A Study on the Obstacle Recognition for Autonomous Driving RC Car Using LiDAR and Thermal Infrared Camera

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***Abstract*—** In this paper, we propose a new obstacle recognition method by using infrared camera that can detect the heat and LiDAR sensors, so that the front car and the pedestrian are recognized without error. Collision avoidance from obstacle recognition is the most important feature in ADAS (Advanced Driver Assistance System), aimed at providing correct, timely and reliable warnings before an imminent collision. Conventional obstacle recognition technologies using LiDAR and radar have caused serious accidents, because they fail to recognize objects accurately in bad weather and at night. In this paper, an infrared camera that can detect the heat is additionally introduced, so that the front car and the pedestrian are recognized in advance. In the future, if the AEB (Automatic Emergency Brake) through the proposed method is supplied to elderly drivers at low prices, it is expected that the mortality rate due to traffic accidents of the elderly will be significantly reduced.

Keywords—Automatic emergency break, LiDAR, Infrared camera, Obstacle recognition, Autonomous driving car

I. Introduction

As Korea becomes an aging society, traffic accidents caused by drivers aged 65 years and older are rapidly increasing. A further problem is that in the event of a traffic accident, the mortality rate is higher because of the greater severity of injury to the elderly than the younger ones [1]. Nonetheless, since elderly people want to drive their own vehicles for work or social life, a system for protecting elderly drivers from car accidents has become a necessity.

Therefore, advanced driver assistant systems(ADAS) are developed to enhance safety and better driving for the elderly [2-3]. Many safety features are designed to avoid collisions and accidents by offering technologies that alert the driver to avoid collisions by implementing safeguards and taking over control of the vehicle [4-5]. From SAE(Society of Automotive Engineering) defined stage 3, it is called an autonomous vehicle, which frees the driver from the obligation of care, but driver is always responsible for reacting to the control warnings [6]. In conclusion, while the current ADAS is a good technology, it is complex and expensive to implement, and there is still a limit to the driver being responsible for the final accident. On the other hand, AEB (Automatic Emergency Braking) through obstacle recognition is the most realistic technique to protect elderly people from serious traffic accidents such as car collision or personnel accident among autonomous driving technology [7-8]. Recently, a large number of obstacle recognition technologies using LiDAR, Radar, ultrasonic sensor, and camera have been developed and applied for AEB [9-11]. However, even with LiDAR and Radar, severe car accidents such as Waymo have occurred because obstacles were not recognized due to bad weather such as snow, rain, fog, sunlight reflections and night time [12]. Also, it is very dangerous to use real cars for autonomous driving tests. For that reason, RC-Car can be equipped with various riders, radar, ultrasonic sensor and infrared camera to improve the performance of obstacle detection and avoidance technology.

In this paper, we propose a new obstacle recognition method for minimizing the risk of vehicle dispatch in bad weather by adopting several of sensors in RC-Car for recognizing obstacles by making full use of them. We demonstrated the feasibility of the proposed algorithm by installing LiDAR and thermal infrared camera on RC-car, as testbed of autonomous vehicle.

II. Conventional Obstacle Recognition

A. Conventional Obstacle Recognition Methods

Figure 1 shows Google's autonomous driving car and devices for obstacle recognition. In order to recognize obstacles, we need sensors that can be used for recognition and a CPU that can process corresponding sensor data. There are four major sensors that are used in the recognition of the surrounding obstacles in autonomous vehicles.

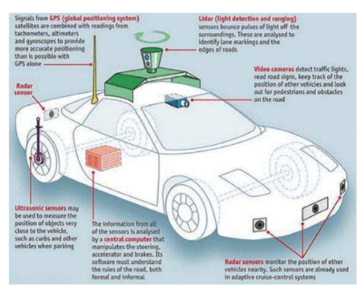

Fig. 1. Google's autonomous driving car [10]

First, the LiDAR sensor can detect the distance from the obstacle by using light, distances from surrounding obstacles

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within a certain range are presented in the form of points by using the straightness of light. At this time, the acquired point data can detect the accurate surroundings only to have an error of about 1 to 2 [8-10].

