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Research on Urban Agriculture Scene Innovation Driven by Generative AI

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Abstract: With the acceleration of urbanization and the intensification of the impact of climate change, traditional urban agriculture is confronted with challenges such as tight resources, low production efficiency, and complex management. Generative artificial intelligence (GAI), as an emerging technology, has provided a new path for the intelligent transformation of urban agriculture with its powerful data modeling and content generation capabilities. This article analyzes the compatibility of generative AI with urban agriculture from both theoretical and technical perspectives, explores its specific application scenarios in production optimization, marketing innovation, and farmer education, and summarizes the current problems, such as agricultural data silos, model adaptability, cost, and talent shortages. Research shows that generative AI can drive urban agriculture to shift from experience-dependent to intelligent decision-making, enhancing resource utilization efficiency and industrial sustainability. However, its wide application still requires the collaborative support of multiple parties, including policies, technologies, and talents.

Keywords: Generative artificial intelligence; Urban agriculture; Scene innovation; Smart agriculture; AIGC

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1. Introduction

1.1. Research background

Urban agriculture is the embodiment of modern agriculture in cities. It serves as both an ecological security barrier for cities and a key carrier for the green transformation of industries, shouldering the significant mission of promoting agricultural modernization and facilitating the integration of urban and rural areas [1]. With the acceleration of urbanization and the intensification of climate change, traditional urban agriculture is confronted with multiple challenges: tight land resources, rising production costs, and the difficulty in adapting to the complex urban environment relying on traditional experience. At the same time, consumers' higher demands for the quality of agricultural products have further increased the pressure on production management.

In the digital age, generative artificial intelligence (such as GPT technology) brings new opportunities to

urban agriculture. This technology can be deeply integrated with urban agriculture, facilitating its transformation, and is of great significance for ensuring food security. For instance, as a megacity, Shanghai has limited arable land and a low self-sufficiency rate of vegetables, with the majority relying on imports from other regions [2]. Generative AI can optimize resource utilization, enhance the risk-resistance capacity of agriculture, and thereby improve the level of food security guarantee.

From a technical perspective, generative AI can handle complex agricultural data, assist in precise decision-making, and reduce the decision-making costs for farmers. In terms of policy, the Ministry of Agriculture and Rural Affairs' "National Smart Agriculture Action Plan (2024–2028)" sets the goals of achieving an agricultural production informatization rate of 30% and 32% by 2026 and 2028, respectively [3]. The State Council's "Opinions on Deeply Implementing the 'Artificial Intelligence Plus' Action" also emphasizes promoting the digital and intelligent transformation of agriculture, providing strong support for the scene innovation of generative AI in urban agriculture [4].

1.2. Overview of generative AI

Generative Artificial Intelligence is a branch of artificial intelligence technology that generates text, images, sounds, videos, codes, and other content based on algorithms, models, and rules. It mainly includes generative adversarial networks (GANs), variational autoencoders (VAEs), autoregressive models (such as the GPT series), diffusion models, Flow-based models, etc. Its technology is mainly reflected in its powerful language understanding and generation capabilities, which can learn the complex structures and expressions of languages from massive amounts of data through pre-training, thus performing outstandingly in various language tasks [5]. Generative AI has six major advantages in the agricultural field: creative generation, data augmentation, supplementation of missing data, multimodal generation, style transfer and transformation, and creative assistance [6]. Therefore, it can be combined with urban agriculture to solve the current predicament of urban agriculture.

2. Analysis of the compatibility between generative AI and urban agriculture

2.1. Theoretical compatibility

Generative AI uses Parameter Fine-tuning (PEFT) technology to prevent pests and diseases. This technology enables the model to quickly adapt to specific tasks, such as agricultural pest and disease Q&A and control plan generation, with only a small number of parameters updated by the LLM. However, the above-mentioned technology has some drawbacks. This can be addressed by constructing an agricultural knowledge graph and dynamically injecting the information of the knowledge graph into the LLM context through retrieval enhancement generation (RAG). In this way, the relevant systems, based on environmental data, intelligently reason and generate personalized agricultural procedures, promptly answering farmers' questions during the planting process.

Generative AI utilizes large-scale, multimodal data, understands the underlying structure of the data through deep learning models, and accomplishes tasks such as simulation, prediction, and generation. Urban agriculture also requires the utilization of large-scale and multimodal data, but it is necessary to understand the complex relationship between various environmental variables and crop growth, so as to simulate the growth status of crops, predict crop yields and pest and disease conditions, and generate the optimal planting plan. The paths of the two are consistent. Generative AI can provide a powerful engine for urban agriculture.

In terms of goals, generative AI pursues personalized output, possesses context awareness and adaptive

capabilities, as well as ultimate efficiency. Urban agriculture needs to provide agricultural products with different requirements for different groups of people in the city. It should be aware of the fluctuations in the internal and external environment, adjust the plan in a timely manner, and at the same time achieve the maximum output with the minimum resource input. From this, it can be seen that both generative AI and urban agriculture are striving to achieve personalized optimal solutions under constraints.

