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Research on multi-point monitoring anti-collision system for vehicle auxiliary driving

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ABSTRACT

Multi-point monitoring anti-collision system for vehicle auxiliary driving is mainly used in advanced vehicle on-board active safety systems, such as forward anti-collision systems, active collision warning systems and adaptive cruise control systems and so on. The system plays an important role in the improvement of vehicle active safety and the reduction of traffic accidents. The stability of vehicle active anti-collision system in dynamic environment is still one of the most difficult problems to break through nowadays. According to driving habit and the existed detecting technique of sensor, combining the infrared laser range and galvanometer scanning technique, design a multi-point monitoring anti-collision system which can be used to assist navigation, obstacle avoidance and the speed control for the vehicle initiative safety. Lots of experiments using the system prototype are made, and main performance of it is under tested. The results of these experiments show that the imaging speed of the system can reach up to 33 frames per second, the detectable distance range 10–200 m. The maximum ranging error is 3.24 m, the minimum ranging error is 0.26 m and the average error is less than 0.46 m.

1. Introduction

In recently years, with the rapid growth of the number of cars, traffic accidents are increasing year by year because of the drivers' judgment mistakes, not timely response, the approximately night of vision and weather. The active safety system used in automobile auxiliary driving has good application prospect, with high reliability, low price, alarming at a critical moment and taking measures such as braking or evading [1].

The existing auto collision avoidance system is divided into the target detection method by means of millimeter wave, ultrasonic, infrared, laser and other methods of anti collision system [2]. The detection principle of these methods is different, but the purpose is to receive the echo signal from the information and obtain the relative distance and relative velocity between the vehicle and the obstacle after treatment. Through the results, the risk degree between the vehicle and the obstacle is determined, and the corresponding preventive measures are given [3,4].

Because of the good monochromaticity, directivity and coherence of laser, the laser beam which passes the alignment system has following advantages, such as less diffusion, energy concentration, the far transmission distance. So the accuracy of laser ranging is high. The detection method of collision avoidance of vehicles has been studied for many years, but the traditional laser detection has the corresponding shortcomings that the single point detection can only be carried forward

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and the detection information is too limited. When the vehicle turns and the road is poor, information is prone to miscarriage of justice [5].

According to driving habits and the existing sensor technology, a multi point monitoring collision avoidance system has been proposed in the auto safety system. The system is combined with the infrared laser pulse ranging and high-speed mirror scanning, and it can be used to assist in navigation, obstacle avoidance, control speed and other functions.

The active safety system which can emit a laser beam installed in front of the car. Through the deflected polarizer shoots the field before the car, the laser beam carries the distance information of the vehicle and the obstacle. Therefore, the spatial information of each measuring point can be obtained. The measurement data which can respond road conditions in front of the car should be gotten after a cycle of vibration mirror. Whether there are obstacles in front of the car through the information processing of each point or not, so as that the corresponding warning signal and control signal have been sent out.

2. Emission optical system design

2.1. Selection of laser light source

Laser is selected as the emission source. The light source has advantages, such as good monochromatism and strong direction. The radiation intensity at the focal point is 10^8–10^{10} times higher than ordinary light, so it has been widely used in various fields. In order to reduce the natural light interference and make the detection distance farther, the laser has a high transmission power. Because high power laser beam may cause damage to the human eyes, therefore, the light source should be selected by laser which is safety to eyes. Laser is relatively safe for human eyes which wavelength is higher than 1400 nm. The wavelength of laser can be absorbed and cannot be damaged the retina [6].

The pulsed laser, which pulse is several nano-seconds and the wavelength range is 1530 nm–1550 nm, the intensity is relatively safe for the human eyes. Due to the relatively maturity of the 1550 nm laser technology, the wavelength of the laser is the preferred source of the system. 1550 nm semiconductor narrow line-width laser which model is LRS1550NL is selected as the laser source of the system.

2.2. Laser ranging system

Because of the requirement of measuring distance in concrete application, and the accuracy of measurement is not high, the pulse method is used to measure laser ranging. Pulse laser ranging measures round trip time which is reached the target by laser pulse and returned to the receiver by target, that making use of a very narrow laser pulse. Depending on the round trip time and the speed of light, the distance between target and the receiving system can be calculated [7].

The distance between the target and the receiving system is $S = \frac{ct}{2}$.The speed of light is c in the air, the round trip time of the laser is t.

Laser pulse ranging can inform distance by using of measuring the round trip pulse interval time. The method of measuring time is filling count by using of clock pulse in the determination of time between the stops, and it can get the accuracy of the 10^{-10} s above measurement. Laser pulse which is generated by a laser emitter for a few action time and a few cents firing angle passes optical system at the measured target pulsed laser, and it has been returned to the receive system after the target diffuse reflection. The distance can be measured by measuring the time difference between the main pulse and the echo pulse [8].

A timing pulse with a pulse width of t is obtained by controlling the trigger. The pulse insertion frequency is $f = \frac{1}{\Delta T}$ and the pulse width can be counted. If the value is N, the pulse duration is $t = N\Delta T = \frac{N}{f}$.

The distance of two cars can be derived, it is $S = \frac{ct}{2} = \frac{Nc}{2f} = KN$.

In the formula, $K = \frac{c}{2f}$. K expresses a measured distance corresponding to a counter pulse, and the size of value determines the accuracy of the measurement.

$$\Delta K = \frac{c}{2}\Delta T \tag{1}$$

If the range resolution is $\Delta K \le 0.75m$, the request is $\Delta T \le 5ns$. So the insertion count pulse frequency should be greater than or equal to 200 MHz. The 200 MHz count pulse is obtained by FPGA frequency doubling, which satisfies the requirement of the system.

2.3. Laser scanning system

Working diagram of the vibrating mirror is shown in Fig. 1. Incident laser comes in X reflecting mirror in the direction perpendicular to the axis of the X axis. The rotation of X reflecting mirror determines the direction of the scanning image. The outgoing light of X reflecting mirror comes in the Y reflecting mirror. The rotation of Y reflecting mirror determines the pitch angle of the scanning image [9].