ISSN: 2472-3703 DOI: 10.6911/WSRJ.202211_8(11).0029

Intelligent System of The Quadcopter Depend on Visual Analysis and STM32 Microcontroller

Jiaqi Cui*

School of Electrical and Control Engineering of North China University of Technology, Beijing, China

*Corresponding author: 2324360198@qq.com

Abstract

The speed and power of quadcopter can be controlled by controlling the motor speed and pulse number. There are four important parts of designing the quadcopter: The mechanical structure、MCU hardware circuit、the control of the four motors、attitude algorithm. Besides, the visual analysis can be realized by deep learning. In recent years, the intelligent navigation technology of aircraft, multi-aircraft formation control and other new technologies are based on the control of quadcopter. And after combining the visual analysis, quadcopter can be used in a variety of scenarios, community danger inspection, home intelligent elderly monitoring, workshop inspection and so on. This article will expound how to use the quadcopter which combine the visual analysis in the elderly people assistance part.

Keywords

STM32; Quadcopter; Attitude algorithm; deep learning.

1. SOCIAL BACKGROUND RESEARCH

With China's aging population getting more and more serious, "Respect the elderly in your family as well as you respect the elderly of other families", from Mencius. Until 2030, the proportion of old people population will over 20%, and the old ones who are over 80 years old will increase more pronounced.

Accompanied by an increase in the number of old man, social pressure is growing for pension, responsibility is more and more problems, including some elderly people living in remote mountain areas whose children living far from them, in some community the most population are composed of the elderly , if encounter a situation such as the elders fell down, without found in time and there will be a great danger.

In the current domestic market, the application of pension robots in the elderly market is still relatively small, and the most widely used is in domestic service, all of which are cleaning robots. In the elderly risk monitoring market, it is still in the pilot stage. Therefore, we developed a quadcopter with STM32 microcontroller control with deep learning, which can patrol the home community, identify whether elders falls or other dangerous situations to give alarm in time.

2. DESIGN SCHEME OF QUADCOPTER WITH VISUAL ANALYSIS

A four-rotor aircraft is harder to control than a single axle.Adopt Nonlinear digital filtering, Mahony complementary filtering algorithm, Euler Angle description direction cosine matrix, cascade PID, quaternion solving, SPI bus communication, machine learning, deep learning these key technologies.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202211_8(11).0029

