation and distance measurement in the atmosphere. In addition, LIDAR sensor technology is mounted on aircraft, satellites, etc., and used for precise atmospheric analysis and global environment observation. It can also be used for simple purposes, such as remote measurement or speeding up a car. In recent years, its utilization and importance are gradually increasing as it is used as a core technology for future driverless vehicles. The basic configuration of a LIDAR sensor is shown in Fig. 3.

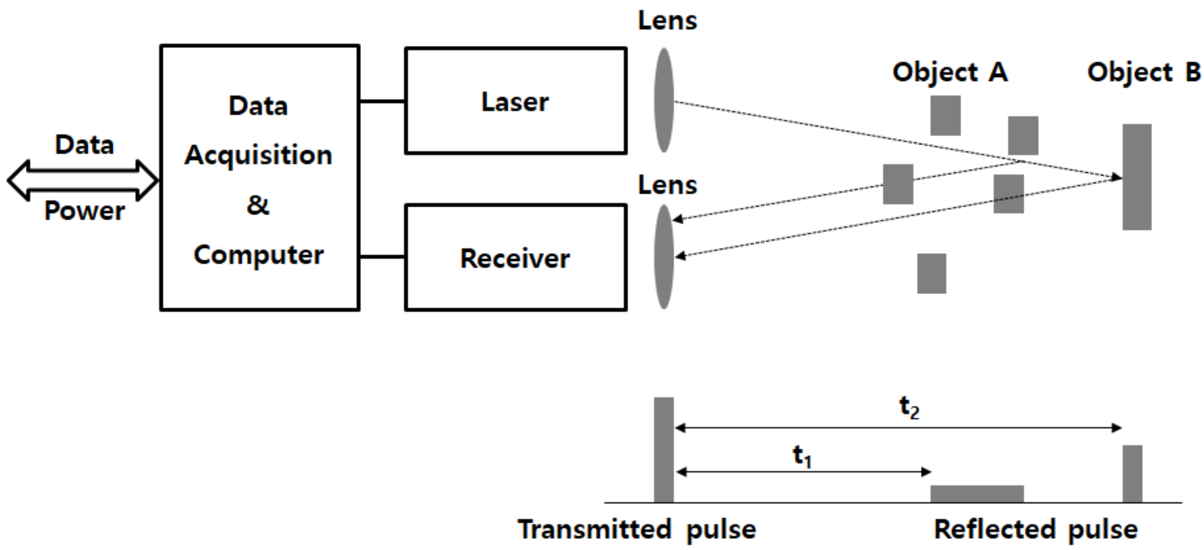

Figure 3. LIDAR system configuration and operation principle

LIDAR sensors are divided into laser transmitter, laser detector, data collection and processing, and data transmitter and receiver. Self-driving requires distance measurement and application to objects.

Therefore, the concept of LIDAR sensor should be applied in self-driving education system. The LIDAR sensor uses the TOF(Time-of-Flight) method and the phase-shift method to measure the distance to the object. The TOF method is a method of confirming a distance by emitting a laser pulse signal and measuring a time when reflected pulse signals arrive at a receiver from objects within a measurement range. In addition, the phase-shift method is a method of measuring the distance by calculating the amount of phase change of the signal to emit a laser continuously modulated with a specific frequency.

Third, we designed a sign recognition education system using camera image recognition. Image recognition technology applied to autonomous vehicles is a technology that recognizes the image around the vehicle to autonomously drive in accordance with the surrounding objects. Because of this role, image recognition technology is being applied as a core technology to autonomous vehicles. In self-driving cars, image recognition is based on machine learning. While experiencing the surrounding objects, we constantly learn how to recognize the surrounding objects and how to drive autonomously. There are various types of machine learning techniques, and for image recognition, 'CNN (convolutional neural network)' is representatively used. CNN is an advanced technology in neural network algorithm for image recognition. The neural network algorithm assigns weights to derive the cause and effect calculations. The neural network algorithm analyzes events related to the phenomenon A and extracts common factors a, b, c, and d. Then, the weighted factor for each factor according to the frequency is used to generate a relationship with the factor for the phenomenon A. Image recognition based on neural network algorithm divides image by pixel unit of specific space. However, when a specific space changes or an image moves in a specific space, there is a problem in that it is not recognized at all. The technology made to compensate for this is CNN. CNN does not analyze the image in a specific space, but extracts the features of the image. The image is then judged by weighting the feature factors.

