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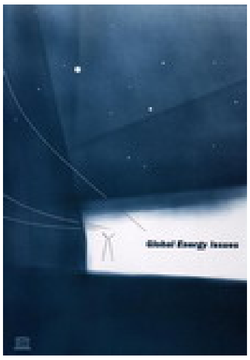

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Field information monitoring system for micro-small quadrotor UAV based upon wireless sensor network

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Abstract: At present, information wireless sensor is a research hotspot. The wireless sensor network for drones provides a management method that can monitor farmland data. Farmland information collection is the research base of modern agriculture and digital agriculture. Its main content is to realise the dynamic, accurate and real-time monitoring of farmland geographical environment, soil structure, climate parameters, crop growth status and other information. Quadrotor drones are widely used in military, civilian, scientific research and education fields, and have the advantages of light weight, simple structure, low cost, and strong mobility. The influence of natural wind on quadrotor drones cannot be ignored, and it is one of the main reasons restricting the use of quadrotor drones. This paper takes quadrotor UAV as the research object, and studies a quadrotor UAV control system suitable for farmland data collection.

Keywords: wireless sensor network; miniature quadrotor unmanned aerial vehicle; farmland information monitoring system; anti-wind disturbance.

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1 Introduction

With the advancement of flight control theory and new materials, UAVs have been put on the market more than 90 years ago. But it's not the tiny quadrotor drones currently being studied, but the first generation of drones. In the 1980s, with the development of embedded sensor technology and small electromechanical systems, UAV technology has gradually matured and has begun to be suitable for applications such as munitions and civilian products. Among them, quadrotor UAVs have received widespread attention in the military, commercial and academic circles in recent years. Owing the small size, convenient use and low cost of the quad-rotor UAV, it has a very wide range of applications and engineering value. UAVs have many uses, and agriculture is one of the main uses of UAVs. It is mainly used for land pesticide spraying, liquid fertiliser, disaster warning and outdoor farmland information data collection, etc. Agricultural aviation engineering is also becoming a hot spot in precision agriculture research. In summary, quadrotor UAVs are gradually playing an irreplaceable role in many fields. Although it has its own unique advantages, e.g., light weight, simple structure, low cost and high mobility, due to its own special structure and control characteristics, there are still many technical problems that need to be solved.

The impact of natural wind on quad-rotor UAVs cannot be ignored. Improving the wind resistance of quad-rotor propellers is an important research and has very important practical value, whether it is for military or civilian purposes. The use of quadrotor drones can quickly and accurately record plant growth data, which enables production managers to make fast and accurate decisions. It is an important part of the implementation of precision agriculture, and is of great significance to the promotion of agricultural modernisation.

This article focuses on the height control requirements of quadrotor drones that collect farmland information. It also provides a method for calculating air pressure, which can effectively control the lift and height of the drone. This paper analyses the arrangement of wireless sensor network nodes in agricultural areas, and the relationship between the height of the node, the effective transmission distance of the battery voltage and the received signal strength index. Finally, this paper obtains the effective transmission range of a single node when the node is placed.

2 Related work

In recent years, with the rapid development of UAV remote sensing surveillance technology, developed countries such as the USA are applying the technology to land, military, forestry, transportation and other fields. For the development and research of agricultural drones, the United States also involves the collection of agricultural land information. Do et al. (2020) believed that determining the appropriate sensor location on the quad-rotor UAV is a very important issue for the chemical reconnaissance platform, because the wind speed and direction are different at each location. In this study, they studied a custom chemical reconnaissance system consisting of a quadrotor drone and a chip-sized chemical sensor to detect dimethyl methylphosphonate (DMMP; sarin mimic). And through indoor experiments to study the chemical detection characteristics related to the sensor location and the system's Particle Image Velocimetry (PIV) analysis, they found that the proposed chemical reconnaissance system is realistic for practical applications (Do et al., 2020). Merheb et al. (2017) focused on the design, implementation and experimental verification of the Tube-Based Model Predictive Control (TBMPC) law for stabilising the horizontal dynamics of the Unmanned Aerial Vehicle (UAV) quadrotor. These dynamics are modelled by discrete-time linear systems constrained by additive perturbations and polyhedrons. The model is derived from the recognition strategy in the experimental flight data, which is suitable for the subsequent design of the invariant set (Merheb et al., 2017). Labbadi and Cherkaoui (2021) believed that quadrotors have many potential applications, such as predictive maintenance of infrastructure in railway mining tunnels. In order to use quadrotor drones to navigate in these environments, there are many challenges, such as aerodynamic disturbances, parameter uncertainties and noise measurements. It proposes a Robust Adaptive Global Time-Varying Sliding Mode Controller (RAGTVSMC) to solve the quadrotor path with random disturbance and uncertainty. Finally, in order to prove the effectiveness of the proposed controller in this work, a simulation was carried out (Labbadi and Cherkaoui, 2021). In the article, Merheb et al. (2017) developed an emergency fault-tolerant controller (FTC) for a quad-rotor drone with a complete loss of actuators (rotor/motor). His experimental results using the AR Drone 2 platform showed that by implementing a conversion manoeuvre from a four-rotor to a three-rotor, the nominal PID controller achieved strong fault tolerance, and the infected drone successfully maintained its required path. Despite the complete loss of yaw control, activation delay, the asymmetric structure of the tri-rotor and the odd-numbered rotors that produce rotor torque imbalance, the performance degradation considered to be oscillating did not cause the UAV to crash (Merheb et al., 2017). In the article, Zareb et al. (2020) proposed an offline design strategy for a micro-UAV quad-rotor intelligent 3D autopilot. Initially, in order to obtain the controller parameters, a simulation test was performed on a commercial Quadrotor named AR.Drone V2. Finally, it tests these parameter values in experiments using the robot operating system. The results of these experiments confirmed the effectiveness of using genetic algorithms in the design of intelligent PID autopilots (Zareb et al., 2020). Kotov et al. (2017) considered the control of quadrotor trajectory movement in the article. The selection of the required differential Formula form in the previously proposed moving target tracking method is reasonable. The experimental results of the AR.Drone quadrotor confirmed the operability of the control system in the presence of measurement noise and external disturbances (Kotov et al., 2017). Das et al. (2018) proposed an improved state estimation technology-the fusion of monocular Simultaneous Positioning and Mapping (SLAM) and Inertial Navigation System (INS). It is used to land a commercial low-cost quadrotor (Parrot AR Drone 2.0) in an indoor environment along a trajectory generated by a bionic guidance method. The depth camera (Microsoft Kinect) helped the quadcopter to make a very accurate landing at the end of the trajectory. It designed a controller based on dynamic inversion as the outer loop controller of the quadrotor (Das et al., 2018).

