ABSTRACT: To solve the traffic safety problems of Intelligent Transportation Systems (ITS) and improve the operational efficiency of road transportation, a new automatic adjustment system for high-low beams of intelligent vehicle is designed. Automatic adjustment systems for vehicle high-low beams can automatically adjust the light state of vehicle headlights, but at present most of them are only limited to vehicle’s meeting or overtaking situation, rarely involved in other driving states. Based on analyzing the changes of operating parameters of vehicles when driving in the curve, the new automatic adjustment system for high-low beams is especially designed for this state. It contains three kinds of sensors and ECU control technology. Through presetting computer control algorithm, the new system will automatically adjust high-low beams when vehicle is driving in or out of the curve. It can improve driver's vision, reduce driving fatigue, provide a new field for the application domain of automatic adjustment systems for intelligent vehicle high-low beams and have a great development prospect for ITS or AVCS.

Index Terms: ITS, traffic safety, automatic adjustment, high-low beams, corner driving.

I. INTRODUCTION

With the soaring increase of automobile population, the incidence of traffic accidents has arrived at a higher height, making traffic safety become a hotter focus of people’s attention. Traffic safety is a vital part in Intelligent Transportation Systems (ITS) (Marell, Kajiya, Hanbali, Safety) and in order to reduce security concern and improve operational efficiency of road transportation, a new automatic adjustment system for high-low beams of intelligent vehicle is designed in this paper. The proposed system is especially directed at vehicle’s state of driving in the curve at night.

When driving at night, in order to improve the lighting conditions and improve visual field, drivers usually open vehicle headlights (Anderson 1995). As driving on the road which allows higher speed and whose surface status is quite good, such as the highway, drivers tend to choose high beam, while driving on the road with complex condition and allowing low speed, such as the city road, they will choose low beam. The high beam can enlarge the driver’s field of observation, improve visual range, especially in the conditions where there are no street lamps or the lighting conditions
are poor. But the high beam will produce instant blinding to driver's vision who are driving from the opposite side, affecting his perception of speed and distance, and hence it is extremely easy to cause traffic accidents. When driving at night, the driver will constantly switch vehicle headlights between high beam and low beam according to the changes of road condition (Strickland 1968), which greatly increases driver's driving load.

At present, in order to reduce driver's driving fatigue, people have achieved considerable progresses in the research on automatic adjustment of vehicle high beam and low beam (Hamm, Allen, Taniuchi, Albert, Hung). The technology of automatic adjustment system for high-low beams is mainly divided into two aspects, including signal acquisition and operation control. Signal acquisition mainly uses the photoelectric effect of sensitive materials to sense the vehicle coming from the opposite direction, but literature (Lv, Gao) uses Doppler effect of radar to detect the target in front of the vehicle and sends out some corresponding signals. Chang Rongjun (Chang 2010) adopts infrared signal technology to sense the vehicle coming from the opposite direction. Wang Hai (Wang 2014) uses video and image processing technology to identify and detect the headlights of vehicle driving in the opposite direction. Based on photosensitive resistance, Li Jiandong (Li 2012) and other people add the laser sensor to jointly detect obstacles, effectively improving the system reliability. As to the aspect of operation control, except Chang Rongjun (Chang 2010) who adopts simple controller circuit and Gao Yan (Gao 2012) who uses ECU electronic unit, most of the others use microcontroller to collect, process and judge signals (Lv, Li, Ou, Zou), which can effectively switch vehicle high-low beams. However, most of the literature is only involved in the case of the intersection of two vehicles, and they are not suitable for other driving states.

In this paper, through analyzing the change of vehicle operation parameters when vehicle drives into or out of curve, an automatic adjustment system for vehicle high-low beams is proposed (Nordbruch 2013), which includes speed sensor, angle sensor of the steering wheel, yaw rate sensor, relay, etc.. When vehicle is driving in the curve at night, the light of vehicle headlights will shift from the central of the road to the edge of it, making it difficult for driver to look the road surface of front curve clearly, and this is extremely easy to cause driver’s false operation. This system can automatically switch headlights to low beam when vehicle is driving into the curve, and switch the headlights to high beam when vehicle is driving out of the curve. It will improve visual field of driver's vision, reduce operation burden on the driver, abate occurring rate of potential road safety accidents, provide a new direction for the application domain of automatic adjustment of high-low beams and have a great development prospect for ITS or AVCS.

