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Orchard Intelligent Supervision System Design based on New Energy Wireless Charging Base Station

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Abstract

Pinggu District of Beijing, known as "China's peach Township", has a huge area of peach trees planted and a long history. It has the world famous Great Peach Township, the world's largest peach orchard, China's largest peach township, and the capital's largest fruit area. However, the whole supervision of peach orchard is completed by manual experience, which is difficult and inefficient, and effective technical standards are difficult to land. The amount and time control of fertilization and spraying are not accurate, which greatly reduces the quality and output of fruit. For this reason, our team independently developed an unmanned unit monitoring system based on the wind-wind complementary base station. The wind-solar complementary wireless charging base station effectively solves the problem of poor endurance of the UAV and frequent round-trip replacement of the battery. The UAV group distributed control effectively improves the monitoring efficiency and accuracy. Big data analysis and processing can provide real-time and accurate guidance for agricultural planting, which has good practicability and energy saving and emission reduction benefits. The experiment and calculation results show that compared with manual supervision, the system can increase the yield by 20%, the efficiency by 48%, and the comprehensive energy saving by 42%. At the same time, the system has simple and integrated operation, and has high applicability and superiority in large-scale orchard supervision.

Keywords

Big Data; Smart Agriculture; Wireless Charging; New Energy; Generation; Distributed Control.

1. Introduction

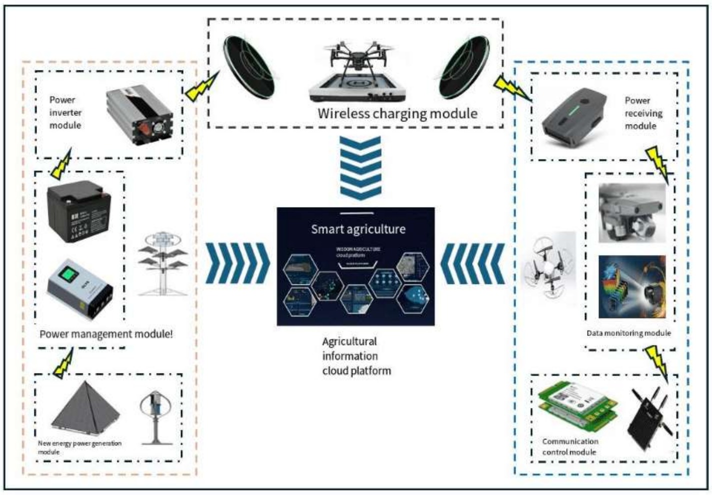

Figure 1. Overview of the design scheme

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The system design includes two parts: the wind-solar complementary wireless charging base station and the intelligent monitoring UAV. The terminal platform controls the intelligent monitoring UAV, completes the collection of orchard information, and controls the wind-solar complementary charging base station to improve the accuracy of the UAV operation and the endurance of the UAV group. The system consists of six parts: wind-solar complementary power generation module, energy management module, power transmission module, power acceptance module, data acquisition module and communication module.

2. Design Scheme

2.1. Wind-wind Complementary Wireless Charging Base Station

Wind and solar complementary wireless charging base station includes wind power generation and photovoltaic power generation two parts, wind power generation part adopts composite vertical axis wind turbine, which can effectively solve the problem of starting difficult under low wind speed, improve starting performance and power generation efficiency; Photovoltaic power generation part independently designed the open and close photovoltaic power generation structure, when the sun is full, the photovoltaic power generation sheet automatically opens to generate electricity, when encountering bad weather or night, it can automatically rewind to protect the safety of the drone, and designed an alarm to drive away the birds and animals[2] near.

