

Research on the Applications of Artificial Intelligence in Agriculture

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Abstract. With the continuous growth of the global population, agricultural production faces unprecedented challenges. Traditional agricultural methods exhibit numerous deficiencies in food production, quality control, and environmental protection, necessitating urgent intervention by modern technologies. This paper investigates the application of artificial intelligence (AI) technology in the agricultural sector, exploring its significant contributions to enhancing agricultural production efficiency, precision, and sustainability. Drawing on the research findings of several scholars, this paper demonstrates specific applications of AI in soil moisture classification, unmanned aerial vehicle (UAV) thermal imaging for nest detection, and crop health monitoring. Additionally, this paper discusses the crucial role of AI technology in the modernization of agriculture in China, particularly its potential in cultivating intelligent agricultural talents and promoting high-quality agricultural development. In summary, AI is injecting new vitality into modern agriculture with its unique advantages, driving agriculture towards green and sustainable development. Through efforts in intelligent machinery, precision agriculture, and talent development, AI presents a promising outlook for its application in agriculture, offering new perspectives and solutions to address global agricultural challenges.

Keywords: AI, Agriculture, Applications.

1. Introduction

In today's society, AI technology has penetrated into all corners of people's lives, in which the application in the field of agriculture is of particular interest. The continuous growth of the world's population has brought great challenges to agricultural production, and traditional agricultural methods have revealed many shortcomings in food production, quality and environmental protection, etc. The rapid development of AI technology is injecting new vitality into agriculture, which greatly improves the efficiency, accuracy and sustainability of agricultural production [1, 2].

The application of AI technology is first reflected in intelligent agricultural machinery and automated operations, an innovation that subverts the traditional agricultural model that relies on manual operations. Driverless tractors, automated harvesters and intelligent planters, with the help of advanced sensors and AI algorithms, are able to analyze soil conditions and crop growth in real time, and autonomously adjust operating parameters to ensure the best farming results. This fully automated operation not only significantly improves production efficiency, but also significantly reduces the labor intensity of farmers and reduces the need for artificial labor. At the same time, the application of AI in precision irrigation and water resource management has also shown great potential, AI system through the analysis of soil moisture, meteorological data and the actual needs of the crop, to provide accurate water supply solutions for irrigation equipment. Intelligent irrigation system can dynamically adjust the irrigation plan according to the real-time monitoring data to ensure that the crops get the right amount of water supply, avoiding the waste of water [3]. Such a management model not only improves the efficiency of water utilization, but also promotes the healthy growth of crops and significantly improves the quality of agricultural products.

The contribution of AI in the detection and quality improvement of agricultural products should also not be ignored. Using image processing and pattern recognition algorithms, AI systems can quickly and accurately detect the appearance and quality of agricultural products. AI analyzes images of fruits, vegetables, and other agricultural products, identifying characteristics such as size, color, and blemishes, thereby improving detection efficiency and accuracy. By analyzing this data, farmers

can make timely adjustments to their planting and management strategies to further improve the overall quality of their agricultural products. In terms of agricultural data analysis and decision support, AI demonstrates a strong capability. The AI system processes and analyzes a large amount of agricultural data, including information on weather, soil and crop growth, to provide farmers with scientific decision support. By analyzing historical data and real-time monitoring information, AI is able to predict future crop growth trends and pest and disease risks, and help farmers develop scientific planting plans, thus improving the output efficiency of farmland.

Although the application of AI in agriculture has been very common, the summarized research for the application of AI in agriculture is not sufficient. For this reason, this paper analyzes the specific application of AI in agriculture in detail.

2. AI Recognizes Crops and Pest Detection

In modern society, the health and safety of food has become an issue that everyone cannot afford to ignore. Ensuring that the food on our table is healthy and harmless is one of the most important tasks in agricultural production. And in this task, AI is changing the way of crop identification and pest detection with its unique advantages. With the continuous progress of science and technology, AI has realized the accurate identification of crops and efficient detection of pests and diseases through advanced means such as image recognition, deep learning and big data analysis, significantly improving the science and efficiency of agricultural production.