3 Micro-four-rotor UAV

At present, the research on the four-rotor UAV power system is basically limited to a single component, such as propeller specifications, motor KV-value, battery reduction characteristics, etc. It is difficult to comprehensively consider all factors, such as pulling force, lift force and propeller rotation force and so on. This paper will comprehensively study the rotor power system parameters on the basis of the existing four-rotor flight research combined with other factors (Michel et al., 2019). This article will first design and build a set of power system test equipment, design the software and hardware of the test equipment and then use sensors and upper computer to integrate and analyse the collected experimental data, and finally complete the experimental research.

3.1 UAV test platform

For quad-rotor UAVs, the quality of its power system determines the flight performance to a large extent. Among them, the power system and flight performance show a positive relationship. In order to study its simple and efficient power supply system, a test device was designed and developed. Figure 1 is a system block diagram of the designed rotor power system test device, and Figure 2 is a schematic diagram of the structure of the rotor power system test device.

3.2 Dynamic model system

The power system of a small four-rotor UAV is generally composed of a propeller, a DC brushless motor and an electronic speed controller. A certain PWM signal is given to the ESC through the host computer, and the ESC converts the PWM signal into a voltage signal through the internal circuit system and outputs it to the motor, driving the motor to drive the propeller to rotate (Martins et al., 2019). The modelling block diagram is shown in Figure 3.

Figure 1 System research block diagram of the rotor power system test device

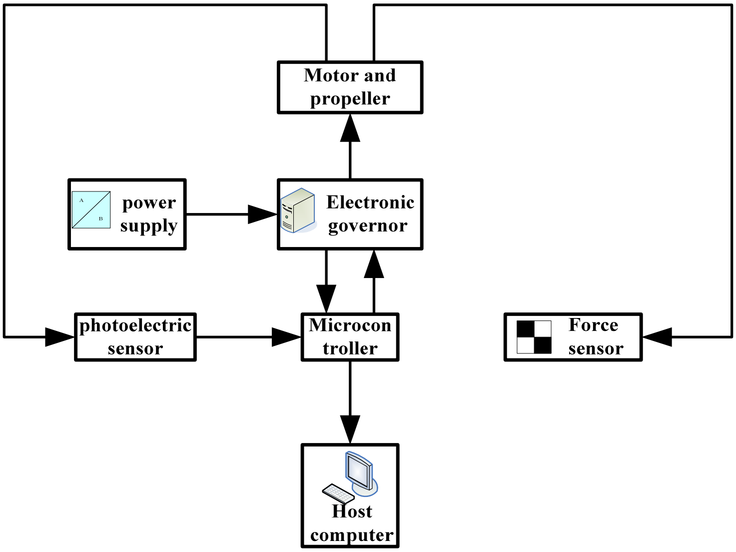


Figure 2 System research block diagram of the rotor power system test device

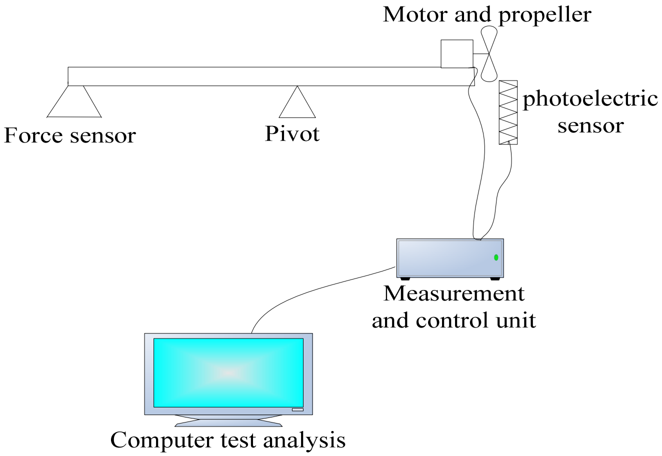
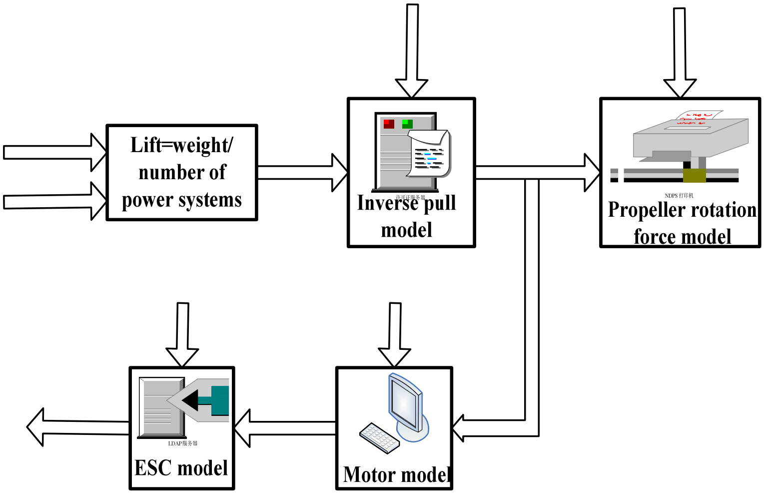


