Review Article

The Implementation of Artificial Intelligence in Veterinary Diseases and Practices: A Comprehensive Review

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Abstract | There currently exists no regulatory structure controlling the development and application of artificial intelligence (AI) tools in veterinary medicine and infectious diseases (viral, bacterial, and parasitic), in contrast to the heavily regulated field of the development of medical devices (which include AI) in human medicine. When introducing such potent technology that might affect the welfare of both humans and animals, we must acknowledge the significance of exercising prudence and accountability. As veterinary experts, it is therefore our responsibility to hold ourselves responsible for guaranteeing the security, precision, and dependability of any AI technologies we create or use. Effective outcomes in an area where data misunderstanding, even hostile misinterpretation, is commonplace depending on data transparency and use. The AI tools can be tricked by deliberate manipulation of data. It has been shown how image disruptions that the human eye interprets as slight changes can cause an AI tool to incorrectly show a tabby cat image as more likely to be guacamole. Although this is a humorous example, it raises a very important question regarding what happens if the self-driving car's camera is covered, causing the system to misinterpret blurry images of pedestrians. Expanding the use of an evidence-based approach to creating AI is necessary, as is supporting openness, continuous quality control, and a risk-benefit analysis. We think AI tools should only be used in clinical settings once they have undergone thorough validation. Once that is done, we think they should be continuously checked in clinical settings. Furthermore, it is imperative that veterinary practitioners receive precise instructions and guidelines for the best possible use of these tools.

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Introduction

Opinions on AI in veterinary medicine-risks and concerns: The most possible concerns posed by AI, according to survey respondents, are the introduction of automation bias, clinical blunders, and a lack of regulation. Overall, fewer hazards were identified, including data bias, the elimination of human employment functions, and adverse patient effects. Even if the use of AI were thought to be

low-risk, strong scientific research and instruction would reduce the dangers brought forth by a lack of supervision and medical mistakes to some extent.

Additional concerns raised included the potential skills loss

• Veterinary staff deskilling due to over-reliance on AI.
•Customers that show automation bias will completely avoid seeing physicians if technologies are made publically available.
• The owner could always be more likely to believe in an AI solution than in the veterinarian. similar to Dr. Google at the moment.
• Clients mistreating their own pets after diagnosing them with it. I support customers conducting their own research, but I worry that if they do so in place of seeing a veterinarian and overlook something, cases may be handled improperly.
• The danger of adopting a one-size-fits-all strategy and depending too much on technology. Isn't it amazing how human minds allow us to evaluate a given circumstance and handle each animal as an isolated case?
• We can talk among ourselves about reasons and remedies, but we also must give the owner the final says. Vet care involves feelings, thus I don't think we should merely follow computer recommendations.

Just over half of respondents indicated they would be delighted to use AI in the field of veterinary medicine, and a third said they were not sure. It is obvious that we have a long way to go before we can encourage widespread adoption of AI technology and inspire faith in it. When questioned about the kind of instruction and data that would promote the adoption of AI, instructions regarding certain instruments, their signs, restrictions, precision, and methods of use developed were given top priority. Also, half stated that having a basic understanding of AI was either vital or would be greatly beneficial.

As in human medicine, where the use of artificial intelligence (AI) tools for medical purposes requires FDA/EMA permission, strict regulation might guarantee that AI technologies are proven, dependable, and repeatable. In addition to their qualifications, veterinarians cannot be expected to possess sufficient knowledge in data interpretation and technology application, even though a certain level of understanding of how AI technologies operate is required to appreciate their usage. A regulatory organization with such cross-sector experience may establish criteria to demonstrate the effectiveness of AI technologies and foster the confidence required for those that pass its inspection.

AI in diagnostics

In veterinary medicine, one important application of AI is in illness detection and prognosis. AI has been used, for instance, to help diagnose canine hypoadrenocorticism, a condition that can be deadly to patients and is difficult to diagnose but has a great outlook with suitable medical care. These instruments can increase the diagnostic process's cost-effectiveness, particularly in cases of non-specific demonstration. Visceral leishmaniasis is one instance where AI techniques are used to analyze features of physical inspection and are being investigated for precision in diagnosis (Ferreira *et al.*, 2022).

