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Digital twins in poultry farming: A comprehensive review of the smart farming breakthrough transforming efficiency, health, and profitability

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Abstract
Digital Twin (DT) technology is revolutionizing the poultry farming by integrating the real-time data analytics, artificial intelligence (AI) and Internet of Things (IoT) to enhance the farm management and productivity. This review examines the role of DT in optimizing poultry health monitoring, disease prevention, feed efficiency and breeding strategies through virtual simulations and predictive analytics. By replicating,real-world farm operations in a digital environment, DT enablea data-driven decision-making option which reduce operational cost and improves overall efficiency.This study follows a literature-based review approach, by analyzing peer-reviewed articles and industry reports to evaluate the current advancements, applications and challenges of DT in poultry farming. Key themes explored in this review include IoT driven monitoring, AI-powered predictive models and cloud-based data processing on precision farming.Despite its transformative potential, DT adoption in poultry farming faces challenges such as high implementation costs, technical complexity and data security concerns. To overcome thes barriers requires AI-driven predictive models, cost-effective solutions and standardized frameworks to facilitate wider adoption. As the poultry sector increasingly embraces smart farming methods, Digital twin (DT) technology is taking on growing significance on it. It plays a significant role in ensuring enhanced sustainability, greater efficiency in operations, as well as overall profitability growth on the poultry farm. This technology is driving towards making the future of poultry production intelligent, data-driven, with technology facilitating informed decision-making as well as optimized farm outcomes.

Keywords: Digital Twin Technology, Poultry Farming, Artificial Intelligence (AI), Internet of Things (IoT), Predictive Analytics, Smart Farming

1. Introduction

In India, the livestock sector has become a significant engine of growth in agriculture and playing a vital role in the overall agricultural landscape. The poultry sector in particular has emerged as a key contributor to animal husbandry, providing a crucial source of protein to the population and a steady income stream for farmers (Economic Survey, 2024) [8]. This sector has demonstrated remarkable growth, with a Compound Annual Growth Rate (CAGR) of 7.38% at constant prices. The livestock sectorwhich includes poultry has increased its contribution to Gross Value Added (GVA) in the agricultural and allied industries from 24.32% in 2014-15 to 30.38% in 2022-23 (Economic Survey 2023–24; Department of Animal Husbandry and Dairying, Basic Animal Husbandry Statistics 2024) [8, 4]. In 2019, the total number of poultry birds in the country increased by 16.81% that reaching a total of 851.81 million. Within this the population of commercially raised poultry birds3 specifically grew by 4.5% which reaching 534.74 million. (As per the Annual Report 2024) [3]. As advancements in technology significantly transform agricultural farming practices into more efficient (Slob & Hurst, 2022) [25]. The rapid evolution of digital technologies, including the Internet of Things (IOT) and Artificial Intelligence (AI) has revolutionized various sectors including animal husbandry. These technologies allow farmers to monitor both animals and their environment, providing better insights into animal behaviour, distress signals, disease control and overall management. Among the modern technologies, the most ground-breaking technologies is

Digital Twin technology (Neethirajan *et al*., 2021) [18]. In poultry farming, Digital Twin technology has a direct impact on the health, performance, and productivity of birds by continuously monitoring environmental factors such as temperature, humidity and CO_2 concentration. This real-time monitoring aids in health management and disease prevention (Abubakar *et al*., 2024) [1]. However, the implementation of Digital Twin technology in the livestock sector is still in its early stages, revealing a vast opportunity to fully leverage its potential in areas such as animal monitoring, environmental management, precision farming and supply chain optimization. These technologies have immense potential to enhance animal welfare, health, and productivity (Arulmozhi *et al*., 2024) [2]. A Digital Twin is a real-time virtual representation of a physical system that allows for enhanced monitoring, analysis, and optimization of farming processes (HLPE-FSN Steering Committee *et al*., 2022) [24]. In poultry feed plants Digital Twin technology has played a crucial role in optimizing job scheduling algorithms, by facilitating the effective redistribution of workloads among machines. It also improves job scheduling systems by enhancing the distribution of operational tasks in poultry feed production plants (Tarek *et al*., 2023) [23]. Essentially a Digital Twin is a virtual model of a physical poultry farm that enables farmers to track and optimize farm performance in real-time. By reducing the need for constant human oversight this technology allows for remote management, leading to more efficient and effective poultry health management. Through real-time data, poultry farmers can make informed decisions that accurately reflect the current conditions, rather than relying on assumptions (Abubakar *et al*., 2022) [1].

