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Design of Vehicle High Beam Violation and Capture System

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Abstract

This paper proposes a motor vehicle Driving-beam headlamp violation and capture system to standardize the use of motor vehicle lights and reduce traffic accidents at night. We use the OV5640 image sensor and 16mm focal length security lens to collect the information of the vehicle lights and determine whether the motor vehicle uses Driving-beam headlamps in terms of the spot size and light intensity. The experiment results show that the proposed system can differentiate the high and passing-beam headlamp of motor vehicles. The smaller distance leads to the smaller difference between the Driving-beam headlamp and the passing-beam headlamp. Moreover, the use of a small aperture is an effective way to remove the interference of other light sources.

Keywords

High Beam; OV5640; IMX6; Violation Detection.

1. Introduction

With the rapid development of road traffic, increased number of motor vehicles lead to some security problems, especially the illegal use of Driving-beam headlamps at night, which becomes the main reason for night-time traffic accidents [1].

Statistics from the Ministry of Public Security in 2019 show that motor vehicle accidents account for 86.82% of the total number of traffic accidents [3], and the unsafe driving behavior of motor vehicle drivers is the main cause of accidents [4]. Compared with the daytime, the risk of death from traffic accidents at night is higher [5-7] due to the unreasonable use of Driving-beam headlamps at night [8].

To normalize the use of Driving-beam headlamps at night, 'Implementation Regulations of the Road Traffic Safety Law of the People's Republic of China'was proposed on May 1, 2004. No. 58 stipulates that when a motor vehicle drives at night without street lights, poor lighting, or in low visibility conditions such as fog, rain, snow, sand, hail, etc., the headlamps, position lamps and rear position lamps should be turned on. However, Driving-beam headlamps are not allowed to be used when the distance between the vehicle behind the current vehicle and the vehicle on the other side is very small.

For the above situation, the method of digital image processing is proposed to judge and identify whether the motor vehicle uses the Driving-beam headlamp.

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2. Characteristics for Driving-beam and Passing-beam Headlamps of Motor Vehicles

2.1. Difference between Driving-beam and Passing-beam Headlamps

The main difference between the high and the passing-beam headlamp is the emission angle. The passing-beam headlamp is emitted at a certain angle horizontally downward, as shown in Figure 1, while the Driving-beam headlamp is similar to a horizontal launch, as shown in Figure 2. When a faraway camera catches beams, situations for different beams with different distances are shown in Figure 3 and 4, in which beams marked in the boxes are Driving-beam headlamps and others are passing-beam headlamps. Figures show that the halo of the high beam is large, and the light spot displayed on the camera is large.

Fig 1. Irradiation range of near-light lamp

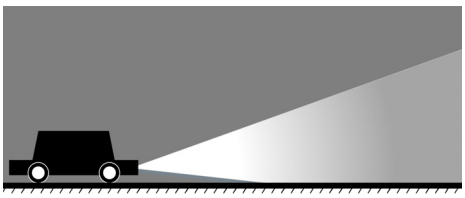

Fig 2. Irradiation range of high beam lamp

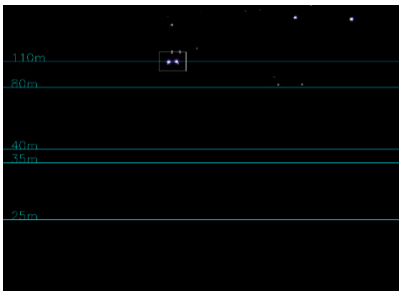

Fig 3. High beam at 110 meters

Fig 4. High beam light at 80 meters

2.2. Characteristics of Motor Vehicle Headlights

The conditions on the road at night are very complicated. Before differentiating whether a motor vehicle uses a Driving-beam headlamp, it is necessary to determine whether the headlights belong to the motor vehicle.

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In the image captured by the camera, lights belonging to the same motor vehicle have the following characteristics:

①Two headlights of a motor vehicle are on the same horizontal line.

②In a fixed position, the distance between two lights of a motor vehicle is within a limitation. If the distance is out of or less than this limitation, these two lights will not belong to the same motor vehicle.

③The distance between two headlights of a motor vehicle is related to the distance between the motor vehicle and the camera. A longer distance between the vehicle and the camera leads to a smaller distance between two headlights.

In the image captured by the camera, a motor vehicle with opening Driving-beam headlamps has the following characteristics:

①At the same position, there is a threshold for the spot area emitted by the Driving-beam headlamps. This threshold is related to the distance between the camera and the vehicle. A longer distance leads to a smaller threshold.

②The area of the light spot emitted by the two headlights of a motor vehicle is approximately the same.

③ The light spots emitted by the two headlights of a motor vehicle are centrally symmetric.

3. System Design and Realization

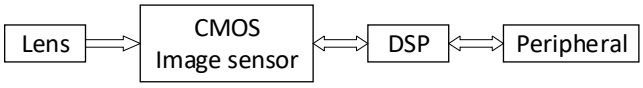

Fig 5. System structure diagram

The architecture of the system is shown in Figure 5, which is mainly composed of three parts: lens, camera and digital signal processing module. Lens are responsible for collecting lights on the road and projecting them to the image sensor. Then the image sensor converts light signals into digital signals and transmits them to the digital signal processor. The digital signal processor analyzes those signals according to the algorithm and sends results to other peripherals.