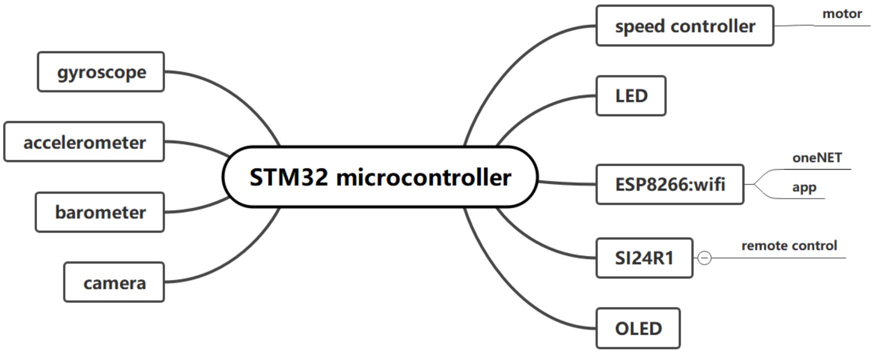

Figure 1. Design scheme

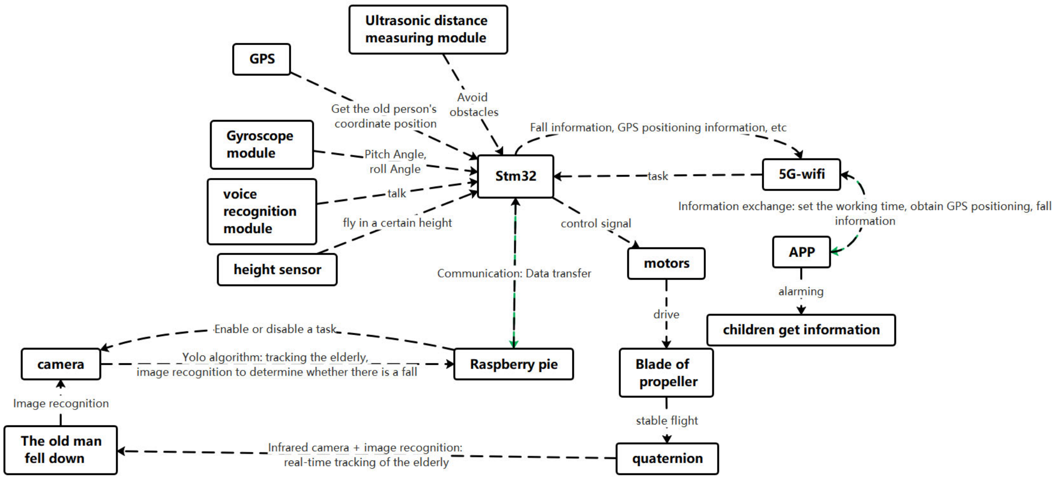

Figure 2. Thinking of accompanying the elderly

3. MECHANICAL STRUCTURE AND HARDWARE DESIGN OF QUADCOPTER

3.1. The Flight Control

STM32F411 is used as the main control chip, MPU9250(+3acceleration +3 gyroscope +3magnetometer) is used for attitude and height detection. Which compatible with BMP280, FBM320, SPL06, OpencV and yolov5 algorithm. Communication mode SI24R1 compatible with NRF2401and ESP8266-WiFi. Human-computer interaction is through RGB single-line full-color light. Parameter adjustment mode: wired and WiFi wireless parameter adjustment mode. THE motor with 50000 RPM under 3.7V, with 720 hollow cup, and 55mm positive and negative propeller blade. The control mode includes the controller remote control and mobile APP.

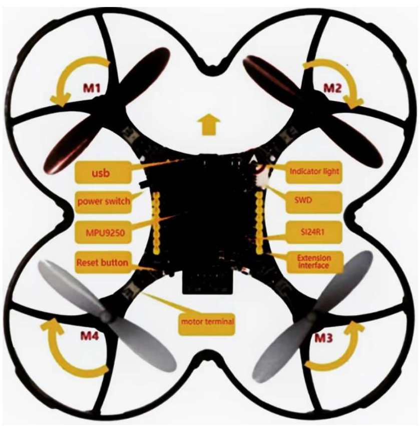

Figure 3. Body of quaternion

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202211_8(11).0029

Table 1. Meanings of the LED signal

lamp signal	Meaning of lamp signal	task
1234Purple light normally on	NRF Initialization failure	Power on and wait
1234 Green light normally	MPU9250Initialization failure	Power on and wait
1234 Blue lights flashing	FBM320Initialization failure	Power on and wait
1234 Blue lights flashing	The triaxial gyroscope has been calibrated	Pre-flight preparation
1234 Green lights flashing	The triaxial acceleration has been calibrated	Pre-flight preparation
1234 Yellow lights flashing	The triaxial magnetometer is calibrated	Pre-flight preparation
1234 purple lights flashing	The barometer is calibrated	Can enter the fixed height mode
1234 Colorful water lamp	The system initializes successfully and waits to be unlocked	Remote control to unlock
12 Green light normally on 34 read light normally on	Quaternion is unlocked The green light indicates the direction of the nose	Ready to take off as soon as possible
1234 Purple light normally	The plane was disconnected from the remote control	Wait for quad landing
1234 Purple light normally	The four-axis battery is too low and needs to be charged urgently	Drop quad to replace battery