2.1. AI in Crop Identification

In crop identification, AI technology has been able to quickly and accurately identify various crops by analyzing high-resolution images. Traditional methods often rely on manual experience, which is not only time-consuming and laborious, but also prone to misjudgment. The intervention of AI has completely changed the situation. AI is able to quickly and accurately identify various crops by analyzing high-resolution images. This technology not only improves the efficiency of crop management, but also helps farmers understand the growth status of crops more scientifically. For example, in some high-tech farms in Japan, AI systems are able to accurately identify crops such as rice and corn and monitor their growth using images of farmland taken by drones. By analyzing the color and shape of the leaves, AI can determine whether the crop lacks a certain nutrient and give timely advice on fertilizer application. This technology application has enabled farmers to precisely adjust their planting strategies, significantly improving the yield and quality of their crops. Another concrete example is China's smart agriculture programs. In these projects, AI systems utilize satellite images and ground sensors to monitor crop growth on millions of acres of farmland [4]. Through big data analysis, AI can provide farmers in different regions with customized planting advice, such as the best time to plant seeds, reasonable irrigation amounts and fertilization programs. These intelligent management measures significantly improve the efficiency and science of agricultural production.

2.2. AI Breakthrough in Pest Detection

Pests and diseases have always been a major challenge in agricultural production, and traditional detection methods are usually labor-intensive and susceptible to human factors. AI can automatically analyze pest and disease images in farmland through deep learning and pattern recognition technologies, detect pests and issue early warnings in a timely manner. For example, in vineyards in California, the AI system utilizes high-resolution cameras to capture images from grapevines, identifying early stages of downy mildew and grapevine sporotrichosis, and notifying farmers in time to take appropriate control measures [5]. This not only improves the efficiency of pest control, but also reduces the use of pesticides and protects the environment.

In India, the AI platform identifies and predicts pest outbreak trends in the cotton crop by analyzing millions of farmland images. Based on historical data and meteorological conditions, the system

successfully predicted the peak season of aphids and bollworms, enabling farmers to take precautionary measures in advance and reduce crop losses. This prediction and early warning function greatly improves farmers' ability to cope with pests and ensures the healthy growth of crops.

More importantly, AI can predict the trend of pest outbreaks based on historical data and meteorological conditions, providing farmers with advice on early prevention. For example, in some areas, the AI system successfully predicted the peak of this year's aphid outbreak by analyzing weather data and pest and disease occurrence records over the past few years, enabling farmers to take precautions in advance and reduce crop losses.

The success of AI in crop identification and pest detection cannot be separated from the support of deep learning and big data analysis. Deep learning algorithms are able to learn features from a large number of images of crops and pests and continuously improve the accuracy of recognition. Big data analytics, on the other hand, helps AI systems find patterns in the vast amount of data and make more accurate predictions and decisions. On a smart agriculture platform, the AI system builds a huge database by analyzing millions of crop images [6]. Farmers only need to upload photos of their farmland, and the system can quickly recognize the type of crops and their growth conditions, and provide appropriate management advice. This intelligent management mode not only improves the efficiency of agricultural production, but also reduces the management costs of farmers. In conclusion, the application of AI in crop identification and pest detection not only improves the efficiency and accuracy of agricultural production, but also provides farmers with scientific planting management programs [7]. With the continuous progress of technology, AI will continue to play an important role in the field of agriculture, promoting the development of agriculture in the direction of intelligence and refinement, and ensuring that the food on our table is safer and healthier.

3. Agricultural Robot

Agricultural robots are one of the important directions in the development of modern agriculture. These robots are controlled by different program software, adapted to the needs of various agricultural operations, equipped with functions such as visual detection and intelligent algorithms, and capable of sensing and adapting to changes in crop types or the environment. Agricultural robots have been widely used in greenhouse agriculture in the Netherlands. These robots perform a variety of tasks from sowing to harvesting through precise navigation and control systems.

- Sowing and Transplanting

The use of agricultural robots for sowing and transplanting can significantly improve efficiency and precision. A typical example is the “See & Spray” robot developed by Blue River Technology in the U.S., which utilizes computer vision technology to identify weeds and crops in the field and realize precise spraying of herbicides. This not only reduces the amount of chemicals used, but also improves crop yields and quality. Certain farms using this technology have seen a 90% reduction in pesticide use and a 20% increase in crop yields. This precision farming technique not only reduces costs but also reduces the negative impact on the environment.

- Fertilizing and Spraying

Traditional methods of fertilizing and spraying suffer from uneven dosage, waste and environmental pollution. Agricultural robots, through precision agriculture technology, can apply fertilizers and sprays in quantitative and targeted amounts according to the actual needs of crops. For example, Japan's Yamaha has developed a drone that can perform automated spraying operations in orchards. Through GPS positioning and sensor feedback, the drone can realize the precise management of each fruit tree. In practice, by using this drone in an orchard, the efficiency of pesticide and fertilizer use has increased by 30%, significantly reducing environmental pollution.