Figure 3 Block diagram of power system model



It can be seen from Figure 3 that, first of all, determine the thrust required by a power system according to the load size that the current power system should reach (Galvane et al., 2018). The buoyancy input is calculated by combining the height, temperature, propeller parameters and other information in the model anti-traction force. According to the established anti-traction force model, the current speed information can be obtained. Speed data is combined with altitude, temperature, propeller parameters and other inputs to build a propeller torque model (Ritchie et al., 2017; Li et al., 2016). It can obtain the measured value of the pulp torque. At the same time, the speed data is input into the motor model to establish, and the motor parameters are combined to obtain a voltage equivalent to the current motor output, and the ESC model is established according to the motor output information and the ESC parameter input. The role of the motor is used to determine the output of the duty cycle of the power system parameters.

The classic leaf element theory can be used to establish the propeller model to find the lift force on each segment. The details are as follows:

The pulling force is:

$$dL = \frac{1}{2} A_1 q W_0^2 cdr \tag{1}$$

q represents the air density.

The resistance is:

$$dD = \frac{1}{2} A_2 q W_0^2 cdr \tag{2}$$

The resultant force of tension and resistance is:

$$dR = \sqrt{dL^2 + dD^2} = \frac{dL}{\cos\gamma} \tag{3}$$

$$\gamma = \arctan\frac{dD}{dL} \tag{4}$$

The unit lift is:

$$dT = dR\cos\left(\phi_0 + \gamma\right) \tag{5}$$

The unit pulp torque is:

$$dH = dR\sin\left(\phi_0 + \gamma\right) \tag{6}$$

Because,

$$\begin{aligned} L &= \frac{1}{2} A_1 QSW_0^2 = \frac{1}{2} A_1 Q\left(\frac{C_q}{2}\lambda D_q a_q\right)\left(\pi\xi D_q\frac{N}{60}\right)^2 \\ &= \frac{1}{2} A_1 Q\left(\frac{C_q}{2}\lambda D_q\frac{D_q}{B}\right)\left(\pi\xi D_q\frac{N}{60}\right)^2 \end{aligned} \tag{7}$$

So the pulling force is:

$$T = \frac{L\cos\left(\gamma + \phi_0\right)}{\cos\left(\gamma - \vartheta\right)} \approx L \propto QN^2 D_q^4 \tag{8}$$

The lift is:

$$T = A_T Q\left(\frac{N}{60}\right)^2 D_q^4 \tag{9}$$

Simplified as:

$$T = A_1 N^2 \tag{10}$$

In the same way, the rotor torque can be obtained as:

$$H = A_h N^2 \tag{11}$$

The inverse model is:

$$N = 60\sqrt{\frac{T}{D_q A_t Q}} \tag{12}$$

The lift is:

$$T = \frac{G}{m_r} \tag{13}$$

The inverse model is:

$$N = 60\sqrt{\frac{G}{m_r D_q^4 A_t Q}} \tag{14}$$

According to the Formula of pulp torque:

$$H = A_H Q\left(\frac{N}{60}\right)^2 D_q^4 \tag{15}$$

Available slurry torque model:

$$H = A_H \frac{G}{m_r A_t} \tag{16}$$

The motor that drives the quadrotor generally uses a brushless DC motor, and its electromagnetic torque Formula can be obtained from its working principle, which is:

$$T_o = D_T I_m \tag{17}$$

Then its output moment is converted to:

$$M = D_T\left(I_m - I_{m0}\right) \tag{18}$$

The equivalent current can be expressed as:

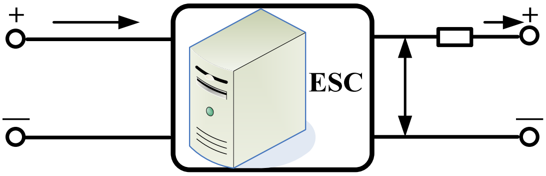
$$I_m = \frac{M}{D_T} + I_{m0} \tag{19}$$

Its equivalent voltage can be expressed as:

$$U_m = D_O N + R_m I_m \tag{20}$$

The full name of ESC is electronic speed governor. It converts the voltage signal from the battery through the corresponding duty cycle adjustment into a voltage of corresponding magnitude and inputs it to the brushless DC motor, driving the brushless DC motor to drive the propeller to rotate (Zhang and Li, 2018). The rough model is shown in Figure 4.

