Application of Artificial Intelligence in Animal Nutrition and Feed Science

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Abstract. Artificial Intelligence (AI) technology, as an important force in the emerging technological revolution and livestock industry revolution, plays a crucial role in the digitalization, informatization, and intelligence process of China's livestock industry. The application of AI technology covers animal feed formulation and production management, animal feeding environment monitoring and regulation, animal health management, and has achieved initial success. AI achieves precise feed formulation through big data analysis and machine learning algorithms, improving nutritional levels and production efficiency; Sensors and IoT technology are used for real-time monitoring and regulation of the feeding environment, improving the animal growth environment; Biometric technology enables animal health monitoring and early warning, improving management level. At present, intelligent monitoring technology has been used in the welfare research of grazing sheep, mainly including key technologies such as audio analysis, visual detection, behavior monitoring, behavior feature recognition, satellite positioning, and drone cruising. Despite the challenges of multi perspective, multi-scale, multi scenario, and small sample size faced by smart animal husbandry, the application of AI technology in animal husbandry has significantly improved production efficiency and management level, demonstrating more significant advantages compared to traditional technologies.

Keywords: Animal nutrition and feed science, Artificial intelligence, Integration

1   Introduction

Traditional animal husbandry is facing a historic opportunity to transform towards modernity and efficiency, and the deep integration of mechanization and intelligence has brought unprecedented productivity improvements, becoming a key force in promoting high-quality development of animal husbandry [1]. As an important industry related to national economy and people's livelihood, animal husbandry is facing multiple challenges in today's society, including increasing environmental pressure, increasing difficulty in disease prevention and control, and rising costs due to resource shortages. But the development of AI technology has provided new ideas and methods to solve these problems: for environmental issues, AI can assist in monitoring and controlling waste

emissions during the breeding process, providing more environmentally friendly treatment solutions; In terms of disease prevention and control, AI can use big data analysis and machine learning algorithms to monitor and analyze animal health data in real-time, and provide early warning of disease outbreaks; In terms of resource management, AI can accurately predict feed demand, optimize feed formulas, and improve resource utilization efficiency. The research on AI in feed science mainly focuses on feed safety and livestock product quality, especially in the research of alternative antibiotic technologies and molecular mechanisms, to produce antibiotic free and high-quality livestock products. AI provides innovative ideas and effective solutions for the livestock industry to address many challenges, but in practical applications, issues such as technology cost, data security, and ethics still need to be fully considered.

The integration of artificial intelligence with animal nutrition and feed science is currently a hot research topic. The results indicated that the greater association of the protein matrix with the starch granules in the endosperm tissue of Valier barley may limit the access of ruminal micro-organisms to the starch granules and thus reduce the rate and extent of rumen degradation relative to that of Harrington barley. It is the first time that the microstructural matrix in the endosperm of barley has been revealed by using the SR-FTIR technique, which makes it possible to link feed intrinsic structures to nutrient utilization and digestive behavior in ruminants [8]. AI technology has made up for the shortcomings of traditional methods, and its development and application have received widespread attention. In terms of animal nutrition, AI analyzes feed composition and animal growth characteristics to design the optimal formula, improve growth rate and health level, and save costs. AI also achieves personalized management by monitoring feed intake and digestion in real-time. In the field of animal feed science, combining sensors, the Internet of Things, and big data analysis to achieve environmental monitoring and regulation, optimize feeding environments, and improve health levels and production efficiency. In terms of disease control, AI analyzes behavioral and physiological data to identify disease risks early and provide accurate warning and management. AI technology has also shown significant advantages in reproductive management.

In summary, the application of AI technology in animal nutrition and feed science has brought significant changes and opportunities, improving breeding efficiency, reducing costs, and demonstrating more obvious advantages than traditional technologies. Future research will further explore how to optimize the application of AI technology in this field, focusing on data accuracy and algorithm stability to ensure its widespread application and development.

