Design of Intelligent Parking System Based on Laser Ranging

Liang Xiurong

Urban Vocational College of Chongqing, Chongqing, China

Keywords: Receiving Unit, Intelligent Parking, Laser Range Finder, Time Interval Measurement

Abstract: in Order to Alleviate the Shortage of Urban Parking Resources, Intelligent Parking Management Has Become a Hot Research Topic. the Traditional Method Has the Problems of Large Error and Long Response Time for the Laser Ranging in Parking. a Laser Ranging System for Intelligent Parking of the Internet of Things is Proposed. Design of the Overall Structure of the System of Pulse Laser Ranging, Laser Ranging Parking System is Divided into the Laser Emission Unit and a Receiving Unit, a Time Interval Measurement Part and Control Part, the Control Panel Aduc7026 is Set to the Core of the Design of Emission Driving Circuit; in the Receiving Unit of Photoelectric Converter and Amplifier Are Analyzed; and the Measurement Part the Time Interval in Detail, Reducing the Error Range to the Target Object, Improve the Accuracy of Laser Ranging, Laser Ranging System to Complete the Parking Network Design. the Experimental Results Show That the Proposed System Can Effectively Reduce the Distance Error and Reduce the Response Time of the Laser Range Finder System.

1. Introduction

With the Development of the Internet of Things, Laser Ranging System is Widely Used in Different Fields [1], and the Laser Ranging System for Parking in the Environment of the Internet of Things is Gradually Valued [2-3]. among Them, One-Dimensional Laser Ranging is to Measure and Locate the Distance [4-5], Two-Dimensional Laser Scanning Ranging System is to Measure the Contour, Locate and Monitor the Area [6]; Three-Dimensional Laser Ranging is to Locate the Three-Dimensional Space [7]. the Laser Ranging System Has the Advantages of High Resolution, Long Ranging Range and Strong Anti-Interference Ability, Which is Favored by Scholars[8].

In Reference [9], a Phase Laser Ranging System is Designed, Which Adopts the Technology of Small Frequency Difference Jitter and the Technology of Equal Frequency Difference Measurement to Achieve High-Precision Measurement in a Specific Environment. the Ranging System is Mainly Composed of Programmable Clock Signal, Laser Transmitting and Receiving, Mixing Filtering and Automatic Gain Control. in the Design of Ranging System Circuit, the Transmitting Circuit of Laser Modulation is Optimized and the Automatic Gain Module is Added. the Experimental Results Show That This Method is Simple and Practical, But It Has the Problem of Large Ranging Error. in Reference [10], a Design Scheme of Laser Ranging System Based on Orthogonal Modulation is Proposed. According to the Principle of Laser Ranging, the Optical Path and Signal Processing Module Are Designed. the Whole Design of the System is Carried out. the Experimental Results Show That within the Same Measurement Range, the Laser Ranging System Can Achieve 10 Mm Dynamic Ranging Accuracy. the System Has the Characteristics of Fast Measurement Speed, But It Has the Problem of Slow Response Time.

In View of the Above Problems, This Paper Proposes a Design Method of Laser Ranging System for Intelligent Parking of the Internet of Things.

2. Design of Intelligent Parking System for Laser Ranging

By Adopting the Idea of Laser Ranging, the System Control Hardware Flow is Optimized, the Response Time is Shortened, the Parking Efficiency is Improved, and the System is Redesigned.

  DOI: 10.25236/ISMHI.2019.053

2.1 Overall Design of Laser Ranging System

The Pulse Laser Ranging System Has the Advantages of High Speed and Simple Structure. According to the Requirements of Ranging System, Pulse Laser Ranging System is Composed of Transmitting and Receiving Circuit, Time Interval and Measurement and Control Unit[11].

