Applications of Artificial Intelligence in Veterinary Medicine: A Review

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ABSTRACT

This paper explores the transformative applications of Artificial Intelligence (AI) in veterinary medicine, including diagnostic enhancements, personalised treatment, and animal welfare monitoring. Key areas included using AI in image interpretation, automated pathology, wearable health-monitoring devices, and outbreak prediction. AI's integration in education is also discussed, highlighting virtual reality for skill development. Challenges, such as data security, bias, and ethical implications, are addressed to emphasize responsible AI deployment, besides discussing the AI's potential to improve diagnostic accuracy, streamline treatments, and advance animal health, paving the way for future innovations in veterinary care.

Keywords: Artificial Intelligence, Disease Surveillance, Predictive Analytics and Veterinary Medicine

INTRODUCTION

Artificial Intelligence (AI) has revolutionized various sectors, and veterinary medicine is no exception. AI offers immense potential for enhancing the efficiency and accuracy of veterinary diagnostics, treatment planning, and animal health management. AI technologies like machine learning, deep learning, and natural language processing could enable veterinarians to make more accurate and timely decisions. From interpreting diagnostic images and analyzing genetic data to monitoring animal behaviour and predicting disease outbreaks, AI might transform the landscape of veterinary medicine. This shift enhances animal care and advances research and promotes animal welfare. With the growing need for precision in animal care, AI-based tools and technologies transform how veterinarians approach diagnostics, disease prevention, and therapeutic interventions (Appleby *et al.*, 2022 and Akinsulie *et al.*, 2024). This review paper explores the diverse applications of AI in veterinary medicine, as well as its benefits, challenges, and prospects.

AI IN VETERINARY DIAGNOSTICS

Accurate and timely diagnosis is critical in veterinary medicine to ensure appropriate treatments. AI-powered diagnostic tools can assist veterinarians in analyzing medical images, detecting diseases, and predicting outcomes with unprecedented accuracy.

Image Recognition and Interpretation: AI algorithms can help to interpret medical images such as X-rays, ultrasounds, MRIs, and CT scans. AI models trained on vast datasets of medical images can detect anomalies like fractures (Jung *et al.*, 2024 and Kutbi, 2024), tumours, and organ abnormalities in animals (Pereira *et al.*, 2023). AI tools such as convolutional neural networks (CNNs) have shown promise in identifying patterns that may be challenging for the human eye, enabling earlier diagnosis of diseases such as cancer, arthritis, and cardiovascular disorders (Mohammed *et al.*, 2024).

Automated Pathology: AI can also transform veterinary pathology. Machine learning algorithms can analyze histopathology slides and identify specific markers for diseases such as cancer, mastitis, and parasitic infections. Automated pathology reduces the workload for veterinarians while increasing diagnostic

precision, especially in large-scale operations such as livestock health monitoring (La Perle, 2019 and Pritchett, 2023).

Wearable Devices and Predictive Analytics: Wearable devices integrated with IoT technology have shown potential to monitor various health indicators in livestock and pets, such as temperature, heart rate, and physical activity. These wearables collect real-time data through AI and machine learning algorithms and utilize predictive analytics models to assess and anticipate health challenges, including infections and metabolic or reproductive issues, enabling early intervention and optimized animal health management (Klingstrom *et al.*, 2024 and Sheela *et al.*, 2024).

AI IN TREATMENT AND DISEASE MANAGEMENT

Personalised Treatment Plans: AI-driven systems can analyse large datasets to provide personalised treatment recommendations tailored to each animal's unique characteristics (Rahman, 2023). For instance, AI can optimize drug dosages and combinations by analyzing a patient's genetics, disease progression, and historical data. This is especially useful in managing chronic conditions like diabetes, cardiovascular diseases, and renal disorders in pets.

Veterinary Surgery and Robotics: AI-powered robotics is emerging as a tool in veterinary surgeries, enabling more precise and less invasive procedures (Lisacek-Kiosoglous *et al.*, 2023). Robots, guided by AI algorithms, can assist in complex surgeries, such as orthopaedic and neurological procedures. These AI-driven technologies promise to boost surgical accuracy, minimize invasiveness, and enhance overall patient outcomes. Though obstacles persist, continued research and development, along with expanded access and training, will be essential to unlocking the full potential of AI-driven robotics in veterinary surgery (Celeritas Digital, 2024)**.**

Disease Surveillance and Outbreak Prediction: AI plays a vital role in disease surveillance, particularly in livestock management and public health. Machine learning models (Guitian *et al.*, 2022) can analyse data from various sources such as climate patterns, wildlife populations, and animal movement to predict potential disease outbreaks. These approaches aid in predicting outbreaks and managing zoonotic diseases, offering timely data to prevent and control potential health threats in both animals and humans.

AI IN VETERINARY EDUCATION AND TRAINING

Simulations and Virtual Reality: Virtual reality and AI-driven simulations are transforming veterinary education by providing immersive, interactive platforms that enable students to practice complex procedures in a safe, controlled environment. These technologies enable students to refine skills in diagnostics, surgical techniques, and emergency response through realistic scenarios that closely mimic real-life challenges. With integrated feedback mechanisms, VR and AI-powered systems deliver instant guidance on technique, accuracy, and procedural steps, which enhances students' confidence and competence. By allowing repeated practice and fostering skill retention, these platforms are invaluable in preparing students for hands-on, high-stakes veterinary work (Hunt *et al.*, 2020 and Tran *et al.*, 2024). Virtual clinical trials, also called *in silico* imaging trials, are another means to efficiently evaluate imaging technologies in the medical and veterinary fields (Abadi *et al.*, 2020).

