Design of Three-Dimensional Gesture Recognition and Motion Tracking Human-Computer Intelligent Interaction System based on PAJ7620

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Abstract: With the increasing degree of informatization and intelligence in modern society, human-computer interaction technology has become one of the commonly used scientific and technological achievements. "Gesture" can be used as inputting image information, and make more intuitive and convenient for perception of user interface. To a certain extent, it can complete the intelligent interaction function between human and computer. The design is a human-computer intelligent interaction system for 3D gesture recognition and motion tracking based on gesture sensor PAJ7620. STM32 chip is used as the main control unit to recognize accurately, analyze and process different gestures collected by the gesture sensor, and control the OLED screen to display the gesture information. It can further drive the carrier to take corresponding actions and realize the intelligent human-computer interaction recognition of gestures. The experimental test results show that the recognition rate is lose to 100% when the distance is within 10cm.

1. Introduction
In human-computer interaction, "gesture" has the obvious characteristics of intuition, image and vividness, and has a strong visual effect. Vision based gesture recognition technology, involving image processing, pattern recognition and computer vision, is a hot research topic [1]. In order to obtain high-precision detection, the traditional recognition algorithm depends on the complexity of the control system algorithm and the ability of graphics processing. At present, Kinect, the somatosensory peripheral of Microsoft, is widely used in XBOX360 game machine. Leapmotion, a somatosensory manufacturing company for PC and MAC, is also widely used in software and games developed by Disney, Google and other companies. On this basis, this paper proposes a human-computer interaction system based on PAJ7620 gesture sensor, which makes the detection
algorithm relatively simple, low dependence on the control system, and low bit error rate.

2. General design of the system
As a gesture signal, the gesture recognition sensor chip separates the gesture signal from the given video signal, analyzes the gesture by establishing a gesture model, including the analysis of gesture features and model parameters, and then forms different gesture descriptive languages according to different gesture recognition results, Then through the main control chip to drive the target device for specific applications, so as to achieve the role of gesture recognition and control.

The intelligent human-computer interaction system based on gesture sensor is composed of minimum single-chip microcomputer system, power supply module, sensor module, serial port module, display module and so on. The PAJ7620 gesture sensor obtains the original data of the target features to be measured through the recognition of different gesture actions, and then processes the original data of the features. Finally, the gesture results are stored in the memory of the controller. The IIC interface is used to retrieve the original data and the gesture recognition results, and the STM32 main control chip is used to process and analyze them, so as to recognize different gestures, Then the gesture information and the effect of different responses of the driving carrier are displayed on the OLED screen. The overall structure is shown in the Figure 1 below.

3. Hardware design

3.1 Main control unit
The main control unit is composed of STM32F103C8T6 chip and corresponding external circuit. The chip is a type of STM32 series, with 64 pins and 128KB flash. It adopts serial output single line and JTAG interface debugging mode, and has many advantages, such as high performance, low cost, low power consumption, etc. This system uses the main control unit to ADC the gesture signal collected by the gesture sensor, and carries out on-chip signal processing, which is convenient to identify different gestures, and then controls the display screen to display the corresponding gestures correctly, and can also drive the carrier to make the corresponding action[2].The minimum system is shown in the Figure 2 and Figure 3.
3.2 Gesture sensor module
PAJ7620 gesture recognition module is an 3D optical array sensor device newly launched by pixart company. It has an integrated special LED inside. Inside the LED are various sensors and some built-in integrated light sources. It can still maintain a high alert working state in the dark or weak light environment. What's more powerful is that it also supports up, down, left, right, front, back, clockwise rotation, counterclockwise rotation and waving of the nine gesture types and output gesture interruption and results[3]. The signal returned from gesture recognition can be used as the control signal received by the robot. The gesture module adopts IIC interface communication protocol, and its circuit diagram is as following Figure 4.

