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Exploration of the application of artificial intelligence in modern agricultural production—Take orchard management as an example

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Abstract. In the context of increasing global agricultural challenges, the application of artificial intelligence technology in the agricultural field is increasingly a trend, especially in the production of agricultural products, intelligent identification technology has shown the potential to significantly improve production efficiency and optimize yield and quality. By the mid-21st century, demand for food production is expected to reach 50 percent, and there will be enormous pressure to achieve this goal with traditional agricultural technologies, which could be achieved through the application of artificial intelligence. The application of artificial intelligence technology in modern agricultural production will be analyzed in detail in this paper, the guidance of future research fields will be proposed, and the existing challenges and technical problems will be identified and discussed in order to promote the deepening and wide application of intelligent agriculture. This paper specifically discusses examples of applications in orchard management, pest detection, and automated harvesting and summarizes the effectiveness and obstacles of these techniques.

Keywords: Agriculture Intelligence, artificial intelligence, intelligent identification technology, orchard management

1. Introduction

Technology-intensive agricultural production mode has gradually replaced the traditional labor-intensive mode, which is particularly critical in agriculture, the basic industry of human society. In recent years, the progress of deep learning and computer vision technology has significantly promoted the application of artificial intelligence in agricultural production. As a major apple producer, China needs to consume a lot of manpower and material resources in its picking stage. Therefore, China gradually began to develop intelligent agriculture. In the fields of fruit and vegetable cultivation management, disease and pest warning, and agricultural harvesting automation, advanced identification technologies, such as YOLOv5-driven target detection algorithms, have shown significant potential and efficiency [1]. The modern agricultural landscape is witnessing an unprecedented foray of Artificial Intelligence (AI) technology, which is profoundly transforming productivity and output quality through sophisticated smart recognition mechanisms. Focusing particularly on the intricate dynamics of orchard management, we uncover AI's exceptional capabilities in pinpointing diseases and pests with accuracy, and its transformative influence on the sphere of automated harvesting. Within the domain of crop yield, the

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assimilation of AI has unleashed a significant surge in operational efficiency, lessened dependence on manual labor, and fostered superior-grade produce, thereby escalating their competitive edge in the market. Bridging the gap between practical agricultural situations and extensive scholarly research, this investigation sheds light on the myriad uses and technological prowess of AI in farming, ultimately striving to propel the growth of China's agricultural sector [2].

2. Overview of intelligent agricultural technology applications

The infusion of artificial intelligence into the fertile soil of agricultural methods is sowing the seeds of a groundbreaking revolution, fundamentally reforming the way we nurture and reap the bounties of our earth. The labor-intensive conventional farming approach frequently struggles with inefficiencies and precision deficits. Thanks to cutting-edge artificial intelligence technologies, including big data analysis, computer vision and image recognition technologies, automated and intelligent agricultural production has been realized. Fruit tree cultivation and management is a key stage of agricultural production, covering many fields such as planting technology, pruning process, irrigation and fertilizer application as shown in figure 1. For example, Liu Zilong et al. proposed the upgraded YOLOv5 algorithm, combined with the coordinate attention mechanism, perceptron components and adaptive spatial feature fusion strategy, which can significantly improve the efficiency of apple growth monitoring [1]. Intelligent irrigation and fertilization systems, based on artificial intelligence technology, accurately evaluate the water and nutrient needs of crops and realize accurate irrigation and fertilization to reduce resource consumption. By integrating artificial intelligence technology into orchard operations, not only can the environmental burden be reduced, but also the management efficiency can be significantly improved, thus promoting the development of green and sustainable agriculture.