After the Laser Ranging System Sends the Measurement Instruction, the Laser Emits Part of the Pulse. the Light Reflection Signal is Reflected by the Light Path and Stored in the Atmosphere. When Encountering Obstacles, It Will Return and Enter the Receiving Part of the Signal. in the Process of Laser Ranging, in Order to Scan the Parked Vehicles, the Rotating Mirror Drive is Used to Monitor the Parked Vehicles. the Outline Drawing is Shown in Figure 1.

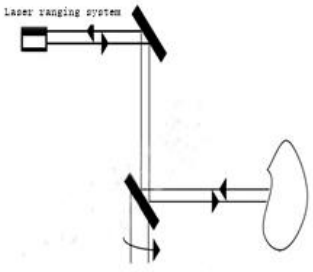

Fig.1 Optical Path of Laser Ranging System

According to the shape and function requirements of the laser ranging system, the work flow chart of pulse laser ranging is designed, which is represented by Figure 2.

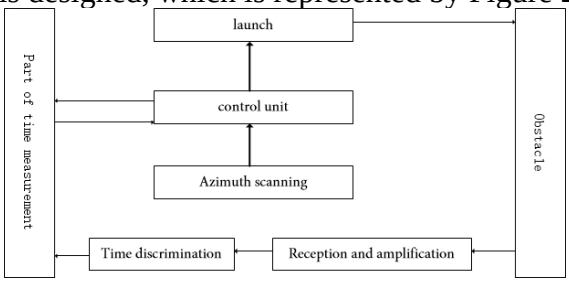

Fig.2 Laser Ranging System

The working process of the parking laser ranging system is: after the initialization of the laser ranging system, the controller of the ranging system will wait for the scanning unit. When the system sends a clear signal, the laser ranging terminal will operate this operation, and use pulse emission to distance the parked vehicle. When the time interval measurement part is used to transmit the time to the ranging system controller, the ranging system controller will store the time. When the scanning part counts the counter value, the ranging system will shut down the terminal and transmit data [12].

2.2 Main Control Part

The laser ranging system measures the parked vehicle, and makes simple adjustment to the ranging system when scanning the parked vehicle for the part of receiving data and upper computer communication control [13].

The ranging system has the characteristics of fast measurement and data acquisition, so the controller is the control panel of ARM7TDMI and aduc7026 ARM7. Because of the oscillator and phase-locked loop on the chip, it has its own clock. After programming the frequency division part, the clock working frequency is obtained. Arm7tdm is the core processor with high processing speed.

MCU and FPGA are connected through parallel port to receive FPGA signal and read data. Data transmission is completed through RS232 serial port. The application of laser ranging is actually considered, and the laser ranging control system is shown in Figure 3. The measurement of parking position is that the incremental encoder measures the zero point position and the angular displacement of the measuring point [14].

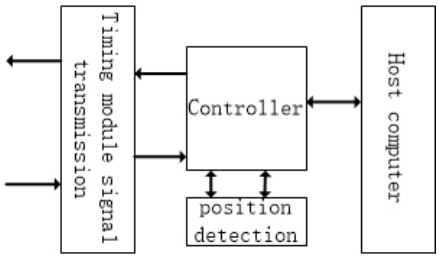

Fig.3 Control Structure of System Unit

C51 language is used to develop the controller of laser ranging system. After starting the ranging system, the MCU is initialized and the signal is sent, and the FPGA module is initialized. Query the communication mark of the system. The main program logic of the system is shown in Figure 4.

