ATLANTIS PRESS
Advances in Engineering Research (AER), volume 131
3rd Annual International Conference on Electronics, Electrical Engineering and Information Science (EEEIS 2017)

A Method for Improving the Attitude Calculation's Fault Tolerance Rate by Using Hardware + Software

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Keywords: Attitude calculation, result verification, hardware + software, fault tolerance, MPU6050.

Abstract: the UAV attitude calculation is an important technique in UAC's technology, many other teches are dependent on it, read the sensor's signal, and calculate after trans is the main method of UAV attitude solution by now, but this kind of method use the software method to calculate in general. If error, no way to correct. This paper uses hardware + software way for attitudes calculate. And checking the results, improve the tolerance of attitude's solution. Enhance the correct attitude calculation results.

1. Attitude Operator Sensor Data Stream Analysis [1]

The UAV attitude calculation [2] is one of the most important technology in UAVs'. It's depend on the hardware and software. But its' dependence on hardware and software can be adjusted. It can be completely through the hardware solution, and the software does not use any method of calculation, Or can also use the software combined with sensor data for indirect attitude calculation, we can see that in the hardware components, at least one group of sensors needed to provide software solution data, this is the hardware's Min-requirement.

The UAV system in this paper has a high degree of dependence on hardware. It takes the MPU6050 as the core, calculate the attitude directly, and the attitude's data trans to the STM32 microcontroller. In the software aspect, the sensor data is read from the HMC5883L and the MPU6050, and after the A/D conversion circuit, the data is processed in the STM32 microcontroller without the MPU6050 processor of the DMP. The software method is used here as calibration and verification of data results, improve the fault tolerance, and replacing the calculation work when the hardware is in error.

This paper focuses on the system structure and the underlying design method, and describes the design ideas and implementation methods of the attitude calculation function.

The medal of data flow is a data's processing model, which describes the process of data processing.

The data flow to the sensor and processor in the attitude calculation. Show in fig. 1.

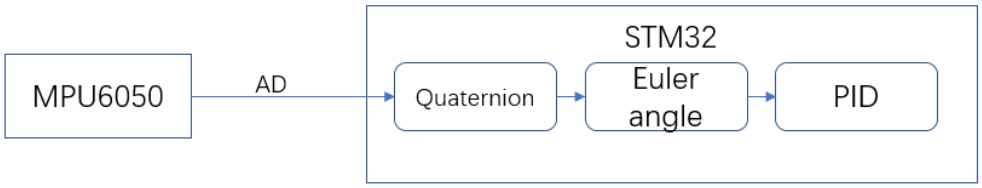

Fig. 1 Data flow

This is software's procession, the PY's output is not present in figure. whether the PY, or accelerometer, the sensors' data are read from the IIC bus, and after A/D conversion, trans into the processor. Get the data of attitude and to control it. (if only need the angle, we can omit the trans(PID))

The hardware solution is a little different, which is get quaternion in DMP without the A/D.

2. Hardware Interface Design of Attitude Module [3]

MPU-6000(6050) [4] is the first integrated 6 axis motion processing modules in the world. Compared with the multi-component scheme, it eliminates the difference between the time axis of the combined gyroscope and the accelerator and reduces a large amount of encapsulation space.

It's DMP and the sensors are the mainly things in the design of attitude module.

The STM32 microprocessor has many signals that are common to chip pins. When using the corresponding functions, the associated registers need to be preset in the initialization program.

3. Device Driver Software Design

STM32 can drive MPU6050 directly.

The connection diagram of STM32 and MPU6050 and compass HMC5883L is roughly shown in fig. 2:

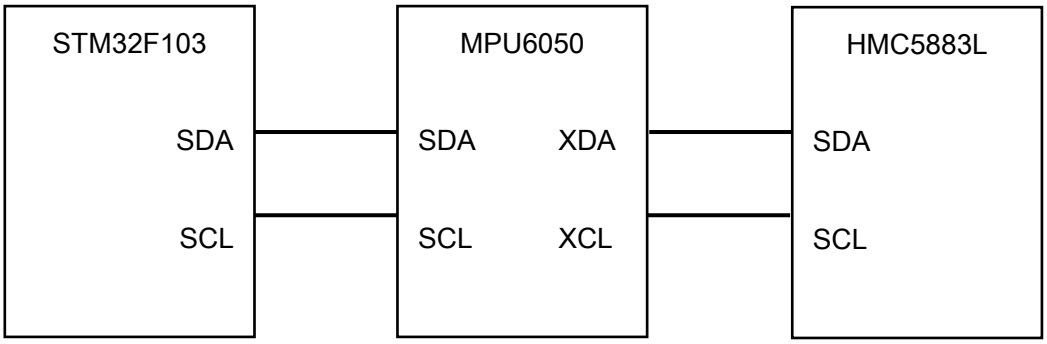

Fig. 2 The connection of MPU6050

First, according to the introduce, the configuration of the MPU6050 is primarily needed:

1. power on chip serial number, self-test.
2. setting the threshold and detection frequency of the acceleration gyroscope.
3. set the drive mode and address of the external link device.
4. set the interrupt mode, such as the need to open the free fall interrupt required settings, data ready to interrupt the required settings, etc.
5. set the power management mode to prevent sleep.
6. loop reads the data.