3.3 Display unit
In order to make the recognition results and effect more intuitive and clear display, at the same time, the design needs the screen as the front-end input tool, but the digital tube can not achieve this function, so the display circuit is OLED1602 LCD. Compared with traditional LCD and CRT, the OLED display has many advantages, such as low starting voltage, fast response, active lighting, foldable, light weight and so on. The display interface is shown in the Figure 5.

3.4 Power supply unit
The output voltage of the circuit is filtered by C1 to remove most of the AC components, and then added to the filter circuit composed of AMS117 chip. The capacitive reactance of C2 and AMS117 chip constitute a voltage divider circuit. Because the capacitive reactance of C2 is very small, the partial voltage attenuation of AC component is very large to achieve the purpose of filtering. For direct current, because C2 has the function of isolating direct current, AMS117 and C2 voltage dividing circuit have no effect of partial voltage attenuation on direct current, so the voltage is output through AMS117, as shown in the Figure 6.
3.5 Button circuit
The setting of keys is realized by independent keys. The outstanding advantage of this button is that its software and hardware are relatively simple and easy to operate. When the key is in the normal state, that is, when it is not turned on, the input state of the I/O interface corresponding to the CPU is high due to the internal pull-up resistance; When a key is pressed by our user, the corresponding I/O interface changes from high-level state to low-level state. When the system program is running, we only need to know what kind of state the I/O interface is in, then we can judge which key is on and which key is off. The design circuit diagram is as follows Figure 7.

4. Software design
The operation of the system is to detect and process the data. First of all, each module will initialize the pin information, which is conducive to the follow-up operation of the system and the self-test of the machine. Because the system will not tell the system to run to that stage at this time, but through the programming prompt to carry out the corresponding human-computer interaction, compile to understand the operation of the whole device, and then the sensor collects the user's action information. The MCU reads the data collected by the sensor through IIC, and reads the nine defined gestures in the sensor bank1 register, Then, the gesture information is sent to the display module for display. In order to realize the recognition and display of data[4]. The detailed process is shown in Figure 8.
When there is gesture, the communication between infrared sensor PAJ7620 and SCM STM32 is realized through peripheral IIC interface. After the gesture is recognized by gesture classification algorithm, it is displayed on LCD screen in real time by triggering interrupts to display gesture results. The ADC sampling module of STM32 collects the information of PAJ7620 infrared sensor, and analyzes the collected data through the custom protocol of serial port.

5. Experimental test & Conclusions

According to the working characteristics of PAJ7620, an experiment is designed to test the recognition rate of eight hand gestures from 5cm to 30cm. Eight different hand gestures are made 50 times each 5cm interval, and the influence of distance on recognition results is tested. The test results are shown in the following table.

It can be confirmed from the below table that the recognition rate is close to 100% when the distance is between 0 and 10 cm; When the distance is between 10 cm and 25 cm, some results are not accurate, and the recognition rate can reach more than 60% after removing the influence of light and object moving speed; When the distance is more than 25cm, the recognition rate is close to 0, so the maximum recognition range of the system is within 25cm, and the distance within 10cm is the most accurate.

Table 1 Gesture recognition rate

| distance(cm) | left | right | upward | downward | front | back | clockwise | anticlockwise |
|--------------|------|-------|--------|----------|-------|------|-----------|---------------|
| 5            | 100  | 100   | 100    | 100      | 100   | 100  | 100       | 100           |
| 10           | 100  | 100   | 100    | 100      | 100   | 100  | 100       | 100           |
| 15           | 87   | 93    | 95     | 96       | 95    | 88   | 87        | 90            |
| 20           | 78   | 77    | 81     | 83       | 89    | 84   | 71        | 76            |
| 25           | 72   | 71    | 67     | 71       | 65    | 69   | 67        | 71            |
| 30           | 0    | 0     | 0      | 0        | 0     | 0    | 0         | 0             |

In a word, the system has high recognition rate, strong compatibility and good human-computer interaction experience. The next step of 3D gesture recognition and motion tracking human-computer intelligent interaction system should consider the further optimization of gesture recognition algorithm, and carry out the development of 3D gesture in complex environment, so that the system has higher recognition rate and better environmental adaptability.

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