Study on the Simulation of Electromagnetic Squint

Jian Huang*
XiJing University, Xi'an 710123, China
*Corresponding author e-mail: huangjian@xijing.edu.cn

Abstract. This paper introduces the simulation electromagnetic gun device based on STM32, which mainly uses openmv and laser ranging module as recognition sensor. The system obtains the target position through openmv, uses PID algorithm to control the steering gear with two degrees of freedom to make the gun barrel aim at the target, then obtains the target distance through the laser ranging module, obtains the target and controls the energy storage capacitor voltage of the electromagnetic gun, increases the voltage through the DC power supply, charges and discharges the capacitor through the thyristor controlled by the relay, the capacitor discharge generates the magnetic field through the coil, and generates the magnetic field inside the steel ball instead, a magnetic field ejects the ball. This design realizes the closed-loop control of the capacitor voltage to ensure the stability of the projectile exit velocity. The system is stable in operation and has high precision.

Keywords: Laser Ranging, PID, Voltage Control, Thyristor

1. Design

1.1 System Design
The main control equipment of the simulation electromagnetic gun is a single-chip microcontroller. Its model is STM32. The firing distance and firing direction of the shell are achieved by inputting data through the keyboard, and then the barrel is turned to output. The barrel is controlled by the PTZ and two servers. In practice, when testing, first place a circular target where you want to place it, and then input the data of transmitting distance and transmitting direction through the keyboard, so that the single-chip microcontroller will operate through the system algorithm, the server receives the signal and starts to change the direction, and finally hit the circular target accurately^[1-3].

1.2 Design of Main Control Module
Fast speed, complete firmware library makes its operation very simple. The highest working frequency of 72mhz can meet the data detection speed of most control systems.

1.3 Camera Module
Openmv is a programmable single-chip camera with image processing function, which can easily realize machine vision. Its stm32h7 single-chip processor has powerful computing power. After the
image data is solved and processed, it will be sent to the main control system of the single-chip microcomputer, thus greatly improving the working speed.

1.4 Ranging Module
It has strong directivity and is almost point ranging. The measurement range is wide and the measurement accuracy can reach millimeter level, and the response is very fast, which can measure the high-speed moving objects\cite{4-5}.

2. Working Principle

2.1 Working Principle of Electromagnetic Gun
The principle of the circuit is to boost the DC power supply and control the thyristor to charge and discharge the capacitor through the relay. First, the DC power supply is used to input the 12V DC voltage, which is divided into two branches. One branch controls the thyristor to charge the capacitor through the boost circuit of the electromagnetic relay. With the disconnection, the instantaneous discharge of the capacitor generates the inverter magnetic field in the coil and pushes the metal pellet at a high speed Move out.

The charging and discharging of capacitance are realized through this circuit. The charging of capacitance needs a charging switch to control. Because the high-voltage capacitance required by the electromagnetic gun is 450V / 1000uf, a system for boosting voltage needs to be installed, and this switch is connected between the battery and the boosting system. In the same way, the discharge of a capacitor requires a discharge switch to control the discharge, that is, to connect the winding resistance at both ends of the capacitor, but it needs to connect a switch tube, commonly known as the thyristor, otherwise it will burn out if it is connected in the circuit. The winding resistor connects a diode that can conduct electricity continuously to discharge it, so when the G is set high, the K & terminal is on\cite{6-8}.

There is a system called electromagnetic system in the composition of electromagnetic gun. The reason why shells can be launched quickly depends on the force generated by the electromagnetic field in this system. It is to convert the generated opposite magnetic force into kinetic energy, so as to promote the firing of shells. In this way, the firing speed of shells will be faster, and the firing distance will be longer, so this device will obtain enough kinetic energy To shoot the target. It can be seen that the technology of launching with electromagnetic force, after further strengthening and transformation, has obtained an advanced and kinetic energy launching system, namely electromagnetic gun. Magnetic cannonball, capacitor, coil, inductor and some other auxiliary parts constitute the launching system of electromagnetic gun. The firing of shell is realized by Ampere force, which is generated by magnetization of magnetic field. The magnetization current and the current generated by driving coil of driving device form ampere force, and Ampere force acts on shell to launch it. The reason why the projectile can be launched faster and faster is that the projectile is attracted. This force is formed because the direction of magnetizing current is the same as that of driving coil.

2.2 Openmv Image Processing
This program can be used for color recognition, STM32 is used for main control and interaction. I'll talk about how it interacts first, and then briefly describe the code of the program. Most of the procedures are also presented below. All operation and interactive operation are displayed and completed on the resistance screen. First, we entered the school team of the advanced program screen. In normal circumstances, as long as the screen was operated once, but there was no problem, and there was no good solution. The development board of my purchase did not have the code of 24CO2 program, so I added one on the development board.