Figure 4 ESC model



but:

$$U_{oe} = U_m + I_m R_o \tag{21}$$

The duty cycle of the output voltage is:

$$\delta = \frac{U_{oe}}{U_o} \approx \frac{U_{oe}}{U_b} \tag{22}$$

Then the input current is:

$$I_o = \delta I_m \tag{23}$$

The input voltage is:

$$U_o = U_b - n_r I_o R_b \tag{24}$$

In summary, the propeller model is:

$$T = A_T Q \left(\frac{N}{60}\right)^2 D_q^4, H = A_H Q \left(\frac{N}{60}\right)^2 D_q^4 \tag{25}$$

The motor model is:

$$U_m = f_{U_m}\left(\theta_m, M, N\right), I_m = f_{I_m}\left(\theta_m, M, N\right) \tag{26}$$

The ESC model is:

$$\delta = f_\delta\left(\theta_o, U_m, I_m, U_b\right), I_o = f_{I_o}\left(\delta, I_m\right), U_o = f_{U_o}\left(\theta_b, I_o\right) \tag{27}$$

4 Farmland information monitoring system experiment

4.1 The purpose and method of drone height measurement

When the quad-rotor UAV studied in this paper collects agricultural land information at low altitude and close to the ground, the flying height of the quad-rotor should be maintained to complete the task of collecting agricultural land information. UAV flight height control keeps the UAV flying at a higher altitude (Kim et al., 2017). The control system needs a feedback control method, so the height measurement information is the basis of the flight height control system. At the same time, height measurement information is an important parameter to achieve ultra-low altitude autonomous take-off and landing or flight control in a complex terrain environment (Yue et al., 2018). The accuracy of height measurement information not only affects the height control state, but also plays an important role in achieving accurate spraying. The height of the flight drone directly affects the spray width and spray deposition, which is the key spray parameter of the drone (Tang et al., 2018; Wang et al., 2021; Lv, 2019).

According to the selection of the reference plane, the most commonly used altitude information includes four types: absolute altitude, relative altitude, true altitude and standard atmospheric pressure (Liu et al., 2018). Their meanings are:

- Absolute height refers to the vertical height of the drone relative to sea level;
- Relative height refers to the vertical height of the drone relative to the horizontal plane of loading (such as the ground plane of an airport taking off or landing);
- True height, also known as geometric height, refers to the distance between the plane and the ground directly;
- Standard atmospheric pressure refers to the vertical height at which the drone reaches the standard atmospheric pressure level.

In the agricultural system of drone height control, the method of measuring the relative height is adopted. Only by keeping the drone and the canopy at a relatively suitable height can the work effect and quality be guaranteed (Zhang and Wang, 2021).

Relative altitude measurement methods include radio altimeter, laser rangefinder, barometer, echo reflection measurement, etc. (Gao et al., 2018). Radio altimeters and laser rangefinders generally calculate UAV ground height information based on the time difference between the wave transmitted to the ship and the received ground reflected wave. Generally speaking, small drones are not equipped with these two methods, so this work will not be studied for the time being.

The four-rotor UAV height measurement method mainly adopts the indirect measurement method, that is, measuring other physical quantities that have a functional relationship with the height and obtaining the estimated value of the height through calculation (Lomba et al., 2017). The configuration of the micro-drone sensor is usually limited by the model size and price, so light and small sensors are selected, so this article adopts the barometric altimeter measurement method.

With the continuous development of MEMS technology, digital barometers are widely used in small drones and commercial barometers are also commonly used as barometers for altitude measurement. Among them, the amount of data collected by the digital barometer and the commercial barometer at the same time is different. The barometer altimeter receives the information about the altitude of the aircraft indirectly by measuring the ambient atmospheric pressure according to the law that the atmospheric pressure decreases with the increase in altitude (Yang et al., 2018). Air pressure measurement has the advantages of high accuracy and good dynamic performance, but the long-term stability is poor. In this article, digital barometers and commercial barometers are used to compare measurements to compare results and errors. Since altitude measurement is calculated based on air pressure, it is important to ensure the accuracy of the air pressure value. Therefore, most values of moving average power and first-order low-flux volume are derived from barometer measurement data. The maximum average filtering method can eliminate random errors in the data and effectively eliminate the inconsistency of the measured data. When continuously measuring n, remove the minimum and maximum values and calculate the average of the remaining n–2 values as the current measurement value. Then, perform the first-row lowpass filtering on the measured value after most of the average value of the filter is switched. The measured data is shown in Table 1.

Table 1 Actual and measured altitude values

Height value	*Digital barometer*		*Commercial barometer*	
	Measure air pressure	*Measuring height*	*Measure air pressure*	*Measuring height*
0	1003.75	0.1	1002.3	0
4	1003.35	3.7	1001.6	3.98
7.65	1002.9	7.19	1001.05	7
11.3	1002.6	10.6	1000.9	10
14.9	1002.2	14	1000.5	14.1
19	1001.9	17.3	999.98	17
22.5	1001.4	21.4	999.65	20.5

After the model algorithm, the error data comparison is obtained, as shown in Table 2:

