An ADB Headlight Module with Coaxial Optical System for Lighting and Sensing

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ABSTRACT

We proposed an ADB headlight module with coaxial optical system for lighting and sensing. In this method, the unlit area easily corresponds to the position of a vehicle to the front. Also, our headlight's response speed is estimated to be about 20 times faster than that of the traditional method.

1 Introduction

In recent years, the automotive industry has seen the rapid progress of automotive headlight technology. One example is the miniaturization and high efficiency of headlight modules [1].

Alternatively, Adaptive Driving Beam (ADB) technology is attracting attention as a lighting technology that can contribute to safe and secure driving [2]. Usually, ADB uses the image processing of a vehicle-mounted camera to detect a vehicle to the front. The ADB operation principle is to turn OFF the area that could irradiate the detected vehicle.

However, it is thought that the following issues could exist for detecting a vehicle to the front using a vehicle-mounted camera. First, a vehicle to the front position and the ADB unlit area might not match because the headlights and the vehicle-mounted camera are placed at different locations. Usually, the vehicle-mounted camera is placed near the rear-view mirror. Because they are placed at different locations, the position of the vehicle to the front as seen from the vehicle-mounted camera could be different from that seen from the headlights. Calibration is required to match the actual position of the vehicle to the front with the ADB unlit area. Second, because the detection of the vehicle to the front by the vehicle-mounted camera requires image processing, the problem is that the response speed can tend to be slow.

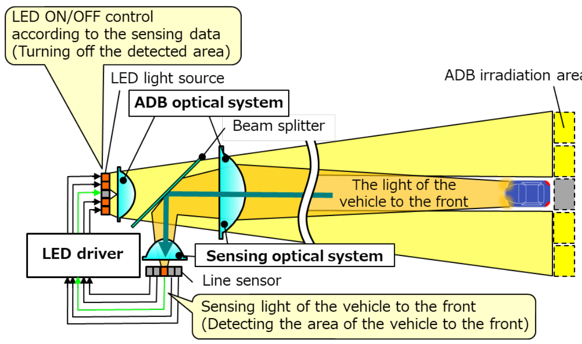
Therefore, we have proposed and developed an ADB headlight that contains a sensing function, and that makes collaboration with a vehicle-mounted camera unnecessary.

2 ADB headlight module with coaxial optical system for lighting and sensing

This section describes the basic principles of the proposed ADB headlight module with coaxial optical system for lighting and sensing and the characteristics of this headlight.

2.1 Principles

Here, we describe the principles of our ADB headlight module with coaxial optical system for lighting and sensing. Figure 1 shows a schematic. This module contains an ADB irradiation function and an ADB-based sensing function.



The ADB headlight's elements are an LED light source, an ADB optical system, a line sensor, a sensing optical system, a beam splitter, and an LED driver. The beam splitter is used so that the ADB and sensing optical systems can share a common lens placed in front of them, and they are configured coaxially. When the ADB irradiates, light emitted from the LEDs passes through the ADB optical system and is projected. For the headlight's sensing, light emitted from a vehicle to the front (for an oncoming vehicle, its headlight's light and for a preceding vehicle, its rear light's light). passes through the sensing optical system and enters the line sensor.

Regarding the LED light source and the line sensor, each of their segments is composed of one or more elements, and those in which several such segments are arrayed will be used for such. As shown in Fig.1, the optical systems are configured so that an individual segment of the LED light source corresponds to an individual segment of the line sensor one-to-one. Through this, it is possible to identify an individual segment of the ADB headlight illumination area that corresponds to an individual segment of the sensing area where the line sensor detects a vehicle to the front.

In operation, the line sensor detects light from a vehicle to the front to identify the sensing area of the vehicle in front. The information of detection is fed back to the LED light source to turn OFF one of its segments that corresponds to the vehicle to the front. Therefore, the ADB headlight can be operated without collaborating with a vehicle-mounted came.

