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Design of an Eyesight Tester Based on Motor Control

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Abstract

With the development of human society, electronic products are ubiquitous in our lives, which has led to a gradual increase in the number of patients with refractive errors in young people in China. Optometry is the most important method for checking refractive errors and plays an irreplaceable role in correcting and preventing vision loss. The traditional optometry technology in China uses LED vision meters for testing, which is complex and time-consuming. The measured data is not comprehensive, with uneven brightness and large volume The high failure rate and the existence of blind guessing by patients can lead to inaccurate testing data. Therefore, the quality of the optometry tester is of great help in correcting and preventing visual impairment. This article studies this type of optometry tester and discusses the application of programmable controllers (PLC) in diopter testing equipment, using Mitsubishi PLC programming control, The overall design scheme, design process, composition, and control ladder diagram and instruction table of the PLC control system for automatic diopter detection have been proposed. The design process includes software limit programming and compensation programming, and a program flowchart is provided.

Keywords

Diopter ; Ladder diagram; Soft limit design.

1. Introduction

Vision detection is very important in optometry. The purpose is to diagnose visual pathway diseases by detecting whether the eye's vision is normal, which is very helpful for the prevention of myopia or hyperopia. At present, there are mature products for lens diopter detection devices, but most of the products are developed and produced by foreign companies and scientific research institutions, and are used for complex applications. The price of Degree distribution lens measurement devices is high, However, there are still some manual optometry devices in China, which are inconvenient, cumbersome, and have significant errors. In order to improve the performance and efficiency of domestic diopter detection equipment, a diopter detection automatic control system with PLC as the core controller has been designed to replace traditional manual diopter detection equipment. In the core control section, Mitsubishi Fx3U-48m PLC is used, and Gx Works2 is used for programming and control, During the normal operation of the diopter detection instrument, it has greatly improved the convenience and ease of operation in equipment fault inspection and maintenance, effectively solved some human interference and danger caused by manual operation, and achieved good expected results. The model of the diopter detection equipment is Mitsubishi Fx3U-48m[1-3].The PLC program design is written using logic of basic instructions and step instructions, The designed program requires the completion of the functions of the diopter detection device, such as the touch screen interface, work interface (execution and pause switching, cancel to cancel all current commands), parameter setting interface and parameter setting program (including gap compensation value), I/O allocation interface, diopter distance calculation, front and rear position limit parameters, etc., regarding the basic structure of the PLC control system and the installation and debugging of the diopter detection instrument control system.

The control system of the diopter testing device is divided into three parts: speed regulation, signal, and remote control and monitoring[4-7]. This determines the overall structural plan of the system. The signal control is achieved by PLC, the speed regulation is achieved by stepper motor and servo motor, and the touch screen is used for remote control and monitoring. The selection of motor and programmable controller (PLC) is completed. According to the operation process of the system, the selection of PLC, the allocation of I/O points, and the connection to PLC are completed, After analyzing the working requirements of the equipment, a flowchart was designed, and a modular programming concept was proposed. Finally, the diopter testing device was simulated and debugged

2. Electrical control requirements

Due to the current method of optometry being tested using a visual acuity chart, this method has poor reliability. In order to facilitate the use of medical staff and testers, it is of great significance to modify and research the optometry method, thereby improving the convenience and strong performance of optometry technology. In response to the shortcomings of traditional visual acuity charts such as poor functionality, high failure rate, and single functionality, a programmable logic controller (PLC) with strong functionality, low failure rate, and strong reliability is proposed for control transformation. The main task of the research project is to use programmable logic controllers (PLC) as the core device to control the diopter detection instrument, in order to achieve stable, safe, and efficient operation of the diopter detection equipment.

The main process of a diopter testing device is to fix the detector's head on a dedicated bracket, press the execution distance button on the display screen, drive the transmission rod to move the lens forward, move it to a relative position, and ask the patient if they can see clearly. If they cannot see clearly, they can press the word movement distance button on the display screen for fine adjustment, and finally determine the distance that the patient can see clearly. At this moment, press the movement angle button again to operate as above, Calculate the patient's diopter based on the results of the two evaluations.