Historical Evolution of Digital Twin Technology

The concept of digital twin technology may appear to be a modern innovation, but its origin can be traced back to the Apollo space missions conducted by NASA during the late 1960s and 1970s. During these missions, NASA developed sophisticated stimulation techniques for evaluating and overseeing embedded systems that were employed in space missions to ensure mission safety and success (Arulmozhi *et al*., 2024) [2]. As early as 1993, David Gelernter in his book entitled Mirror Worlds wrote about the possibility of software models that represent aspects of reality. However, NASA had already used this technology on spacecraft for complex simulations. Apollo 13 suffered an explosion in its oxygen tank, which resulted in engine failure and a shift from its path. The leak in the oxygen threatened the lives of the astronauts. SO NASA scientists quickly modified high-fidelity simulators on Earth to mirror the real conditions of the damaged spacecraft using real-time data. This approach allowed them to derive solutions that enabled the astronauts to return safely to Earth. This was the first real-world application of digital twin technology (Neethirajan *et al*., 2021) [18]. The concept of Digital Twin (DT) was introduced by Michael Grieves in 2003 during a lecture on Product Life Cycle Management (PLM). He initially called it the "Conceptual Ideal for PLM." Later, John Vickers from NASA collaborated with Grieves to refine and implement digital twin technology for aerospace applications. From 2010, onwards the emergence of the Internet of Things (IoT), cloud computing, and data analytics had significantly accelerated the development of digital twin technology. Industries such as manufacturing, aviation, and automotive began leveraging DT technology for to enhance predictive maintenance and system optimization. In 2016, Siemens integrated DT technology into Industry 4.0 for smarter automation and interconnected industrial processes (Arulmozhi *et al*., 2024) [2]. The original digital twin model proposed by Michael Grieves was three-dimensional, consisting of a Physical Entity, Digital Twin, and Data Connection. Later it evolved into a five-dimensional framework. This includes Physical Space, Virtual Space, Data Interaction, Service Functions and Application Scenarios (Arulmozhi *et al*., 2024) [2].

Overview of Digital Twin Technology

A digital twin is an advanced technology that creates a virtual representation of a physical object or system. It collects data through real-time monitoring, enabling continuous tracking, verification and analysis of the physical counterpart's current state. Additionally, it can forecast potential future behavior based on the collected data. The concept of digital twins (DT) varies across domains depending on the nature of information in each domain (Sanabria *et al*., 2022) [5]. This technology supports prediction, optimization and enhanced decision-making. DTs are now widely used in various sectors including agriculture, electronics, smart manufacturing, renewable energy, education, healthcare and transport (Tarek *et al*., 2023) [12]. The effective implementation of DT technology requires both Technical infrastructure such as software, sensors and actuators and a solid understanding of supportive frameworks**,** including industrial resource management, technology lifecycles, natural resource management and communication tools (Salem *et al*., 2022) [20].

Enabling Technologies for Digital Twins in Poultry Farming

Digital Twin Technology (DT) incorporates various technologies such as cloud computing, machine learning, artificial intelligence (AI) and the Internet of Things (IoT). These technologies not only provide essential functionalities, but they also help to enhance intelligence and user interactivity within the DT framework.

Internet of Things (IoT)

The Internet of Things (IoT) is defined by the International Organization for Standardization (ISO, 2018) as an infrastructure made up of linked systems, people and information resources together with intelligent services that enable them to manage and respond to information from both the real world and the virtual world (Kor *et al*., 2021) [12]. A key factor in IoT and DT integration is the creation of standardized frameworks**,** These frameworks ensure that sensors, data processing platforms, and decision-making systems can work together seamlessly (Jacoby & Usländer, 2020) [10]. Therefore, IoT unites the physical and digital system by incorporating components such as sensors, actuators, cloud services, communications, and protocols (Kor *et al*., 2021) [12]. Significantly, IoT sensors enable the synchronization of digital twins with the condition of physical assets by identifying one or more conditions within physical assets, transforming those circumstances into signals that humans or machines can read and connecting to the internet to facilitate communication. The IoT sensors had come in a wide range variety of forms and the AEC sector frequently uses sensors such as GPS, image sensors, proximity sensors, radio frequency identification sensors, motion sensors, and biosensors (Lee *et al*., 2021) [14]. Developing DT frameworks often involves integrating the Internet of Things (IoT), BIM and finite element models. These frameworks provide updates that are practically real-time to improve management