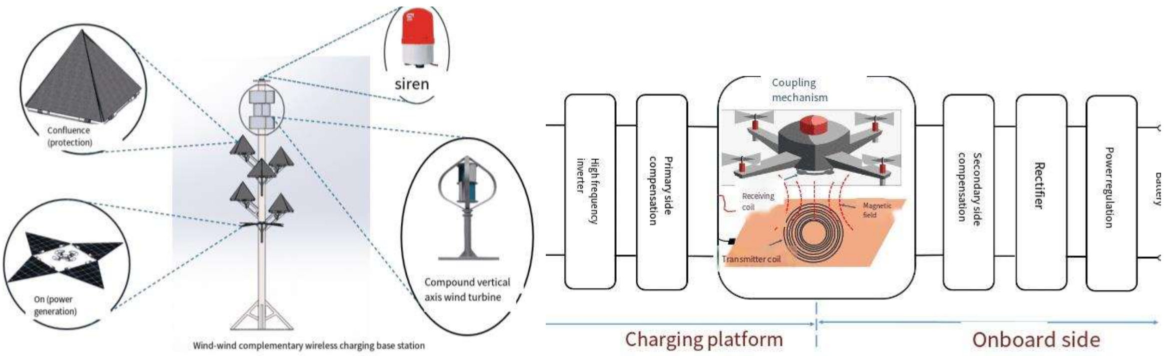

Figure 2. Detail picture of wind-solar complementary wireless charging base station

2.2. Distributed UAV Group Control

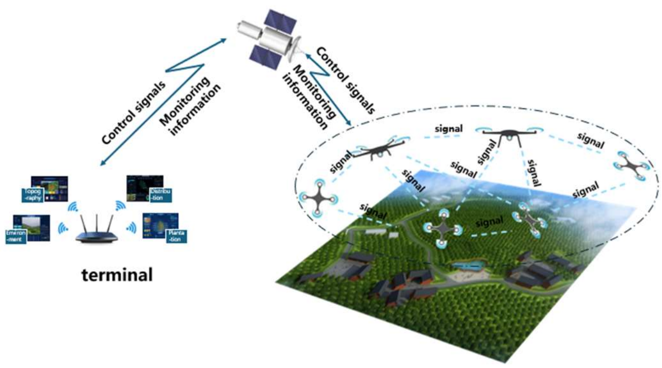

Figure 3. Control of distributed unmanned unit

Uav group control adopts whale optimization algorithm, data control terminal realizes the overall control of UAV group, converts the task into multiple sub-tasks, and then assigns to each UAV, each UAV carries out information sharing and information interaction according to its own task, and works out the most reasonable operation plan to improve the speed and accuracy of

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execution. At the same time, complete the fine operation, automatic route planning, autonomous obstacle avoidance and other functions[3].

2.3. Multi-spectral AI Intelligent Vision System

The UAV is equipped with an integrated multi-spectral imaging system[4]and AI intelligent vision system. The UAV collects agricultural data through multi-spectral imaging, and the AI intelligent vision obstacle avoidance system intelligently detects obstacles and judges obstacle avoidance or obstacle avoidance strategies. At the same time, real-time monitoring and transmission of various data are completed through various sensors and visual transmission systems, so that farmers can timely obtain the basic information of the orchard, real-time monitoring, and ensure the healthy growth of fruit trees.

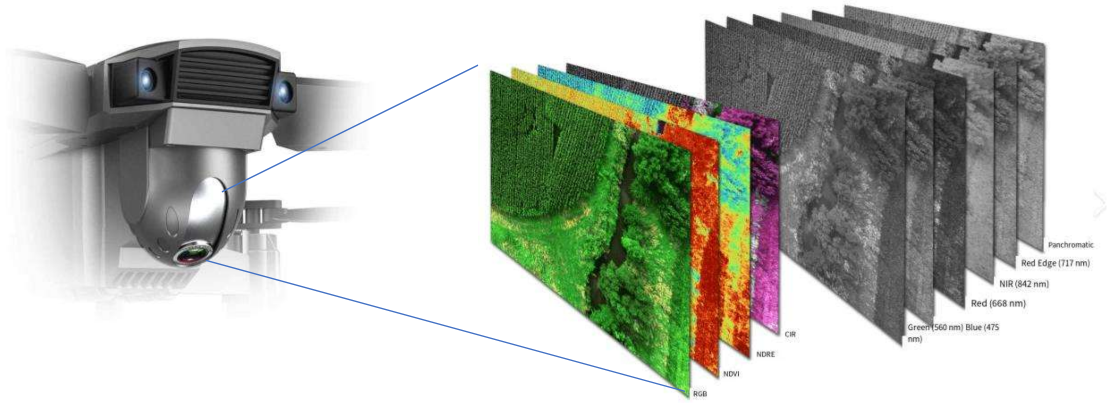

Figure 4. Multi-spectral AI intelligent vision acquisition pattern

2.4. Big Data Information Processing and Analysis

The data collected by UAV is effectively collected, stored, managed, processed and analyzed by big data[5]technology to extract useful information, calculate the potential laws and trends of agriculture, and then formulate corresponding solutions.