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image data is solved and processed, it will be sent to the main control system of the single-chip microcomputer, thus greatly improving the working speed. Openmv is shown in Figure 1.

![Figure 1. Openmv physical map](image)

According to the requirements of the topic, in order to identify the target position accurately and quickly, and not affected by other dark objects, we choose openmv. According to micropython in scheme 3, advanced image processing can be easily realized, creating more possibilities for our works.

Since the guide sign is a circular red plate, shape recognition and color block recognition can be used to identify the guide sign. Hough transform is used for circle detection, which has a large amount of calculation, which will make the frame rate of target detection greatly reduced and is not suitable for dynamic detection. Therefore, in order to ensure the accuracy and high frame rate of recognition, only circle detection is used for the first time after the system is powered on, and the coordinate range of circle area is obtained, which is used as ROI (region of interest) for the first color block detection. If it is detected that the color block is red, lock the color block, and the color block is the target color block. Taking the center of the target color block as the center and the rectangle area with twice the width of the color block as the side length as the ROI of the next color block detection, only the red block within the ROI range will be detected, which reduces the interference of the surrounding environment color.[9-11].

2.3 Barrel and Coil

The design of the simulated electromagnetic gun is actually to use the electromagnetic force to shoot the shell out of the special barrel. This design concept is a design device of the power brought by the new energy of electromagnetic force, which can make the shell have a higher speed, but the electromagnetic gun I designed also has some problems.

The first is the damage to the barrel when firing the shell. The main reason is that the charging and discharging process of the relay module installed cannot accurately grasp the voltage, so the shell will touch the barrel. The power generated by electromagnetic force will resist the thermal energy generated by the friction between the shell and the barrel, which will make the power insufficient.

Secondly, the electromagnetic force generated by the electromagnetic gun will generate power consumption when generating kinetic energy. Generally speaking, the kinetic energy of gunpowder gun is only 20%, but the electromagnetic gun we designed is different. It is an advanced modern weapon, and its kinetic energy is as high as 150%. But the bad part is the relay module technology, and the hardware selection part, so in the design of electromagnetic gun, it has a special power consumption.

After the barrel is selected, it is the most important part. The winding and selection of the coil. The barrel of the electromagnetic gun I designed is also a general non lethal barrel. All the coils are common enameled aluminum wires, whose diameter is also between 0.5 and 0.8 cm. The length should be longer, and the winding thickness should be thicker. After the winding is completed, take
something under the barrel and seal it. Make the shell of electromagnetic gun coincide with the bottom of coil, which will maximize the speed and distance of shell.

2.4 Step Up and Step Down Modules
In the booster and depressurization hardware of the relay module of the electromagnetic gun, there is a fuse in the booster, which is very easy to be burned out. Therefore, we must be sure that the voltage displayed on the display does not exceed 11V in the process of boosting. In addition, we need to charge the capacitance in the booster, and discharge the capacitance before charging, so that the capacitance can be opened from 0. Start charging, and then pay attention to that we should never press the button of the anti pressure device again when loading and boosting.

2.5 Hardware Connection Precautions
First of all, the fuse will burn out when the electromagnetic gun is connected to the development board and the power supply device, so we need to prepare more fuses, so the power supply device we use is the charger and 11V battery, although the higher the charging voltage, the farther the emission, but the voltage we control is between 11V.

2.6 Precautions for Launch
There are several variables that need to be adjusted in the launching process of electromagnetic gun. The first is to charge, and grasp the charging voltage and time. Its choice is to think of the firing speed of the electromagnetic gun, and then the angle between the electromagnetic gun and the ground. There is a detailed introduction of the experimental operation below. If we add a light gate at the gun nozzle, we will get a better speed.

3. Test

3.1 Commissioning Plan
Find a fixed point to place the designed electromagnetic gun on this point, which can accurately hit the circular target. According to the design requirements, the included angle parameters and the distance to be measured are input into the program, then displayed by the display screen, and the vertical angle, rotation angle and horizontal Tuo machine are calculated by the single-chip microcomputer through accurate calculation. Finally, the machine and program are started to carry out shooting experiments on the circular target.