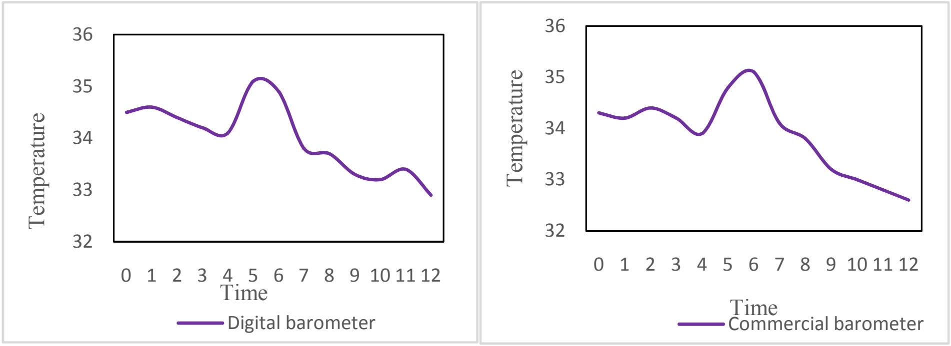
Table 2 Height measurement error

Height value	*Digital barometer*		*Commercial barometer*	
	Absolute error	*Relative error*	*Absolute error*	*Relative error*
0	0.1	0%	0	0%
4	0.3	7.5%	0.02	0.5%
7.65	0.46	6.01%	0.65	8.5%
11.3	0.7	6.19%	1.3	11.5%
14.9	0.9	6.04%	0.8	5.37%
19	1.7	8.95%	2	10.53%
22.5	1.1	4.89%	2	8.89%

It can be seen from Table 2 that after substituting the data in Table 1 into Table 2, the average absolute error of the digital barometer at the same measuring height is about 0.75 m, the maximum error is about 1.7 m and the minimum error is about 0, 1 m. The relative error value is about 5.65%, the maximum error is 8.95% and the minimum error is 0%. Commercial barometers also have errors. The average absolute error is about 0.97 m, the maximum error is about 2 m, the minimum error is about 0 m, the relative error is about 6.47%, the maximum error is 11.5% and the minimum error is 0%. Different air pressures at different altitudes will cause measurement errors, and changes in temperature and weather will also cause the errors to change accordingly. In a real-atmospheric environment, due to the influence of weather, the atmospheric temperature and pressure in the same place will change over time. The air pressure rises in the morning and falls at night; in winter, the air pressure is higher and the temperature is higher. In summer, the air pressure is low. Sometimes under the influence of cold waves, the air pressure will rise and become higher and the air pressure will drop after the cold weather passes. When the temperature and pressure change, the calculated altitude value also changes.

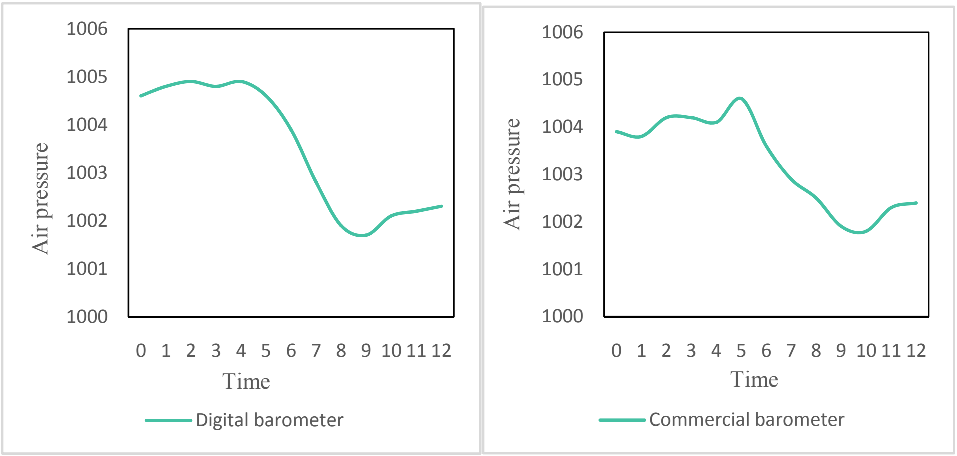
In order to check the temperature and pressure changes at different times in the same place, a digital barometer and a commercial barometer were measured at the same time and the time period was selected from 7 am to 7 pm for a total of 12 hours. The measurement method is to collect data every hour, and the test results can be extracted within 300 seconds at a certain time. The ratio of test results is shown in Figures 5, 6 and 7.

Figure 5 Comparison of temperature test between digital barometer and commercial barometer



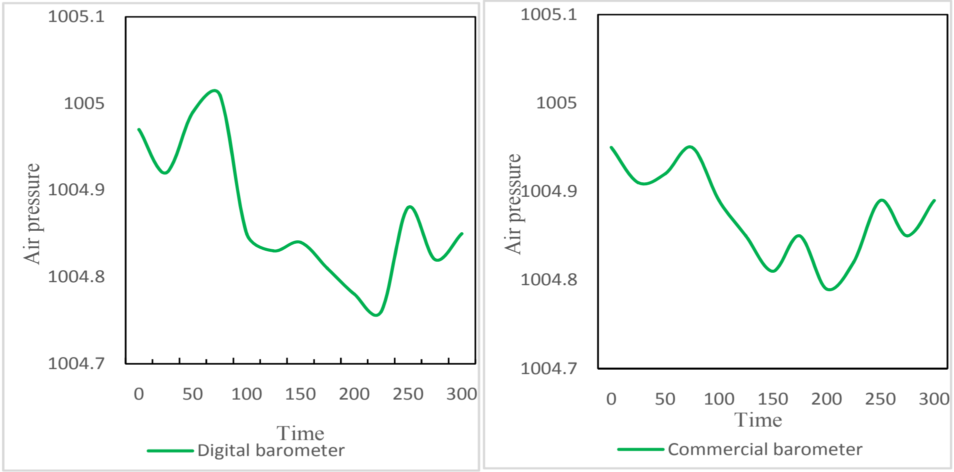
A B

Figure 6 Comparison of barometric pressure between digital barometer and commercial barometer