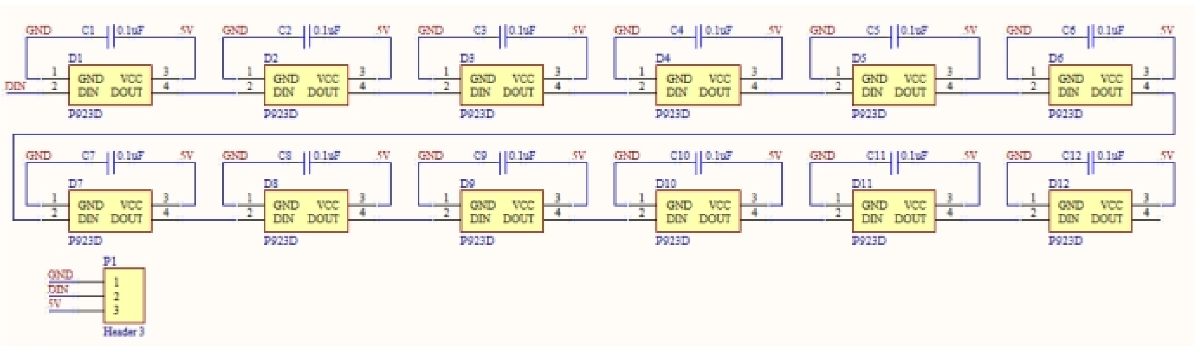

Figure 4. Schematic diagram of LED

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202211_8(11).0029

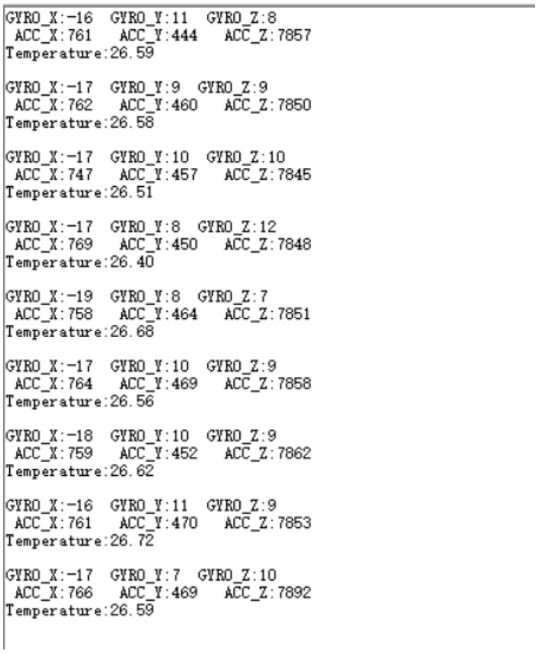

Figure 5. Gyroscope raw data

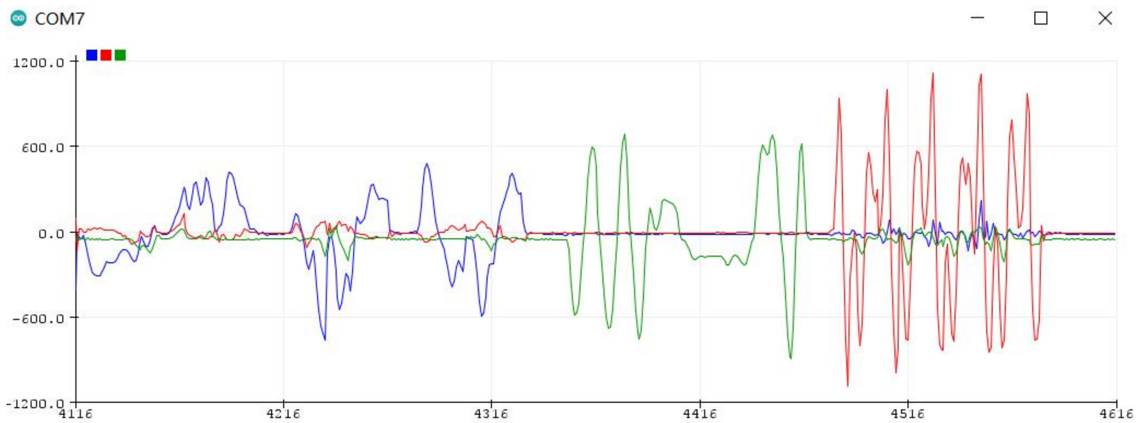

Figure 6. Gyroscope data reception

3.2. The Remote Control

With STM32F103C8T6 as the main control chip, the communication mode adopts NRF2401, PA, whip antenna, and the human-computer interaction mode is: 0.96 inch yellow and blue OLED, LED light; Battery parameters: 380mA, 3.7V, 20C. The communication distance is 60 meters, and E-Link32 simulator is used for simulation.

4. QUADCOPTER SOFTWARE DESIGN

4.1. Theory of Flight

The speed of the four rotors is solved by the single-chip microcomputer attitude, and then the control amount is given to the four motors to achieve different attitudes. The attitude is changed with six degrees of freedom, allowing the vehicle to translate or roll along a three-dimensional coordinate axis. The body structure of the quadcopter can be divided into "X" type and "+" type. Different structure types correspond to different control methods. This study adopts the "X" structure.

World Scientific Research Journal Volume 8 Issue 11, 2022
ISSN: 2472-3703 DOI: 10.6911/WSRJ.202211_8(11).0029

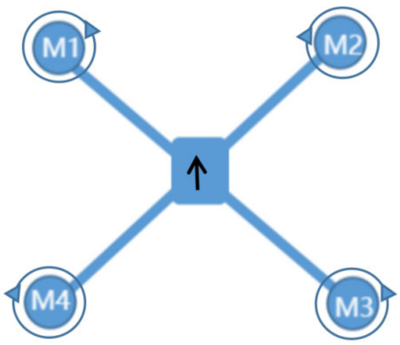

Figure 7. Schematic diagram of "X" type structure

4.2. Feedback Control System