2   Artificial Intelligence Technology in Animal Nutrition Research

2.1   AI Provides a Data Foundation for Smart Animal Husbandry

(1) Data collection and analysis: AI technology achieves real-time data collection through the Internet of Things, improving data accuracy and real-time performance,

and reducing labor costs. Artificial intelligence technology achieves real-time collection of information on the growth status and breeding environment of individual livestock and poultry through Internet of Things technology, providing a rich data foundation for smart animal husbandry. Compared with traditional manual recording and monitoring, this not only improves the accuracy and real-time performance of data, but also reduces labor costs.

(2) Application of core technology: The Internet of Things collects information in real-time through sensor networks, and cloud computing and big data technology provide means for intelligent data analysis. The Internet of Things technology uses a monitoring network composed of a large number of sensor nodes to collect real-time information on the growth status and breeding environment of individual livestock and poultry, providing a data foundation for smart animal husbandry. Cloud computing and big data technology provide important means for intelligent analysis of livestock data, handling multi-source, heterogeneous, and cross platform big data features. Artificial intelligence technology, including machine vision, speech recognition, virtual reality, and wearable devices, is integrated into the livestock production and management process from multiple perspectives, improving production management efficiency and reducing labor costs.

(3) The development of intelligent monitoring through the integration of multi-source data and multiple technologies: In the future, intelligent monitoring technology will integrate multi-source data and various advanced technologies to improve monitoring accuracy and efficiency. The future intelligent monitoring technology will pay more attention to the fusion of multi-source data and the integration of multiple technologies. In addition to traditional sensor data, various types of data such as image data, sound data, and text data will be considered in the monitoring system. At the same time, various advanced technologies such as sensor technology, image recognition technology, and natural language processing technology will be organically combined to jointly build a comprehensive and three-dimensional monitoring system for the health status and environmental conditions of livestock and poultry. This multi technology fusion approach will greatly improve the accuracy and efficiency of monitoring, providing stronger technical support for the healthy development of animal husbandry [2].

2.2 Cloud Computing and Big Data Technology are Important Means for Intelligent Analysis of Livestock Data

(1) Monitoring of breeding environment: By real-time monitoring of environmental factors, optimize the growth environment of poultry. In the poultry breeding environment, the environmental factors that affect the growth and production of poultry mainly include temperature, humidity, light intensity, harmful gases in the air, etc. Monitoring the breeding environment is the monitoring of environmental impact factors. The system can understand changes in the breeding environment through real-time monitoring of influencing factors, promptly and quickly handle abnormal situations, and create a suitable environment for the growth and production of poultry [3]. This automated environmental monitoring and control is more precise and efficient than traditional manual monitoring.

(2) Precision feeding: AI achieves timed, quantitative, and precise feeding through scientific calculations, improving feeding efficiency. Artificial intelligence technology accurately calculates the precise feed demand based on individual physiological information of livestock through scientific calculation methods, and conducts timed and quantitative precise feeding through intelligent devices. This precise feeding technology is more scientific and efficient than traditional experiential feeding, and can dynamically meet the nutritional needs of livestock at different stages. The prospect of precision feeding technology for individuals is broad. Through intelligent precision feeding technology, personalized timing, quantitative and precise feeding based on individual physiological information of livestock can be achieved.

(3) Disease prevention and control: AI enables early diagnosis and warning of diseases, providing remote intelligent diagnosis and treatment systems. Artificial intelligence technology has also shown great potential in disease prevention and control. Through machine learning and big data analysis, artificial intelligence systems can achieve early diagnosis and warning of diseases, improving the efficiency and accuracy of disease prevention and control. This is more timely and effective than traditional manual diagnosis and prevention methods. Key technologies such as the Internet, cloud computing and big data have been used for remote diagnosis of epidemic diseases. A variety of remote intelligent diagnosis and treatment systems have emerged to realize remote diagnosis and treatment, image diagnosis, disease control information release, product traceability and other functions.

2.3   Artificial Intelligence is the Core Driving Force for the New Round of Livestock Industry Transformation

(1) Animal welfare and behavior monitoring: Intelligent monitoring technology comprehensively monitors the behavior and welfare status of livestock and poultry. Intelligent monitoring technologies such as audio analysis and visual inspection have been used to monitor the behavior and welfare status of livestock and poultry, providing a foundation for automated healthy farming and meat product traceability. The application of this technology is more comprehensive and detailed than traditional manual observation.