A B

Figure 7 Comparison between digital barometer and commercial barometer 300 s



A B

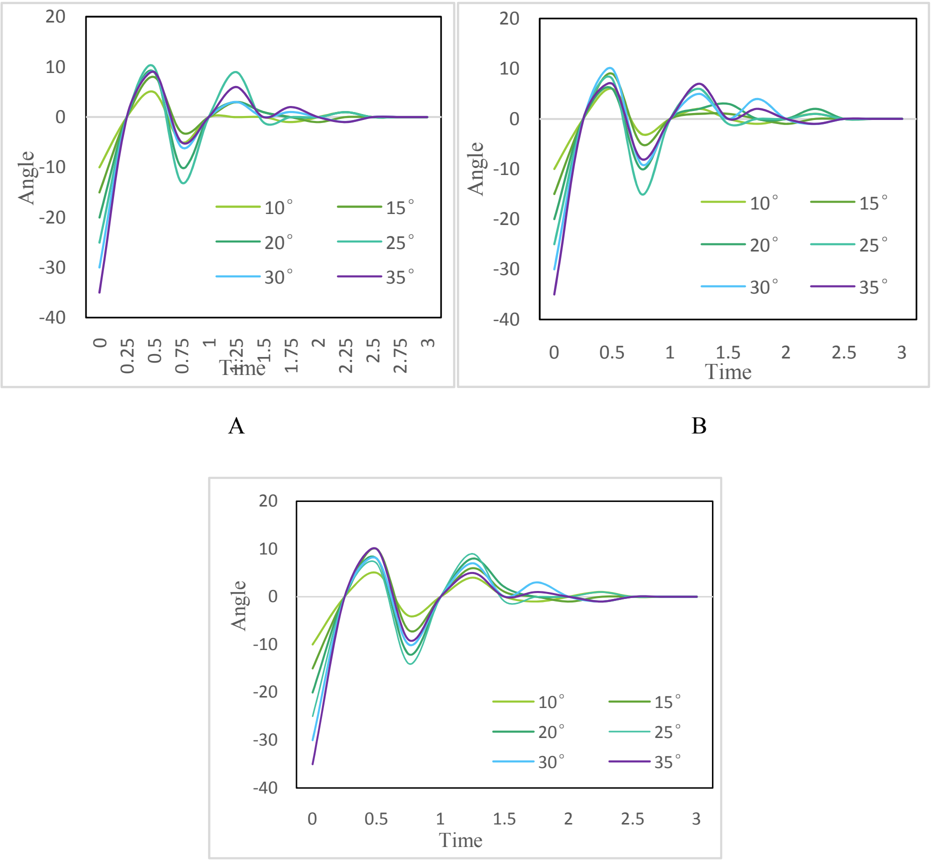
Comparing Figures 5, 6 and 7, it can be seen that the digital barometer is slightly better than the commercial barometer, the deviation of the collected data is small and after internal correction and temperature compensation, the height measurement information is reliable and efficient and can meet higher control requirements.

4.2 *UAV anti-jamming experiment*

The impact of natural wind and other disturbances on quad-rotor UAVs cannot be ignored, which is one of the main reasons for restricting the use of quad-rotor UAVs. Double closed-loop experts have realised the robust control of roll, pitch and yaw (Bhatti et al., 2017). In order to test the stability of the UAV's roll, pitch and yaw angles, input the specified angle and transmit the measured angle to the computer through the wireless data transmission system. Adjust the height of the cushion block to a fixed position, so that the platform support frame and the cushion block fit together, and the side inclination angles are 10°, 15°, 20°, 25°, 30°, 35°. Move the remote-control throttle to the middle position, apply external force to the experimental platform support frame, touch the cushion block, simulate interruption of the disturbed UAV and observe the recovery of the UAV after being disturbed. Figure 8 shows the change of the attitude angle of the UAV after the roll, pitch and yaw directions are disturbed.

As shown in Figure 8, the UAV quickly returns to a balanced state, the action of proportional and derivative control changes slightly, and the integral control makes the UAV position close to 0° when it is in balance. These tests prove that the double closed-loop expert control method can effectively reduce interference and ensure that the UAV can quickly recover and maintain a stable state under strong interference.

Figure 8 The roll, pitch and yaw directions are disturbed by different angles and the recovery state



A

B

C

In order to improve the reliability of the data, the recovery time of the UAV from different angles of interference is also counted and the rise time and adjustment time of the position curve are recorded. The specific data is shown in Table 3:

Table 3 Time statistics of the UAV's recovery to equilibrium state after being disturbed

	Roll direction		*Pitch direction*		*Yaw direction*	
Interference angle	*Rise time*	*Adjustment time*	*Rise time*	*Adjustment time*	*Rise time*	*Adjustment time*
10	220	2290	180	1120	210	2010
15	240	2125	190	1090	350	1950
20	180	2000	200	1546	340	3190
25	220	1490	240	2800	510	3020
30	230	1480	220	3600	520	3450
35	240	3333	280	3500	480	3920

It can be seen from Table 3 that in traditional control, when the interference increases, the UAV rise time and the UAV adjustment time both increase. However, under the influence of speed change, when the interference angle is large, the rise time does not increase continuously, but increases or decreases from time to time. In the roll and pitch directions, the UAV's ascent time does not exceed 0.6 s. In the case of large-angle interference, the maximum adjustment time for the UAV to establish balance does not exceed 2.8 s and the movement angle does not exceed 4 s. This means that the UAV can quickly return to a stable state after being interfered by a large angle.

