Design of Four Axis Aircraft Based on Arduino System

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Abstract

In the process of the short distance food transportation and distribution, the four axis aircraft is used as a new type of UAV system, which can save a lot of labor time. According to the principle and design of the four axis aircraft, this paper selects the Atmega2560 processor platform based on Arduino system. The MPU-6050 of the integrated of accelerometer and gyroscope is used as the sensor of the flight attitude data acquisition, Neo6 GPS U-box and MS5611 are respectively used as GPS positioning system and fixed height barometer, the 2.4Ghz global opening band is used for the wireless data transmission. The flight attitude of the algorithm is based on the smoothing filtering algorithm and fusion algorithm, then using PID control motor speed to adjust flight attitude. Finally, the paper makes the experiment and debug of the four axis aircraft prototype and the results were basically met the expected results of the design..

Keywords

Arduino system, Four axis aircraft, Arduino, Attitude calculation.

1. Introduction

Four axis aircraft is a representative of the multi-rotor aircraft which has four symmetrical cross distribution of propeller, controlling the attitude of the aircraft through adjusting the speed of the propeller. It has the characteristics of small size, light weight, simple structure, reliable performance, flexible control, flight stability and so on. Because four axis aircraft is more stable and reliable than conventional helicopters and has almost no mechanical structure problems, it can become a very good UAV platform and has a great advantage in the implementation of the task.

2. System hardware components

In order to achieve the stability of the four axis aircraft flight, and of some kinds of attitude control, we should design a reasonable hardware system, including the sensor elements, signal control and receiving part, drive circuit etc. The complete structure of hardware system is shown in Figure 1.

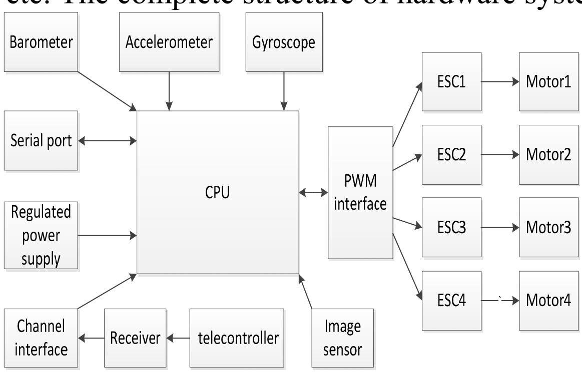

Figure 1 Control system

Microprocessor unit is the core of the structure of the hardware system, each sensors' real-time data transferred via I2C to processor, thus the processor performance determines the corresponding control system's speed. The main measurement unit is accelerometer and gyroscope, which measure three axis acceleration and angular velocity respectively; baro meter is used to measure the current altitude, the magnetometer and the GPS module are used to locate the motion direction and the space position of the aircraft. In the control and drive system, we send and receive signals through the remote controller and receiver. According to the current attitude and control command, the system drives the electronic speed controller in the way of PWM to control the rotation of the motor. This constitutes a basic four axis aircraft system.

We use the GY-86 module as sensors, which integrates MPU6050 accelerometer and gyroscope module, ms5611 pressure meter module. The size of this module is very small and it can be fixed on the development board through adhesive.The NEO-6 Gps is used as the Gps module, it’s a high precision Gps made by U-blox which can set specific parameters through PC software U-center, meanwhile it can be connected directly through the Arduino development board serial communication port. The image sensor uses the RC832 receiver and the TS832 transmitter, and uses the micro FPV camera to reduce the weight, the real-time monitoring can be carried out by liquid crystal display. The wiring of hardware as shown in Figure 2.

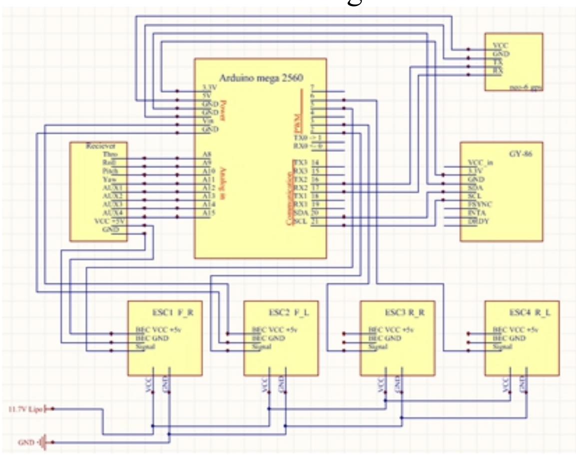

Figure 2 Hardware system

3. Software system design

The control core of the four axis aircraft is the attitude calculation process, a stable detailed algorithm can accurately calculate the current flight attitude, the main process is to calibrate accelerometer, gyroscope, barometer’s value to obtain an accurate results, so we adopt the attitude fusion algorithm. The main flow chart is shown in figure 3.

