A brief discussion on the development of agricultural modernization enabled by digitalization

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ABSTRACT With the rapid development of information technology today, digitalization has become a key force to promote agricultural modernization. This paper deeply discusses how digitalization provides power for agricultural modernization, analyzes the application of digitalization technology in agricultural production, management, marketing and other key links, and puts forward corresponding strategies and suggestions. This paper first introduces the basic concept of digitalization and the connotation of agricultural modernization, then analyzes the application status of digitalization technology in the agricultural field, then discusses the role of digitalization technology in promoting agricultural modernization, and finally puts forward the strategies and suggestions to promote the development of digitalization enabling agricultural modernization.

Keywords Digitalization; Agricultural Modernization; Information Technology; Smart Agriculture.

I.INTRODUCTION

As the basic industry of the national economy, the development level of agriculture is directly related to the food security of the country and the quality of life of the people. With the growth of the global population and the constraints of resources and environment, traditional agriculture is facing unprecedented challenges. The rise of digital technology provides new solutions for agricultural modernization. Through the application of digital technology, agricultural production efficiency can be improved, costs can be reduced, market competitiveness of agricultural products can be enhanced, and sustainable development can be achieved. Therefore, it is of great theoretical and practical significance to study how digitization enables agricultural modernization [1].

II.Overview of Digitalization and Agricultural Modernization

2.1 Digital Concept

processing, storage, transmission and application of these signals through digital technology. In the field of agriculture, digital technologies such as the Internet, big data, cloud computing, the Internet of Things, artificial intelligence, etc. [2-4] are changing the way agriculture is produced, managed, and marketed. For example, through the Internet of Things technology, real-time monitoring of farmland environment can be realized, crop diseases and market trends can be predicted through big data analysis, and intelligent identification and diagnosis can be carried out through artificial intelligence [4-6].

2.2 Connotation of Agricultural Modernization

Agricultural modernization refers to the process of using modern science and technology and modern management methods to transform and upgrade traditional agriculture, achieve large-scale, intensive, standardized, and intelligent agricultural production, improve agricultural production efficiency and agricultural product quality, and achieve sustainable development of agriculture. This involves not only the transformation of agricultural production mode but also the optimization of the agricultural industry chain and the improvement of the agricultural service system [7]..

III.The Application Status of Digital Technology in the Field of Agriculture

3.1 Precision Agriculture

Precision agriculture is an agricultural production mode based on modern information technology. It uses advanced scientific and technological means, such as global positioning system (GPS), geographic information system (GIS), remote sensing technology, Internet of Things (IoT), big data, and artificial intelligence, to carry out fine management of agricultural production process [8, 9]. The core goal of precision agriculture is to improve agricultural production efficiency, reduce production costs, reduce

resource waste, and protect the environment. Key features and applications include:

a) Data-driven decision-making: help farmers make more scientific planting decisions by collecting and analyzing large amounts of agricultural data, including soil conditions, crop growth, climate data, etc.

b) Variable rate technology: According to the specific needs of different areas in the field, accurately adjust the amount of fertilization, sowing, and spraying of pesticides, which is conducive to improving the utilization efficiency of pesticides and fertilizers, reducing agricultural costs, reducing the use of pesticides, reducing pesticide residues and reducing environmental pollution;

c) Soil mapping: the use of soil sensors and GIS technology to create detailed maps of soil composition and properties that are important for agricultural, environmental, and scientific research;

d) Crop monitoring: satellite images and cameras mounted on drones are used to monitor the growth of crops in real-time, and diseases, pests, and nutritional deficiencies are discovered and dealt with in time [10].

3.2 Intelligent Agricultural Machinery

By installing digital equipment such as sensors and controllers, intelligent agricultural machinery can realize automatic navigation, intelligent operation, and remote monitoring of agricultural machinery. These devices can improve operational efficiency, reduce human error, and improve the safety and reliability of farm machinery. The key technologies of unmanned agricultural machinery include:

a) Precision positioning technology: Through high-precision GPS and Beidou navigation systems, unmanned agricultural machines can accurately position the field and achieve accurate operations.

b) Intelligent control system: Through preset programs and real-time data, automatic control of agricultural machinery for sowing, fertilization, harvesting, and other operations greatly improves the efficiency and accuracy of the operation.

c) Image recognition and data processing technology: Through high-definition cameras and advanced image processing technology, unmanned agricultural machines can identify crop conditions, carry out pest monitoring and precision spraying, and effectively improve crop yield and quality.

d) Autonomous navigation technology: agricultural machinery can drive autonomously in complex farmland environments, avoid obstacles, and realize all-weather operation [11-13].