In CNN, feature map size is decided according to filter size and stride size for input data. When the height of the input data is H and the width is W, the filter height is FH, the filter width is FW, the Strid size is S, and the padding size is P. The output data size is shown in equation (1). The result of equation (1) must be a natural number. Also, if the convolution layer is followed by the pooling layer, the row and column size of the feature map must be a multiple of the pooling size.

$$\text{OutputHeight} : \text{OH} = \frac{(H + 2P - FH)}{S} + 1$$

$$\text{OutputWeight} : \text{OW} = \frac{(W+2P-FW)}{S} + 1 \tag{1}$$

For example, when there is a layer composed of one convolution layer and one pooling layer, the output data shape and parameters of the two layers can be calculated as follows. That is, when 20 filters having shapes of (4, 4) are applied to the input image, the process of calculating the shape of the output data is shown in Equation (2).

$$\text{Row}_{\text{size}} = \frac{N - F}{Strid} + 1 = \frac{39 - 4}{1} + 1 = 36$$

$$\text{Column}_{\text{size}} = \frac{N-F}{Strid} + 1 = \frac{31-4}{1} + 1 = 28 \tag{2}$$

CNN divides the image into three layers to analyze and judge the image as shown in Fig. 4. The first layer, the convolutional layer, extracts the features of the image. Then, in the pooling layer, we tie together similar ones of the numerous features. Finally, the image type is determined in the feedforward layer. In other words, if a person is a person, if a car is a car. Self-driving cars use CNN technology to distinguish between people, roads, and traffic lights. Autonomous cars that can recognize these images can drive on their own.

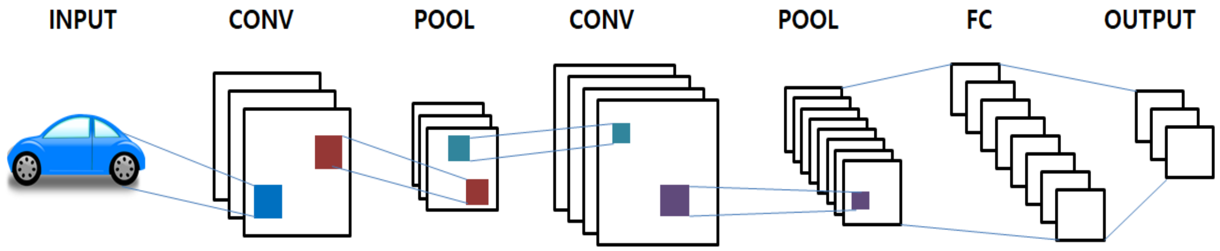

Figure 4. CNN based car image learning classification

Finally, the autonomous driving car training professional trainer system to be manufactured through the system design is based on the Arduino-based control part of the autonomous vehicle such as camera image recognition, LIDAR sensor, ultrasonic sensor, laser scanner, GPS sensor, driving motor, etc. It is autonomous driving car trainer system that integrates automobile-based technology. Fig. 5 shows a central controller system for an autonomous vehicle training system. As autonomous vehicle technology develops, autonomous vehicle technology education and training trainer systems must also be developed and developed. Therefore, the system designed in this paper can be developed as a training system for autonomous driving by developing a professional trainer system for autonomous driving.

