Design on four-axis aircraft control system based on Somatosensory interaction

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Abstract. The four-axis aircraft has the characteristics of small size and symmetrical structure, and has important application value in complex environmental monitoring such as block, tunnel, indoor and close to the ground. However, the aircraft uses remote control and the overall control is difficult. To this end, a four-axis aircraft control system based on somatosensory interaction is presented in this paper. The Leap Motion controller is used to identify and read the hand motion data, and the control system reads the hand motion to realize the flight control of the four-axis aircraft. Research shows that the four-axis aircraft control system can effectively recognize the operator's gestures. The gesture control target attitude value is very close to the aircraft attitude angle, the control rate is high and the corresponding speed is fast, which has certain application value.

1. Introduction

The basic structure of the quadcopter is mainly composed of orthogonal cross frame, four motors, propellers and flight control module which located in the center of the frame[1]. The flight controller is used to drive the motor to the electronic governor signal and adjust the speed to change the position and attitude of the aircraft. The four-axis aircraft mainly has vertical lifting motion and hovering, rolling motion, pitching motion and yaw motion. At the same time, in order to better describe the attitude of the quadcopter, the reference coordinate system n and the body coordinate system b are respectively established[2-5].

The four-axis aircraft is controlled by somatosensory interaction, mainly using the Leap Motion controller as the gesture data capture sensor, and constructing a single palm as the interactive control model. In the actual control interaction process, the pitch, roll, and yaw angle values of the different posture actions of the palm plane in the Leap Motion controller coordinate system correspond to the body coordinate system.

2. Control system design

Combined with the basic structure of the quadcopter and the principle of interactive somatosensory control, the four-axis aircraft control system is deployed, as shown in Fig 1.
The control system controls the attitude of the four-axis aircraft with hand movement, and control the aircraft through different hand movements and postures corresponding to different flight attitude commands.

The mainly working principle of the control system is as follow: the Leap Motion controller is used to identify and read the hand motion data, and the data is transmitted to the data processing module through the data line; The data processing module accepts the gesture data from the gesture recognition module, uses the SDK program and function of the Leap Motion controller, applies a custom control algorithm to convert the hand motion data into corresponding control commands, and sends the signal to the signal transmitting/receiving module is acquired through the USB interface and displayed in the GUI control program; A stable wireless communication data connection is established between the 2.4 GHz technology and the aircraft, and the control command packet of the data processing module is converted into a radio signal, sent to the aircraft, and the airborne sensor data signal sent by the de-sealing aircraft is received, through the USB interface, transfer data to the data processing module.

3. Software design

3.1. Main program
The software design of the bottom layer of the quadcopter control system was written in C language, and the underlying development of the microcontroller STM32 was performed using Keil μ Vision4 software. In the design, the STM32 timer is set, different interrupts are generated according to the timing time, and different tasks are performed by interrupt nesting to realize different functions. The main program design of the four-axis aircraft control system is shown in Figure 2.
3.2. Somatosensory control

Through the design of the host computer of the four-axis aircraft control system, the gesture recognized by the Leap Motion controller is converted into a control command, and the control of the four-axis aircraft system is realized through the wireless communication module. After the Leap Motion controller recognizes the 3D image depth information of the human body, it recognizes the operator's posture motion by accurately recognizing the operator's body contour and limb position, and finally transmits the recognition result to the quadcopter in the form of instructions. The gesture recognition process is shown in Figure 3. After receiving the control command, the quad-axis aircraft analyzes the command, and performs a corresponding action by calling the action execution function, thereby realizing the gesture control of the quad-axis aircraft.
4. Experiment analysis

4.1. Experimental environment
Combined with the design of the four-axis aircraft control system, a four-axis aircraft physical device was build in this paper, as shown in Figure 4.

