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Precision livestock farming AI and IOT applications

Dr J. Sai Kiran[1] , Dr G. Ganesh[2] and Dr A. Raju[3]
[1]Livestock production and management, [*2]Aquaculture and [*3]Plant protection
ICAR– Krishi Vigyan Kendra Mamnoor, Warangal, District, Telangana (506 166)
India

Abstract

The integration of Artificial Intelligence (AI) and advanced technologies in livestock and poultry farming is revolutionizing traditional agricultural practices. AI enhances key areas such as animal health monitoring, feeding, environmental control and breeding management, thereby improving both productivity and animal welfare. Through tools like machine learning, computer vision, IoT sensors and big data analytics, farmers gain real-time insights to make informed decisions, increasing efficiency and sustainability. In poultry farming, AI supports ventilation, huidity regulation, disease detection and robotic automation, addressing labour shortages and health challenges. Technologies such as infrared thermal imaging (IRTI) and audio analysis allow for early, non-invasive disease detection. Additionally, AI aids in genetic analysis and reproductive management, improving breeding outcomes and vaccine development. Despite its benefits, AI adoption presents challenges, including high costs, data security risks and ethical concerns regarding animal monitoring and job displacement. The reliability of AI also depends on the quality of data, which may vary due to environmental or technical factors. Overall, AI offers a transformative path toward smarter and more ethical farming, but its success hinges on responsible implementation, technological refinement and stakeholder training.

Introduction

Recent breakthroughs in artificial intelligence (AI) have begun to reshape virtually every productive sector, driving major improvements in efficiency, automation, and decision-making (Oyekunle et al., 2024). In agriculture, these technologies have become central to the evolution toward *Agriculture 5.0*, particularly through the adoption of controlled-environment systems that optimize production under monitored conditions. AI-enabled computer vision and automation tools now support real-time crop surveillance, precision management, and even robotic harvesting (Luo et al., 2023).

A similar digital transformation is underway in the livestock sector, where advances in computer science are enabling smarter, more sustainable animal management systems. AI-based monitoring technologies are increasingly used to track animal activity, behavior, and health,

responding to growing societal demands for better animal welfare and sustainable production (Distante et al., 2025).

Modern sensing and computing systems are being designed to ensure that animals—whether on farms, in homes, or in the wild—remain healthy, comfortable, and stress-free. These tools not only improve animal well-being but also support food security and public health by promoting efficient, welfare-oriented management strategies (Jukan et al., 2017). The combination of sensors, real-time monitoring devices, audio and visual analytics, unmanned systems, and AI-based decision-support platforms is transforming livestock farming into a data-driven enterprise (Idoje et al., 2021). Collectively, these innovations enhance productivity, reduce costs, and foster more sustainable farming practices (Morotoa et al., 2018).

The concept of **Precision Livestock Farming (PLF)** has evolved significantly since the 1970s—from the early use of mechanical milk meters to sophisticated systems capable of detecting estrus behavior through automated monitoring (Berckman et al., 2017). The introduction of smart sensors, Internet of Things (IoT) networks, and data analytics tools has accelerated this transformation, paving the way for **Digital and Smart Livestock Farming (DLF/SLF)**. The latest leap forward comes from the integration of AI and deep learning algorithms, which enable real-time pattern recognition, predictive analytics, and fully automated decision-making.

Artificial intelligence is now revolutionizing the livestock sector by enabling predictive and adaptive management systems. These tools help farmers monitor animal health, forecast disease outbreaks, and optimize feeding and breeding strategies using machine learning, IoT devices, and data analytics (Deepika et al., 2024). From managing infrastructure and reducing disease risk to improving feed conversion and production efficiency, AI applications are creating a new era of intelligent and sustainable animal farming (Viejo et al., 2022).

Technologies such as robotics, drones, and precision monitoring platforms have further accelerated AI adoption in modern agriculture (Smith et al., 2006). AI-powered robots and smart systems reduce human labor requirements while maintaining or improving product quality. For instance, Blanes et al. (2010) developed an intelligent barn system equipped with sensors to measure animal weight, movement, and health metrics, all analyzed through AI algorithms to support farm decision-making.

Through real-time data analysis, these tools provide valuable information on animal health, nutrition, and reproduction, facilitating higher productivity and welfare outcomes (Kazembe & Mkandawire, 2024). Their predictive capabilities also allow early detection of disease and potential reproductive issues, thereby minimizing economic losses. AI-driven reproductive technologies—such as heat detection, fertility prediction, and embryonic sex determination—are becoming essential tools for enhancing livestock productivity and meeting global demand.

Applications of AI in Livestock Health and Management

1. Disease Detection and Monitoring

AI-based diagnostic systems can identify early signs of illness through subtle behavioral or physiological changes that may go unnoticed by human observation. These systems rely on sensor data, computer vision, and deep learning to analyze eating patterns, movement, respiration, or vocalization. Early detection enables faster treatment, prevents disease spread, and improves overall herd health outcomes.

2. Behavioral Analysis and Welfare Assessment

Automated monitoring systems analyze animal behavior—such as feeding, resting, or social interactions—to evaluate welfare conditions. AI algorithms interpret video and sensor data to detect stress, lameness, or discomfort, providing actionable insights for better management.

3. Precision Feeding and Nutrition Management

By integrating data from sensors, cameras, and environmental monitors, AI tools help optimize feeding schedules and ration composition. This not only improves growth rates and milk production but also reduces feed wastage and environmental impact.

4. Reproductive Management

AI technologies are transforming livestock reproduction through accurate detection of estrus cycles, prediction of optimal breeding times, and embryo selection. Deep learning models can process large datasets to enhance fertility management and support selective breeding for improved genetics.

5. Smart Farm Automation

From robotic milking systems to climate-controlled barns, AI enables automation across multiple farm operations. Integrated platforms use predictive analytics to control temperature, ventilation, and lighting, ensuring optimal animal comfort and performance.

Conclusion

Artificial intelligence is redefining livestock farming by bridging technology and animal welfare. Through predictive analytics, automation, and data integration, AI enhances productivity while promoting sustainable and ethical practices. Although challenges such as data integration, cost, and technical expertise remain, ongoing innovation and collaboration between researchers and farmers are steadily overcoming these barriers. As AI systems continue to evolve, they promise to transform livestock management into a more precise, humane, and efficient enterprise—ushering in a new era of intelligent agriculture.

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