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New method of automatic control for vehicle headlights

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ABSTRACT

This paper describes a new method and control process for an optical headlight design. A series of experiments were conducted to demonstrate the projection angle of headlights using this method. In addition, the dynamic model of the headlight control system was discussed. Several parameters were considered, including the uphill and downhill road conditions and vehicle speed, to understand the multistage variations of the new headlight control system. The vehicle conditions were monitored by a vehicle speed sensor and electronic level. The variations of the projection angle of the headlight system were simultaneously controlled during the work process.

This study helps in the development of a new headlight system that could be promoted to improve the projection and visibility under different uphill and downhill road conditions and vehicle speed, resulting in improved driving safety. The new system could be useful for application in different front-lighting (low-beam, high-beam) and fog light systems. The control unit comprised a control box and electronic level, which could be modified to allow parameter setting under different operating and functional requirements, resulting in the system having broad application in different vehicles. This new method could decrease the problem of a driver in against the side of a vehicle when the vehicle passes another one, resulting in the prevention of traffic accidents.

1. Introduction

Night driving is difficult for many people. Driving in the dark is very different from driving during daylight hours. The human eye's field of vision is much smaller without the help of natural light. If a driver feels less than confident driving at night, the light from a front-lighting system will help improve his or her night vision and safely reach the destination. Currently, several important lighting companies such as OSRAM, Philips, and Nichia, have developed high-power, white-light LEDs. These developments are further accelerating the integration of LEDs into car headlights. The goal of lamp research and development has always been to produce highly efficient vehicle lamps that have a streamlined appearance while meeting stringent safety requirements. With the assistance of properly designed headlights, drivers are able to accurately evaluate road conditions [1]. However, the light produced by the headlights could be reduced, thereby reducing the risks associated with the glare from oncoming traffic.

The above remarks remind drivers that the final objective of vehicle lighting is to see and be seen. This means that researchers must continuously improve and update their lighting systems and methods to make driving safer. Strambersky

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et al. [2] used the Ackerman steering geometry principle to calculate the headlight deflection angle within the range allowed by regulations. The algorithm, based on the regulations, needed to be improved for accuracy and trajectory prediction. Koji Ishiguro and Yuji Yamada [3], who were employed by Denso and Toyota in Japan, studied the relationship between a vehicle's speed and the driver's fixation distance while driving on a bend in the daytime. They concluded that the fixation distance became larger as the speed increased. By studying drivers' reaction times in dangerous circumstances such as collisions, they regarded $t = 3$ s as an appropriate time, which they used in their adaptive front-lighting system (AFS) algorithm. Chen et al. [4] proposed a new method of AFS, which was called "curvature estimated swivel" in their paper. By using existing devices such as lane departure warning systems to replace global positioning systems for predicting road curvature, the headlight deflection angle was calculated. Predictive AFS solved the error problem of non-predictive AFS to some extent when the road's curvature changed significantly but it did not take the driver's visual characteristics into consideration. Sina et al. [5] used the regular patterns of head turning angles in daytime and nighttime to guide the design of a front-lighting system, but the paper did not mention the specific algorithm of the front-lighting system, and the precision could not be guaranteed because of the limitations of the measuring devices. In the development of nighttime onboard vision-based detection technology, all of the reviewed works begin by segmenting the image by some variant of adaptive thresholding and then performing a classification based on features related to color, shape, size, and image location. The simplest classification methods use a set of heuristic rules with fixed thresholds [6–9]. Other works employ more sophisticated machine learning techniques such as decision trees [10], Bayes factors [8], hidden Markov models [9], and support vector machines [11–16], which can be trained and therefore possess much greater adaptability. Some of these works recognize that the classifier outcome is not sufficiently reliable and that the decisions for one blob are not stable for a long time.

In this study, we adopted a new technology that is very helpful for adjusting the illumination angle of headlights for different road conditions and vehicle speeds. This is an effective method for reducing the traffic accidents that are caused by a lack of illumination from vehicle headlights. The test method, which was another novelty of this work, is reported first. The test results of this newly designed apparatus are also reported. The results of this study should help in the development of a more efficient vehicle headlight system that could be applied in different categories of vehicles.

2. Experimental setup

2.1. Working structure of apparatus

Fig. 1 shows the current experimental apparatus of a headlight control system. The headlight system device consisted of a vehicle speed sensor (VSS), direct current (DC) motor, electronic level, control box, stepper motor, relay, headlight, oscilloscope, power supply unit, and battery. The VSS was used to measure the speed signal of the vehicle. The variation signal of the VSS used in this study was collected from the rotational speed of the DC motor. The vehicle inclination was measured by the electronic level. The control box received the signals from the VSS and electronic level and converted the analog data from the measurement signals into an assembler directive. This would then drive the operation of the stepper motor. The projection angle of the headlight was adjusted by the stepper motor. The variations in the output frequency of the VSS were monitored by an oscilloscope. In this study, the dynamic model consisted of a VSS, electronic level, control box, stepper motor, relay, and headlight, which could be useful in applications for different categories of vehicles. Ancillary equipment for the test included a DC motor, oscilloscope, power supply unit, and battery.

2.2. Optical design and processes

The work process flowchart of the headlight control system is shown in Fig. 2. The work process can be divided into two steps. First, the VSS obtains the vehicle speed signal. Simultaneously, the inclination condition of the vehicle is measured by the electronic level. Then, both signals are sent to the control box. According to the variations in vehicle speed and inclination, the control box generates an assembler directive to the stepper motor. Next, the variation in the projection angle of the headlight system is adjusted by the stepper motor. The control unit is composed of the electronic level and control box.

3. Experimental results and discussion

3.1. Retrieving the signal for VSS

In this study, a type of Hall effect sensor (55075, Littelfuse, Inc.) was adopted. Besides, the VSS signal was obtained when direct current was generated by the rotational speed. Fig. 3 shows the variation in the output frequency of the VSS with vehicle speed for three categories of vehicle. From the test results, the variations in the slope of output frequency with vehicle speed were almost the same for the vehicle categories of Tiida 1.6, Accord 2.0, and Saab 9000. Furthermore, an increase in the speed of a vehicle caused an increase in the output frequency of the VSS. Consequently, in this work, the accuracy when measuring the speed of a vehicle could reach almost the same value for the three categories. It can be seen