(2) Economic benefits: AI technology significantly improves production efficiency and economic benefits. The application of artificial intelligence technology has significantly improved the production efficiency and economic benefits of animal husbandry. For example, through the application of AI technology, the labor cost of farms has been significantly reduced and production efficiency has been significantly improved. This is more economical and efficient than traditional manual management and operation. The connection between animals and feed is also closer, the engineering focus in this field may be on understanding enough about animal nutrition and feed science to envision the following factors: Critical control issues in feed production and processing chains; Methods of monitoring relevant processes; or Contributions to innovations in relevant processes, equipment, and infrastructure. These factors support continuous improvements in animal health and appropriate productivity in the management and care of animals [7].AI technology has a better understanding of factors such as animal

digestion ability and taste preferences, which helps to produce feed that is more suitable for them, improve feed utilization, and increase economic benefits.

(3) Intelligent equipment research and development: Promote the leapfrog development of smart animal husbandry and develop various intelligent devices. Strengthen the research and development of intelligent equipment for animal husbandry, promote the leapfrog development of smart animal husbandry, including integrated and innovative intelligent sensing and control systems for breeding farms, livestock and poultry health monitoring systems, breeding robots, livestock product harvesting and processing robots, automated manure treatment systems, etc.

(4) Stereoscopic Smart Livestock Cloud Platform: Creating a "cloud+end" smart livestock cloud platform to comprehensively promote the upgrading and development of smart livestock. Integrate the information flow of the entire industry chain, including breeding management, precise feeding, epidemic prediction and diagnosis, biological asset management, lineage management, and product traceability. The high-quality development of animal husbandry means a higher level of intelligence, mechanization, and informatization in animal husbandry production; The links in the industrial chain are more closely connected, enabling information sharing and high collaboration; Products are of higher quality and safety, with a wider range of categories and higher added value, better meeting the diverse needs of consumers [4].

3 Specific Applications of Artificial Intelligence in Animal Nutrition and Feed Science

3.1 Nutritional Precision Analysis and Personalized Management

(1) Accurate calculation: The Internet of Things lays the foundation for intelligent analysis through real-time data collection. The Beijing Institute of Animal Husbandry and Veterinary Medicine of the Chinese Academy of Agricultural Sciences has achieved significant results in this regard: digital feed formulation technology is based on animal nutritional needs, feed nutritional components, and price data, and accurately calculates the optimal feed formulation that meets animal growth needs through mathematical models, reducing feed costs and improving breeding efficiency; Data models and decision support systems help farmers choose the best feed formula and breeding management strategy based on their actual situation. The Beijing Institute of Animal Husbandry and Veterinary Medicine of the Chinese Academy of Agricultural Sciences provides scientific basis and technical support for the feed industry, promoting the precision of feed formulas and the modernization of animal husbandry.

(2) Accurate allocation: The intelligent feeding system achieves precise feeding based on real-time animal needs. The precise nutrition formula technology requires accurate assessment of the nutritional composition and quantity ratio of feed raw materials, and design based on comprehensive factors such as different animals and different growth stages. Through the promotion and application of precise nutrition formula technology, feed costs can be reduced, environmental pressure on breeding can be alleviated, and the quality of livestock and poultry products can be improved, thereby

promoting the sustainable and healthy development of China's feed industry and breeding industry[5].The pig feeding robot is an intelligent pig raising equipment integrating artificial intelligence and Internet of Things technology. It solves the problem of Congee mildew through artificial intelligence technology, realizes continuous feeding of Congee 24 hours a day, and can save about 10% of water, food, and medicine, and reduce the cost of pig raising. During the feeding process, the robot can perceive and report the pig's feed intake, environmental parameters, and individual identification information in real time.