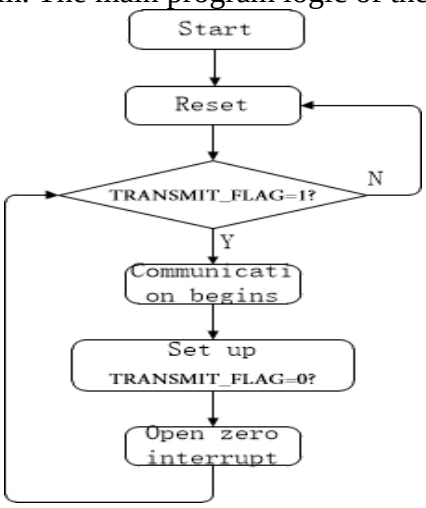

Fig.4 Logic Diagram of Main Program

2.3 Transmitting Unit

The launching unit of the parking laser ranging system is shown in Figure 5. The transmitting unit is composed of signal input circuit, driving circuit and laser, shaping circuit and energy storage circuit. After transmitting the signal of the laser ranging system to the transmitting unit, it is transmitted to the laser driver circuit by pulse shaping. The energy storage circuit provides charge and generates current to drive the laser [15].

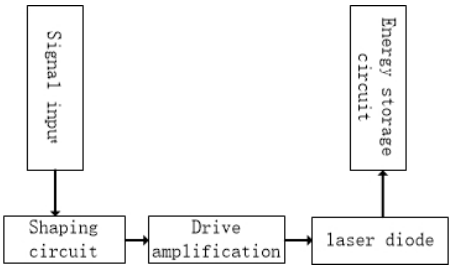

Fig.5 Transmitting Unit

The motor encoder signal of laser ranging system is triggered by MCU. After pulse shaping, the signal is sent to the laser driver circuit to drive the laser.

In the design of the laser ranging system, the laser ranging system ensures the maximum stability. The integrated components are used to reduce the interference caused by the elements, so that the circuit of the transmitting unit is simple and stable.

The pulse parking vehicle carries on the laser ranging to calculate the distance of the parking vehicle at the target interval of the parking vehicle after the laser signal. In order to improve the accuracy and speed of the ranging system, it is necessary to determine the characteristics of the parking target and the laser emission frequency. The pulse power of laser ranging system is determined according to the measurement of the distance between parked vehicles and the

characteristics of parked vehicles. The response speed and pulse width of photodiode are determined according to the comparison of the working frequency and laser performance of laser ranging system.

2.4 System Receiving Unit

The receiving pulse laser unit is composed of receiving and amplifying circuit, time discrimination and mixing circuit. The receiving and amplifying circuit includes photodiode, amplifier circuit and preamplifier. It is shown in Fig. 6.

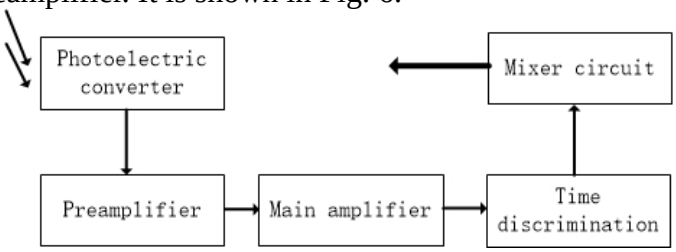

Fig.6 System Receiving Part

It can be seen from Figure 7 that when designing the receiving circuit, the relationship between the intensity of the reflected signal generated by the laser and the distance shall be taken into account to control the amplitude of the output signal within a certain range, reduce the distance error and expand the measurement range [16].

In the receiving part of the stop laser ranging system, the received signals are shaped and amplified, and the useful signals are extracted as the time interval measurement timing trigger signals. In the design of receiving part, photoelectric converter and time amplifier are included. Requirements for each link are as follows:

(1) photoelectric converter

In order to improve the sensitivity of the photoelectric converter, the response speed and response time of the time spectrum are considered.

The spectral response is mainly to respond to the incident light of different wavelengths generated by the photoelectric converter.

Spectral responsively of current $R_i(\lambda)$ The current of λ the photo detector signal is expressed as:

$$R_i(\lambda) = \frac{I(\lambda)}{P(\lambda)} \tag{1}$$

In formula (1), $I(\lambda)$ is the current output signal, $P(\lambda)$ is the incident power.

Detection degree is an important index to evaluate the ability of detecting weak signal.