The rest of this paper is organized as follows. Section II analyzes the vehicle’s state of driving in the curve and the changes of its motion parameters. Section III presents the components of proposed automatic adjustment system for high-low beams. Section IV describes working principle of proposed system. Section V discusses the performance of this system. Section VI presents conclusion.
II. ANALYSIS OF VEHICLE DRIVING IN THE CURVE

The curve part of road is used to connect the straight line part, which usually makes the driving vehicle produce a centrifugal force and it is easy to cause a traffic accident. Therefore, generally driving speed will be dropped down when the vehicle is driving in the curve (Winsum 1996). In addition to the change of speed $\sigma$, vehicle’s driving in the curve can be viewed as object’s circular motion (as shown in Figure 1), so the steering angle of steering wheel $\alpha$, yaw rate $\beta$, lateral acceleration $\gamma$ will all be changed (Reymond 2001). When vehicle is driving into the curve, because of its deceleration, the speed of it will decrease obviously, the steering angle of steering wheel will slightly increase, and the other data values above will all significantly increase. When vehicle is driving out of the curve, the situation will be the opposite.

![Figure 1. Simulation Figure of Vehicle’s Driving in the Curve.](image)

Modern vehicles tend to be more and more intelligent, equipped with a variety of sensors to collect operating parameters of vehicles, such as speed sensors and angle sensors. But general vehicles are not equipped with on-board gyroscopes because of the price. So the automatic adjustment system for vehicle high-low beams in this paper chooses speed sensor, steering angle sensor of steering wheel and yaw rate sensor. Through these three kinds of sensors collecting relevant parameters when vehicle is driving in the curve, it is effective and reliable to judge the vehicle’s behavior of driving into or out of the curve.

III. SYSTEM COMPONENTS

In this paper, the automatic adjustment system for high-low beams mainly consists of the following components: speed sensor, steering angle sensor of steering wheel, yaw rate sensor, electronic control unit ECU, relay, etc.. The system is divided into two aspects: data acquisition and operation control, among which three kinds of sensors are used to collect vehicle motion parameters. Based on data acquisition, electronic control unit ECU will judge whether vehicle is driving into or out of the curve and then give a corresponding signal to the relay, trigger it switching between high beam and low beam.

A. DATA ACQUISITION

Data acquisition is used to judge driving state of vehicle, then the system
determines whether switch the high-low beams, so the accuracy of data acquisition is particularly important. In this system, speed sensor of vehicle, steering angle sensor of steering wheel and yaw rate sensor are involved. All the three sensors will work together, which improves the accuracy of judging vehicle’s behavior of driving in the curve and increases the reliability of the system.

Speed sensor is used to detect the real-time driving speed of vehicle, which is installed in the output shaft of the transmission. Its signal output terminal is connected with the signal input terminal of electronic control unit ECU, so the speed signal can be transmitted into ECU. According to the speed signal, ECU calculates the change of speed, providing a criterion to determine whether vehicle is driving in the curve. The speed sensor here is required to be accurate, real-time and highly reliable.

Steering angle sensor of steering wheel is used to detect the real-time rotating angle of steering wheel. It is installed in the shaft of vehicle steering wheel whose signal output terminal is connected with the input terminal of electronic control unit ECU, and it will pass the angle value of steering wheel to ECU. This sensor is required to have a high sensitivity, and its real-time should be accurate.

Yaw rate sensor is used to detect the real-time yaw rate of vehicle, which is installed in the vehicle armrest box. Its signal output terminal is connected with the input terminal of electronic control unit ECU, and ECU receives the yaw rate value of vehicle transmitted by the sensor. This sensor is required to have a good reliability, and its real-time should be accurate.

**B. OPERATION CONTROL**

According to the real-time operating parameters of vehicle, vehicle's motion state can be judged and then relevant lighting switch is performed. The operation control of this system mainly includes two parts: electronic control unit ECU and the relay. ECU is mainly responsible for data processing and judgment, and the relay is responsible for light switch.

Electronic control unit ECU is the control center of this system, which is used to run internal program, process data and make corresponding judgment. The input terminal of ECU is connected with the selected three kinds of sensors while the output terminal of it is connected with the relay. According to three numerical changes of speed, steering wheel angle and yaw rate and the preset control strategy, ECU can determine whether it is the time to switch lights and export a relative signal to the relay.