Knowledge Discovery and Research: AI facilitates knowledge discovery in veterinary medicine by processing vast scientific literature and research data. Natural language processing (NLP) algorithms can quickly analyze research papers, clinical trial results, and historical data to uncover patterns, trends, and correlations. This helps veterinarians stay updated with the latest advances and apply evidence-based practices in their clinics (Bouchemla *et al.*, 2023).

AI IN ANIMAL WELFARE AND BEHAVIOUR MONITORING

Behavioural Analysis: AI systems monitor animal behaviour, identifying abnormal

patterns that may indicate stress, pain, or illness. For instance, AI-powered cameras and sensors in farms can track livestock behaviour, detecting issues like lameness by intelligent perception models (Qiao *et al.*, 2021), aggression, or changes in feeding habits. Sound analysis and radio-frequency identification devices (Li *et al.*, 2020) can be used to analyse the behavioural traits in broilers and layers in commercial poultry setups. Analysing these behaviours allows prompt intervention, improving animal welfare and reducing production losses.

Emotion and Stress Detection: AI technologies are being leveraged to analyze animal emotional states by interpreting facial expressions, body posture, and vocalizations. These advancements help in assessing stress and discomfort, particularly in pets and livestock. AI-powered systems utilize machine learning to detect and classify emotional cues from facial indicators, such as ear and eye movements (Boneh-Shitrit *et al.* (2022) in dogs and Feighelstein *et al.* (2024) in horses)), and body postures (Ferres *et al.*, 2022), allowing for non-invasive assessments of stress or anxiety. Such systems can identify behaviours associated with stress or illness in livestock, such as changes in feeding behaviour or movement, which are crucial for timely intervention and animal welfare management. Similarly, in pet transport and veterinary contexts, AI tools can help manage stress by recognizing signs of anxiety, allowing veterinarians or handlers to take action to improve the animal's experience during these potentially stressful situations (Tanaka *et al.*, 2023).

CHALLENGES AND ETHICAL CONSIDERATIONS

Data Privacy and Security: In veterinary and livestock management, AI applications are increasingly utilized to process vast datasets, including medical records and animal health parameters. However, this rise in AI usage brings critical privacy and security challenges, especially in large-scale agricultural and food production settings, where safeguarding sensitive data is paramount (Fuentes *et al.* (2022), Lustgarten *et al.* (2020), and Basran *et al.* (2024)). Aligning AI systems with data protection standards such as the GDPR in Europe, Information Technology (Reasonable Security Practices and Procedures and Sensitive Personal Data or Information) Rules, 2011, under the IT Act in India, emphasizes the protection of sensitive data, along with relevant privacy frameworks. To mitigate security concerns, experts advocate encrypted data transmission, anonymization techniques, and, in some cases, blockchain technology to enhance data integrity and transparency. In India, the potential of blockchain is recognized for secure livestock data sharing, as seen in pilot programs within the agriculture sector. AI data management systems in veterinary setups should incorporate continuous monitoring and audit trails, addressing vulnerabilities while ensuring compliance, as recommended in guidelines such as the U.S. FDA's Good Machine Learning Practices (GMLP). In addition, India's National AI Strategy highlights the importance of secure data practices, transparency, and accountability in AI-based applications. By adopting these best practices, the veterinary and livestock industries can leverage AI's capabilities to enhance animal welfare and health outcomes, maintaining a balance between innovation and data privacy across diverse operational landscapes.

Bias in AI Models: AI models can sometimes inherit biases from the data they are trained on. If the datasets used to train AI systems are not diverse, the algorithms may not perform well across different species, breeds, or geographical regions (Nazer *et al.*, 2023). This can lead to misdiagnosis or inappropriate treatment recommendations, making validating AI models with a wide range of animal populations critical (Gaonkar *et al.*, 2020).

Ethical Use of AI in Decision-Making: AI plays a valuable role in veterinary diagnostics and treatment assistance, yet it is widely recognized that final decision-making should remain with the human veterinarian. Ethical concerns like overdiagnosis, trust and distrust, and autonomy of clients (Coghlan *et al.*, 2023) may arise from fully automated decision-making systems, as they might lack the nuanced understanding that

comes from a veterinarian's clinical expertise. Best practices for integrating AI into veterinary care emphasize a "human-in-the-loop" approach. This includes rigorous validation of AI models in real-world scenarios and under clinical supervision, ensuring that AI tools supplement, not override, the clinician's expertise. Veterinarians remain essential in interpreting AI-driven results within a broader context of the patient's history and condition. Implementing frameworks like Good Machine Learning Practice (GMLP) ensures that AI in veterinary settings maintains transparency and ethical integrity, and is regularly monitored to avoid biases or automation errors that could impact animal care quality (Appleby *et al.*, 2022 and Bouchemla *et al.*, 2023).

FUTURE PROSPECTS

The future of AI in veterinary medicine looks promising as technology continues to advance. In the coming years, we can expect more sophisticated AI-driven tools for remote diagnostics and telemedicine allow veterinarians to care for animals in rural or underserved areas, enhanced integration of AI with genomics, enabling precision medicine approaches tailored to individual animals' genetic profiles, and the development of AI-powered wearable devices for continuous health monitoring, enabling early detection of diseases in pets and livestock.

CONCLUSION

AI can be a tool to revolutionize veterinary medicine by improving diagnostics, treatment planning, disease management, and animal welfare. As AI technologies evolve, they will play an increasingly important role in enhancing the quality of veterinary care. However, addressing the challenges and ethical considerations is essential to ensure that AI is used responsibly and effectively in veterinary care.

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