High-precision video acquisition system based on three-axis linkage

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Abstract: The main research content of this system is to realize the linkage control of multi-axis motor through LabVIEW and single chip microcomputer. The operator can operate the upper computer software to send the speed and spatial coordinate instructions remotely. The expansion chip ch438q is used to store temporarily, and then the data is transmitted to the processor of max13487 for control. According to the RS485 serial port communication mode, the analyzed data parameter information is transmitted In the stc15 single-chip microcomputer on four single axis control cards, the motor is controlled by the driver to make the controlled object move to the specified position quickly and accurately. In the process of movement, the upper computer can display x, y in real time. In order to test and use the system to achieve certain functions, a set of high-precision multi angle video acquisition system based on three-axis linkage and four axis control is designed. The selected camera is a 120° wide-angle camera, which can make the range of scenery observed from a certain point of view much larger than that of human eyes in the same view point Monitoring. After many experiments, the accuracy of the system can reach 1μM. The system itself can also expand a variety of functions according to different needs, which has a certain practical value.

1. Introduction
With the emergence of urbanization ideas, the country has proposed the idea of building a "harmonious society, safe city"[1]. The whole society urgently needs to use advanced monitoring technology to prevent emergencies and hidden safety hazards. Fundamentally, the core of the video capture system is to control the camera to reach the appropriate shooting position. Through its internal high-speed A/D conversion chip, the analog quantity is converted into digital quantity, and the data is stored, transmitted and processed all the time. Generally, large conference rooms or concerts need to be equipped with dozens or even hundreds of monitoring points for safety and supervision requirements. Therefore, a high precision video acquisition system based on three axes is designed. The system can be controlled by the controller through the motion platform to drive the camera for mobile tracking shooting[2].

2. System structure and principle
Figure 1 shows the system block diagram of the video capture system. This system is mainly composed of five parts: host computer labview, core board, single-axis control card, stepper motor driver and stepper motor. The system is first configured by the STC15 single-chip microcomputer that completes data exchange and the host computer labview that implements human-computer interaction[3]. To achieve precise control of the speed and position of the multi-axis system, the single-axis control card
controls the operation of the stepper motor by connecting with the stepper motor driver to achieve precise positioning. The running speed of the motor and the relative position of the sliding table can also be adjusted in real time, and the running status of the corresponding stepping motor can be transmitted to the single-axis control card and the microcontroller on the core board through the internal counter and timer, and finally displayed on the screen. In the user interface, this system adopts a screw drive mechanical design. Through the control of four 17HS4401 stepping motors\textsuperscript{[4][5]}, the rotation of the stepping motor is realized, acting on the corresponding screw, it drives the slide table on the optical axis to do linear motion. The camera is fixed on the fourth motor shaft at the end of the Z-axis sliding table, and under the action of the rotating shaft, the upper computer adjusts its shooting angle through the rotation control of the fourth axis to meet the shooting requirements. High-precision, multi-angle video capture work.

Figure 1. System block diagram.

3. System hardware design

3.1. Core board hardware circuit

The CH438Q chip includes eight compatible asynchronous serial ports. It supports communication baud rate up to 4Mbps, and can be used for RS232 serial port expansion of single-chip computers and embedded systems, high-speed serial ports with automatic hardware rate control, and RS485 communication. The main function of this circuit is to register the data parameters in the communication expansion chip CH438Q\textsuperscript{[6]}, then use the chip select signal to select four of them, then transmit the data to the processor corresponding to MAX13487 through these four channels for control. This can reduce the workload of the main CPU and free up excess CPU memory for more peripherals to expand.

Figure 2. SCM schematic.
3.2. Isolation circuit design
In the isolation circuit module, 6N137 is an electrical-optical-electrical conversion device that uses light as a medium to transmit electrical signals\cite{7}. When the left path is turned on after obtaining a high level, the light-emitting diode will light up, the triode in the right circuit will also turn on the circuit where it is located, completing the transition from electrical signal to optical signal to electrical signal. Regarding the design of the communication mode in the module, the communication mode of TTL to USB and RS485 serial communication are adopted to facilitate the programming of the program and the stability during long-distance transmission. After CH438Q receives the data sent by STC15 on the core board, it sends the registered data to the processor corresponding to MAX13487 through the chip select signal and selects the corresponding communication channel for control, then MAX13487 transmits the data to Single axis control card\cite{8}.

3.3. Physical display

![Figure 3. Display Diagram of High Precision Acquisition System Based on Triaxial Linkage](image)

4. System software design

4.1. Software implementation flow chart

![Figure 4. Software implementation flow chart.](image)

4.2. Software design ideas
According to the practical application, the system is designed as follows:

- The operator controls the upper computer to send the parameter information of each axis to the core board, in which CH438Q chip processes the data.
- CH438Q after data processing to each axis corresponding to the single axis control card.
• According to the parameter information, the single axis control card of each axis controls the motor rotation through the driver.
• The guide rail drives the camera to move in space and feedback the collected data to the upper computer for real-time display.

4.3. Space algorithm program design
Among the four relative positioning axes, each of them requires 6 digits to represent, so a total of 18 digits are spliced together\cite{9}. And usually the first digit of every 6 digits is 1 or 2 to judge the forward and reverse, and the last 5 digits are used to indicate the distance of each axis. Due to the short travel range of the actual slide, we only retained 2 integer digits and 3 decimal places. Since the displacement is accurate to three decimal places, its positioning accuracy is high. The spatial positioning algorithm of the upper computer is shown in Figure 2 below.

![Figure 5](image)

Figure 5. Program diagram of spatial positioning algorithm

5. Experimental results and analysis

5.1. Experimental procedures and methods
In this paper, the system is applied to video acquisition work, the measurement method of amplifying error is adopted\cite{10}. The measurement method is as follows: Vernier calipers with measuring tools as mm precision 0.02, the moving distance of the stepping motor is set to 100mm in the upper computer interface, the experiment has measured the movement distance of the sliding table 15 times.

![Figure 6](image)

Figure 6. Set the actual measured value of 100mm system

5.2. Analysis of experimental results
According to the measurement values in Figure 4 above, the average error per 100mm of movement is
calculated to be 0.08mm, and the error per millimeter is 0.8um, which is less than 1um, so the accuracy of the sliding table movement of this system can reach 1um.

Since the standard step angle of the two-phase four-wire stepping motor is 1.8°, the driver of this system is set to 6400 subdivision, so the step angle is 0.00028125°, which is less than 0.001°, so the control accuracy of the camera is 0.001°.

6. Conclusion
The high-precision multi-angle video acquisition system based on three-axis linkage and four-axis control designed in this paper can be applied to the field of automated industrial equipment. The four-axis control technology of the system’s three-axis linkage can be applied to four-axis robotic arms and 3D printers. Gantry laser engraving machine, CNC machine tool; In urban infrastructure construction[11], the high-precision, multi-angle video capture function of the system can be used in small systems such as remote control cameras, automatic teller machines, cash recycle machines, to achieve small size, low-cost operation, convenient maintenance and superior performance.

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