With feedback control system, the attitude and motion of quadcopter can be controlled through change the pitch Angle, roll Angle and heading Angle. Means need three different PID control algorithms to figure it out.

The Mahony filter algorithm is used to calculate the received data of the quadcopter aircraft, and get an error with real attitude. After PID algorithm, the control quantity is converted into PWM signal output by timer under STM32 microcontroller, the speed of four motors is adjusted, the attitude of the four-axis aircraft is adjusted, and then the new gyroscope data is read to the input as feedback, and the new error value is obtained.

Since the single PID controls the flight attitude, the remote control is not perfect for the Angle change. The speed of the propeller is not proportional lift, which means that the single PID will cause the aircraft to be unbalanced or follow the delay phenomenon. Then, Angle PID control and diagonal velocity PID control work together can solve the problem. Compared with the closed-loop PID control, the double-cascade PID improves the anti-interference ability of the system.

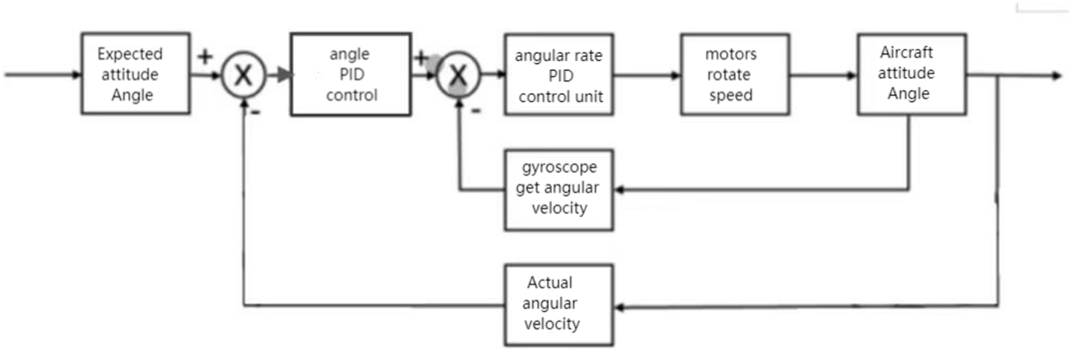

Figure 8. Side to side motion

4.3. Four Way Motor Power Distribution

The calculation result of attitude cascade PID controller output to the motors. By adjusting the duty cycle of PWM, the continuous change of the voltage on the IO port can be adjusted. Therefore, the power of the peripheral can be controlled for continuous change, and the speed of the DC motor can be controlled.