Figure 5. Big data information processing

3. Theoretical Design Calculation

3.1. Design Science

Table 1. UAV design parameters

Items	Parameters	Design basis
Mechanical parameters	· Length: 50 cm · Height: 20 cm · Width: 50 cm	Ultralight Aircraft - Aircraft Design (T/AOPA000X -2019)
Electrical	· Operating power: 600 W	
parameters	· Battery capacity: 4000 mAh	

3.2. Whale Optimization Algorithm

The Whale optimization algorithm is an algorithm used to solve optimization problems, usually for optimization in continuous Spaces. The strategy is based on Gaussian distribution to generate random step size, and dynamically adjusts the step size according to the current optimization progress, in order to balance its exploration and development capabilities. The individual position update formula is as follows:

$$step = (1 - t/\max t) * adis * randn(1,D) \tag{1}$$

$$x(i,;) = x(i,:) + step \tag{2}$$

Where, step is the step size, t is the number of iterations, max t is the maximum number of iterations, adis is the step size factor, randn generates random numbers with normal distribution, D is the problem dimension, x is the population individual, and i is the serial number of the corresponding individual. In the whale algorithm, the lead whale is the optimal individual. In order to assist its position update and constantly modify its direction of advance, the second whale is designed to perform dimensional-by-dimension optimization on the lead whale. The fitness value of the second whale is second only to that of the lead whale in the population. Through this strategy, the convergence speed is accelerated.

$$newleaderpos(i) = leader2pos(i) + leaderpos(i)/2 \tag{3}$$

Among them, Leader2 pos is the 2nd best whale location, if the new location newLeaderpos is better, it will be the lead whale individual.

3.3. Calculation of Wind-wind Complementary Energy Generation

3.3.1. Photovoltaic Power Generation

Approximate calculation formula of solar intensity and air quality:

$$I = 1.1 \times I0 \times 0.7(AM0.618) \tag{4}$$

According to the above formula, the power density of sunlight is about$PS = 700W/m2$, now more mature solar cells, its power generation efficiency can be approximately reached$\eta = 20\%$ above, meaning that a square meter of solar panel power is about 140W. $S = 10.39m2$The $te = 1520h$solar panel area of the device is.

The average annual sunrise time is taken, and the annual solar power generation is[6] calculated as:

$$Q1a = Ps\eta teS = 0.7 \times 20\% \times 130\% \times 1520 \times 10.39 = 2874.29kW \cdot h \quad (5)$$

Daily solar power output is:

$$Q1 = Q1a \div 365 = 7.87kW \cdot h \quad (6)$$

3.3.2. Wind Power Generation

The power P of the resistance fan[7] is equal to the product of the resistance F and the speed U generated by the thrust of the wind turbine blade, so P1 can be written as:

$$P1 = (F1 - F2)U \quad (7)$$

The torque M of lift type wind turbine can be obtained by blade element integral:

$$M = Bl \quad (8)$$

The power P2 of the lift type wind turbine is:

$$P2 = Mw \quad (9)$$

The total power of wind turbine is:

$$P = P1 + P2 = 700W + 800W = 1500W \quad (10)$$

The average daily wind time is 15h, then the daily wind power generation is 22.5kW·h.