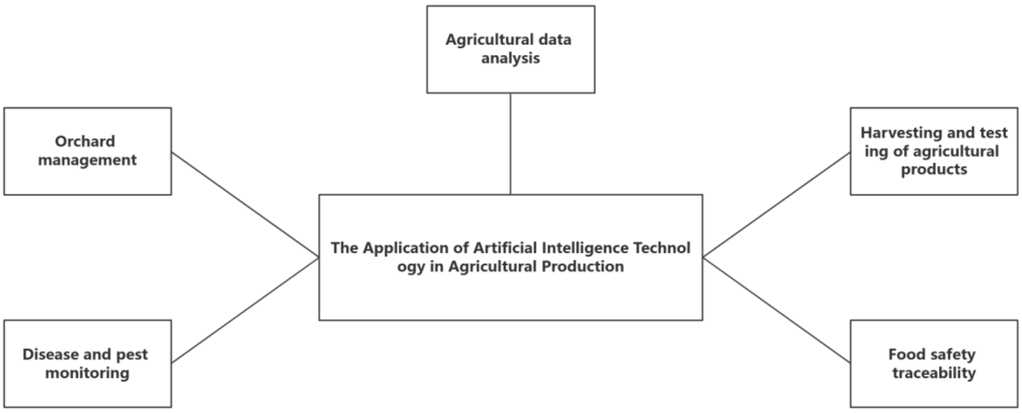

Figure 1. The relationship diagram of AI application in agriculture

3. Specific application of artificial intelligence in orchard management

3.1. Application in the monitoring of diseases and insect pests

In the process of crop production, the pests and diseases always constitute a major agricultural challenge. The occurrence of major crop diseases and insect pests may lead to a significant decline in yield and cause irreversible damage to national agriculture and peasant household economy. Real-time crop health monitoring can be achieved by using image recognition technology and using deep learning methods to achieve pest control. With the help of remote sensing technology and Internet means, the detection of diseases and pests of crop plants can be implemented, which can accurately identify diseases and pests. For example, Shi Jialu et al. proposed that through image acquisition technology to analyze the plants affected by diseases and pests, we can identify the specific pest category[3]. Through the interaction of image recognition technology and the Internet, these functions can be realized; on the other hand, convolutional neural network (CNN) can also play a key role by learning the images of a large number of diseases and pests, automatically extract and identify the unique characteristics of diseases and pests, improve the accuracy of diseases and pest diagnosis, enable farmers to take effective control measures and reduce pesticide dependence.

3.2. Application in agricultural product harvest

As the amber glow of fall blankets the countryside, farmers delve into the strenuous endeavor of harvesting nature's abundance.For ages, Chinese agriculture has been steeped in labor-intensive techniques and rudimentary tools, a centuries-old tradition that now stands in stark contrast to the rapid advancements in artificial intelligence. The drawbacks of these conventional approaches have increasingly become evident, primarily their time-consuming nature, physical rigor, and, sadly, the risk of crop wastage and inefficient resource utilization. However, the emergence of AI technology signals a paradigm shift, ushering in an era of smart and autonomous farming. This revolutionary innovation not only amplifies crop yields exponentially but also fortifies the financial robustness and competitive stance of the agricultural sector. A groundbreaking revolution lies in an innovative visual system, skilled in decoding the intricate layers of crop canopies. This paves the way for a deeper comprehension of the spatial dynamics that unfold within fruit orchards, ensuring the seamless and optimized operation of robotic harvesters. The secret to unlocking the latent power of our farming techniques resides in this trailblazing technology [4]. As proposed by Gao Rongliang, integrating image recognition with the might of big data can create algorithmic models that mimic and elevate existing harvesting approaches. By harnessing the power of data analytics, it refines operational routes and tactics, thus amplifying productivity. Agricultural robots, armed with intelligent recognition technology, can now accurately identify ripened fruits and execute their picking duties with remarkable precision, thereby significantly boosting harvest quantities and reliability [5]. By leveraging advanced artificial intelligence systems and fusing them with cutting-edge camera and sensor technologies, the exact pinpointing of fruits amidst complex agricultural terrains becomes achievable. As a result, a dexterous robotic arm performs the harvesting task with a delicate touch, ensuring minimal fruit bruising and maximum crop yield. This innovative approach caters to the escalating need for streamlined and efficient agricultural output, appealing to a broader audience concerned with sustainable food production.

3.3. Application in agricultural product detection

As scientific advancements march forward, the bar for product excellence is consistently raised. In the realm of agricultural produce assessment, conventional approaches fall short due to their sluggish pace and susceptibility to human bias. By harnessing the power of image recognition technology and sophisticated machine learning algorithms, we can promptly and precisely evaluate both the external appearance and hidden quality of agricultural goods, revolutionizing the industry. Step-by-step classification benefits from the optimized image recognition algorithm. By detecting the color, shape, and size of fruits and vegetables, we efficiently screen high-quality products, improve the quality utilization rate of various products, and reduce loss.

3.4. Application in data analysis

Accurate agricultural data analysis plays a crucial role in shaping national agricultural development strategies. Leveraging artificial intelligence technology to optimize agricultural data analysis can effectively provide more precise and robust support for the country's agricultural strategies. In a recent study conducted by Ye Ting and her team in 2022, they explored the application of data mining in the agricultural sector. The research highlighted the significant potential of integrating data mining technology into agricultural production to improve the efficiency and scientific validity of agricultural management and operations[6].

By tapping into the capabilities of artificial intelligence, a profound comprehension of agriculture's past and present scenarios unfolds, shedding light on the essence of crop vitality, weather fluctuations, and soil attributes. This knowledge equips farmers with the tools to devise sharper and more efficient cultivation approaches. A predictive model, powered by the LSTM algorithm's sophisticated memory, accurately forecasts optimal planting and harvesting moments, aligning with crop life cycles and meteorological data. Integrating cutting-edge recognition technology and extensive data analysis, the incessant well-being of crops is diligently monitored, facilitating immediate interventions and insightful choices.This pioneering approach empowers farmers with the skill to promptly detect and remedy any agricultural mishaps, thereby mitigating potential hazards and reducing losses significantly. As a result, it boosts the overall efficiency of farming endeavors. Furthermore, the groundbreaking fusion of Artificial Neural Networks (ANN) and Multi-Objective Genetic Algorithms (MOGA) revolutionizes the way energy consumption and greenhouse gas emissions in fruit farming are modeled, paving the way for their optimal management[7].