(2) amplifier

It mainly considers bandwidth, input impedance and magnification.

(3) input impedance

If the input impedance of the amplifier is large, the influence on the detector of the ranging system is small, and the current is small when the system is driven. When the input impedance is high, the signal current does not need to be consumed to drive.

(4) magnification

The magnification is determined by the ability to receive pulses. Fig. 7 shows a mixing circuit.

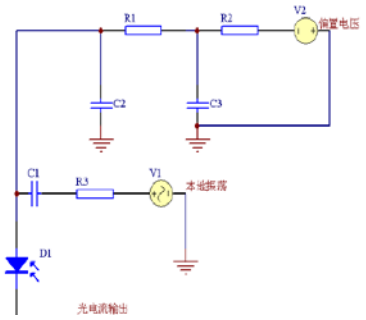

Fig.7 Mixing Circuit Diagram

2.5 Time Interval Measurement Part

By measuring the pulse time interval, the distance between the parking vehicle target and the laser rangefinder is calculated. Therefore, measuring the pulse time interval plays an important role in the accuracy of the laser rangefinder system in the environment of the Internet of things.

According to the principle of pulse ranging, the formula of laser ranging is as follows:

$$L = c \times \frac{t}{2} = \frac{1}{2} cnf \tag{2}$$

In formula (2), L is the target distance. t is the pulse round-trip time, c is the speed of light in the air, n is the count value, f is the clock frequency.

By differential extraction of the two ends of formula (2), we can get:

$$dL = L(dc / c) + L(df \ / \ f) + L(dn / n) \tag{3}$$

The error of the speed of light caused by atmospheric refraction, the stability of the counter clock frequency and the error of the accuracy affect the precision of the pulse laser ranging. The error of the speed of light can be compensated by using the control environment parameters, and the clock error can be reduced by using the high precision and stability time clock source. Therefore, the error of measuring time interval needs to be solved to improve the precision of laser ranging.

3. Analysis of Experimental Results

The experiment is based on the environment of MATLAB. Using laser rangefinder, the range is 0 ~ 3000m, and the detection probability is more than 98%. It can range multiple targets. The experiment also uses the laser AC signal source, the laser signal generated by the signal source, the reference frequency of the laser signal generated by the laser signal source, the cutoff frequency of the laser signal is 500KHz. Some parameters of laser rangefinder are shown in Table 1.

Table 1 Parameters of Laser Rangefinder

Energy of pulse/mJ	17
Pulse width of signal/ns	8.5
Wavelength of signal/μm	1.33
Power of signal peak value/W	2.5×10^6
Receiver's field of view/mrad	0.5
Maximum distance of counter/m	9000

When the parking laser ranging system based on phase type measures the parking distance, the response time of the system is not stable. This is because the pressure of the phase type measuring system is large and the response time of the system is relatively slow in a short time, which is about 0.6 ~ 1s. The response time of the orthogonal modulation system is relatively stable, but the response time is 0.4 ~ 0.6s, and the response time is longer. In this paper, the response time of the parking laser ranging system based on pulse is relatively short, and the response time is relatively stable, generally within 0.1 ~ 0.3s. The reason is that the overall structure of the pulse laser ranging system is relatively simple, and it can integrate signals. When the laser ranging system is used for

parking in the Internet of things environment, the shortest time can be used to generate response and reduce the time consumption of ranging.

The laser ranging error produced by the target vehicle is mainly the difference between the range value and the real value of the measured distance.

In this paper, the error rate of the parking laser ranging system based on pulse is always less than 10%, and the error rate is basically stable at about 5%, which proves the stability and accuracy of the system. The maximum error rate of the system is 27%, which shows that the error rate of the system is large and the accuracy of laser ranging is low. The error of orthogonal modulation system is relatively stable, about 10%, and its error rate is large, which is not suitable for practical application.