(Shishehgarkhaneh *et al.*, 2022) [21]. In poultry farming, IoT-based sensors and cameras continuously collect real-time environmental data, aiding in precision monitoring and automated decision-making (Jia *et al*., 2025; Ojo *et al*., 2022) [11, 19].

Artificial intelligence

Artificial intelligence (AI) is one of the components of digital twin technology. AI performs predictive functions, such as making a prediction according to the current situation. It also possesses other capabilities like data analytics, decision-making and scenario simulation, which vary with the use case (Kreuzer *et al.*, 2024) [13]. The capabilities of artificial intelligence, sophisticated sensor technologies and virtual reality are used to create a fully operational and high-capability digital twin (Elfarri *et al.*, 2023) [7]. Processes such as tracking and recording are also extremely important. They can be achieved by incorporating machine learning-based AI modules into digital twin technology. AI continuously tracks and records the external usage of the digital twin autonomous driving test platform. Additionally, it creates a database of usage information and compares different aspects based on usage data (Lv *et al.*, 2022) [16]. This AI model helps to process the data for early disease detection and resource optimization (Tarek *et al.*, 2023).

Cloud computing

The cloud platform is designed within a cloud-based environment and enables scalability, accessibility, as well as real-time data processing. Cloud computing allows data to be stored, analyzed and shared, especially from wearable devices. Real-time monitoring, diagnosing and predicting are supported by cloud computing in accordance with the conditions. It facilitates precision simulation technology along with enhanced decision-making. It makes use of cloud computing to process large amounts of data from IoT-enabled devices for customized management. Cloud computing provides remote access and optimized allocation of resources, especially for elderly healthcare management (Liu *et al.*, 2019) [15]. Cloud computing also facilitates data processing, sharing and remote farm monitoring (Jia *et al.*, 2025) [11].

Digital Twin Architecture

The architecture of digital twins varies according to their industries or applications. The processes, procedures and facilitating technologies employed in DT will vary based on the type of data and information needed for each application area. These three components are used in all common standard frameworks for all DT systems.

The Physical World

It represents real-world objects, systems, or processes. It includes physical twins which are the actual assets such as sensors to collect real-time data and actuators to enable interaction with the environment. They may also feature edge processing and data security mechanisms to ensure safe data transmission (Sanabria *et al.*, 2022) [5]. In poultry farming; it represents the real-world poultry farm, including livestock, the environment and equipment. It is equipped with IoT sensors to collect real-time data on parameters like temperature, humidity, feed intake and birds behavior on the poultry farm (Tarek *et al.*, 2023) [23].

The Digital World

It houses the digital twin a virtual model that replicates the physical system. It uses machine learning (ML) and artificial intelligence (AI) for processing and analyzing information. Additionally, it stores information in databases to improve predictions, simulations and decision-making (Sanabria *et al.*, 2022) [5]. It is used for disease prediction, feed optimization and behavioral analysis (Jia *et al.*, 2025) [11].

Communication Interface

This interface acts as a bridge between the physical and digital worlds, enabling data exchange and interaction. It uses the wired and wireless communication protocols such as wifi, Bluetooth, satellite and wired networks. It also ensures real-time synchronization between the physical asset and its virtual representation (Sanabria *et al.*, 2022) [5]. Additionally, it enables the data synchronization, predictive modeling and automation of farm operations (Tarek *et al.*, 2023).

Significance of this Architecture

The architecture supports real-time monitoring of real-world systems. So the users are able to see real-time data and make decisions accordingly. It supports automation, optimization and predictive analysis across sectors such as manufacturing, healthcare and agriculture (Sanabria *et al.*, 2022) [5].

