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Analysis and Prospect of Key Technology Applications in Unmanned Smart Farms

Jian Gao

Shaanxi Provincial Land Engineering Construction Group Co.,Ltd., Xi 'an, Shaanxi 710075, China

Abstract

Due to the large agricultural population and limited arable land area, China's agriculture has always been based on small farms. However, with the gradual intensification of population aging and the advancement of urbanization, the agricultural labor force is now decreasing. In the future, China's food security will face the challenges of "who will cultivate land" and "how to cultivate land". One of the implementation paths to solve this problem is unmanned farm technology. This article systematically elaborates on the concept and technical architecture of unmanned farms, as well as key technologies such as infrastructure, operating equipment, data monitoring systems, and control service platforms, through the technical practice of unmanned farms in Jiading District, Shanghai. It deeply explores the development of unmanned farms and has certain guiding significance for the development of unmanned farms.

Keywords

Unmanned Farms; Smart Agriculture; Construction Status; Technology Application; Countermeasure Research.

1. Introduction

China is a large agricultural country and also a populous country. China has always attached great importance to the development of agriculture and rural areas, continuously promoting the adjustment and optimization of agricultural structure. However, due to the relative shortage of arable land resources in China, the per capita arable land area is far lower than the per capita level in Asia. It can be seen that food security has always been a challenge we face. Although China's agricultural production has basically achieved mechanization in major crops such as rice, wheat, and corn, it is still based on traditional agriculture and traditional agricultural machinery. There is a significant gap between China and developed countries in terms of full hydraulic control, intelligence, and information technology. With the increasing aging population, the impact of agricultural labor shortage on agricultural production is becoming increasingly prominent, and the challenges faced by China's agricultural production are becoming greater, The pressure on agricultural production is also increasing day by day. The cost of labor has increased, and the income from migrant workers far exceeds that from agriculture. Rural labor has also flooded into cities, and traditional agricultural mechanization models are no longer able to adapt to the development of society and technology. Agricultural labor productivity still needs to be further improved.

In recent years, with the acceleration of urbanization, the problem of agricultural labor shortage has become prominent, which has constrained the pace of agricultural and rural modernization. How to improve the level of agricultural mechanization in China and reduce the dependence on manual labor in agricultural production has become an important issue in the current development of agricultural mechanization. The deep application of modern information technology in the agricultural field has provided favorable conditions for the

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construction of "unmanned farms". The "unmanned farm" utilizes a combination of cutting-edge technologies such as the Internet of Things, big data, artificial intelligence, 5G technology, and robotics to achieve autonomous operation of equipment, machinery, and robots, achieving precise operation and information-based management of unmanned (few people) agricultural production. Promoting the construction of "unmanned farms" and accelerating the pace of "machine replacement" in agricultural production is not only a practical requirement for rural revitalization, but also an important direction for future agricultural development in China.

2. Connotation of Unmanned Farms

Unmanned farms mainly refer to the entire production process of agricultural products being completed by various automated machinery, without the need for manual labor, and crop production and related agricultural production activities can be monitored in real-time. In the past, the farming, sowing, crop management, and harvest processes that required a large amount of labor were all completed by automated machinery that did not require human driving. At the same time, through real-time monitoring and feedback from relevant monitoring equipment, provide relevant data support for the agricultural production operation system, allowing the farm production operation system to accurately control various stages of crop watering, fertilization, pesticide application, etc. based on detailed data, so as to accurately control the amount of water, fertilizer, and pesticide required for crops, and avoid waste caused by manual crop production and inaccurate quantity control. By establishing an unmanned farm, the amount of manpower required in the entire process of agricultural production can be effectively reduced. Unmanned agricultural machinery automates the operation and movement between the hangar and the field, and the crop production process is fully monitored, enabling precise and intelligent control of various resources required for crop growth.

3. Development Status of Unmanned Farms

The proposal on vigorously developing overseas agriculture to create large-scale unmanned farms suggests that China should increase the application scope of automated machinery related to agricultural production and establish a corresponding implementation foundation for unmanned farms through investment in relevant equipment. At the same time, many high-tech companies have also participated in the construction of unmanned farms, promoting the establishment of unmanned farms by effectively combining their expertise in information technology with agricultural production. Alibaba has organically integrated artificial intelligence and pig farming to establish an "Internet Farm", while Huawei has assisted in the intelligent and digital transformation of agricultural production through various digital support. With the gradual attention of the government and the active participation of various high-tech enterprises, unmanned farms in China will experience rapid development in the coming years. At that time, workers participating in agricultural production can use relevant equipment, with the support of technologies such as the Internet of Things, big data, and artificial intelligence, and use accurate data provided by sensors such as weather, soil, and water quality, as well as sensing devices such as insect pest analyzers and spore catchers. Based on the analysis of data using AI technology and providing operational suggestions, Remote control of unmanned machinery for large-scale agricultural planting on hundreds of hectares of farmland greatly improves the production efficiency of agriculture in China.