Second, Radar is the most commercially available sensor on the current vehicle. The radar uses the Doppler effect to measure the distance to the object after receiving the radio wave reflected by the object after shooting the radio wave. While Radar has the advantage of long sensing distances, when there are multiple objects in the same area or there are highly reflective metals, it is difficult to distinguish each object correctly [9].

Third, the ultrasonic sensor is widely used as a rear sensor, but its sensing distance is short and it cannot be utilized when driving on the road, but it can be used for automatic parking. Since the price is low and the performance is constant, it is commercialized and actively used [10].

Finally, the camera is a sensor that has been used for a long time. The advantage is that the price is low, and the ability to secure rich data is also an advantage. However, it is vulnerable to environmental changes and requires a large amount of computing resources for computation [11]. On the other hand, thermal cameras can classify and identify objects at high speed all day in the dark, where the field of view is disturbed (smoke, sunlight, fog). Since thermal imaging cameras sense heat, people and animals can be more effectively identified than other ADAS sensor technologies [13].

B. *Conventional Prototype for Obstacle Recognition Test*

Fig. 2 shows a prototype for autonomous mobile robot using LiDAR sensor of Hanback Electronics Co. Ltd. and the detection results of surrounding obstacles [14]. As shown in the figure, the prototype adopts Arduino as a H/W platform for system control, and has LiDAR sensor, infrared sensor and ultrasonic sensor for obstacle recognition. Taken together, since the laser is reflected by the atmospheric particles, LiDAR causes malfunctions in rain, fog, and dust. The radar is also prone to malfunctions in building forests where there are irregular metal objects with strong reflections.

Therefore, in this paper, we propose a new obstacle recognition algorithm for minimizing the risk of vehicle collision in bad weather by using Laser sensors combined with thermal camera in RC-car, which is a prototype to be used for testing detection performance for obstacle recognition.

(a) (b)

Fig. 2. Prototype for Obstacle Recognition (a) RC-car of Hanback Electronics, (b) Point mapping with LiDAR Sensor [14]

III. The Proposed Obstacle Recognition Method

The most lethal type of traffic accident is a collision with the front vehicle or a human accident that strikes a pedestrian because the sight is not visible. At this time, since the muffler and the pedestrian of the preceding vehicle are generated heat, they can be easily recognized by the thermal infrared camera.

Particularly, since the infrared camera detects obstacles when it is snowy and rainy, we receive input data by increasing the weight of information of the infrared camera in bad weather. Otherwise we ca raise the weight of LiDAR data than infrared camera input in hot weather.

A. *Block Diagram for the Proposed Obstacle Recognition*

Figure 3 shows the H/W block diagram of the RC-car used in the autonomous driving experiment. As shown in the figure, environmental sensors (temperature, humidity, illumination, etc.), a LiDAR sensor and a thermal infrared camera are mounted on the RC-car. When the RC-car recognizes the obstacles ahead, and LiDAR uses a medium-range infrared camera over long distances. In this way, the RC-car uses LiDAR for long distances to identify obstacles ahead, while an infrared camera uses a medium distance.

In particular, infrared cameras can be useful for detecting serious obstacles (front car, pedestrian) in advance, especially at nighttime or in bad weather without light.