2.2. Technical compatibility

Generative AI uses Parameter Fine-tuning (PEFT) technology to prevent pests and diseases. This technology enables the model to quickly adapt to specific tasks, such as agricultural pest and disease Q&A and control plan generation, with only a small number of parameters updated by the LLM. At present, there are mainly three types: LoRA, Adapter, and Prompt Tuning. All three types of PEFT technologies can maintain the original language capabilities of LLM while endowing them with rich professional knowledge of agricultural pests and diseases. They also feature high training efficiency and low deployment costs, meeting the actual application scenarios of urban agriculture. However, the above-mentioned LLM has some flaws. These can be addressed by constructing an agricultural knowledge graph and dynamically injecting the information of the knowledge graph into the LLM context through retrieval enhancement generation (RAG). In this way, the relevant systems, based on environmental data, intelligently reason and generate personalized agricultural procedures, promptly answering farmers' questions during the planting process.

In terms of meteorological environment, the cross-modal generation technology of generative AI can be utilized to automatically convert meteorological data into planting plans and then automatically transform them into visual reports, demonstrating the automation from data to decision-making. Meteorological data is input into AI, which converts it into planting plans by leveraging time series data understanding and prediction, knowledge graph and rule embedding, prompt word engineering, and text generation technologies. After obtaining the above planting plan, input the text plan into the system and use tools such as the chart generation tool of the diffusion model to generate corresponding charts, line graphs, Gantt charts, etc. Finally, the original meteorological data, generated text, and charts are input into the system. Through multimodal large models, layout generation and content generation, and natural language generation, a relatively complete report is obtained.

When making decisions, although the traditional cloud computing architecture has advantages in data processing capabilities, it cannot guarantee real-time decision-making in agriculture, solve the problems of data privacy protection, and network dependence. Edge computing, by sinking computing, storage, and analysis capabilities to the vicinity of data sources and integrating them with lightweight artificial intelligence models, is becoming a key technological force driving the evolution of urban agriculture from digitalization to intelligence.

3. Innovation in application scenarios

3.1. Production optimization

The combination of urban agriculture and generative AI can bring new ideas to urban agriculture in terms of production. Take China Mobile's "Wanxiang Gengyun" agricultural large model as an example. This model utilizes intelligent production management and decision-making technologies. Its intelligent early warning capability for agricultural conditions builds a disaster prevention shield through multi-source data, combined with satellite remote sensing and Internet of Things sensors, to detect agricultural disasters as early as possible.

Relying on the linkage of soil moisture monitoring and meteorological early warning, intelligent control of irrigation equipment is carried out to enhance fertilizer utilization rate and water-saving efficiency, and a "water-saving—yield-increasing" dual-effect mechanism is established. This model also employs satellite remote sensing combined with unmanned aerial vehicle (UAV) field patrol, which can predict yield fluctuations in advance and provide suggestions for production decisions. Generative AI can also be linked to agricultural smart devices for precise operations, thereby achieving fruit recognition and picking, automatic environmental control, and more. Shanghai Jiqing Technology integrates cutting-edge technologies such as the Internet of Things, big data, and artificial intelligence to create an AIPaaS intelligent agriculture platform. The system can sense the subtle changes in temperature, humidity, light, and wind speed inside the greenhouse, and use intelligent algorithms to operate automatic sprinkling, ventilation, shading, and other environmental control operations, creating the most comfortable environment for crops. Not only did it liberate productivity, but it also increased crop yields by 30%. In addition, generative AI can also intelligently design breeding and build crop growth models. The "Implementation Plan for the Development of Smart Agriculture in Shanghai (2025–2030)" proposes to support seed industry innovation platforms and seed enterprises in jointly building smart breeding innovation application platforms such as breeding accelerators, and to develop intelligent design breeding tools by applying technologies such as large model intelligent agents and digital twins, promoting the transformation from empirical breeding to intelligent design breeding.

3.2. Marketing innovation

The combination of generative AI and urban agriculture will unleash tremendous creativity in marketing. AI can not only generate marketing materials such as pictures, promotional copy, and short video scripts for agricultural products, but also create brand stories and promotional short films based on the basic situation of agricultural products, enhancing the emotional value of the brands. Take the common prosperity AI developed by Tencent as an example. This system generates design materials for local specialty stores and offers comprehensive marketing solutions for agriculture, culture, and tourism. With just one process, it can produce the key materials and plans needed. Relevant technologies can also be utilized to create digital humans for 7x24-hour unmanned live streaming. These digital humans support real-time multilingual translation and cultural adaptation, thereby enhancing the conversion rate. Baidu's "Huibo Star" digital human technology has enabled three former Party secretaries to have AI avatars, achieving 7x24-hour non-stop live streaming. The sales in the live streaming room have exceeded 150,000 yuan. Circle You and Me Artificial Intelligence Technology Co., Ltd. has launched a short video matrix tool, which can generate 1,000 localized short videos in one minute. It has also introduced a digital human live streaming system, enabling virtual hosts to sell products 7x24 hours a day and achieving large-scale dissemination where "one person can operate a hundred accounts." In addition, AI digital humans, by leveraging real-time multilingual translation and cultural adaptation, help agricultural enterprises break through language barriers and seamlessly connect with the global market. In terms of precise marketing, AI uses big data to accurately identify target groups, push meal information to them in a targeted manner, and then adjust marketing scripts and promotion plans based on their consumption preferences. Xiye Agriculture utilized the Internet and AI to precisely analyze consumer demands and push product information. Within a month, the sales volume of water dropwort exceeded 30,000 orders, with sales reaching 300,000 yuan. When empowering the marketing chain, generative AI can digitize the entire chain, building an AI product matrix ranging from the smart seed industry, farm management, to digital and intelligent marketing, providing data and support for marketing. For