- Harvesting and Sorting

Harvesting is one of the most laborious aspects of agricultural production, especially for crops such as fruits and vegetables that need to be picked manually. Agricultural robots can automate harvesting and sorting through robotic arms and vision recognition systems. For example, the

strawberry picking robot developed by Agrobot in Spain greatly improves picking efficiency and quality by recognizing ripe strawberries and picking them accurately. In a specific case, a farm after using this robot, strawberry picking efficiency increased by 40%, reducing the dependence on human labor, and because of the precise picking to reduce fruit damage, product quality has also been improved. Fig. 1 illustrates AI robots harvesting fruits.



Figure 1. Agricultural intelligence enters the "just-needed era"[6]

The emergence and development of agricultural robots have greatly changed the traditional way of agricultural labor, improved the efficiency of agricultural production and promoted the development of modern agriculture. They can perform a variety of tasks, including but not limited to fertilization, weeding, harvesting, picking and so on. With precise navigation and control systems, these robots are able to operate autonomously in farmland, reducing reliance on human labor while lowering agricultural costs. Globally, many countries are actively researching and developing agricultural robotics. These robots not only improve agricultural productivity, but also help solve the problem of agricultural labor shortage. With the continuous progress of technology, agricultural robots will play a more important role in the future and promote the sustainable development of agricultural production.

4. The Role of AI in Agricultural Transportation

With the continuous advancement of global agricultural modernization, AI is playing an increasingly important role in the field of agricultural transportation. The application of AI technology not only greatly improves transportation efficiency and accuracy, but also optimizes resource allocation, reduces costs, and promotes green and sustainable development. This thesis will deeply explore the specific application of AI in agricultural transportation, analyze the extensive impact it brings, and elaborate in detail with real cases [8].

- Intelligent Planning and Optimization

AI technology can optimize the process of agricultural transportation through big data analysis and intelligent planning, significantly improving transportation efficiency. For example, China's logistics giant Jingdong (JD.com) uses AI systems to develop optimal transportation routes by taking into account traffic conditions, weather conditions, cargo attributes and real-time order quantities. JD Logistics, Jingdong's intelligent logistics platform, implements dynamic route optimization, and this optimization technology enables Jingdong to maintain efficient logistics and distribution services during large-scale promotional events such as Double Eleven, greatly reducing delivery time and operating costs. In addition, the AI system can use predictive maintenance models to identify possible problems in the transportation process in advance. DHL, a German transportation and logistics company, uses AI for equipment predictive maintenance to reduce transportation delays caused by equipment failures by analyzing the historical operating data of the equipment and predicting potential failure risks. These intelligent transformations and the ability to improvise significantly reduce ineffective time and costs in the transportation process and improve overall operational efficiency.

- Demand Forecasting and Inventory Optimization

AI analyzes historical sales data and market dynamics through machine learning algorithms to accurately predict demand for agricultural products and thus optimize inventory management. Walmart uses AI technology to analyze store sales data and external factors (e.g., weather, seasonal changes, local events, etc.) to achieve highly accurate demand forecasts, reducing overstock and out-of-stock issues. Walmart's machine learning models are able to predict demand for goods up to four weeks in advance, enabling highly coordinated logistics and supply chain collaboration. Similarly, in the agriculture sector, Cargill uses AI predictive models to optimize its grain supply chain management. By analyzing data such as customer orders, weather forecasts, and global market trends, Cargill is able to accurately predict grain demand and optimize transportation and warehousing plans. In 2017, the company used AI technology to successfully respond to the global food supply chain volatility caused by the “La Niña” climate, avoiding food supply shortages and price fluctuations caused by extreme weather. Demand forecasting and inventory optimization not only improves supply chain response speed and accuracy and reduces waste and costs, but requires significant investment in data collection and model optimization to respond to dynamic changes in the market.

- Automation and Unmanned Transportation

In the field of agricultural transportation, the application of automation and unmanned operations greatly reduces the reliance on human resources and improves transportation safety and efficiency [9, 10]. Iron Ox, a California-based company, utilizes fully automated robotic systems for harvesting, packing, and transporting crops. Iron Ox's self-driving trucks and drones are capable of autonomously completing transportation tasks from farms to warehouses, realizing logistics and distribution without human intervention throughout the entire process. In addition, the company uses AI-based visual recognition technology to ensure the quality and safety of agricultural products during transportation [11]. In contrast, Switzerland's Zipline uses drone technology to deliver medicines and blood to hard-to-reach remote areas. Operating in Rwanda and Ghana since 2016, Zipline's drones are able to deliver much-needed medical supplies to clinics in a fraction of the time through AI control and optimization. Zipline's operational data shows that these drones significantly reduce transport time and costs, especially in areas with incomplete infrastructure, and provide the perfect solution for emergency medical transportation.