During the flight of the quadcopter, the space between the camera and the background grid is used as the flight space. During the experiment, the controller controls the aircraft flight by gesture according to the mission target, the camera controller captures the flight attitude in the flight mission, and records the aircraft graphics control interface video of the data processing module through the screen recording software. After the experiment starts, the screen recording software and the high-speed camera are simultaneously turned on, the gesture control aircraft system is connected, the gesture control interaction personnel perform the flight task, and the camera controller takes the flight attitude photograph of the aircraft.

After the experiment task is completed, the screen recording software and the high-speed camera are closed, the experimental data, the duration and the photo shooting time are recorded, the experimental duration, the photo shooting time and the like are referenced, and the graphic control interface screen...
corresponding to the recorded time in the recorded video is intercepted. Combine the two images into the final experimental picture to verify the integrity and accuracy of gesture control and flight control.

4.2. Experiment analysis

Through the design of the somatosensory control model, the quadcopter mainly realizes the front and rear movement, the left and right movement, the lifting movement, the pitching movement, the rolling movement and the yaw movement. To this end, the gestures are set in the control system, corresponding to the basic motion of the aircraft, respectively. The gesture information is recognized by the Leap Motion controller, and then the recognized gesture information is converted into command information and transmitted to the quadcopter through the wireless serial port module. After receiving the control command, the quad-axis aircraft analyzes the command, and performs a corresponding action by calling the action execution function, thereby realizing the gesture control of the quad-axis aircraft.

The four-axis aircraft control system is tested for the recognition of human gestures. The basic motion control of the quadcopter is controlled by testing eight dynamic gestures. The specific results are shown in Table 1.

| gesture          | movement | frequency | Correct times | Recognition | Response time |
|------------------|----------|-----------|---------------|-------------|--------------|
| Left hand lift   | Rise     | 100       | 99            | 99.00%      | 45.23ms      |
| Right hand lift  | Go down  | 150       | 149           | 99.33%      | 45.52ms      |
| Left hand half   | Left yaw | 100       | 98            | 98.00%      | 45.29ms      |
| Right hand half  | Right yaw| 150       | 147           | 98.00%      | 45.33ms      |
| Left waving      | Pitching | 100       | 99            | 99.00%      | 46.55ms      |
| Right waving     | Pitching | 150       | 148           | 98.67%      | 46.23ms      |
| Left forward     | Left rolling | 100 | 99         | 99.00%      | 46.56ms      |
| Right forward    | Right rolling | 150 | 149        | 99.33%      | 46.53ms      |
| Total/average    |          | 1000      | 988           | 98.80%      | 45.905ms     |

As can be seen from Table 1, the four-axis aircraft control system can effectively recognize the gesture, the overall recognition is 98.80%, and the response time is short, with an average of 45.905ms. It can meet the accuracy of the gesture control of the quadcopter. Real-time requirements.

Combined with the experimental analysis, the four-axis aircraft is tested in the field, and the control of the aircraft can be realized through gesture control. Field tests were conducted using ascending motion and yaw motion as examples. In the ascending motion, the controller maintains the level of the palm level, and the initial height of the palm is the intermediate interval of the interaction space, slowly increasing the height of the palm ordinate, completing the vertical vertical movement of the aircraft, and recording the experimental data.

5. Conclusion

In view of the cumbersome operation of the aircraft, the somatosensory interaction control of the four-axis aircraft is presented in this paper. The four-axis aircraft control system based on the somatosensory interaction controls the flight attitude of the four-axis aircraft with the hand motion attitude, specifically, uses the Leap Motion controller to recognize the hand motion and transmits it to the system data processing module, and the aircraft receives and executes the flight control command. Achieve flight control of the aircraft. The experimental analysis and field test results show that the four-axis aircraft control system can effectively recognize the gestures and has a short response time. It can meet the accuracy and real-time requirements when performing gesture control on the quadcopter.

Moreover, the four-axis aircraft control system can realize the gesture recognition of the operator and realize the motion control of the four-axis aircraft. The gesture control target attitude value is very close to the aircraft attitude angle, the control rate is high and the corresponding speed is fast, achieving a good Control effect.
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