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4. Key Technologies for Unmanned Farms

4.1. Agricultural Machinery Unmanned Driving System

In recent years, with the promotion and implementation of various national policies, agricultural machinery has developed rapidly. The main intelligent products such as unmanned vehicles, drones, and agricultural robots have been put into use one after another, and can adapt to various working conditions. They can complete the cultivation, planting, management, and harvesting of different crops in paddy and dry land environments, and have reached the leading level of similar products at home and abroad. However, in the case of autonomous operation without human intervention, compared with traditional agricultural machinery, unmanned machinery has strong job targeting, long work cycles, high work efficiency, and high utilization of resources such as land. How to ensure the safety of autonomous operation of mechanical facilities is a major challenge, so high-precision automatic navigation systems are a major core of unmanned agricultural machinery. In response to various operating conditions, conditions, and locations of farm operations, agricultural machinery operations need to focus on solving three major challenges, namely navigation positioning, navigation control, and system integration.

4.2. Context-awareness

The environmental perception system mainly consists of drones and growth environment detection sensors. The drone is equipped with environmental detection and remote sensing sensors. During the crop growth process, the drone is responsible for monitoring and analyzing atmospheric, crop, and soil field information, playing a role in agricultural warning and crop yield prediction. The analysis of crops involves using optical remote sensing technology and thermal remote sensing technology to detect the reflected energy on the surface of crops to create crop images. On the one hand, it can monitor the leaf area, plant coverage, biomass, and chlorophyll content of crops, and detect pests in a timely manner. On the other hand, crop weeds, nutrients, etc. can be monitored to achieve precise planning, optimized management, and agricultural production and investment. This not only provides timely and accurate information for managers, but also effectively prevents and reduces economic losses caused by pests.

4.3. Digital Farmland

Agricultural digital management specifically involves combining remote sensing images, geographic information, positioning information, plant information, soil information, atmospheric information, real-time monitoring of crops and soil in the agricultural production process. Realize regular acquisition of information on crop growth, development status, pests, water and fertilizer status, and corresponding environment, generate a dynamic spatial information system that simulates phenomena and processes in agricultural production, achieve reasonable utilization of agricultural resources, reduce production costs, improve ecological environment, and provide crop yield and quality.

4.4. Comprehensive Control Platform

By comprehensively utilizing data communication, navigation and positioning, multi-spectral and visual remote sensing multi-source heterogeneous data fusion processing technology, a collaborative operation system for unmanned agricultural machinery equipment throughout the cultivation, management and harvesting process has been formed. Store, analyze, and process data collected from environmental perception systems, intelligent agricultural machinery and equipment through the intelligent agricultural comprehensive control platform, achieving information visualization, quantitative decision-making, remote task issuance and control, etc; After receiving information, the 5G receiving module equipment automatically

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sends instructions according to the assigned tasks at the specified time. The mechanical equipment completes automatic ignition and completes tasks such as entering and exiting the hangar, plowing, transplanting, fertilizing and spraying, harvesting, and storage.

5. Conclusion

Compared to traditional agricultural mechanization, unmanned farms can significantly increase labor productivity and improve the utilization rate of land and agricultural resources. It can be said that it represents the most advanced agricultural productivity and is also a new stage of agricultural development. It is the foundation and direction of future agriculture and the integrated application of emerging technologies such as digital technology, satellite navigation, and the Internet of Things in agricultural production. However, the application of new technologies first faces cost issues. The current focus of unmanned farms is to solve the problem of "who will cultivate the land" in the context of agricultural labor shortage. The construction cost of unmanned farms is too high, and only when labor costs increase and unmanned farm technology becomes more mature, can the cost become relatively low, can true large-scale application be achieved. It is expected that around 2050, as the level of urbanization in China further improves, the agricultural population decreases, agricultural labor costs are higher, and technology matures, unmanned farms will experience rapid popularization and promotion. Starting from now on, the layout of unmanned farm research, technology, and products is of great significance for accelerating the modernization of agriculture and food security in China.

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