3.1. Image Sensor

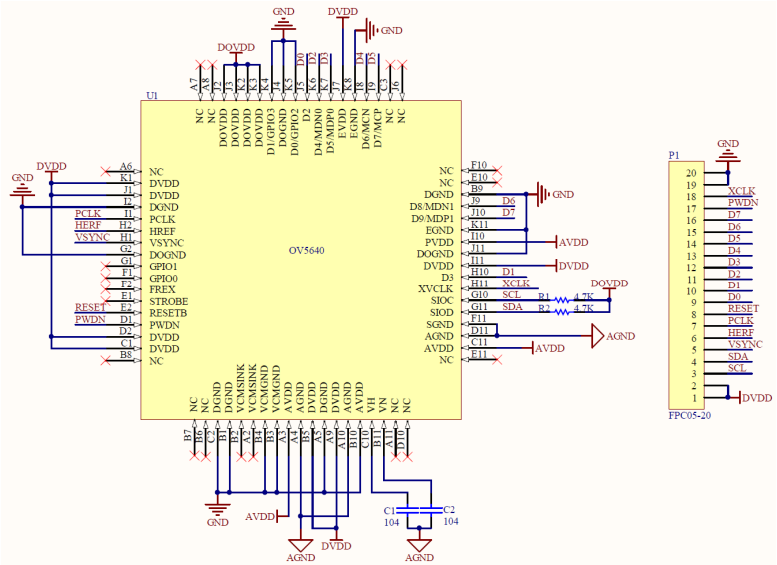

Fig 6. Schematic diagram of the circuit

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We use a CMOS sensor OV5640 with a resolution of 2592*1944 and a photosensitive size of 1/4 inch. The schematic diagram of the circuit is shown in Figure 6. Image sensors exchange information through cables and digital signal processing systems. To improve the speed of image processing, the high 8-bit data is selected as the effective value.

3.2. Lens

We adopt a security industrial lens and its main parameters are as follows:

Table 1. Lens parameters

resolution rate	12 million pixels
Format	1/1.7 inches
focal distance	16mm
clear aperture	F2.0
aperture	Fixed aperture

Since light information of all vehicles is collected for further analysis, we prefer the deeper the depth of field with the less other information. Therefore, we modify the clear aperture of the lens, and the diameter is 2.5mm.

3.3. Digital Signal Processor

The digital processing system is built by the MYZR-I.MX6-CB200-6Q6A core board of Mingyuanzhirui. The CPU is NXP i.MX 6Q (Quad) and the architecture is ARM Cortex-A9 with the main frequency 1GHz. The wiring diagram of the core board and the sensor OV5640 are shown in Table 2.

4. Experiments and Results

To verify the feasibility of this system, we design the following experiment. The system with an additional real-time camera is installed at a height of 6 meters above the ground. The motor vehicle starts at a distance of 150 meters from the system with the speed of 30 km/h and samples are collected at the distance of 120, 90 and 45 meters, respectively. The results are shown in Figure 7, Figure 8, and Figure 9. Figures on the left are real-time pictures and figures on the right are pictures obtained by the system.

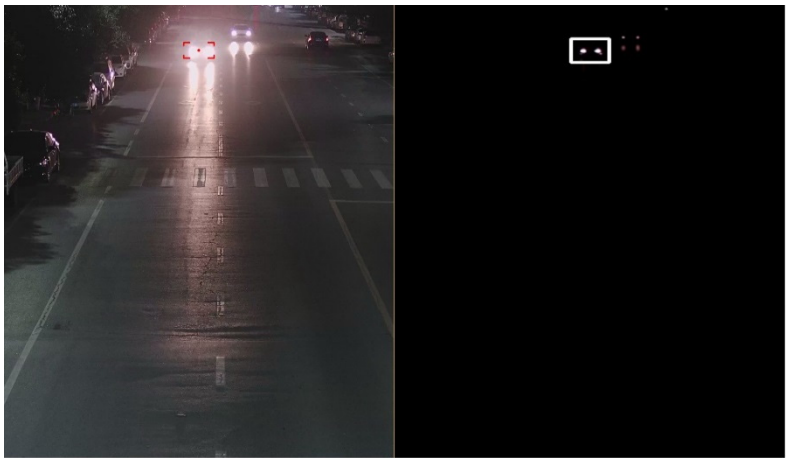

Fig 7. High beam at 120 m

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Fig 8. High beam at 90 m

Fig 9. High beam at 45m

As shown in the above figures, the lighting information is complex and road reflection is a non-negligible interference in the system. Moreover, the smaller distance leads to smaller difference between the Driving-beam headlamp and the passing-beam headlamp.

5. Conclusion

In terms of image processing methods, this paper proposes a system that processes light signals of motor vehicles during driving to differentiate whether vehicles turn on the Driving-beam headlamp. The experimental results show that this system can differentiate between the Driving-beam headlamp and the passing-beam headlamp. However, to determine whether a motor vehicle uses high beams illegally, we also should consider other conditions, which will be discussed in the future.

Acknowledgments

Project Information:

1. Key Science and Technology Projects of Henan Province: Vehicle high-beam violation detection and Capturing system, Project No. : 182102310784; The main research is the detection of high beam violation, computer recognition and the research and development of software and hardware system for capturing the relevant information of illegal vehicles.

2. Key science and technology projects of Henan Province: 222102240117, Research on fusion technology of electric vehicles, smart grid and distributed power generation: Research content

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around the electric car, distributed generation, energy storage, power grid interactive integration features, research targets in the safety management and economic operation of energy management and control strategy, set up the electric car with smart grid, a distributed power generation system integration security integration model, study the charging infrastructure and the safety of power grid and distributed generation fusion strategy; Formulate a security integration mechanism for electric vehicles, smart grid and distributed power generation in multiple scenarios.

3. Research on torque ripple of switched reluctance motor speed control system based on DSP (No.: 192102210306), Henan Science and Technology Research Project.

4. Key Science and Technology Projects of Henan Province: Monitoring system of Internet of Things based on sparse characteristics of agricultural environment signal (No.: 212102110218), project of Science and Technology Department, what can I write in the future to bring this project, so as to close the project in the future.

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