Digital Twin in Livestock Farming

The Digital Twin (DT) methodology has been applied and validated on five smart agriculture use cases within the European Iof 2020 project, including arable farming, dairy farming, greenhouse crops, organic vegetable production and livestock breeding (Verdouw *et al.*, 2021) [26]. Recent studies in the Agriculture 5.0 framework have highlighted DT's role in livestock production systems. This is especially true for improving resource efficiency, predictive analytics, and animal welfare (Symeonaki *et al*., 2024) [22]. A digital twin may be defined as a digital representation of a real-world entity. It models the physical condition and monitors the biological condition and behavior of the real-world entity based on input data. It assists in predicting, optimizing and enhancing decision making. Artificial intelligence (AI) and machine learning (ML) specifically are extensively employed in animal husbandry for continuously monitoring the animal's conditions as well as the surrounding environment this resultin better insights into animal behavior and distress, disease prevention and control and efficient business decisions for the farmers. Digital twins can assist farmers in constructing more energy-efficient farm buildings, forecast heat cycles for breeding and dissuade undesirable behaviors of livestock (Neethirajan *et al.*, 2021). DT systems assess temperature, humidity and air quality to ensure optimal environmental conditions for livestock. These DT models are used to evaluate animal feed intake, digestion and weight gain patterns, optimizing nutrition programs for improved growth and feed conversion efficiency. The intelligent feeding systems which combine with IOT and AI driven digital twin technology provide automatic feed distribution in accordance with the needs of each animal (Tarek *et al.*, 2023) [23]. Recent systematic reviews show that DT integration in livestock farming improves productivity, resource efficiency, and animal welfare across different species (Hasan *et al*., 2024) [9].

Example: ADT-based smart feeding system in pig farming reduced feed waste by 20% and improved weight gain consistency (Jia *et al*., 2025) [11].

Materials and Methods

The systematic review was conducted using a systematic approach by analyzing research articles sourced from various scientific databases and academic sources. The selected articles mostly focused on the how the Digital Twin (DT) technology used in poultry farming for environmental monitoring, disease forecast, feed optimization, breeding management and supply chain optimization by remote management without any physical supervision of the humans. A comprehensive search strategy was employed by using specific keywords and Boolean operators to ensure detailed and in-depth coverage of digital twin in poultry farming. These keyword were chosen together to gather a wide range of information such as the applications of the DT in poultry farming. The main keywords included such as Digital Twin in poultry farming, AI and IoT in poultry production, Smart farming in poultry, Precision poultry technology, and DT architecture. The Studies published between 2010 and 2025 was taken for the study to keep things relevant and up to date. A total of 23 article were gathered and surveyed that includes review articles, case studies, and experimental research were reviewed to determine technological advancements, implementation frameworks, and current challenges facing the digital twin technology in the poultry industry.

Results and Discussion

Overview of Digital twin technology in poultry farming

The Digital Twins technology upgrades intelligent agriculture through enhanced productivity and sustainability. They form a virtual duplicate of actual poultry systems, simulating behavior and conditions in real time. This technology supports remote management of farms by giving real-time data, eliminating the necessity of manual observation and intervention (Verdouw *et al.*, 2021) [26]. In poultry farming the farmers requires a meticulous attention to the environmental conditions such as temperature, humidity and Co_2 concentration. These factors significantly influence the well being of the poultry birds and consequently also the productivity of the poultry birds. By implementing the digital twin technology in the poultry farm the poultry farmers can gather real-time data from their movements and behavior that enable them to make the decisions based on the actual conditions rather than assumptions. This integration allows for actionable insights, helping farmers to respond proactively to any deviations from optimal conditions (Dwiyaniti *et al.*, 2019) [6]. Also this technology can modify feeding times according to the birds eating habits and health monitoring, optimizing use of feed while reducing wastage. It can also independently control cooling systems in order to provide optimal temperatures. This establishing a more stable and efficient poultry production (Dwiyaniti *et al.*, 2019) [6]. In broiler breeding, genetic selection is replicated through digital twins based on real-time data and AI and this allows for exact trait prediction, optimal breeding and enhanced flock performance. These are the Revolutionary Concept that have Potential to Reshape poultry Industry **(**Neethirajan *et al.*, 2023) [17].