The calculated results of the attitude cascade PID controller need to be output to the "actuator" in the end, so the actuator in the four-axis control system is the motor, and then correctly allocate the control output of the three attitude angles to the four motors.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202211_8(11).0029

5. ATTITUDE CALCULATION OF QUADCOPTER

5.1. Explanation of Principles and Terms

The attitude angle can describe angular position relationship between a rigid body and a rigid body. The mathematical representation includes Euler angles, quaternions, matrices and axial angles. The reference frame corresponds to the navigation frame, which is fixed. The purpose of attitude calculation is to obtain the attitude angle of the aircraft in the Earth system. Based on IMU data such as gyroscopes and accelerometers, the calculation can be performed using Mahoney's complementary filtering algorithm.

5.2. Mahony Attitude Solution Algorithm

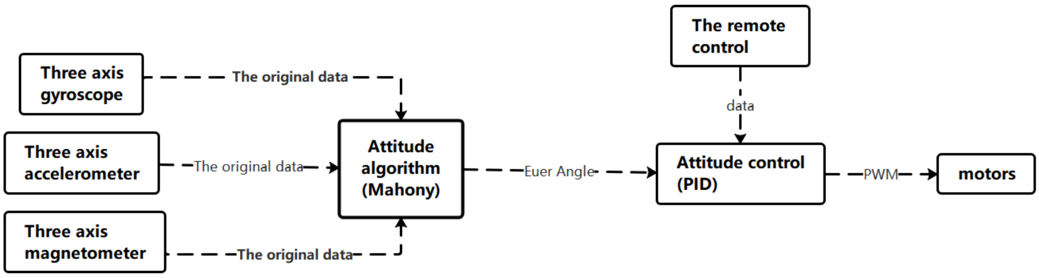

Figure 9. Algorithm block diagram

When control is needed, the quaternion is converted to Euler Angle, but the conversion of quaternion to Euler Angle needs to be achieved with the help of the direction cosine array. The attitude is represented by quaternion, and the AD value output by MPU9250 is obtained by the attitude solving algorithm. Then the quaternion is converted to Euler Angle, which is used in the attitude control algorithm. $[q_0\ q_1\ q_2\ q_3]^T_{t+\Delta t}$ Is the current quaternion, $[q_0\ q_1\ q_2\ q_3]^T_t$ is the quaternion of the last period, WX,WY,WZ is measured by gyroscope, if the gyroscope data is ideal, we can accurately find the quaternion. If there is noise, errors will be introduced and the accelerometer and magnetometer will be required to calibrate the gyroscope data.

5.3. Sensor Data Fusion

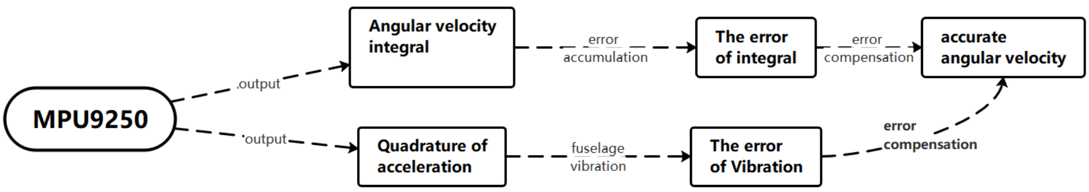

Figure 10. Algorithm block diagram

The gyroscope measures angular velocity, which is an indirect device for measuring angular velocity. The Angle can be obtained by integrating angular velocity with time. Due to the influence of noise and other errors, it accumulates continuously under the action of integration, and there will be low-frequency interference and drift. The accelerometer measures the direction of the current acceleration.