3.5. Application in the traceability system of agricultural products

At the core of agricultural produce consumption lies the pivotal concern of food security, a decisive factor that profoundly influences the well-being and existential peace of mind of consumers. Ensuring food safety through conventional means, such as rigorous laboratory assessments and painstaking visual inspections, often entail intricate procedures and lengthy durations. In this context, the groundbreaking integration of artificial intelligence technology into developing a smart traceability system promises to greatly enhance protective measures, thereby revolutionizing the entire domain of food safety.

By harnessing sophisticated intelligent recognition technology alongside the robust backbone of blockchain technology and profound data insights, a revolutionary Smart Traceability ecosystem can be forged for seamless and all-encompassing food safety oversight and authentication. This cutting-edge system knits together smart labeling and the magic of QR codes, weaving a comprehensive narrative of food's journey from inception to delivery. In the fertile landscape of agriculture, this technology takes center stage, seamlessly uploading details of provenance and cultivation into the unalterable blockchain ledger, thereby fortifying the reliability of agricultural information. Furthermore, stealthy sensors nestled within the packaging serve as diligent guardians, monitoring environmental conditions and product integrity throughout their voyage, ensuring that only the highest quality offerings reach the hands of consumers

4. Future prospects and existing challenges

Although in the process of intelligent agricultural production, artificial intelligence technology has shown great development, but its popularization and implementation are still facing significant obstacles. Yuan Shufang mentioned in her publication "Discussion on the Application of Artificial Intelligence Technology in Intelligent Agriculture Production" that in the complex agricultural ecological environment, the accuracy of intelligent identification may encounter challenges, and it is necessary to continue to optimize the algorithm and expand the data sample database[8]. The high cost of introducing a large number of advanced equipment into modern agriculture is also a big problem. Globally, small farms account for a third of the total, compared with 80 percent in China, putting a heavy burden on many small farmers. Implementing a collaborative farming paradigm and fostering a spirit of collective endeavor could dramatically reshape the economics of rural regions. Coupling this innovative approach with state-of-the-art machinery and technological advancements paints a promising picture. However, the hurdles of limited tech penetration and farmers' inadequate technical prowess call for intensified efforts in knowledge dissemination, training programs, and skill-enhancing seminars. These steps would facilitate the seamless integration of intelligent agricultural innovations. Furthermore, the pivotal role of supportive policies and industry backing in hastening the adoption of smart agri-tech solutions cannot be overlooked. The crucial role of government involvement is undeniable, especially when it comes to empowering small-scale farmers with state-of-the-art tools and technological know-how. Through sponsorships and financial assistance, governments foster a paradigm shift in agriculture, boosting overall productivity. This empowerment doesn't just energize farmers; it ignites a transformative agricultural revolution, opening up new horizons in the domain.

5. Conclusion

A comprehensive delve into the realm of intelligent agriculture reveals the far-reaching impact and pervasive presence of artificial intelligence within the fertile soil of farming. It has revolutionized conventional farming methodologies, uplifting productivity and accuracy to unparalleled levels, and skillfully harmonizing resource allocation for enhanced crop quality. This discussion uncovers the unique contributions of mammoth data analysis, intricate deep learning algorithms, perceptive computer vision, IoT-driven sensor networks, revolutionary robotics, unmanned aerial vehicles (UAVs), and cutting-edge remote sensing technology. These interconnected innovations form a robust scaffold, propelling the evolution of modern agriculture.

Despite the progressive infiltration of intelligent agricultural technology, certain limitations persist. Sensors and Internet of Things (IoT) devices, though prolific data generators, still call for enhancements in data precision and reliability. Likewise, the promise of deep learning and computer vision technologies is conditional upon the caliber of data sets and the refinement of algorithms. The realm of agricultural robotics encounters challenges in navigational exactitude and economic feasibility. Though Unmanned Aerial Vehicles (UAVs) and remote sensing technology offer comprehensive surveillance, their operational reach and monitoring intensity could be more robust.

In the realm of future exploration, several key areas warrant attention. Primarily, advancements in data acquisition and processing methodologies are crucial to guarantee the excellence and uniformity of data. Secondly, refining deep learning algorithms and computer vision techniques can significantly enhance their efficacy within the agricultural domain. Concurrently, it's imperative to lessen the financial burden associated with agricultural robotics while boosting their operational precision. In conclusion, the exploration of Unmanned Aerial Vehicles (UAVs) and remote sensing technology must push beyond conventional limits to forge advanced and resilient instruments for agricultural oversight and governance. The realm of intelligent agriculture ushers in a fresh era of eco-conscious farming progress, revealing a wealth of untapped potential. Despite current challenges, the relentless evolution and enhancement of these technologies augur a pivotal role for smart agriculture in the future. It stands ready to significantly influence global food security and foster the sustainable transformation of agricultural methods across the globe.

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