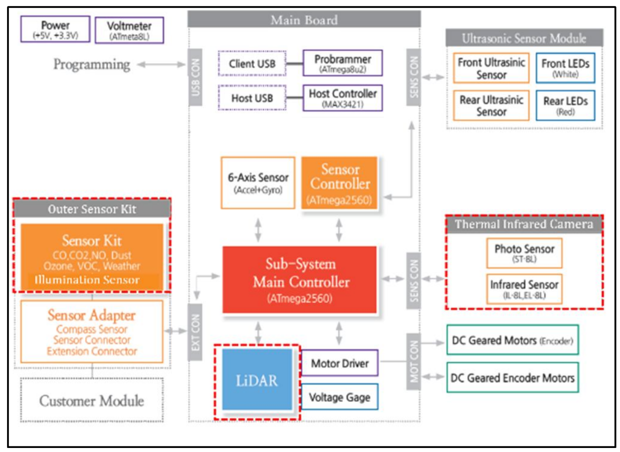
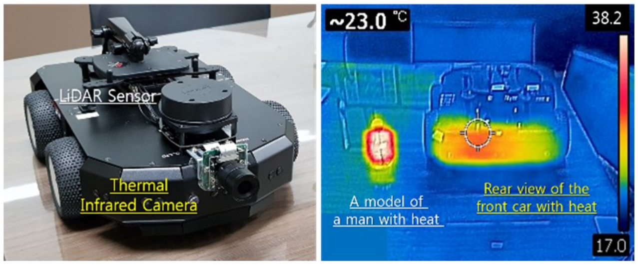


Fig. 3. H/W Block Diagram of the Proposed System

B. *Test of Autonomous Driving in RC-car with Adaptive LiDAR Sensor and Thermal Infrared Camera*

Figure 4 shows the autonomous driving RC-car through the proposed obstacle recognition. First, it uses the environmental sensor to determine whether it is night /day and rainfall. In the case of night or rainy weather, the infrared camera preferentially determines obstacles. On a clear day and hot weather, LiDAR is adopted mainly to measure distances to obstacles.

Experimental environments were divided into bright, dark, and sudden bright light from the front. First, we used the LiDAR sensor alone to perform autonomous driving in a space with a human model and RC-car in front. Secondly, by using a thermal infrared camera, the autonomous driving was proceeded by stopping at a situation where the temperature of the front obstacle is higher than 25 degrees. Lastly, the obstacle detection was performed by considering the two sensors simultaneously. In conclusion, test with LiDAR alone did not cause any problems in bright scenes, but when suddenly darkened or brightened, there was more error than test with thermal infrared cameras.



(a) (b)

Fig. 4. Prototype for Obstacle Recognition (a) RC-car with LiDAR and thermal infrared camera (b) An image of a front car and a person model taken with a thermal infrared camera

Table 1 compares obstacle detection performance between LiDAR, infrared camera and the proposed method in various experimental environments. The probability of obstacle detection was tested by three methods in a suddenly darkened environment and water-spray environment. Also, obstacle detection probabilities of small human models heated to more than 25 degrees were also tested. As you can see from the table, the proposed method has better detection performance than LiDAR only and infrared cameras only cases.

TABLE I. COMPARISON OF OBSTACLE DETECTION PROBABILITY

Test Environment	**Obstacle Detection Probability**		
	LiDAR only	***Thermal Infrared Camera only***	***The Proposed (Combined)***
Night	0.45	0.75	0.85
Foggy (water spray)	0.8	0.75	0.9
Small Target (model of man)	0.85	0.9	1.0

However, due to the poor performance of the LiDAR and thermal infrared camera applied in the Prototype and the low specifications of the controller(CPU) used, the adaptive switching to the two sensors was not possible depending on the ambient conditions.

IV. CONCLUSION AND DISCUSSION

As emergency braking devices become mandatory for all vehicles since 2020, the development of accurate obstacle recognition technology has become an urgent task. By doing so, the number of deaths due to traffic accidents can be reduced most effectively. In this paper, we propose a new obstacle recognition method by using infrared camera that can detect the heat and LiDAR sensor, so that the front car and the pedestrian are recognized without error. In the future, it will be a new way to improve the reliability of autonomous driving by comprehensive analysis of superhuman sense such as heat, humidity and sound.

However, the poor quality of the sensors and processors adopted in the prototype prevented the proposed method from operating adaptively in a changing environment. Hence, we will solve the problem by applying real-time video signal processing through the increase of additional CPU specification.

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