3.3 Agricultural Internet of Things

The agricultural Internet of Things aims to realize real-time monitoring and control of the agricultural production environment through sensors, wireless communication, and other technologies and improve the intelligent level of agricultural production [14,15]. The Internet of Things technology can monitor environmental factors such as soil moisture, temperature, and light to provide a scientific basis for agricultural production. It is an emerging technology that promotes the intelligent development of modern agriculture and has been widely used in every link of agricultural production [16]. Its core includes:

a) Information perception: New perception technologies such as spectroscopy, spectral imaging, and machine vision provide new ideas for achieving fast, real-time, and lossless perception.

b) Information transmission: New technologies such as 5G are combined with multi-source information fusion, artificial intelligence, blockchain, edge computing, and other information processing technologies to make information transmission and processing faster, safer, and more reliable[17,18].

c) System application: In-depth analysis of agricultural Internet of Things technology from the four core levels of perception, transmission, processing, and application to explore the frontier trend of future research [2-4].

3.4 Big Data and Cloud Computing

Big data and cloud computing technology can help agricultural managers analyze and process massive agricultural data and provide a scientific basis for agricultural production decisions. Through big data analysis, crop diseases, market trends, etc., can be predicted to provide guidance for agricultural production. The details include:

a) Data system: Agricultural big data is a system that collects, identifies, and identifies data in an open system and builds databases to combine and optimize multidimensional and massive data through parameters, models, and algorithms.

b) Decision support: provide the basis for production operations and business decisions and realize partial automatic control and operation [5-8].

3.5 Artificial Intelligence

The application of artificial intelligence technology in the field of agriculture includes intelligent identification, intelligent diagnosis, intelligent prediction, etc., which can improve the intelligent level of agricultural production. The application of example intelligent technology in the agricultural field includes intelligent identification, intelligent diagnosis, intelligent prediction, etc., which can improve the intelligent level of agricultural production. Specific applications are:

a) Intelligent recognition: AI can be used to identify crop diseases, predict crop yields, optimize planting strategies, etc.

b) Improved decision-making level: The development of artificial intelligence, such as Alpha Go, has improved the decision-making level of AI and injected a strong shot into the development of digital agriculture.

IV. The Theoretical and Practical Basis of Agricultural Digitalization

In the field of agricultural digitization, the type, structure, and quality of multi-modal data have a multi-dimensional and multi-breadth impact on information processing. Information perception, circulation, and aggregation are the basic tasks of smart agriculture. With

the development of Internet of Things technology, agricultural systems have established more data acquisition methods, including soil moisture sensors, weather stations, drone images, and so on. This isomerized, multi-modal, and diversified information (such as sensor data, image data, text data, etc.) has been produced in large quantities and continues to accumulate. Therefore, it is urgent to systematically integrate new agricultural data by establishing a more robust corpus. Aiming at multi-heterogeneous, multi-modal, and diversified data, this paper studies the data security storage, processing, and distributed learning technology of new agricultural systems [15,16].

4.1. Multi-Modal Data Distributed Preprocessing Algorithm

In order to process and analyze agricultural data from different sources and types, a multi-modal data distributed preprocessing algorithm is developed. These algorithms are capable of processing large data sets, extracting critical information, and supporting subsequent data analysis and decision-making[19].

4.2. Adaptive Multimodal Data Processing Model Architecture

Multi-modal agricultural data processing is an adaptive multi-modal data processing model architecture based on unified feature coding, which aims to establish a method that can flexibly process and correlate data from the security and scheduling fields of multi-modal new agricultural systems[20]. This model architecture uses a frozen encoder that can spontaneously form multi-modal perception without any paired multi-modal training data. In particular, raw agricultural data from various modes are mapped to a shared token space, allowing subsequent encoders with fixed parameters to extract high-level semantic features of the input data [21].

4.3. Construction of a Corpus of New Agricultural System Security and Scheduling

The purpose of establishing the corpus of safe operation of agricultural systems is to meet the need for the safe and stable operation of a new agricultural system network. The corpus is mainly composed of a data collection layer, processing layer, storage layer, protection layer, and analysis layer. The data collection layer comprehensively collects and collates agricultural system data to ensure the quality of data information network security processing. The data processing layer adaptively pretreats, cleans, integrates, and enhances the heterogeneous agricultural data with a variety of methods[22]. The data storage layer ensures that all data is securely stored in the corpus of the secure operation of the new agricultural system network, avoiding the risk of data loss and leakage.

4.4. Distributed Computing Learning Technology Based on Federated Learning

The data of the new agricultural system has the characteristics of spanning multiple scattered devices, large and diversified data, strong data correlation, and high availability and security requirements. Federated learning can solve the problem of data dispersion by sharing model parameters among multiple data owners. Therefore, a high-performance distributed federated optimization algorithm is proposed[23,24].

4.5. Vertical Domain Large Language Model Construction Technology

Based on self-directed fine-tuning technology, external input enhancement technology, and prompt word technology, the vertical domain construction of a large language model is realized. Through the self-guidance technology, the task is generated by the pre-trained language model variant, and the generated data is used to adjust the instruction so as to improve the instruction compliance ability of the language model.