Requirements for electrical control of diopter testing devices:

1)The designed electrical circuit must meet the production process requirements of the production machinery.

2)The action of the electrical control circuit should be accurate, and the action sequence and installation position should be reasonable. The electrical control circuit requires accurate action of its electrical components, and requires that when individual electrical components or wires are damaged, the working sequence of the entire electrical circuit should not be disrupted. When installing, the installation position should be both compact and leave room.

3)In order to prevent malfunctions in electrical control circuits that may cause harm to equipment and personnel, necessary interlocking and various protective measures should be taken between each link of the electrical control circuit.

4)The electrical control circuit should be simple and economical. On the premise of ensuring the job security and reliable operation of the electrical control circuit, the control circuit should be as simple as possible, the selected electrical components should be reasonable, the capacity should be appropriate, the number and model of electrical components should be reduced as far as possible, and standard electrical components should be used; The selection of the cross-sectional area of the wire should be reasonable, and the cross-sectional area should not be too large; The wiring should be economical and reasonable.

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5)Convenient maintenance and repair.

In order to ensure the safety of the lens movement distance, a certain range is set for the movement distance. When the lens reaches or exceeds this distance, the device will automatically stop providing protection. The device uses a proximity sensor, which is a device with the ability to sense the proximity of objects. It uses the displacement sensor to have sensitive characteristics to approaching objects to identify their approach and output corresponding switch signals, And it adopts a node free output mode to extend the lifespan of the sensor. Compared with daily lighting, it is effective and fast, not affected by surface color, water, stains, etc., and does not need to be accepted to avoid wear and damage. It is widely used in various automated production lines and mechatronic integrated equipment.

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3. Software Design of Equipment Control System

3.1. Compensation program

The rotating mechanism of this equipment is driven by Timing belt. It is composed of driving wheel 1, driven wheel 2 and annular Timing belt tensioned on two pulleys; The motion is transmitted through the meshing of equidistant transverse teeth on the inner surface of the transmission belt and corresponding grooves on the pulley, thus transmitting the power of the driving shaft to the driven shaft. Figure 1 shows the working principle of Timing belt transmission.

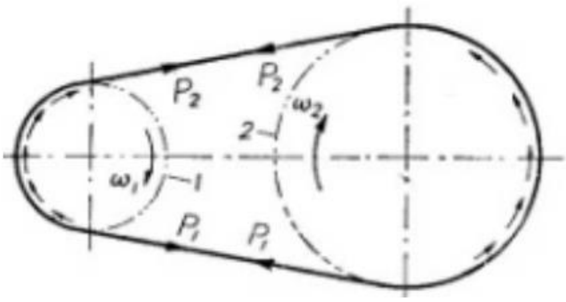

Fig.1 Working principle of Timing belt transmission

The advantages of Timing belt transmission include:

1. Stable operation and very low noise: suitable for transmission situations with large center distance between two axles.

2. Cushioning and vibration absorption function: the Timing belt has good elasticity, and it can buffer and absorb vibration when driving stably.

3. Overload protection function: if overload is encountered during operation, the Timing belt will slip on the pulley, which can prevent weak parts from being damaged and play a role in safety protection.

4. Low requirements for manufacturing and installation accuracy: low cost, simple structure, simple manufacturing, low cost, no need for lubrication, as well as characteristics such as buffering, shock absorption, easy installation and maintenance.

5. Suitable for long-distance transmission (amax=15m): Timing belt is an intermediate part, and the length can be selected according to the needs within a certain range to meet the working requirements of large center distance requirements.

However, there is a big problem with Timing belt transmission. The Timing belt itself is elastic. In addition, there must be a gap between the teeth of the Timing belt and the teeth of the gear. The Timing belt and the gear cannot be fully meshed. After a long time of operation, the rotating mechanism will certainly have large errors, which is not allowed by the design requirements. So we added an automatic compensation program for the displacement of the rotating mechanism.