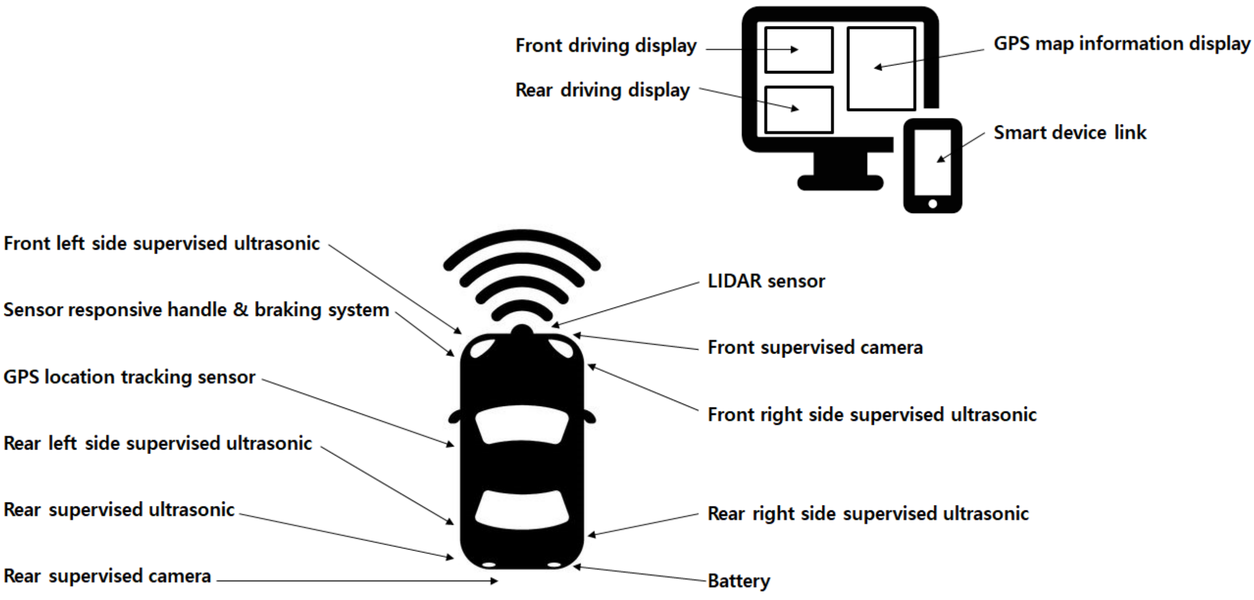

Figure 5. Autonomous driving car education system sensor plasement

4. Conclusion

As the Fourth Industrial Revolution is nearing, the changes in the transportation system that autonomous vehicles will bring are significant and the feasibility of technology is becoming increasingly visible. Global leaders, as well as Google, are trying to dominate the automotive market with the goal of commercializing

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autonomous driving in 2020. In Korea, part 3 autonomous vehicles will be mass-produced in 2020, requiring driver intervention only in certain situations. In addition, the fourth stage of fully autonomous driving cars is expected to be practical by 2035. With the advent of autonomous vehicles, the share of SW in automobiles is increasing rapidly. In the future automotive market, SW development competitiveness is the key to the quality and safety of automobiles. If a fatal accident occurs due to the SW defect of autonomous vehicles, the loss and damage caused by this will be enormous.

The autonomous driving car training and trainer system designed and proposed in this paper is a autonomous driving car training trainer using technologies such as overall system control through Arduino, obstacle detection / avoidance / stopping based on rider sensor, and sign recognition using camera image recognition. It's about system design. In other words, it is an original research to develop an educational autonomous vehicle trainer system applying the functions of an autonomous vehicle such as a camera image recognition, a LIDAR sensor, an ultrasonic sensor, and a laser scanner. Despite the national interest in autonomous vehicles, there are very few institutions or personnel who can participate in the development of autonomous driving technology. Under these circumstances, basic education is very urgent to popularize autonomous driving technology. It is a unique trainer system that can cultivate experts in autonomous vehicle platform who have acquired interest in autonomous vehicles and autonomous driving car technology in line with global trends.

Therefore, in this paper, we designed a trainer system for autonomous driving car education. To this end, we conducted a study on the design of autonomous driving car training trainer system applying technologies such as overall system control through Arduino, obstacle detection, avoidance and stop based on rider sensor, and sign recognition using camera image recognition. Therefore, it has originality and differentiation in the education system related to the field by developing a technology for a new type of autonomous vehicle trainer system that does not exist. That is, the present invention relates to the development of a professional trainer system that can perform training on autonomous vehicles by applying various sensors for autonomous vehicle technology education.

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