3.2 Launch Debugging
When the launching angle of electromagnetic gun is zero, the relation between launching and input distance is shown in Table 1:

| Preset distance/cm | 300 | 300 | 270 | 270 | 250 | 250 | 230 | 230 | 220 | 210 |
|--------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Actual distance/cm | 395 | 290 | 260 | 265 | 250 | 240 | 235 | 240 | 220 | 220 |
| Error/cm           | 5   | 10  | 10  | 5   | 0   | 10  | 5   | 10  | 0   | 10  |

We can get from the table obtained from the experiment that there are few values provided during the fitting, so there are some differences in the function to, but I can't exceed 20cm by keeping the deviation distance between 5cm and 15cm. When the launching angle of electromagnetic gun is not zero, the relation between launching and input distance is shown in Table 2 below:
| Preset distance/cm | 300 | 300 | 270 | 270 | 250 | 250 | 230 | 230 | 220 | 210 |
|-------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Actual distance/cm| 300 | 295 | 275 | 265 | 250 | 255 | 240 | 235 | 235 | 210 |
| error/cm          | 0   | 5   | 8   | 5   | 0   | 5   | 10  | 5   | 15  | 0   |

Through this set of data, we can get that the shooting distance of the electromagnetic gun I has a small deviation at the central axis, and the error of the electromagnetic gun when changing the direction is also between -1 and 1. I have also changed the deviation angle several times and carried out several experiments, which are similar to the above results. I think there are some mistakes in the hardware assembly process, which has a bad stability, so that in the experiment process, the electricity angle instability of the magnetic gun makes the experiment deviate.

4. Summary

In the design of the electromagnetic gun, the AC coaxial coil gun is the main part, and two capacitors are used to provide energy for each launch of the equipment. The maximum value of the instantaneous voltage between the capacitor electrodes is 12V. An electromagnetic relay connected to a single-chip microcontroller controls the full cycle charging. There are two ways to determine the horizontal and vertical direction when the electromagnetic gun fires the target. One is to use the openmv program to operate the keyboard, and the other is to install the camera. In this way, we can get the operation angle of a two-dimensional cloud platform, which is composed of two DC steering engines. In the experiment, STM32 is used to control PWM and PWM to control the horizontal and vertical servos. This design in the choice of power supply, combined with the whole design of the circuit, choose 3V DC voltage source is the most appropriate. The power supply mode of single chip microcontroller is to reduce the voltage first, and then to provide power. On the contrary, the power supply mode of the components of the electromagnetic gun is the first step-up to provide power, and the step-up process is realized by the step-up module.

References

[1] Zhang Hao, Chen Minghui, Li Zhenyang, Wang Cheng, Zheng Gang. Optical low coherence interference method for measuring glucose concentration [J]. Optical technology, 2018, 44 (3): 287-290
[2] Chen Donghe, Liang Xiaochong. Measurement of glucose concentration by microwave spectrometer [J]. Experimental technology and management, 2018, 35 (12): 75-77
[3] Zhang Shuren, Xu ya, Xie Dailiang, Xu Zhipeng, Liu Tiejun, Wang Yuebing. Study on the measurement of suspended matter concentration in ultrasonic water based on ant colony algorithm [J]. Journal of sensing technology, 2019,32 (8): 1163-1168
[4] Yang Xuan, Su Mingxu, Cai Xiaoshu, Wu Jian. Study on density measurement of ethanol solution by ultrasonic multiple echo reflection method [J]. Journal of sensing technology, 2011,24 (7): 937-940
[5] Wu Lijie, Jiang Zhidi, Wu Zhenqian. High precision measurement method of ultrasonic liquid concentration based on curved surface fitting [J]. Journal of sensing technology, 2018,31 (8): 1169-1175
[6] Wan Haoping, Yang Nan, Fan Yi. Measurement method and system research of concentration field in large area water area [J]. Water conservancy and hydropower technology, 2017,48 (3): 71-76
[7] Crawford HD, Wild JJ, Wolf PI, et al. Transmission of Ultrasound Through Living Human Thorax[J].IRE Transactions on Medical Electronics, 2009, ME-6, Issue:3, pp141-146
[8] Ma Kui, Luo Yimin, Liu Wei. Circuit design of positioning and tracking system based on electromagnetic induction principle [J]. Packaging engineering, 2017, (11): 153-158.

[9] Yan Ziyang, Su Chengyue, Zhang Hongxin. Application analysis of VHDL in digital integrated circuit design [J]. Automation and instrumentation, 2017, (05): 131-133.

[10] Wang Bin, Li Jian, Xiao Ziyi. Circuit design of a low noise preamplifier [J]. Electronics and packaging, 2017, (05): 24-27.

[11] Shuai Wei, Guo Aiyun. Hardware circuit design of a portable data acquisition system [J]. Instrument technology, 2017, (05): 41-43