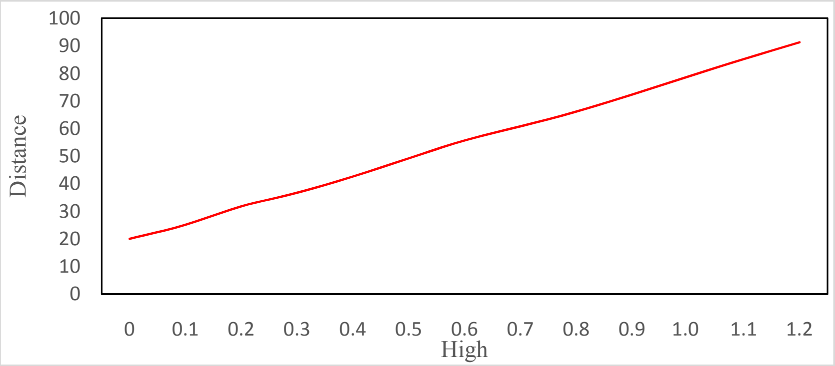
4.3 Experimental analysis of sensor node transmission for farmland information monitoring

The deployment of wireless sensor networks is the organic combination of front-end information collection and back-end information processing in the sensor network system. It plays an important role in the sensor network system and is a prerequisite for the normal operation of the entire network (Wietzke and Leuschner, 2020). The installation of the wireless sensor network is related to the selected installation method, the effective transmission distance between nodes and the area of the monitoring area. Therefore, by separately analysing the effective transmission distance between the monitoring node and the field area, the number of monitoring points and the scheduling plan, the specific number of nodes and the specific plan can be finally obtained.

Owing the influence of the surrounding environment of the crop and its growth, when the sensor node is placed on the farmland at different heights from the ground, the battery voltage is different. The value of this point (received signal strength index) will be affected to a certain extent, and the effective transmission distance node information will also be different (Li et al., 2017). Because the hardware structure of the node is determined, it is less affected by the gain of the antenna node and the communication speed. At the same time, the surrounding environment of the farmland is relatively empty, there is no signal interference such as base stations, high-voltage towers and the topography of the farmland is not large. In order for sensor networks to be deployed more economically and naturally, it is still necessary to analyse the relationship between *R*-value and efficiency. The *R*-value refers to receiving signal strength indication.

The experiment was conducted using a square wheat field. The size of the battery voltage and the height of the node placement will affect the effective communication between the nodes, as shown in Figure 9.

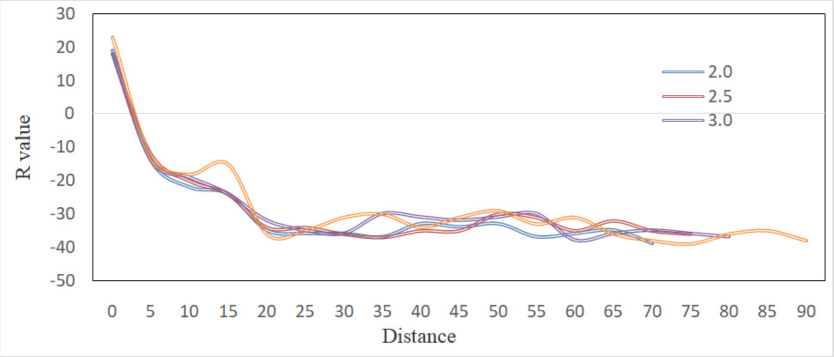
Figure 9 Curve chart of the relationship between height and effective transmission distance



It can be seen from Figure 9 that when the sensor node is on the ground, the effective node transmission distance is about 20 metres and the effective node transmission distance increases as the height of the node increases. The results show that when the sensor nodes are distributed in the wheat field, under the influence of crops, the arrangement of the nodes in the soil is not suitable for effective communication between nodes and different nodes should be deployed in different environments.

When deploying nodes on farmland, the nodes set to be too high are not suitable for real-life applications. Therefore, it is necessary to place the sensor node at a position about 1 metre above the ground based on the analysis result and the estimated wheat height, then select several batteries of the same type and transmission distance with different voltages and transmission values, it can measure the *R*-value between nodes, as shown in Figure 10.

Figure 10 Graph of the relationship between *R*-value and distance (see online version for colours)



The following conclusions can be drawn from Figure 10:

1 Under different voltage conditions, with the gradual increase of the transmission distance, the *R*-value will generally decrease accordingly, especially when the transmission distance is within the range of about 0 to 20 metres, the trend of the decrease of the *R*-value is very obvious;

2 When the transmission distance starts from 20 metres to the effective range of the transmission distance, the value of *R* does not change much, but only slightly increases or decreases;

3 Within the normal operating voltage range of the node, the higher the battery voltage, the greater the effective transmission distance.

It can be seen from the results that comprehensive consideration of node voltage, effective transmission distance and other factors, analysis of effective communication characteristics between nodes, can provide references for optimising point topology, saving point energy and improving data transmission quality. In order to determine the number of sensor nodes to be deployed in a given area, it is necessary to determine the effective transmission distance between the nodes. Through the analysis, when the node is located in the wheat field and is about 1 meter above the ground, the transmission distance is about 40 to 60 metres and the *R*-value between nodes is relatively stable.