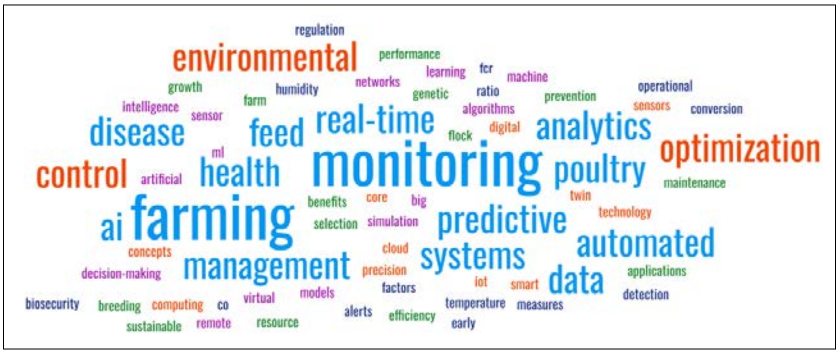

Fig 1: Word cloud representation of key concepts in Digital Twin applications for poultry farming.

This technology has the potential to revolutionize conventional poultry farming by redirecting attention towards real-time information of the birds. Through AI-powered analysis, it facilitates more data-driven business decisions, better animal health, welfare and maximum utilization of resources. The method also enables remote monitoring and intervention, avoiding frequent on-site visits (Verdouw *et al.*, 2021) [26].

Application of Digital twin technology in poultry farming

The DT technology in poultry production combines sensor-based monitoring; AI-powered analytics and cloud computing to enhance operational efficiency and improve the animal welfare (Neethirajan *et al.*, 2021) [18]. The main applications of digital twin in poultry farming and management are Precision Farming and Smart Monitoring, Disease Prevention and Health Management, Feed Optimization, Growth Improvement of the bird's.

Precision Farming and Smart Monitoring

Digital Twin (DT) technology, combined with Artificial Intelligence (AI), Machine Learning (ML) and Cloud Computing is transforming poultry farming by making it possible to monitor birds and environmental conditions in real-time, through the creation of a virtual poultry system simulation. DT enables farmers to examine bird behavior, detect distress signals, and improve welfare management. Furthermore, this technology is important in the prevention and control of diseases, the optimization of farm operations and facilitating data-driven decision-making for enhanced productivity and sustainability (Neethirajan *et al.*, 2021). Cloud computing technologies offer the scalable infrastructure needed to handle the large volumes of data produced by DT systems in poultry farming. Through remote access to storage and computational resources, cloud computing enables real-time monitoring, data processing and predictive analytics. This promotes innovation in Precision Poultry Farming, Smart Monitoring and Remote Management (Arulmozhi *et al.*, 2024) [2].

Abubakar *et al.*, (2022) [1] created a Digital Twin coupled with an IoT-based reinforcement learning algorithm to maximize poultry production and health condition. The system made the environmental parameters, such as temperature, humidity, CO_2 concentration and feeding times, automatic adjustments based on real-time information. Consequently, this technology resulted in healthier poultry, better growth rates and increased yields. It also minimized human super vision and human error leading to better overall management of poultry health.

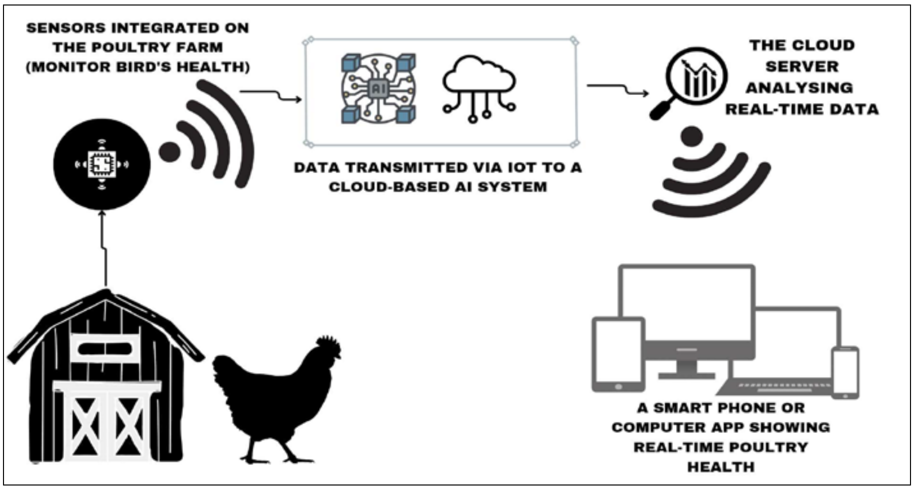

Fig 2: A conceptual framework of Digital Twin-based poultry monitoring. Sensors integrated into the poultry farm collect real-time data on bird's health. The data collected which is transmitted via IoT to a cloud-based AI system. The analyzed remotely data is displayed on a computer or Smartphone application for farmers to monitor poultry health.