Theoretically, the **VB** calculated by quaternion and the actual gravity acceleration measured by the accelerometer are completely coincident, but due to the error in the angular velocity calculated by the quaternion, the two are no longer coincident, so the cross product of vectors is used to measure the magnitude of this error.

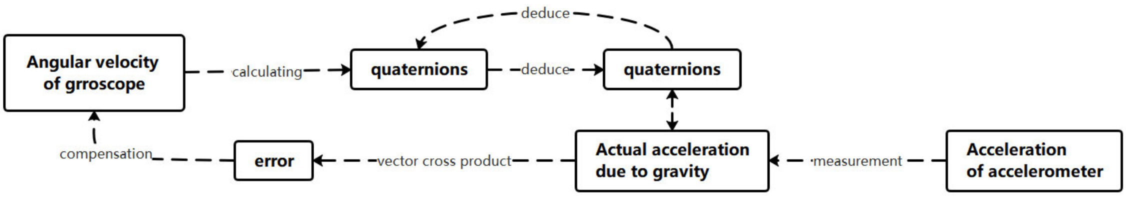

Figure 11. Accelerometer corrects gyroscope data

6. MACHINE VISION ANALYSIS

6.1. yolov5 Algorithm

It is an object detection algorithm, through which a large number of pictures of falls can be trained and a mathematical model can be obtained. Then, when judging whether someone falls, you only need to take photos at that moment and compare them in the mathematical model to see the matching rate. If the matching rate is high, it means that someone has fallen.

6.2. Model Training Effect

The deep learning algorithm of YOLOV5 was used to train 1000 fall。 The accuracy is shown below.The detection effect is very good, and the success rate of falls is 73%, and the success rate of no falls is 92%, which is enough to be used in life.