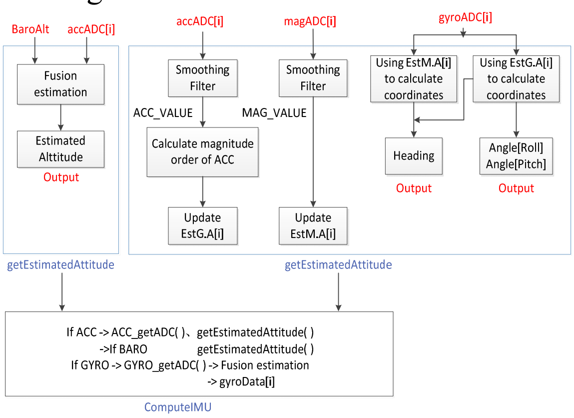

Figure 3 Attitude solution process

3.1 Attitude solution process

In the actual movement, the system will move along each direction, not a single axis movement, the movement of each axis will produce superimposed. So, so we have to carry out the operation of a attitude matrix, the original data is from the accelerometer, gyroscope, barometer, electronic compass. Because of the high frequency vibration of the system will influence the accelerometer, the gyro will drift after a long period of time working, so the original data value of the sensor must be filtered to obtain more accurate value.

In the same, the magnetic force gauge and accelerometer value after smoothing filter can be used to rotate matrix operations, and the two rotation matrix EstG and EstV are obtained. Since the motion of the four axis vehicle is a fusion process, so we decompose the process of motion, and then superimposed, the process is the first Y axis, then the X axis, the final Z axis. We assume that the aircraft rotated γ degrees around Y axis, then rotated θ degrees around X axis, finally rotated φ degrees around Z axis. Superposition the obtained attitude matrix after each rotation, since the time period of our sample is very small, the angle of the change is very small, so we can use the small angle approximation method, $\cos\theta \approx 1$, $\sin\theta \approx 0$, than we can get:

$$\begin{pmatrix} X_b \\ Y_b \\ Z_b \end{pmatrix} \approx \begin{pmatrix} 1 & -\sin\varphi & \sin\gamma \\ \sin\varphi & 1 & \sin\theta \\ -\sin\gamma & -\sin\theta & 1 \end{pmatrix} * \begin{pmatrix} X_n \\ Y_n \\ Z_n \end{pmatrix} \tag{1}$$

This can calculate the three axis euler angle from the attitude matrix which has been corrected, the direction of the aircraft can be obtained by the fusion of the magnetic force meter matrix and the acceleration matrix. The current flight height can be obtained by the measurement of the air pressure gauge and the temperature compensation, now we have finished the calculation.

3.2 Regulation of control signal

This can calculate the three axis euler angle from the attitude matrix which has been corrected, the direction of the aircraft can be obtained by the fusion of the magnetic force meter matrix and the acceleration matrix. The current flight height can be obtained by the measurement of the air pressure gauge and the temperature compensation, now we have finished the calculation.

However, when the four axis aircraft normal flight, will be subject to external force or magnetic interference, there will be a distortion on accelerometer or magnetometer values. The system is difficult to run stably with the single closed loop, so the acceleration can be added as the inner loop, the angular velocity is collected by the gyroscope, and the collection value is not affected by the external conditions, anti disturbance ability of the system is strong, and the angular velocity of the system is sensitive to the change of the system. In the same way, the air pressure sensor in the high ring is also affected by the external interference. The introduction of the acceleration loop can effectively avoid the influence caused by outside interference, and enhance the robustness of the system. Therefore, the calculation and the height of the euler angles are selected on the dual closed-loop PID control system, the PID output is the throttle value, through the electronic speed regulator to control the motor speed.

The throttle output is the fusion of multiple outputs, and the output value of the PID regulation of the three axis euler angle is:

$$AngelPIDOut(t) = k_p e(t) + k_i \sum_{j=0}^{t} e(j)T + k_d \frac{e(t) - e(t-1)}{T} \tag{2}$$

In the formula, $e(t)$ is the difference between desired angle and actual angle.

In the actual regulation, the P value is correct aircraft back to the initial position of the force, increase the P value will produce a efforts to prevent vehicle's shift, but too large P value will shock the vehicle. I value indicates if there is a deviation of angle change when sampling and average calculation of the time period, return to the initial position has a modified process. In the process of revision efforts will be more and more until it reaches the maximum value, increasing the I value will decrease the drift and improve the stability effect. The D value indicates that the speed of the aircraft return to the Initial position, improve the D value will speed up the initial position of the aircraft.

4. Flight test

After careful inspection and calibration of the aircraft, this paper carried out several tests. The test results show that: In the case of using 2212KV980 motor and APC1047 paddle, the maximum load can reach 3kg, the maximum speed can reach 4 m/s and it can achieve smoothly fly in the 4 level wind. The transmission distance of the image sensor can reach 5km, which is sufficient to meet the monitoring and control of the flight direction. Different capacity of lithium battery can reach different flight time, the use of high capacity of lithium battery can improve the flight time, but will increase load. So after many tests, the final choice is 4400mA lithium battery, the flight time can reach about 17 minutes, enough to meet the short distance and light weight food distribution.

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