- Real-time Monitoring and Management

Using AI and Internet of Things (IoT) technologies, real-time monitoring and management of the agricultural transportation process has been greatly improved. Bayer Crop Science, a precision agriculture company in the Netherlands, has developed an intelligent monitoring system that combines smart sensors and AI algorithms to monitor key parameters such as temperature, humidity, and vibration during the transportation of agricultural products in real time. Fig.2 Smart agriculture - Enabling the modernization of agriculture and high-quality development [9]. During the transportation of grapes, the system is able to detect and adjust the temperature to ensure that the grapes are stored and transported in the most appropriate conditions, avoiding quality degradation due to temperature changes. Lineage Logistics, a U.S.-based cold chain transportation company, also uses AI technology to monitor cold chain transportation comprehensively. Working with an AI data analytics platform, the company monitors the temperature and humidity inside refrigerated trucks in real time and uses machine learning algorithms to predict potential temperature anomalies. Lineage Logistics not only improves the reliability of cold-chain transportation, but also drastically reduces the amount of food wasted due to temperature issues, saving its customers millions of dollars annually [12].



Figure 2. Smart agriculture - Enabling the modernization of agriculture and high-quality development [9]

- Green and Sustainable

Artificial Intelligence promotes green and sustainable development of agricultural transportation. AI helps protect the environment by optimizing transportation routes and reducing fuel consumption. For example, the AI system jointly developed by Microsoft and Royal Dutch Shell reduces fuel consumption and carbon emissions by optimizing ship routes and speeds. This technology is also applicable to land transportation and can effectively reduce the carbon footprint in agricultural transportation. Climate Corporation, a leading global agri-tech company, uses AI technology to analyze and optimize planting options, reducing wasted resources in agricultural production and transportation. The company's FieldView platform monitors environmental data on farmland in real time and uses AI models to predict crop growth and help farmers develop optimal planting and transportation plans. This precision agriculture technology not only improves crop yield and quality, but also reduces the use of pesticides and fertilizers, promoting sustainable agriculture.

5. Optimization of AI in Farming

- Intelligent Agricultural Machinery and Automated Operations

AI technology combined with intelligent farm machinery realizes the automation and intelligence of agricultural operations. For example, equipment such as driverless tractors, harvesters and planters are able to accurately complete operations such as tilling, seeding, fertilizing and spraying in farmland. Equipped with advanced AI algorithms, these devices are able to analyze soil conditions and crop growth in real time and automatically adjust operating parameters. For example, during fertilizer application, the driverless tractor will automatically adjust the amount of fertilizer applied according to the nutrient content of the soil, thus achieving the best fertilizer application effect. Traditional agriculture relies on manual operation, which is less efficient and prone to human error. ai agricultural machinery not only improves operational efficiency, but also reduces the workload of farmers and reduces labor dependency. In addition, intelligent agricultural machinery can also effectively reduce resource waste and environmental pollution through precise operation.

- Precision Irrigation and Water Management

The application of AI technology in agricultural irrigation can realize intelligent water resource management. By analyzing soil moisture, meteorological data and the water demand of crops, AI systems can provide precise water supply solutions for irrigation systems. For example, by using sensors to monitor soil moisture, intelligent irrigation systems can dynamically adjust irrigation schedules according to actual needs, ensuring that crops are supplied with sufficient water without waste. For example, the drip irrigation system developed by Israel's Netafim realizes precise irrigation through sensors and AI algorithms, significantly saving water resources. Compared with traditional diffuse irrigation, precision irrigation not only improves the efficiency of water utilization, but also promotes the healthy growth of crops and improves the quality of agricultural products.

- Agricultural Product Testing and Quality Improvement

While traditional agricultural product inspection usually relies on manual observation, which is inefficient and subjective, the AI system not only improves inspection speed and accuracy, but also provides planting improvement suggestions through data analysis to improve the overall quality and market competitiveness of agricultural products [12].

AI's image processing and pattern recognition algorithms excel in agricultural product inspection and quality control. For example, through machine vision technology, AI systems can quickly and accurately identify quality characteristics such as the size, color, and blemishes of fruits, which significantly improves detection efficiency and accuracy. In addition, AI can analyze the growing environment and cycle of agricultural products, predict quality trends, and provide farmers with suggestions for improving planting techniques.