instance, the digital and intelligent ecological product system centered on the Fengnong AI large model provides full-chain services in terms of the ecological system, planting fields, farm management, farmer services, and the transformation of agricultural enterprises. At the same time, help agricultural practitioners master AI tools to achieve a transformation from traditional thinking to active market innovation. Taizhou organized AI to empower the practical online sales of agricultural products, making up for the marketing shortcomings of enterprises.

3.3. Publicity and education for farmers

In the scenarios of farmers' publicity and education, generative AI can be applied to AI agricultural technology services and popular science, AI e-commerce and digital marketing, as well as AI brand building and cultural tourism empowerment. For instance, Beijing's "Nong AI Wen", as the core engine of technology consultation in the improvement plan, is widely serving urban agriculture with an innovative model of "AI+ agricultural experts + agricultural managers." Launch online "cloud consultation", online expert Q&A sessions, and campus agricultural science popularization education to ensure that agricultural science and technology benefit every farmer. In April this year, Haikou held the 2025 High-Quality Farmer Cultivation AI+ Short Video Live Streaming Practical Training Camp, aiming to train new farmers through "AI technology + short video live streaming + practical incubation." The main objective of this activity is to learn to analyze the transformation of store data indicators through AI tools, expand the sales channels of agricultural products through short video live streaming on the marketing end, and cultivate the trainees' full-chain AI creation ability from copywriting generation, script design, shooting execution, to data analysis, to achieve efficient production of short videos. In terms of brand building and cultural tourism empowerment, generative AI can not only create regional public brands and design distinctive IPs, but also generate cultural tourism promotional materials and plan tourism routes. For instance, Longgang City has carried out a three-dimensional teaching model of "classroom + field + cloud", systematically learning about the integration of rural industries, brand building, AI marketing, and common prosperity models, and cultivating more leading talents in rural areas.

4. Challenges

Although the empowerment of urban agriculture by generative AI is an inevitable trend, it has a high degree of alignment at both the theoretical and technical levels and has already been put into practice in new scenarios. However, the empowerment of urban agriculture by generative AI is not smooth sailing and is fraught with various challenges. Agricultural data is highly regional and seasonal, which leads to various difficulties during collection. The quality of the data cannot be guaranteed, and "data silos" are prone to occur. Moreover, the real agricultural scenarios are intricate and complex, and it remains questionable whether the constructed models are suitable for the actual situation. Intelligent agricultural machinery equipment is currently in its infancy, and complete mechanization has not yet been achieved. What is more notable is that the production cycle of agriculture is long, and the comparative returns are relatively low compared to other industries. However, the development and maintenance costs of AI systems are high, and it is difficult to have a complete business model in the short term. In addition, our country is short of corresponding talents. There is a serious shortage of interdisciplinary talents who are proficient in both AI algorithms and agriculture. Based on this, the empowerment of urban agriculture by generative AI requires the joint efforts of multiple entities, including the government, enterprises, research institutions, and farmers. To break through the data chain, a unified standard agricultural data information sharing

platform should be formulated to achieve the interconnection, intercommunication, sharing, and common use of data. When conducting research and development, emphasis should be placed on low-cost and easy-to-operate agricultural equipment to lower the threshold for farmers to use it. When promoting the technology, attention should be paid to adapting to local conditions to truly integrate AI technology into agricultural production. At the same time, efforts should be made to enhance the training of talents, cultivate interdisciplinary talents in universities, and train farmers in relevant technologies at the grassroots level.

5. Summary

In the current digital age, it is an inevitable trend for generative AI to empower urban agriculture. In the context of an increasing urban population and limited resources, generative AI assists urban agriculture, not only alleviating the pressure on urban food and reducing resource waste, but also improving quality and efficiency, and enhancing the resilience and sustainability of the supply chain. Not only do the two have theoretical and technical compatibility, but they also receive strong support from national policies. The application of generative AI in urban agriculture has already reached the practical level. In application scenarios, it can not only optimize production and conduct precise marketing, but also promote and educate farmers. However, various problems are also faced in the application promotion, and large-scale promotion and implementation still need further optimization and improvement. In conclusion, generative AI is transforming urban agriculture from a supplementary lifestyle into a new industry driven by intelligence.

Disclosure statement

The author declares no conflict of interest.

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