

Exploration of Solutions for Unmanned Smart Farmland

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ABSTRACT

Unmanned smart farmland is an advanced stage of agricultural production, which integrates emerging technologies such as the Internet of Things, cloud computing, big data, 5G, artificial intelligence equipment and robots. It relies on the smart agricultural production system deployed on the agricultural production site to achieve full automatic control of facilities, equipment, machinery, etc. or autonomous control of robots, realizing intelligent perception, intelligent warning, intelligent decision-making, intelligent analysis, and expert online guidance of the agricultural production environment. It is a 24/7, full process, and full space unmanned production operation mode, essentially realizing machine replacement in agricultural production. Building unmanned smart farmland is an important way to alleviate the shortage of rural labor and promote the modernization of agriculture and rural areas. It provides precise planting, visual management, and intelligent decision-making for agricultural production, and also allows agriculture and rural areas to share the achievements of technological development in the times.

KEYWORDS

Smart farmland; Unmanned farm; Artificial intelligence.

1. CONSTRUCTION BACKGROUND

With the development of information technologies such as the Internet of Things and artificial intelligence, developed countries such as the United States, the United Kingdom, Israel, and the Netherlands have begun to build smart agriculture such as unmanned fields and greenhouses. The combination of high-precision technologies such as the Internet of Things and AI in agricultural production in the United States, including intelligent robots, temperature and humidity sensors, aerial photography, and GPS technology, has greatly improved the operational efficiency of American farmland. At present, unmanned smart farmland in China is in the early stage of demonstration and promotion, and technological research mainly focuses on single machine intelligent control technologies such as autonomous driving and precision operation. However, there is a lack of related technologies such as multi machine collaboration, host machine and machine operation collaboration, and collaboration between agricultural production scenarios and autonomous operation of agricultural

machinery. In terms of application, the main focus is on government guidance and demonstration promotion, and the commercialization process is in the guiding stage. As of the end of 2022, there are about a hundred unmanned smart farmland projects in China, mostly facility agriculture with less field planting. The development of unmanned smart farmland in China has a certain foundation, but most of it is still in the exploratory stage, and there is a lack of technological maturity and economic viability. At present, there is no truly unmanned smart farmland in Shaanxi Province. There are only some small-scale smart agriculture parks mainly focused on facility agriculture, and the field of unmanned smart farmland in large fields is still in the experimental stage.

2. CONSTRUCTION IDEAS

With the unmanned intelligent farmland central control system as the core, supplemented by advanced unmanned agricultural machinery equipment and front-end information collection technology, comprehensive monitoring of farmland operations and soil environment conditions is achieved. Big data analysis is used to realize the intelligence of grain production equipment, management informatization, mechanization of farmland, precision of operations, and scientific early warning.

3. CONSTRUCTION GOAL

Construction objective: The core objective of the smart farmland project is to improve agricultural production efficiency, optimize resource utilization, reduce environmental pollution, and promote sustainable development of agriculture. By applying intelligent technology, traditional agricultural production methods can be changed, agricultural production efficiency can be improved, and sustainable development can be achieved.

Construction task: ①Build smart farmland infrastructure, form unmanned farmland production information management, and achieve precise management of agricultural materials, personnel, costs, equipment, agricultural affairs, harvest, etc.; ②Promote new technologies, improve the quality of agricultural products, and increase product added value; ③Improve the efficiency of agricultural production and reduce production costs.

4. TECHNICAL SOLUTION

Unmanned smart farmland includes three parts: unmanned smart farmland management system, air space integrated monitoring system, and unmanned intelligent agricultural machinery equipment.

The unmanned intelligent farmland management system guides production and operation through big data, improving the efficiency of soil, water, fertilizer, planting, and human resource utilization; The integrated monitoring system of air, space, and earth realizes the perception of farmland information through satellite remote sensing, unmanned aerial vehicle remote sensing, and "four situations" ground IoT monitoring stations; Unmanned intelligent agricultural machinery equipment perceives information from the integrated monitoring system of air, space, and earth, analyzes the precise input of unmanned intelligent farmland cultivation, sowing, fertilization, irrigation, and harvesting processes, clarifies intelligent control methods for key components of cultivation management and harvesting, and conducts real-time and accurate variable operations through unmanned equipment throughout the entire process.

4.1. Unmanned Smart Farmland Management System

Adopting new generation information technologies such as the Internet of Things, big data, artificial intelligence, 5G, and robots to carry out unmanned smart farmland construction, integrating the

construction of a smart agriculture platform with big data collection, analysis, management, and application as the core, remote control of farmland facilities, equipment, machinery, etc., or autonomous decision-making and operation through intelligent equipment and robots to complete all farmland production and management tasks, is an all-weather, full process, and full space unmanned production operation mode, achieving the intelligent management goal of "data production, data management, and data decision-making". The system mainly includes smart production, smart agriculture big data construction, and smart agriculture comprehensive display platform.

4.2. Integrated monitoring technology system for air, space, and earth

Build an integrated IoT monitoring system that utilizes remote sensing systems, IoT measurement and control systems, field comprehensive monitoring stations, and other facilities and equipment to monitor the growth environment and body of wheat and corn in real time. It predicts and forecasts the "four conditions" of soil moisture, seedling conditions, insect conditions, and disaster situations, as well as meteorology, to accurately guide the digital production decision-making of wheat and corn throughout the entire process.