4. Conclusion

In view of the problems of long response time and large error in the system method of laser ranging, this paper proposes a design method of pulse laser ranging system based on intelligent parking of the Internet of things. The transmitting part, receiving unit and time interval measurement part of the laser are redesigned. By using the laser ranging system, the response time and ranging error of the system are compared and analyzed, which proves that the system effectively reduces the ranging error and improves the ranging accuracy.

Acknowledgement

This work is Supported by Science and technology research project of Chongqing Education Commission (kj1603701) .

References

[1] Xue Li, Zhai Dongsheng, Li Yuqiang, et al. Analysis of the action distance of laser ranging system based on superconducting detector [J]. Acta optica Sinica, 2016, 36 (3): 21-29.

[2] Ma Xiaoyu. Design of laser rangefinder for intelligent robot obstacle avoidance in cloud computing environment [J]. Science and Technology Bulletin, 2017, 33 (8): 110-113.

[3] Shen Yanlong, Huang Ke, Zhou Songqing, et al. 10W high efficiency single mode mid infrared 2.8 μ m fiber laser [J]. China laser, 2015, 42 (5): 46-49.

[4] Chen Hui, Ma Shiwei, Andreas nuechter. 3D reconstruction method of non synchronous point cloud based on laser scanning and SFM [J]. Journal of instrumentation, 2016, 17 (5): 1148-1157.

[5] Yu Yongtao, Han Jianwei, Feng Guoqiang, et al. Estimation of event rate of SRAM single particle latch based on pulse laser location [J]. Journal of Beijing University of Aeronautics and Astronautics, 2015, 41 (4): 609-615.

[6] Ji Rongyi, Zhou Weihu, Li Yao, et al. Laser tracker high precision absolute ranging system [J]. Optical precision engineering, 2016, 24 (10s): 148-155.

[7] Zhang Sen, Tao Xu, Feng Zhijun, et al. The influence of dark count of superconducting single photon detector on laser ranging distance [J]. Acta physica Sinica, 2016, 65 (18): 315-320.

[8] Du Yuankun, Wang Lei. Design and implementation of wireless real-time positioning system based on the Internet of things [J]. Modern electronic technology, 2016, 39 (24): 79-82.

[9] Tan Xiaorui, Zhang Pixiang, fan Yuanyuan. Design of new phase laser ranging system circuit [J]. Laser and infrared, 2016, 46 (3): 279-283.

[10] Zhao Wencheng, Xu Xianze, Liu Panpan, et al. Laser ranging system based on orthogonal modulation and ambiguity resolution method [J]. Spectroscopy and spectral analysis, 2017, 37 (2): 659-664.

[11] Lu Bin, Pei Chengquan, Tian Jinshou, et al. Development of intelligent streak camera control system based on the Internet of things [J]. Acta PHOTONICA Sinica, 2017, 46 (5): 80-87.

[12] Tao Xie, Yao Fei, Liu Shouyin. Research on WSN node ranging data filtering and positioning algorithm based on phase difference ranging [J]. Electronic design engineering, 2017, 25 (7): 35-40.

[13] Dai Qin, Mao Youming, Wu Kaixuan, et al. Research on high speed precise time interval measurement in pulse laser ranging [J]. Liquid crystal and display, 2015, 30 (1): 83-87.

[14] Kang Minqiang, Deng Ying, Wang Fang, et al. Discussion on the application of picosecond pulse laser remote ranging and preliminary design of the system [J]. Progress in laser and optoelectronics, 2015, 52 (10): 241-245.

[15] Shi Shi Shi, Wang Wen. High precision double interference optical path FM CW laser absolute ranging system [J]. Infrared and laser engineering, 2016, 45 (8): 33-37.

[16] Guo Jiashuai, Wu Tengfei, Liang Zhiguo, et al. Design of femtosecond laser ranging signal acquisition system based on PCIe high speed bus [J]. Optical technology, 2016, 42 (6): 511-515.