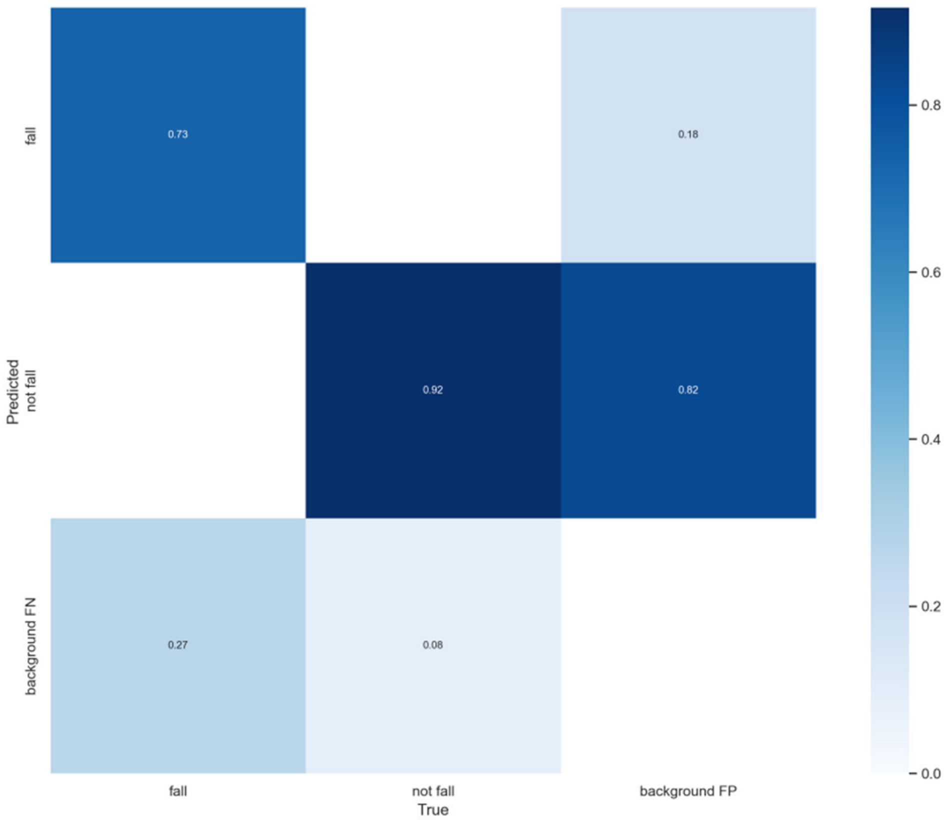

Figure 12. Accuracy of fall model

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202211_8(11).0029

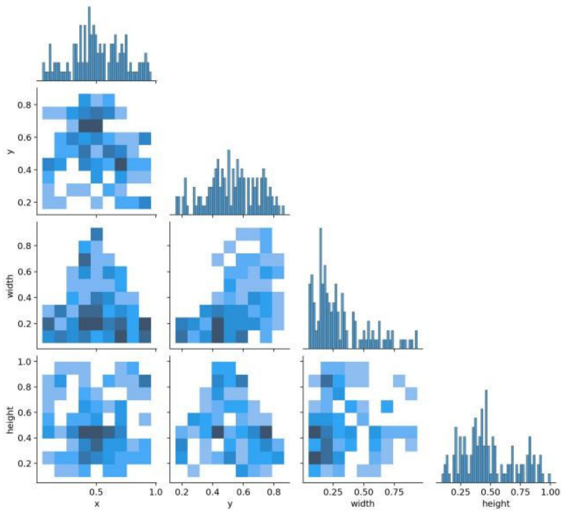

Figure 13. Accuracy of fall model

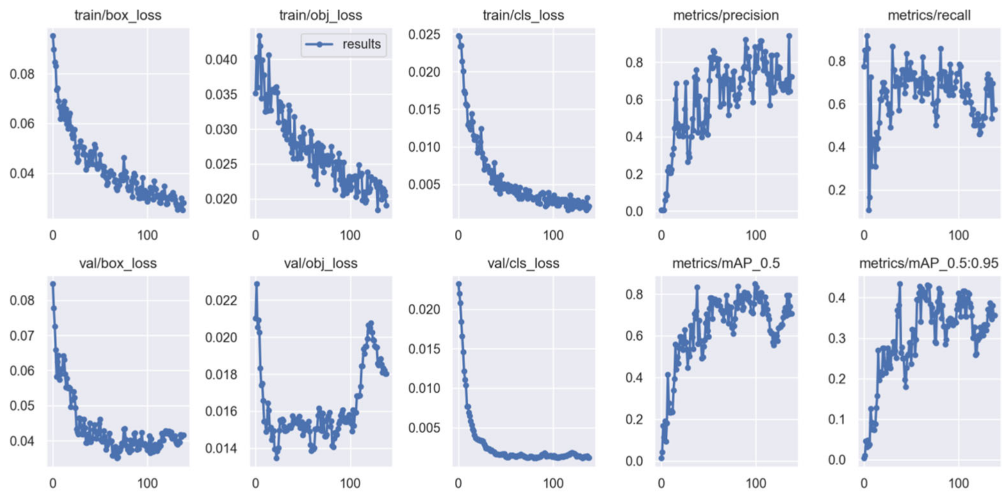

Figure 14. Accuracy of fall model

Figure 15. Test results

7. HUMAN-COMPUTER INTERACTION EFFECT

7.1. OLED Display with Control By Remote Control

Place the quadcopter on the ground, and then turn the power switch to "ON" to power the quadcopter. The full colored light on the quadcopter flashes with the colorful circulation water of "red, orange, yellow, green, blue, purple". Pull the throttle rocker of the remote control to the lowest level at the rear of the quadcopter head and press the K1 button of the remote control to unlock the quadcopter. After unlocking the quadcopter, the LED light D1 on the remote control is steady on.