4.3. Fully mechanized and intelligent technology system

The driverless agricultural machinery covers four major links of tillage, planting, management and harvesting, and is composed of driverless tillage and preparation machine, seeder, self-propelled spray machine, driverless harvester and other parts. Under the unmanned smart farmland mode, unmanned agricultural machinery will make farmland management more information-based and efficient, and make farmland operations more precise and intelligent based on the front-end perception layer and decision-making layer. Unmanned agricultural production operations can be achieved through mobile smart terminals. By establishing a new 5G base station and achieving full coverage of the 5G network, farmers can install an operating system on their mobile devices, allowing unmanned agricultural machinery to replace professional operators and plan the optimal operating path.

5. TYPICAL CASE

5.1. Location scale

The unmanned smart farmland for corn in Gongzhuling City, Jilin Province is located in the Jilin Agricultural Science and Technology Demonstration Park on the south side of National Highway 102. The construction area of unmanned smart farmland is 1000 acres, including 350 acres in the core area.

5.2. Construction content

Mainly including information perception system, intelligent agricultural machinery and equipment, and unmanned intelligent control cloud platform.

5.2.1. Information perception system

The information perception system includes unmanned aerial vehicle remote sensing equipment, field comprehensive monitoring stations, and an integrated sky ground observation and data perception system for IoT measurement and control. It can automatically monitor the farmland environment and crop growth information, and transmit it to the smart agricultural machinery management system.

By deploying unmanned aerial vehicle remote sensing equipment for collecting and monitoring agricultural land and crop information, basic land boundary and crop growth information data are provided for agricultural production management and unmanned operation of agricultural machinery and equipment.

By deploying comprehensive field monitoring stations and IoT monitoring systems, real-time collection of information on maize growth environment such as soil fertility, soil temperature and humidity, atmospheric temperature and humidity, and sunlight radiation, as well as growth status such as leaf age, is provided to provide basic data for agricultural production management and precise operation of agricultural machinery and equipment.

5.2.2. Intelligent agricultural machinery equipment

By transforming existing tractors and their supporting equipment, crop protection machines, harvesters, grain transport vehicles, etc. into unmanned systems, installing unmanned driving systems, precise operation control devices, remote monitoring terminals, etc., and sharing data and exchanging instructions with the unmanned smart farmland cloud platform, unmanned operations for corn cultivation, planting, management, and harvesting can be achieved. Unmanned tractors can be equipped with agricultural machinery such as deep tillage machines and straw returning machines for unmanned tillage operations. They can achieve autonomous path planning, real-time monitoring of operating status, real-time shooting and uploading of work effects, and automatic lifting and lowering of work tools. The unmanned tractor is connected to an electric drive seeder and integrates high-precision satellite positioning system, navigation control system, precision seeding control system, operation path planning system, and network communication system to achieve master-slave cooperation and complete unmanned seeding operations.

In the plant protection process, unmanned aerial vehicles equipped with multispectral cameras are used to collect crop information in farmland. Machine vision algorithms are used to analyze crop growth and nutrient information in the field, generate leaf nitrogen content distribution maps, and make decisions on fertilizer application rates; Equipped with a visible light camera to capture images of farmland environment, analyze and obtain information on corn pests and diseases, and develop pesticide prescription maps; Through the cloud platform control system, the fertilizer and pesticide prescription maps are distributed to the ground operation machine end, and precise variable spraying is achieved by unmanned plant protection machines.

The unmanned high clearance spray bar spray is used to realize the precision variable spraying operation, realizing the functions of autonomous planning of operation path, high-precision path tracking, automatic turning of headland, automatic control of travel speed, integrated control of boom lifting and folding, emergency obstacle avoidance, remote control, etc., reducing the occurrence of drug damage, reducing the cost of employment, improving the utilization rate of high clearance plant protection machine, and providing key technical equipment for the plant protection operation of unmanned smart farmland for corn.

The unmanned harvesting machine integrates a job information detection system, an automatic navigation system, an obstacle detection system, and an intelligent control system for harvesting operations, realizing functions such as unmanned corn harvesting operation status, automatic monitoring of working conditions, unmanned driving, automatic obstacle avoidance, and automatic operation control. The harvesting efficiency is improved by 3-4 times, providing strong support for unmanned harvesting of corn in farmland.

5.2.3. Unmanned Smart Farmland Cloud Platform

The unmanned smart farmland cloud platform mainly includes four parts: unmanned smart farmland basic geographic information management system, unmanned agricultural machinery remote control system, intelligent agricultural machinery precision operation management system, and unmanned agricultural machinery system. Among them, the basic geographic information management system for farmland provides basic geographic information support for precise operation of unmanned agricultural machinery through centimeter level digital map mapping and processing at the scale of farmland plots; The unmanned agricultural machinery remote control system is mainly aimed at the operation control of intelligent agricultural machinery equipment, providing services such as

farmland cultivation management and harvesting operation supervision, working condition monitoring, front-end and back-end interaction, and operation management; The intelligent agricultural machinery precision operation management system and database are mainly aimed at benchmark operations of intelligent agricultural machinery equipment, providing services such as basic agricultural data maintenance and management, variable prescription management, agricultural machinery operation parameter sharing, and agricultural machinery operation quality supervision; The unmanned agricultural machinery operation display system provides a basic platform for the daily operation and maintenance, operation services, and display of farmland systems.

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