The compensation program will first determine whether compensation is needed after pressing the execute button. If the running direction this time is the same as the previous time, no compensation is needed, and the displacement program will be executed directly. If the running direction is opposite, the compensation value will be added to the execution value before executing the displacement program.

The Timing belt transmission mainly relies on the meshing of Timing belt teeth and pulley to transmit power, so that the purpose of synchronous transmission can be achieved. If you want the speed of the driving wheel to be transmitted to the driven wheel normally, the pitch of the Timing belt and the synchronous wheel must be the same. In the process of producing Timing belt, there will be some changes in the pitch, which will lead to the different pitch between Timing belt and synchronous wheel, which is called pitch error. Excessive pitch error can cause unstable transmission of the system, such as tooth climbing, and thus fail to achieve the goal of synchronous transmission.

The factors affecting the pitch error of Timing belt transmission mainly include the following two aspects:

1. Error in manufacturing: Timing belt belongs to an elastic body. Therefore, whether the length between the pitch lines of the Timing belt and the pitch of the belt teeth can be closely related to the manufacturing technology of the belt;

2. Pitch error caused by polygon development effect: because of the tension of Timing belt, plus the height of tooth thickness, it is much larger than the height between teeth. The nodes on the belt will wrap around the teeth of the pulley in a folded line form, so that the nodes on this part of the belt will not overlap with the nodes on the pulley. Therefore, it is necessary to reduce or eliminate the pitch error caused by polygonal effects. When the Timing belt is driven, it is affected by a certain tension, and the skeleton rope in the belt has an elongated elastic structure deformation, which increases the pitch of the belt and causes pitch error.

There are two situations where the device will enter an alarm state

1. When the device is not in the zero return state, any limit sensor is triggered, and the device immediately stops running and sends an alarm. This alarm needs to be cleared by running a reset program.

2. Manually pressing the emergency stop button will immediately stop the equipment and issue an alarm. This alarm can only be eliminated by releasing the alarm button.

X10 is the right limit sensor of the rotating mechanism, X11 is the left limit sensor of the rotating mechanism, X12 is the rear limit sensor of the sliding table mechanism, and X13 is the front limit sensor of the rotating mechanism. X14 is an emergency stop button. M30 and M11 are conditions for servo reset, while M35 and M24 are conditions for step reset, so an alarm will not be triggered when the device is reset.

(1) Limit alarm

When the device triggers a limit alarm, it will be set to M10. After M10 is closed, it will reset M21, M30, M22, M31, M35, and M28. And Y7 will be triggered, and an alarm will sound on the touch screen. M21 and M22 are the conditions for servo movement, while M31 and M28 are the conditions for stepper movement. At this point, a reset is required to eliminate the alarm before running the displacement program.

(2) Emergency stop alarm

During the equipment debugging process, we found that directly using X14 to control M10 would cause the device to trigger an alarm as soon as it is powered on. Therefore, we added a timer T0 to the emergency stop condition, which will close 1 second after the device is powered on, in order to solve the problem of an alarm when the device is powered on.

By using the rising edge signal of M8012 and the DMOV instruction, the number of pulses is read into D0. It is read every 100ms. When we double the number of pulses, we multiply it by 10 times and put it into the D2 register. This is equivalent to calculating the number of pulses that can be sent within 1 second. The number of pulses sent within 1 second is the evaluation. The subsequent control program uses the data from D2 to control, and when the number of pulses is 10 times, we control it by multiplying it by 100 times, and then multiply it by 1000. The high-speed counter is cleared at the end, In this way, the general data is refreshed every 100ms (where the number of pulses required for one revolution of my handwheel is the same as the number of pulses required for one revolution of the stepper motor. If different, a multiplication or division operation needs to be performed based on their ratio). In addition, the 3U PLC does not have the function of handwheel control, and our program cannot achieve absolute consistency. There may be some error in the action, but the error can be ignored. The handwheel program design is shown in Figure 2.