3.2   Animal Health Monitoring

(1) Image recognition processing: Improve detection efficiency and identify disease risks early. Intelligent cameras and sensors can continuously monitor the behavior and health status of animals 24 hours a day, analyze the collected data, and provide accurate health warnings. Jilin Jingqi Shen Organic Agriculture Co., Ltd. has partnered with JD.com to deploy JD's agricultural and animal husbandry intelligent breeding solutions based on AI, IOT, and SaaS technologies in its two breeding parks in Baishan, Jilin, and more than 100 mountain black pig pens. The solutions also incorporate image recognition and other related technologies.

(2) Disease monitoring and warning: AI quickly predicts the risk of infectious diseases and provides personalized treatment recommendations. For example, the ranch overall health assessment system developed by Beijing Xiaolong Qianxing Technology Co., Ltd. utilizes artificial intelligence technology to achieve real-time monitoring and evaluation of the health status of ranch animals. This is an intelligent breeding system based on "deep learning and machine vision" technology, which achieves real-time and accurate collection and analysis of core production data for large pig farms in a "non-contact, zero stress" manner. Through this system, breeding enterprises can achieve digital and intelligent upgrades, improve production management efficiency, reduce costs and increase efficiency, and achieve long-term development.

(3) Food safety traceability: The intelligent breeding system realizes full monitoring to ensure food safety. Through digital intelligence technology, the Internet of Things, sensor network and the Internet are combined, and cold chain technology, dynamic planning technology and modern video technology are used to realize the visualization, dynamic and networking of logistics, so as to improve the logistics operation speed, ensure food safety, enhance the function and efficiency of logistics, and reduce operating costs. Among them, there are logistics intelligent and precise routing, dynamic planning and location selection, cold chain preservation and warehousing, transportation, intelligent control logistics subsystems, etc [6].

3.3   Environmental Protection

Prediction and optimization of processing plan: Based on historical data and current breeding scale, AI can predict the amount of waste such as feces and sewage generated, and plan reasonable storage capacity and processing methods in advance. For example, planning the size of biogas digesters, the capacity of composting facilities, etc.

There are also intelligent recognition systems such as soil detection, pest detection, and climate disaster warning, which can help achieve a green, low-carbon, and circular development model.

3.4   Market Demand Analysis

Data analysis and prediction: AI analyzes market demand through social media data to provide data support for decision-making. By predicting future market trends, breeders can develop reasonable production and sales plans, reduce market risks, and improve economic efficiency.

Consumer preference analysis: AI can understand consumers' preferences and expectations for different breeds and qualities of livestock and poultry products (such as meat quality and taste) through e-commerce platform consumer evaluation data, social media data, etc. Analyze the differences in consumption demand for animal husbandry products among different regions, age groups, and consumer groups, in order to conduct targeted market positioning and product development.

4   Discussion

The application of AI in precision nutrition and scientific antibiotic replacement will further optimize feed formulations and promote high-quality development of the industry. Future research should focus on data quality management, algorithm accuracy improvement, and exploration of more application areas to achieve deep application of AI technology in animal nutrition and feed science.

5   Conclusion

The application of AI technology in animal nutrition and feed science has significantly improved production efficiency, optimized feeding environments, and improved animal health status. Through big data analysis, machine learning, the Internet of Things, and sensing technology, AI has improved production efficiency and management levels, reduced costs, optimized feeding environments, and improved animal health. However, AI technology still faces challenges in terms of data quality, algorithm accuracy, and application scenarios in this field, and the advantages of traditional technologies cannot be ignored. Firstly, the data sources in animal husbandry are diverse, and there may be situations where the data is inaccurate, missing, or incorrect, which affects the training and prediction performance of AI models. Therefore, in terms of data accuracy and completeness, it is necessary to study more effective data cleaning and preprocessing methods to improve data quality. Secondly, there are differences in the development level, climate conditions, and breeding modes of animal husbandry in different regions. AI models need to have stronger adaptability and be able to customize and optimize according to local characteristics. Finally, the production data of aquaculture enterprises involves commercial secrets and personal privacy. How to achieve data

sharing and utilization while ensuring data security and privacy is also an urgent problem to be solved. In the future, it is necessary to explore more application scenarios and combine traditional technologies to achieve deep application of AI in animal nutrition and feed science, promoting the modernization and sustainable development of animal husbandry.

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