This is the specific description of flow chart:

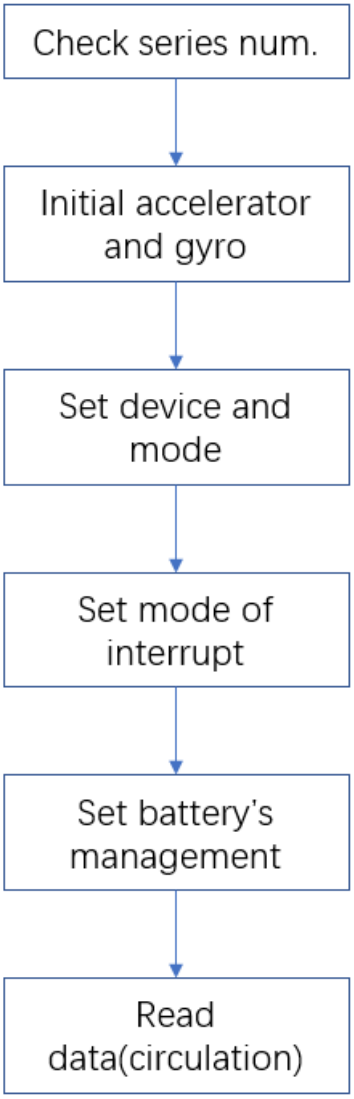

Fig. 3 Prepare for read data

4. Software Design of Attitude Calculation

Attitude calculation's software [5] module needs to complete the conversion from AD value to quaternion, conversion of quaternion to Euler angle and PID control.