Disease Prevention and Health Management

Early disease detection in poultry production is important for avoiding major economic consequences like mortality in birds as well as for ensuring overall health of the flock. Traditional disease detection methods rely on visible signs and they do not reveal themselves until the disease is already established. At this point, the disease might have advanced fully throughout the flock and cause serious health and economic implications. Digital Twin technology transforms the management of diseases by continuously tracking real-time physiological and behavioral patterns, which allow for early identification of warning signs that would otherwise be overlooked. This preventive action makes possible early intervention, targeted treatment and effective isolation of infected birds, greatly limiting the risk of outbreaks and enhancing poultry welfare (Neethirajan *et al.*, 2021) [18]. When This technology blended with IoT and reinforcement learning it improves poultry health management by making environmental control automatically. It continuously adjusts temperature, humidity, CO_2 and feeding time dynamically based on live data with less manual physical intervention required. Through repeated iterations, continuous learning and optimization guarantee the best possible farm conditions and improved poultry health (Abubakar *et al.*, 2022) [1]. This forecasting ability of this DT technology lowers death rates, averts disease epidemics and enhances Biosecurity controls by locating high-risk areas and possible contamination points. In addition AI-based health monitoring systems within the Digital Twin system examine poultry behavioral patterns—e.g., irregular feeding, abnormal movement and alterations in vocalization—to identify early warning signs of disease (Neethirajan *et al.*, 2021). Farmers can adopt targeted treatments and disease containment with real-time notifications, encouraging a sustainable and welfare-based strategy to manage poultry health. This AI-powered, data-driven Digital Twin model greatly enhances disease prevention, flock well-being and overall farm efficiency. It opens the door to smart, precision-based poultry farming (Abubakar *et al.*, 2022) [1].

Feed Optimization and Growth Improvement

Maintaining feed efficiency is a crucial aspect of poultry production, as it directly impacts production costs and profitability. However, various influencing factors such as bird genetics, environmental conditions and dietary composition make it challenging to determine the ideal feeding strategy. By implementing Digital Twin technology, farm owners can model various feed compositions and analyze their impacts on poultry growth, health and feed conversion ratio (Neethirajan *et al.*, 2021) [18].

Digital twins can also be used to simulate these kinds of scenarios in poultry farming like Predict optimal feed intake patterns; Optimize feed efficiency, Improve growth performance, Breeding Management and Genetic Improvement.

Predict optimal feed intake patterns

AI-based models process real-time data to determine ideal feed formulations based on growth rate, health parameters, and environmental factors. Data collected through continuous bird monitoring is used to predict optimal feed intake patterns. This enables Digital Twin (DT) technology to accurately forecast feeding behavior and nutritional needs (Abubakar *et al.*, 2022) [1].

Optimize feed efficiency

By minimizing feed wastage and dynamically adjusting nutritional content, farmers can maximize resource utilization. This technology optimizes the poultry production process by enabling high-quality output, reducing production cycles and improving cost efficiency (Rasheed *et al.*, 2022).

Improve growth performance

To optimize poultry production, farmers must ensure their birds remain healthy. Key parameters such as body temperature, feed quality and quantity and the concentration of gases in poultry sheds serve as effective indicators. Dynamic monitoring and real-time modification of feeding schedules through digital simulations guarantee maximum weight gain while maintaining poultry health (Neethirajan *et* *al.,* 2021) [18].

Breeding Management and Genetic Improvement

In poultry breeding the Digital Twin (DT) technology enables the development of highly accurate genetic selection models by utilizing data collected from parent birds. These models consider specific genetic traits that allows for precise predictions of breeding strategies**.** By integrating data-driven insights with artificial intelligence (AI) and machine learning (ML) algorithms**,** digital twins can analyze a wide range of genetic characteristics. Additionally, they simulate genetic variations and their impact on performance that enables farmers to enhance growth rates, feed conversion efficiency and disease resistance through optimized breeding programs (Neethirajan *et al.,* 2023) [17].