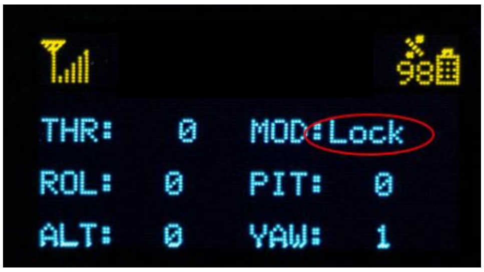

Figure 16. Quadcopter locked

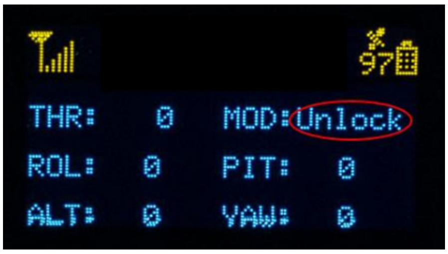

Figure 17. Quadcopter unlocked

7.2. Control by Mobile APP

Through YOLOV5 to identify the elderly, real-time tracking, you can input multiple elderly information.When the old man falls down, the image captured by the camera is uploaded to Raspberry PI, and the fall information is obtained by YOLOV5 algorithm, which is returned to the mobile APP together with the GPS location information and time.Alarm on the mobile APP, and children can see the real-time screen when they open the operation interface.

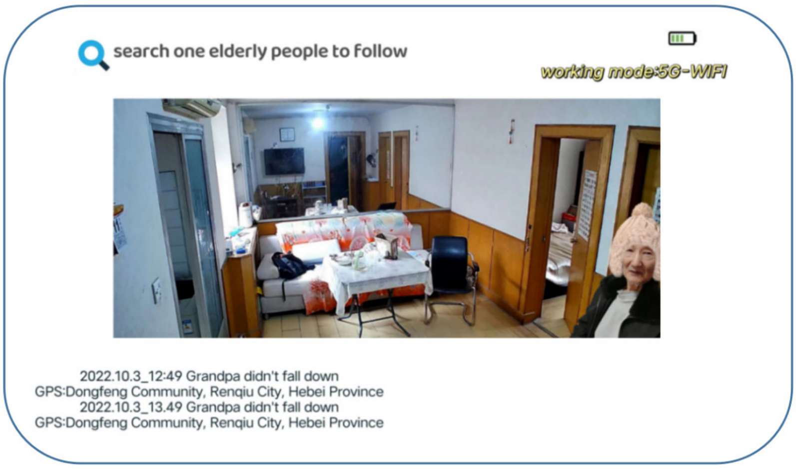

Figure 18. Remote human-computer interaction interface

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202211_8(11).0029

ACKNOWLEDGMENTS

This paper was supported by NCUT.

REFERENCES

[1] ChunLiu,MinHe,Dai Lei. Attitude Solution Method Based on Mahony and improved Kalman fusion [J/OL]. Journal of Electronic Measurement and Instrumentation

[2] Guo Qian-qian, CUI Li-Zhen, Yang Yong, GAO Li-Li, HE Jia-xing. Research on heading estimation algorithm based on denoising autoencoder in underground coal mine [J]. Journal of sensing technology,2021,34(06):797-803.

[3] Ran Mengyuan, Liu Li, Li Yande, Wang Shanshan. Deaf-mute sign language recognition based on inertial sensor fusion control algorithm [J]. Computer science,2021,48(02):231-237.

[4] Chen Guoding, Zhou Penghao, Hu Zhao, Tang Yuesheng, Qin Zhifei. Research on four-axis hardware attitude solution based on MPU6050 [J]. Mechanical & electrical engineering,2018,35(01):95-100.

[5] [IEEE 2017 IEEE 10th Conference on Service-Oriented Computing and Applications (SOCA) - Kanazawa (2017.11.22-2017.11.25)] 2017 IEEE 10th Conference on Service-Oriented Computing and Applications (SOCA) - Analysis of Health and Physiological Index Based on Sleep and Walking Steps by Wearable Devices for the Elderly.