The relay is used to automatically switch vehicle high and low beams, and the input terminal receives the output signal from ECU. The output terminals of it are respectively connected with high beam and low beam. The reliability of selected relay is required to have good quality, and the switch should be accurate and timely.

**IV. WORKING PRINCIPLE OF THE SYSTEM**

In this paper, the automatic adjustment system for vehicle high-low beams when driving in the curve is composed of two parts, which are data acquisition and operation control. The structure is shown in Figure 2, among which, 1-3 is the part of
data acquisition, 4-5 is the part of operation control and 6-7 is front headlight of vehicle.

When this system is working, once vehicle is driving into the curve, speed sensor, steering angle sensor of steering wheel and yaw rate sensor will detect the corresponding changes of vehicle’s operating parameters, and the detected values will be passed into electronic control unit ECU. According to these signals, ECU can judge that vehicle is entering into the curve and then send a signal to the relay to shut down high beam and open low beam. When vehicle is driving out of the curve, the speed of it will increase and the angle of steering wheel, yaw rate will tend to be zero. ECU collects these signals and then makes a judgment that vehicle has finished its action driving in the curve. Then ECU sends a signal to the relay to close low beam and open turn on high beam. Through this, it will realize the automatic switch of high-low beams when vehicle is driving in the curve at night.

Some programs can be written into electronic control unit ECU, and when the values of operating parameters above reach the preset threshold, ECU will send a signal to make the relay perform relevant action. For example, when vehicle is driving into or out of the curve, set the change thresholds of vehicle speed respectively as $\sigma'$ and $\sigma''$, set the change thresholds of steering angle of steering wheel as $\alpha'$ and $\alpha''$, and set the change thresholds of yaw rate of vehicle body as $\beta'$ and $\beta''$. When vehicle is driving into the curve at night, the value of vehicle speed $\sigma$, the value of steering angle $\alpha$ and the value of yaw rate $\beta$ will all change. Once these changes reach to the preset threshold, which means they can meet $\sigma<\sigma'$ and $\alpha>\alpha'$ and $\beta>\beta''$ these three conditions, ECU will conclude that vehicle is entering the curve and then send a signal to the relay to switch the state of vehicle’s headlight. If the current headlight is high beam, the relay will switch headlight into low beam, and if it is low beam, the relay will not take any action. Similarly, when vehicle is driving out of the curve at night and if it satisfies the condition: $\sigma>\sigma''$, $\alpha<\alpha''$ and $\beta<\beta''$, ECU will conclude that vehicle has drove out of the corner and send a signal to the relay to switch the headlight into high beam, as shown in Figure 3.

![Figure 2. Schematic Diagram of System Structure.](image-url)
V. PERFORMANCE ANALYSIS

This system can only be used in the condition that vehicle automatically switches high-low beams when driving in the curve at night. It still needs to pay attention to a number of problems when it is specifically applied to practice, for example, the interference and priority issues in driver’s manual operation and automatic switching when driving in the corner; whether this system can effectively judge that vehicle is driving in the corner when the curvature radius of the corner is quite large; whether it can quickly switch vehicle high-low beams when driving in the corner whose curvature radius is quite small; whether manual operation can be conducted normally when the system fails. The problems above are a part of problems which need to be resolved in the following design of the automatic switching system for high-low beams. Therefore, it is necessary to continue further study to realize the specific application of this system.

VI. CONCLUSIONS

As traffic safety problems becomes a top focus of human life, Intelligent Transportation Systems will be bound to play a significant role in their future travel. In order to improve road safety and reduce the occurrence of potential safety accidents, studies of automatic switching system for vehicle high-low beams arise. These systems can be helpful to improve driver's front vision and illumination condition and reduce driver's manual operation and fatigue load. However, they are mostly limited to the conditions of vehicle’s meeting and rarely refer to other driving states. Through analyzing the changes of vehicle’s operating parameters when driving in the curve, this paper presents an automatic switching system for vehicle high-low beams which is directed at the state of vehicle’s driving in the corner. The proposed system only relies on the sensors of vehicle and it doesn’t need to add other materials.
According to the relevant signals of sensors, it can automatically switch vehicle high and low beams, which is helpful to reduce illumination dead angle of corners, prevent the driver’s error operation causing by improper sight, provide a new field for the application domain of automatic adjustment system for vehicle high-low beams, and, at the same time, have a great development prospect for ITS or AVCS.

REFERENCES