- Ecosystem Monitoring and Protection

AI technology also plays an important role in agroecosystem monitoring and natural environment protection. Through sensor networks and big data analysis, AI can monitor the health of ecosystems in real time, assess the impact of agricultural activities on the environment, and propose targeted protection measures. For example, by monitoring the pollution of soil and water sources, AI can help farmers take effective environmental protection measures to realize green agricultural production. Traditional ecosystem monitoring usually relies on manual sampling and analysis, which is slow and limited in coverage. AI technology enables real-time monitoring and large-scale data collection, which can identify problems in a more timely and accurate manner, propose scientific environmental protection solutions, and promote sustainable agriculture.

6. Conclusion

The application of AI in agriculture has proven to be transformative, addressing various challenges and enhancing productivity. AI technologies, such as machine learning, computer vision, and robotics, have been instrumental in pest detection, crop monitoring, and automated farming processes. These advancements have enabled more precise and efficient agricultural practices, reducing the reliance on manual labor and traditional methods. Furthermore, AI has optimized supply chain logistics, ensuring better resource management and minimizing waste. The integration of AI in irrigation, pesticide application, and quality assessment has significantly improved crop yields and sustainability.

AI-driven pest detection systems use sophisticated algorithms to identify and categorize pests, allowing for targeted and timely interventions. This precision reduces the need for broad-spectrum pesticides, mitigating environmental impact and promoting healthier crops. Robotic systems in agriculture have also made substantial contributions by automating labor-intensive tasks such as planting, weeding, and harvesting. These robots are equipped with advanced sensors and AI algorithms to perform tasks with high accuracy and consistency, further enhancing productivity and reducing labor costs. The application of AI extends beyond the farm to include post-harvest processes and supply chain management. AI technologies are used to assess the quality of harvested produce, sort and grade crops, and predict market demand. This ensures that only high-quality products reach consumers, reducing waste and maximizing profits for farmers.

In summary, the integration of AI in agriculture is revolutionizing the industry, offering solutions to long-standing challenges and paving the way for a more sustainable and efficient agricultural future. As AI technologies continue to advance, their applications in agriculture are expected to expand, further enhancing food security and environmental conservation. The promising developments in AI-driven agriculture underscore the potential for significant advancements in the coming years, making it a critical area of focus for researchers, policymakers, and practitioners alike.

References

- [1] Wang Y., & Zheng, Z.. Artificial Intelligence Technology in the Field of Agriculture: Application Directions and Development Paths. *Information and Communication Technology and Policy*, 45 (6), 29-31, (2019).

- [2] Jiang X. A Review of the Application of Artificial Intelligence in Modern Agriculture in China. DOI: Cnki:sunxdxk.0.2019-05-068, (2019).
- [3] Wang T. Agricultural Artificial Intelligence Technology: The Wings of Modern Agricultural Science and Technology. <https://journal.scau.edu.cn/cn/article/doi/10.7671/j.issn.1001-411X.202008045>, (2020).
- [4] Ding T. Wu M. Application and Prospects of Artificial Intelligence in Agricultural Development. DOI: CNKI:TXSJ.0.2019-09-231, (2019).
- [5] Li X. Ma D. Agricultural Artificial Intelligence Technology: The Wings of Modern Agricultural Science and Technology. https://xuebao.scau.edu.cn/zr/html/2020/6/2020_0601.htm, (2020).
- [6] Agricultural intelligence has entered the "just-needed era", and Weishi Intelligent machine Vision Laboratory enables the training of new agricultural talents. - Industrial Control Information - Industrial Control Classroom (gkkt.com).
- [7] Li, M., Ma, X., Zhang, H., Zhou, M., Wang, J., & Duan, G.. Smart Agriculture—Applications and Prospects of AI in the Field of Agriculture. <https://xueshu.baidu.com/usercenter/paper/show?paperid=efdc3efbd78aff4894dddde24c79b5c2>.
- [8] Cunbing G. Discussion on Application and Development Path of Artificial Intelligence Technology in China Agricultural Field. 2020 International Conference on Artificial Intelligence and Education (2020).
- [9] Tang Huajun: Smart agriculture -- Enabling the modernization and high-quality development of agriculture! - Gansu Sea Innovation Energy Technology Co., LTD. (helio-innova.com)
- [10] Gao X, Lu T, Liu P, et al. A Soil Moisture Classification Model Based on SVM Used in Agricultural WSN, 2014 IEEE 7th Joint International Information Technology and Artificial Intelligence Conference (2014).
- [11] Santangeli A, Chen Y, Klue E, et al. Integrating drone-borne thermal imaging with artificial intelligence to locate bird nests on agricultural land. Scientific Reports, 10 (1), (2020).
- [12] Bhadu A. Application and Participation of Artificial Intelligence in Agriculture. Journal of University of Shanghai for Science and Technology, (2021).