Limitations in digital twin technology

Implementation of Digital Twin technology in poultry farming is confronted with challenges like high cost of implementation, high maintenance requirements, and cyber security threats. Moreover farmer's unwillingness to change from conventional practices and the need for sophisticated technical skills are impediments to widespread adoption. It is important to address these concerns for its effective integration on the digital twin technology in poultry farming.

Maintenance and Updates

The sensors, IoT devices and software are plays a critical role in gathering data and information from the farm. These data and information can be utilized in analyzing and making decisions as well as increasing forecasting capabilities by the DT technology. As a result, DT technology must constantly update in order to ensure that the information provided by it is accurate. Faulty devices will yield wrong data which will cause bad decisions and negatively impact farm operations (Arulmozhi *et al.,* 2024) [2].

High Financial Cost

The implementation cost of digital twin technology in farms is extremely high therefore the small scale farmers cannot able to afford it. It also demands periodic updates and maintenance that adding to the extra expense which renders. It a severe drawback of the technology. In case of improper or inadequate implementation it could produce low-grade data making so it is difficult to achieve the return on investment (Arulmozhi *et al.,* 2024) [2].

High switching Costs

The Poultry farmers have been optimizing their production processes for centuries by closely observing birds. The implementation of new technologies like digital twins which offers possibilities like remote monitoring and control. However, most of the farmers are reluctant to switch from conventional production methods. Because they had already spent their significant time, effort and financial investments are already made in traditional farming practices. Adopting digital twin technology requires additional training, infrastructure upgrades and adaptation to new systems, creating a barrier to its adoption (Neethirajan *et al.,* 2021) [18].

Cyber security and Data Privacy Concerns

As digital twins are working under the technology of cloud-based connectivity with the real-time exchange of the data, they can also able to face vulnerable cyber-attacks. These cyber attacks create unauthorized access to farm data and systems can lead to operational disruptions, data theft and compromised farm security. So ensuring strong cyber security measures such as encryption and secure access controls are essential to avoid these risks (Arulmozhi *et al.,* 2024) [2].

Conclusion

The Digital Twin (DT) technology represents ground breaking advancement in poultry farming offering a data-driven approach to optimizing farm operations. DT enables continues monitoring and prediction of bird's behavior, facilitates early disease detection and allows for controlling the farm environments remotely. By integrating Internet of Things (IoT)**,** Artificial Intelligence (AI)**,** Machine Learning (ML) and the real-time analytics with the cloud computing. This technology facilitates precision farming, improving health monitoring, disease prevention, feed efficiency and breeding strategies. Through these virtual simulations, farmers can optimize resource utilization, reduce losses and enhance overall productivity. Despite of its immense potential, DT technology faces challenges such as high implementation costs, regular maintenance and updates and advanced technical expertise which must be addressed for broader adoption. Future advancements should focus on developing standardized frameworks, integrating AI-driven predictive models and making DT technology more accessible and cost-effective. The Collaboration between the technologists**,** veterinarians**,** and farmers will be essential and very helpful in refining DT systems. As the poultry industry moves toward smart farming solutions, the adoption of digital twins will play a crucial role in ensuring sustainability, efficiency, and profitability. These trends along with rising labor costs and the growing need for scalable, sustainable farming practices holds a promising future for digital twin technology in poultry and livestock farming.

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Conflict of Interest

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Reference

1. Abubakar A, Ali MH, Darma TH. Creating a digital twin and IoT-enabled reinforcement learning algorithm to optimize the health status of poultry production in agriculture. J Sci Technol Educ. 2024;12(3):843–844.
2. Arulmozhi E, Deb NC, Tamrakar N, Kang DY, Kang MY, Kook J, *et al*. From reality to virtuality:

Revolutionizing livestock farming through digital twins. Agriculture. 2024;14(12):2231.
3. Department of Animal Husbandry and Dairying. Annual Report 2023–24. New Delhi: Government of India; 2024. Available from: https://dahd.gov.in/sites/default/files/2024-10/annualreport202324.pdf
4. Department of Animal Husbandry and Dairying. Basic Animal Husbandry Statistics 2024. New Delhi: Government of India; 2024. Available from: https://dahd.gov.in/sites/default/files/2025-01/finalbahs2024book14012025.pdf
5. Botín-Sanabria DM, Mihaita AS, Peimbert-García RE, Ramírez-Moreno MA, Ramírez-Mendoza RA, Lozoya-Santos JDJ. Digital twin technology challenges and applications: A comprehensive review. Remote Sens. 2022;14:1335.
6. Dwiyaniti M, WRN, Tohazen. Development of water quality monitoring systems in super intensive aquaculture system using ESP32 and Blynk. In: Proc 8th Annu Southeast Asian Int Semin (ASAIS 2019). 2019. p. 90–95.
7. Elfarri EM, Rasheed A, San O. Artificial intelligence-driven digital twin of a modern house demonstrated in virtual reality. IEEE Access. 2023;11:35035.
8. Government of India, Ministry of Finance, Department of Economic Affairs. Economic Survey 2023–24. New Delhi: Government of India; 2024.
9. Hasan MK, Mun H, Ampode KMB, Lagua EB, Park H, Kim Y, *et al*. A systematic literature review on the uses, benefits, challenges, and prospects of digital twins in livestock farm management. Adv Anim Vet Sci. 2024;12(12).
10. Jacoby M, Usländer T. Digital twin and Internet of Things—Current standards landscape. Appl Sci. 2020;10:6519.
11. Jia Y, Li L, Gao L. Research on virtual collection method of layer house temperature for the construction requirements of digital twin system. Poult Sci. 2025;104(2):104771.
12. Kor M, Yitmen I. An investigation for integration of deep learning and digital twins towards Construction 4.0. Smart Sustain Built Environ. 2021;12(3):461–487.
13. Kreuzer T, Papapetrou P, Zdravkovic J. Artificial intelligence in digital twins—A systematic literature review. Data Knowl Eng. 2024;151:102304.
14. Lee D, Lee S. Digital twin for supply chain coordination in modular construction. Appl Sci. 2021;11(13):5909.
15. Liu Y, Zhang L, Yang Y, Zhou L, Ren L, Wang F, *et al*. A novel cloud-based framework for the elderly healthcare services using digital twin. IEEE Access. 2019;7:49088–49101.
16. Lv Z, Xie S. Artificial intelligence in the digital twins: State of the art, challenges, and future research topics. Digit Twin. 2022;1:12.
17. Neethirajan S. Digital phenotyping: A game changer for the broiler industry. Animals. 2023;13:2585.
18. Neethirajan S, Kemp B. Digital twins in livestock farming. Animals. 2021;11:1008.
19. Ojo RO, Ajayi AO, Owolabi HA, Oyedele LO, Akanbi LA. Internet of Things and machine learning techniques in poultry health and welfare management: A systematic literature review. Comput Electron Agric. 2022;200:107266.
20. Salem T, Dragomir M. Options for and challenges of employing digital twins in construction management. Appl Sci. 2022;12(6):2928.
21. Shishehgarkhaneh MB, Keivani A, Moehler RC, Jelodari N, Laleh SR. Internet of Things (IoT), Building Information Modeling (BIM), and digital twin (DT) in construction industry: A review, bibliometric, and network analysis. Buildings. 2022;12(10):1503.
22. Symeonaki E, Maraveas C, Arvanitis KG. Recent advances in digital twins for Agriculture 5.0: Applications and open issues in livestock production systems. Appl Sci. 2024;14(2):686.
23. Tarek N, El-Hefnawy NA, Abdelatey A, Abdel-Kader H. Digital twin-based job shop scheduling algorithm for poultry feed industrial factory. Int J Comput Inf. 2023;10(3).
24. HLPE-FSN Steering Committee, Lehmann B, Clapp J, Adeyemo O, Burlingame B, Echeverría R, *et al*. Data collection and analysis tools for food security and nutrition: Towards enhancing effective, inclusive, evidence-informed decision making. 2022. [Report].
25. Slob N, Hurst W. Digital twins and Industry 4.0 technologies for agricultural greenhouses. Smart Cities. 2022;5(3):1179–1192.
26. Van Verdouw C Jr, Tekinerdogan B, Beulens A, Wolfert S. Digital twins in smart farming. Agric Syst. 2021;189:103046.

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