4.6. Construction Technology of Knowledge and Knowledge Graph for Safety and Scheduling of New Agricultural System

This paper aims to accurately characterize the problem of knowledge correlation and fault events in the safety and scheduling of new agricultural systems, accurately grasp the correlation between various factors, and clearly describe the evolution law of fault events by constructing knowledge and reason maps so as to provide help for subsequent intelligent decision-making.

4.7. Intelligent Decision Chain Analysis

Because large models can produce hallucinations during cognitive reasoning, and the reasoning process is a black box, their interpretability is always weak, and the reliability and security of reasoning cannot be guaranteed. Therefore, the external security and scheduling domain knowledge and reasoning map of new agricultural systems are introduced into the big-model reasoning to accurately drive the relevant decision chain in the big-model mining domain map, realize the intelligent decision of security perception and scheduling of new agricultural systems, make the reasoning process traceable, and effectively alleviate the illusion problem of the big model [25].

V. The Role of Digital Technology in Promoting Agricultural Modernization

5.1. Improve Agricultural Production Efficiency

Through precision agriculture technologies, such as Global Positioning systems (GPS), geographic information systems (GIS), and remote sensing, digital technologies can precisely control crop planting and fertilization and improve crop yields. The application of Internet of Things technology has significantly improved the level of intelligence, information, and automation of agricultural production, and agricultural production means are developing towards modernization. In addition, big data, the Internet of Things, blockchain, and other technologies can carry out large-scale land remediation and transformation work, promote the construction of high-standard farmland, strengthen the construction of water conservancy and hydropower, and enhance the ability of agriculture to resist natural risks [26].

5.2. Reduce Agricultural Production Costs

The application of precision agriculture and intelligent agricultural machinery has reduced the use of fertilizers and

pesticides and reduced agricultural production costs. Digital technology reduces labor costs, improves work efficiency, and reduces human error through automation and intelligence. For example, technologies such as intelligent oxygenation and precise feedfeeding can reduce resource waste.[27,28]

5.3. Improve the Quality of Agricultural Products

Digital technology can monitor the growing environment and growth conditions of agricultural products in real-time, find and deal with problems in time, and improve the quality of agricultural products. The Internet of Things technology can monitor environmental factors such as soil moisture, temperature, and light to provide a scientific basis for agricultural production and ensure that crops grow in the best environment.

5.4. Enhance Market Competitiveness of Agricultural Products

Digital technology helps agricultural products achieve precision marketing and improve market competitiveness. Big data analytics can understand market needs and optimize product positioning and marketing strategies. Digital technology uses big data, the Internet, and e-commerce platforms to achieve zero-distance docking between agricultural consumers and producers and accelerate the production of agricultural products with market demand and local advantages.

5.5. Achieve Sustainable Agricultural Development

Digital technology helps to realize the rational use of agricultural resources and environmental protection, as well as the sustainable development of agriculture. Precision agriculture technology reduces the use of fertilizers and pesticides, reducing the impact on the environment. The application of agricultural Internet of Things technology will transform the traditional means of fertilizer and drug application, improve the vital signs of plant growth, the accuracy of disease and pest information, effectively reduce the application amount of pesticides and fertilizers, and ensure the green and safe of agricultural products and the environment.

VI. Strategies and Suggestions for Digitalized Agricultural Modernization

5.1. Strengthen Digital infrastructure

Strengthen the construction of network infrastructure in rural areas and improve the penetration rate and application level of digital technology. Improve network coverage in rural areas, reduce the cost of network use, and ensure that farmers can easily use digital technology [29-32].

5.2. Cultivate Digital Agricultural Talents

Strengthen the training of agricultural science and technology personnel, improve their digital technology level, and cultivate a group of digital agricultural talents who understand technology and can manage. This is achieved through the establishment of agricultural technology training centers that offer both online and offline training courses.

5.3. Promote the Deep Integration of Digital Technology and Agriculture

Encourage cooperation between agricultural enterprises and technology companies, and promote the deep integration of digital technology with agricultural production, management, marketing, and other links. Establish a cooperation platform and provide technical and financial support.

5.4. Strengthen Policy Support for Digital Agriculture

The government should introduce relevant policies to support the development of digital agriculture and provide policy guarantee for agricultural modernization. Provide tax incentives, financial subsidies, technical research, development support and other policies.

5.5. Increase Farmers' Digital Awareness

Promote farmers' awareness and acceptance of digital technology through publicity and education and encourage them to actively adopt digital technology. Organize training, lectures, demonstration projects, and other ways to achieve.

VII. Conclusion

Digital technology provides new impetus and direction for agricultural modernization. The empowerment of digital technology can improve agricultural production efficiency, reduce costs, improve the quality of agricultural products, enhance market competitiveness, and achieve sustainable development. Therefore, we should strengthen the construction of digital infrastructure, train digital agricultural talents, and promote the deep integration of digital technology and agriculture.

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