4. \Working Principle

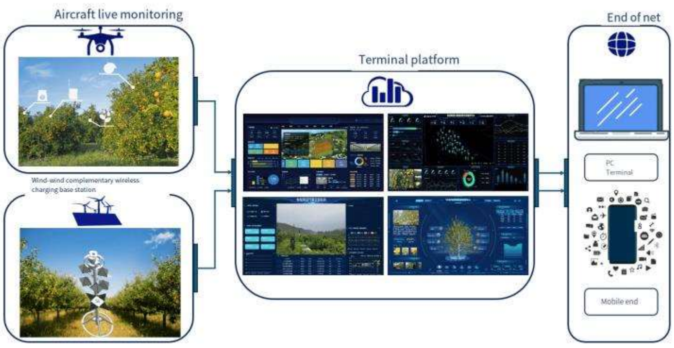

Figure 6. Working principle

The UAV is equipped with multi-spectral imaging system, AI intelligent vision obstacle avoidance system and environmental monitoring, and monitors the orchards in real time through flight. The base station provides energy supplement to extend the flight time of the drone. The data transmission system transmits the monitoring data to the base station or the farmer's terminal to realize real-time monitoring and management, help farmers find problems in time and take measures to improve the yield and quality of the orchard, and provide intelligent solutions for agricultural production. The data picture is uploaded to the network in real time to realize the visualization and transparency of agricultural cultivation.

5. Innovation Points

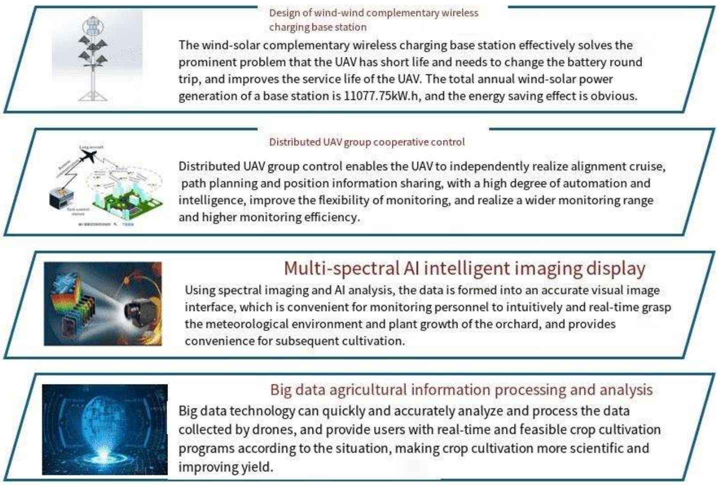

Figure 7. Innovation point

6. Benefit Analysis

6.1. Economic Benefits

Taking 220,000 mu of mountain peach orchard in Pinggu District of Beijing as an example, if the intelligent supervision system is used, the annual output of about 162510 MWh of green electricity is equivalent to saving 32 million yuan of electricity. Before and after the technical reform, the labor cost is saved about 4.95 million yuan, the drug cost is reduced from 154 million yuan to 92 million yuan, the water consumption is also reduced by 10%, and the comprehensive cost is saved at least 128 million yuan. After evaluation, the effective working life of the system is 20 years, and the economic benefits are significant, as shown in Table 3:

Table 2. Economic Benefits

Years	Amount of electricitysaved (megawatt-hours)	Water saving (tons)	Drug saving cost (100 Millionyuan)	Labor cost savings (ten millionyuan)	Economic benefits (billion yuan)
1 year	1.62×10^5	5280	0.62	495	1.5
20 years	3.24×10^6	105600	12.4	9900	30

6.2. Social Benefits

Through multi-dimensional perception of visual UAV group, remote monitoring of intelligent detection and control terminal, monitoring data and pictures combined with the Internet, the system is uploaded to the network for the public in real time, to achieve product transparency and visualization, each fruit can be traced to improve consumer trust, increase sales, and can also carry out science education for minors.

7. Application Prospect and Promotion

The design of orchard intelligent supervision system of new energy wireless charging base station effectively solves the supervision problem of large orchards, and can effectively realize the intelligence, visualization and automation of orchard supervision, and the effect of energy saving and water saving and increase production is remarkable[8]. At the same time, the wind and solar complementary wireless charging base station intelligent monitoring system can also be applied to forest health detection, ecological protection area biomass detection, river environment and vegetation detection and other environmental monitoring fields, the market potential is huge.

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