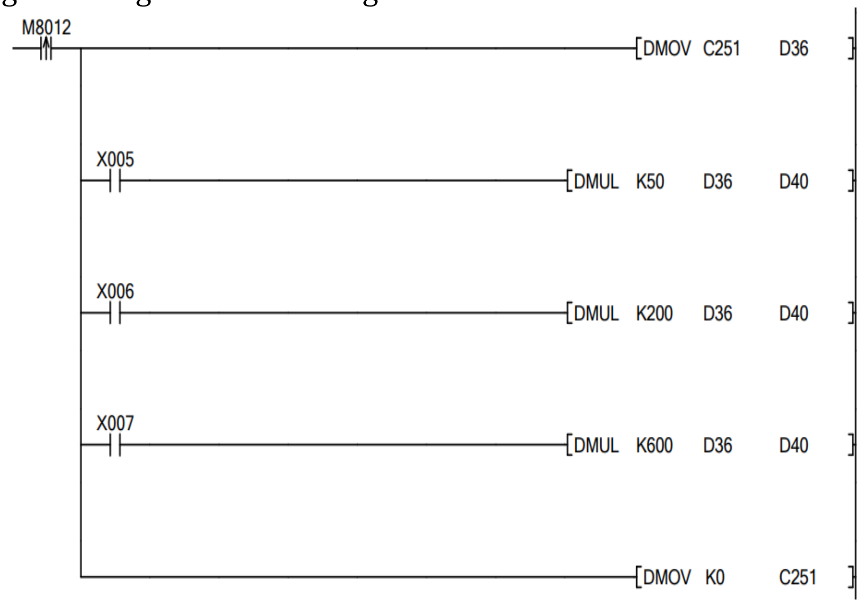

Fig.2 Handwheel program design

4. Equipment commissioning and Conclusion

This equipment mechanism adopts a belt pulley for mechanical coordination. The advantages of the belt pulley are smooth operation and noise. It is suitable for transmission situations with large center distance between two shafts and has a buffering and vibration absorption effect. The belt has good elasticity, and the transmission is stable during operation, allowing for buffering and vibration absorption. However, belt transmission has a major drawback. The belt itself has elasticity, and there will inevitably be gaps between the teeth of the belt and the teeth of the gears. The belt and the gears cannot fully mesh, and the rotating mechanism will inevitably experience significant errors after long-term operation, which is not allowed by design requirements. So we added an automatic compensation program for the displacement of the rotating mechanism. There may be certain errors between machines, which can lead to

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inaccurate numerical calculations. To solve this problem, we have designed a program for gap compensation.

Turn on the power and check whether the designed program will make any errors when completing its simplest control function. If there are no errors in various debugging, use the load method for debugging. The debugging process is as follows: test whether the touch screen can be turned on, and operate according to the buttons on the touch screen. For example, input a movement distance of 5cm in the touch screen, press the "distance" button in the touch screen, and the screw slide will move back and forth once the set distance is set, Measure whether the distance of the movement corresponds to the input value. Alarm reminder: During the machine movement process, manually trigger the sensor, and the machine can immediately stop. Ensure the safety of machines and people. The complete machine model is shown in Figure 3

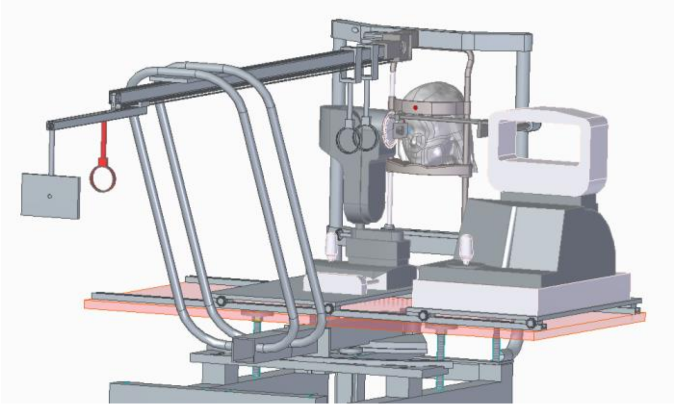

Fig.3 Machine model

Acknowledgements

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