The programming flow chart is shown in fig. 4

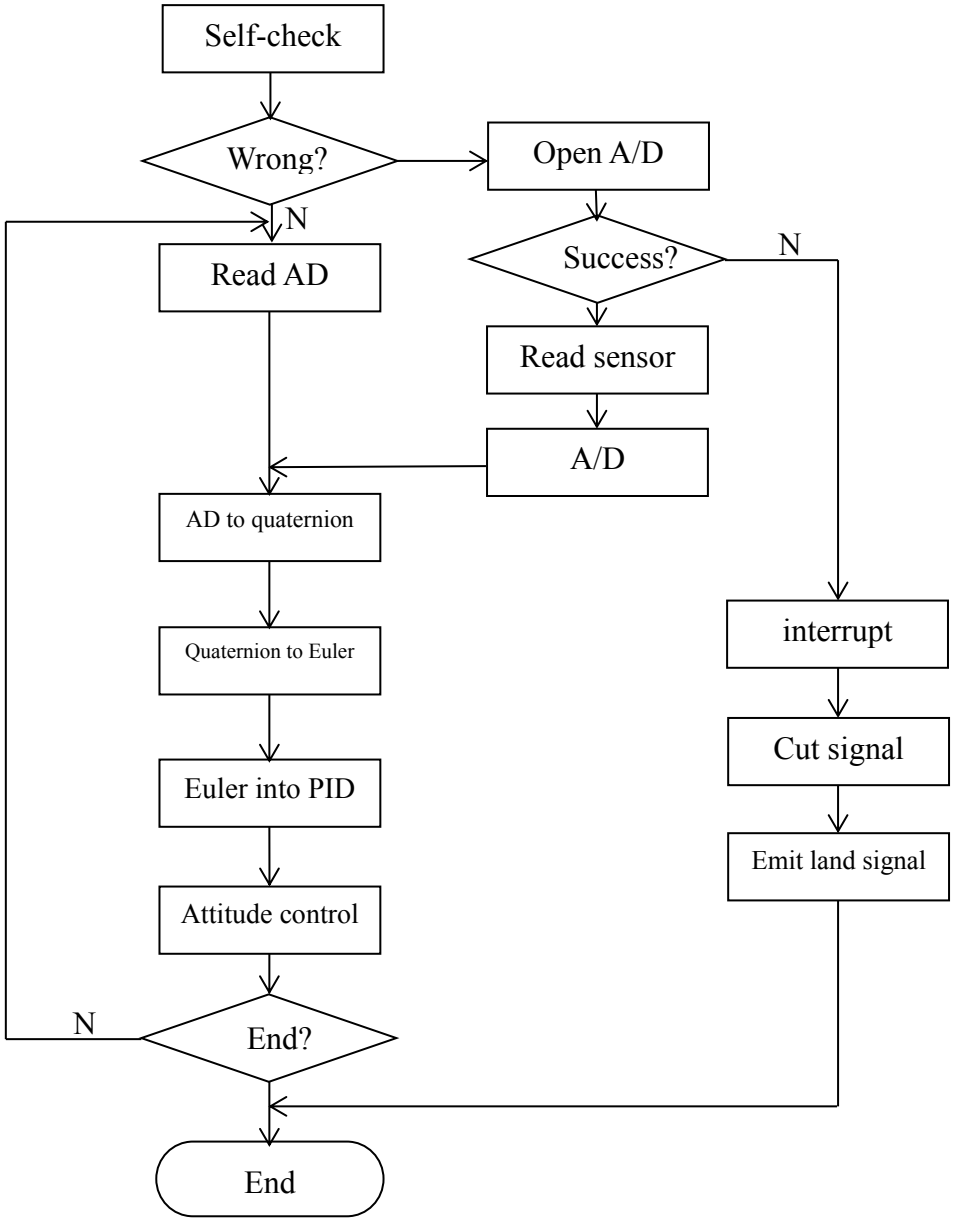

Fig. 4 The chart of algorithm flow

5. Data of Experience

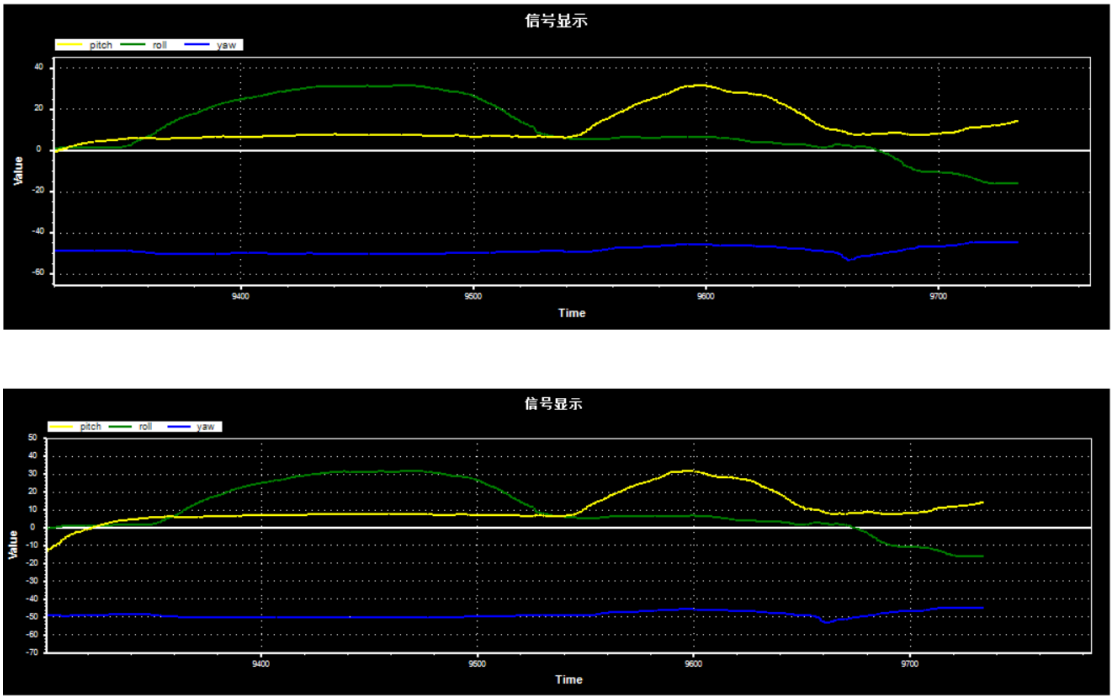

Fig. 5 The data of attitude angle

Fig. 5 shows the measurement data curve of the attitude angle, the yellow line represents the pitch angle, roll angle of the green line, blue line represents the yaw angle.

It is found that the deviation of the data is not very small for many measurements in the same situation.

6. Summary

In the UAV attitude solution, under normal circumstances (not using error correcting method), the data source only, single, check no results when the source of trust attitude data only once, if the calculation error, there is no corresponding method to check, and deal with the error.

Data processing and validation using hardware + software mode, due to the dual source of trust, which is a practical attitude data, a calibration of attitude data, regardless of where the data sources appear problem, it will emit throw exception, then use the software for exception handling. In this way, it not only reduces the error rate, but also enables to process the error in time.

Acknowledgement

The corresponding author is Zhao Hongwei. The authors are grateful to the anonymous reviewers for their insightful comments which have certainly improved this paper.

This work was supported in part by the Jilin province development and Reform Commission Special industrial innovation 2016C035 and State Key Laboratory of applied optics.

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