The reasonable deployment of sensor nodes plays an important role in the efficient communication of sensor networks. If there is no reasonable deployment, the sensitivity of the receiver to receive information will be affected and the reliability of receiving information will not be high. The experiment selects 10 nodes for the experiment and collects data information, and regularly collects the display of node information, including node type, physical address, signal strength (connection quality), battery voltage, light intensity, temperature, humidity, soil moisture, value, etc. The design of an embedded information system for agricultural land monitoring network displays information curves of temperature, humidity, soil moisture and numerical values. It displays the topological diagram of the wireless sensor network status and realises the real-time information query function. When the wireless sensor network is operating normally, that is, when data collection, transmission and reception are normal, the information collected by the sensor can be retrieved. The specific data is shown in Table 4.

Table 4 Statistical results of sensor node information collection data

	Temperature	*Humidity*	*Light intensity*	*Moisture*	*PH-value*
1	23.2	45.1	93	37.2	6.2
2	23.2	45.0	89	35.5	6.1
3	23.2	44.9	91	35.1	6.2
4	23.1	45.2	75	36.1	6.2
5	23.3	45.3	90	34.9	6.0
6	23.2	45.0	86	35.2	6.1
7	23.4	44.8	81	41.5	6.2
8	23.1	44.3	96	45.4	6.0
9	23.2	44.5	73	42.1	6.0
10	23.8	45.3	84	45.7	6.1

It can be seen from the measurement results in Table 4 that the air temperature, humidity and light intensity of the 10 nodes are roughly the same, and the reason for the smaller error may be environmental influences or other external factors. The value of light intensity is measured by using a photoresistor to convert light energy into electrical energy. The soil moisture of the 10 nodes is different. The main reason is that some nodes are close to the irrigation canal at some points between the two valleys, and the moisture content is relatively high. Owing the inaccuracy of the pH sensor used in this experiment, the pH measurement results are basically the same.

Testing the wireless data transmission system outdoors. Data is sent twice per second at the end of the sending plane, and the data sent each time is 20 bytes. In addition, a total of 480 data sets were sent in the order marked 1,2,3,…, that is, a 4-minute data transmission test was carried out. Each distance is 20 to 200 metres, and a test is performed every 10 metres. Checking if there is any data loss during the test. Write down the latest data sent by the aircraft and count the amount of data received by the computer. When the data is lost, part of the data will be lost. The statistical rate of data loss in the wireless data node transmission system is shown in Table 5.

Table 5 Test data loss rate of wireless data node transmission system

Distance	*Loss rate*	*Distance*	*Loss rate*
20	0.0%	120	0.4%
30	0.0%	130	1.5%
40	1.6%	140	0.9%
50	3.7%	150	0.6%
60	0.5%	160	4.2%
70	2.9%	170	0.0%
80	5.5%	180	0.0%
90	2.9%	190	0.0%
100	2.2%	200	3.8%
110	0.5%		

It can be seen from Table 5 that the data loss rate of wireless data node transmission has little relationship with distance, and there is great randomness. Therefore, certain inspection methods must be adopted during data transmission to ensure the accuracy and reliability of the obtained data.

5 Discussion

This article summarises the practical value, research significance and development status of quadrotor UAVs. By combining the four-rotor UAV under the influence of natural wind in actual operation, this paper completes the wind resistance analysis of the design of the four-rotor UAV engine system that can be improved. The quadrotor UAV has better adaptability to irregular terrain; it does not limit surveying terrain, and can be used for agricultural land information and land resource monitoring (Wietzke and Leuschner, 2021). The use of multi-rotor drones can collect crop growth information in a timely and accurate manner, enabling production managers to make wise decisions. This is also an important part of the implementation of precision agriculture, which is of great significance for improving the level of agricultural modernisation. Agricultural aviation technology is a hot spot in precision agriculture research. This article covers the research topics of UAV quadrotors. The stability design and height control system of UAV quadrotor aircraft is suitable for farmland information collection, which has theoretical significance and practical value for UAV flight control technology. At the same time, the wireless transmission system of data nodes at a distance of 20 to 200 metres was tested. According to experiments, the speed at which the system loses data within 200 metres has no direct relationship with the distance and the amount of accidental data loss. To ensure the accuracy and reliability of wireless data transmission, the data transmission design avoids data loss caused by data reception errors.

6 Conclusions

As a country with a large population, agriculture is the foundation of the country and the application of quadrotor UAVs in the agricultural field has important advantages and significance. The farmland operating environment is complex, requiring agricultural four-rotor UAVs to have the characteristics of stable anti-interference, strong carrying capacity, long endurance and strong independent flying ability. Owing limited technology, the sensor nodes designed by this system cannot collect all the attribute information of farmland and can only meet the needs of part of the information. The project team will further add achievable sensors to make the collection of information more complete. Since the current knowledge of this article is not comprehensive enough, there are still many unsolved problems. Therefore, the next generation of agricultural quadrotor drones has the following prospects: (1) The highest control in the article can keep the UAV at a certain altitude, but the barometer is affected by the air pressure, and the measurement altitude changes for a long time, and the measurement range of the ultrasonic sensor is limited. In addition, a high-precision height measurement sensor, such as a laser sensor, can be used to improve the accuracy of height measurement and height control. (2) Many quad-rotor drones are often affected by ground impact during take-off. Future researchers may pay attention to the impact of ground impact on the power system to improve the flight efficiency of quad-rotor drones when flying near the ground. (3) In terms of flight control navigation, explore high-precision navigation methods to enable drones to fly autonomously, suitable for plant protection facilities and improve farmland operation efficiency. (4) The researcher function avoids automatic blockage of the drone control system. When there is a fixed obstacle or a moving obstacle, the drone can automatically cross the obstacle without manual control.

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