



## Artificial Intelligence in Animal Science: Advancements, Challenges, and Future Prospects

H. Asadollahi<sup>1\*</sup>, M. Bagheri<sup>2</sup>

<sup>1</sup>Department of Animal Science, Faculty of Agriculture, University of Isfahan, Isfahan, Iran.

<sup>2</sup>Department of Animal Science, Faculty of Agriculture, University of Tabriz, Tabriz, Iran.

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**\*Corresponding author:** Hamed Asadollahi, Department of Animal Science, Faculty of Agriculture, University of Isfahan, Isfahan, Iran.

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### Abstract

Artificial Intelligence (AI) has emerged as a transformative technology in animal science, offering innovative solutions for livestock management, disease detection, genetic improvement, and animal welfare. AI-driven systems, including machine learning, deep learning, computer vision, and the Internet of Things (IoT), are optimizing decision-making processes and improving efficiency in animal production systems. This article explores the key applications of AI in animal science, discusses associated challenges, and highlights future prospects. The integration of AI in animal science is expected to drive sustainability, improve productivity, and enhance animal welfare.

**Keywords:** Artificial Intelligence (AI); Machine Learning, Deep Learning; Computer Vision; Internet of Things (IoT)

### 1. Introduction:

Animal science is essential for food security, economic development, and environmental sustainability. The increasing global demand for animal-derived products necessitates the adoption of advanced technologies to enhance livestock management and productivity (Wolfert et al., 2017). Traditional methods are increasingly being replaced by AI-powered solutions, allowing for real-time data collection, automated decision-making, and predictive analytics. AI has shown great potential in precision livestock farming, disease detection, genetic selection, and behavior analysis (Neethirajan, 2020).

### 2. AI Applications in Animal Science:

#### 2.1 Precision Livestock Farming (PLF):

Precision Livestock Farming (PLF) involves the use of AI-driven sensors, imaging systems, and data analytics to monitor and manage livestock efficiently (Berckmans, 2017). AI-powered wearable devices, such as smart collars, ear tags, and RFID chips, collect real-time data on animal movement, health, and environmental conditions. This information allows farmers to optimize feeding, breeding, and housing conditions to improve productivity and sustainability.

For instance, AI-based systems can analyze feeding patterns and adjust nutrition plans to maximize feed efficiency while reducing waste. Similarly, automated milking systems with AI capabilities help monitor milk quality, detect early signs of mastitis, and optimize dairy cow health (Halachmi et al., 2019).

#### 2.2 Disease Detection and Prevention:

AI has revolutionized disease diagnosis and prevention in livestock by utilizing machine learning models to analyze images, sounds, and behavioral patterns.

Deep learning algorithms process thermal images, video footage, and bioacoustic signals to detect early symptoms of diseases such as respiratory infections, lameness, and metabolic disorders. A notable example is the use of AI-driven computer vision systems to monitor poultry behavior and detect anomalies linked to diseases like avian influenza (Neethirajan, 2020). AI-powered predictive models can also analyze epidemiological data to anticipate disease outbreaks and recommend preventive measures, thus minimizing economic losses and improving animal health management (Liakos et al., 2018).

### 2.3 Genetic Improvement and Breeding:

AI is transforming livestock breeding programs by analyzing genomic data to enhance genetic selection processes. Machine learning algorithms identify desirable traits such as disease resistance, high milk yield, and improved meat quality, allowing for more efficient breeding strategies (Hayes et al., 2019). AI-based genomic selection accelerates breeding cycles, leading to faster genetic gains while reducing costs and resource use.

In dairy cattle, AI has been integrated into genomic prediction models to enhance milk production efficiency and reproductive performance. Similarly, AI applications in poultry breeding have improved egg production rates and disease resistance through optimized genetic selection processes (Morota et al., 2018).

### 2.4 Animal Welfare and Behavior Analysis:

Ensuring animal welfare is a fundamental aspect of ethical livestock farming. AI-based tools are increasingly being used to assess animal well-being by analyzing facial expressions, vocalizations, and body movements (Czycholl et al., 2020). For example, AI-driven emotion recognition systems can detect stress, pain, and discomfort in animals, enabling farmers to take proactive measures to enhance welfare conditions (Nasirahmadi et al., 2017). Computer vision and AI-based image analysis can assess gait patterns to detect lameness in dairy cows, while bioacoustic AI systems analyze vocalizations to identify distress signals in pigs and poultry (González et al., 2020). These innovations contribute to improving housing conditions, reducing stress, and ensuring compliance with animal welfare regulations.

### 3. Challenges and Limitations:

Despite the potential benefits of AI in animal science, several challenges hinder widespread adoption:

**High Implementation Costs:** AI-driven systems require significant investment in technology, data infrastructure, and training (Wolfert et al., 2017).

**Data Availability and Quality:** The success of AI models depends on large, high-quality datasets, which may not always be accessible, especially in small-scale farms (Liakos et al., 2018).

**Ethical and Privacy Concerns:** The use of AI in animal science raises ethical questions related to data privacy, automation in farming, and the potential displacement of human labor (Papakonstantinou et al., 2024).

**Technical Expertise:** Farmers and veterinarians need specialized training to effectively utilize AI-powered tools and interpret data-driven insights (Neethirajan, 2020).

### 4. Future Prospects:

The future of AI in animal science looks promising, with advancements in robotics, blockchain, and IoT expected to drive further innovation. AI-powered robotic systems for automated feeding, milking, and health monitoring will enhance farm efficiency while reducing labor requirements (Malek et al., 2024).

Blockchain technology, combined with AI, will enable enhanced traceability of livestock products, ensuring food safety and supply chain transparency (Patel et al., 2023). Additionally, AI-driven smart farming applications will integrate climate data, soil conditions, and animal health metrics to promote sustainable livestock production (Mohamed et al., 2021).

AI research in animal behavior analysis will continue to evolve, providing deeper insights into animal cognition, emotional states, and social interactions (Neethirajan, 2021). These advancements will contribute to improving farm animal welfare and optimizing livestock management strategies.

### 5. Conclusion:

AI is revolutionizing animal science by enhancing livestock productivity, disease management, genetic selection, and animal welfare. Although challenges such as high costs, data limitations, and ethical concerns exist, ongoing research and technological advancements will drive further innovation. By integrating AI with smart farming technologies, the livestock industry can move towards a more sustainable, efficient, and ethical future.

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