2.2 Characteristics

The following two points can be mentioned as characteristics. First, for irradiation and sensing, there is no deviation between the actual position of a vehicle to the front and the ADB unlit area due to the difference in the mounting position. Because in this system the ADB and sensing optical systems are configured coaxially, the respective segments of the LED light source and those of the line sensor can correspond to each other one-to-one, in principle. Therefore, calibration is not required.

Second, the amounts of signals to be processed for our ADB headlight are smaller than those for the case where a vehicle-mounted camera is used, and therefore, our ADB headlight can respond more quickly. Compared with a complex image processing method via a traditional vehicle-mounted camera, it can be said that our method is a simpler process of measuring the quantity of light entering the line sensor. In general, while the interval of image processing via a vehicle-mounted camera is about 0.1 s, that of our ADB headlight with a sensing function can be about 0.005 s, and its processing speed is estimated to be 20 times faster than that of a vehicle-mounted camera.

3 Prototype

This section describes the prototype of our proposed ADB headlight module with coaxial optical system for lighting and sensing.

Here, we describe the optical specifications of the prototype. Figure 2 shows the optical systems. The optical systems are composed of a LED light source, a photo diode array line sensor, a common projection/imaging lens, a collecting lens, an imaging lens, and a beam splitter.

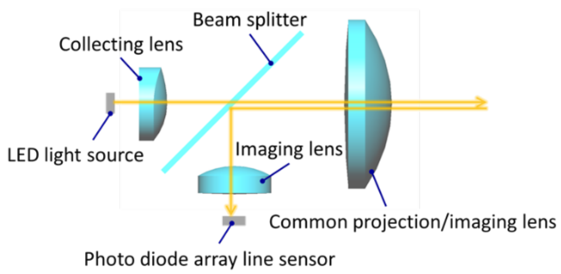


Fig. 2 Configuration of the prototype's optical Systems

We have developed a prototype of the above optical system of the headlight module. Figure 3 shows the prototype. The diameter of the common projection/imaging lens is 30 mm. This prototype satisfies regulation ECE R112 Class B. A light source simulating the headlight of a vehicle to the front was installed in front of the prototype, and the response to the light source was confirmed. Figure 4 is a photograph of the principle confirmation experiment. Fig.4 (a) and Fig.4 (b) show that the light sources exist at different positions, and in each case, the segment in which the light source exists is turned off, and the operation of ADB can be confirmed.

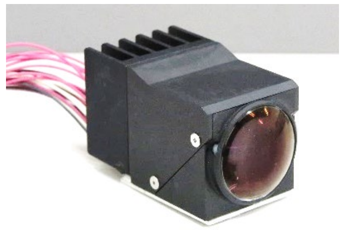


Fig. 3 Prototype of the ADB headlight module with coaxial optical system for lighting and sensing

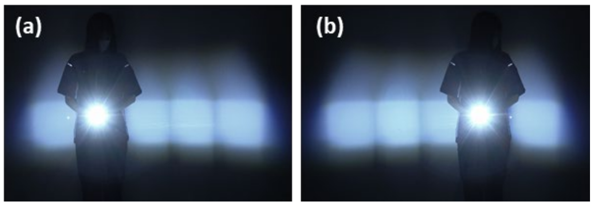


Fig. 4 A photograph of the principle confirmation experiment

4 Conclusions

In this research, an ADB headlight module with coaxial optical system for lighting and sensing is newly proposed. This method does not require cooperation with a vehicle-mounted camera, and is considered to have the following two features. First, because its ADB and sensing optical systems are packed into the same module and located coaxially, the ADB unlit area easily corresponds to the position of a vehicle to the front and calibration is not required. Second, because our ADB headlight doesn't require complex image processing and as the amounts of signals processed are small, our headlight's response speed is estimated to be about 20 times faster than that of the traditional method.

It is thought that this technology will make it possible to realize safe and high-performance headlights.

References

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