Algorithms for machine learning have also demonstrated greater accuracy in diagnosing canine diseases than serological testing for leptospirosis, which carries significant zoonotic consequences as well (Reagan *et al.*, 2022).

Reducing the complexity of necessary diagnostic tests might be another topic. For instance, syringomyelia (SM) and chiarilike malformation (CM) have been linked to welfare issues and pain in Cavalier King Charles Spaniards, although historically, an MRI has been necessary to reach a final diagnosis.

An AI technique that integrates facial image analysis with MRI data can help anticipate the probability of CM/SM based on dog head photos downloaded to an owner's smartphone (Spiteri *et al.*, 2019). AI's capacity to complete laborious, repetitive jobs quickly and without getting tired is what makes it so beautiful. Pathologists can analyse whole sections of canine mast cell tumours that are submitted for histopathology, however due to time constraints, human. Usually, pathologists have focused their research on 10 high-power fields to allow for a more thorough examination of malignant features, as the existence of mitoses (Bertram *et al.*, 2019).This allows time for human pathologists to concentrate on more imaginative, captivating assignments like intricate cases or investigation projects.

Disease monitoring and prediction

Naturally, the ultimate objective is to avoid illness

rather than treat it, or, in the event that prevention is not possible, to forecast and take early action to enhance the prognosis. In light of this, neural networks made up of computers have been utilized for predicting the chance that cats older than seven years will develop a chronic renal illness within a year. Additionally, 11 AI algorithms have been used to predict seizures in dogs that have seizures (Biourge *et al.*, 2020). Early intervention and prevention are made possible by these diagnostic and detection techniques, enhancing welfare and results.

AI in treatments

The treatment of illnesses is a further use of AI in veterinary medicine. According to a study that was published in the International Journal of Veterinary Emergencies and Critical Care, a high degree of accuracy might be achieved in predicting the fates of critically ill dogs using an AI-based tool. Furthermore, a device was employed in a study that was released in the Journal of Feline Medicine and Surgery. learning method to assist in identifying the variables that were most helpful in forecasting the results of felines with renal illness, both acute and chronic (Nejedly *et al.*, 2019).

AI in research and one health

AI, particularly when it comes to genome and protein interrogation, holds great promise for the creation of innovative diagnostics and treatments. AI has been applied to the early identification of cancer using cell-free fragments of DNA in blood samples, following advancements in human medicine. Additionally, deep networks of neurons have been created to forecast the patterns of protein folding, which can greatly speed up the process of finding new drugs, assisting in the fight against issues like leishmaniasis and resistance to antibiotics. AI algorithms may be able to predict protein interactions, therapeutic targets, and the complexity of genetics, which could expedite the process of drug discovery and lessen the need for testing on living animals. Mapping polymorphisms in human malignancies to canine cancers in the realm of cancer research provides the chance to establish comparative species models in order to develop precision therapies that are advantageous to both canines and people (Rodrigues *et al.*, 2021).

There is enormous potential to enhance zoonotic and animal disease prevention, diagnosis, and treatment. The universe of the genome is opened by AI. Regarding the microbiota's effects on animals' welfare, health, and output, accuracy one of the fields where there has been rapid advancement is the human aspect, which will eventually increase the possibility of procedures for treatment depending on technology. The ability to make information easier to access via transfer ought to enhance dialogue. veterinary teams, as well as between clients and even transdisciplinary and cross-sector working together with stakeholders engaged in public health and animal health sustainability of the environment and health. Animals used in food production can be traced. Pharmacovigilance, in addition to epidemiology, Data ought to support public health initiatives coupled with animal welfare. The complexity and diversity of veterinary medicine, together with the lack of readily available high-quality data sets, pose major obstacles to the creation and verification of AI-based systems, despite the fact that AI technology has the ability to transform many aspects of veterinary care. Notwithstanding these obstacles, veterinary care is ideally positioned to gain from the developments in artificial intelligence.

AI in equine practice

The equine sector is a vital component of the world economy and a major employer, as well as a source of sport, culture, and entertainment. As technology develops, it is becoming more and more clear how AI might modernize the breeding, racing, welfare, and disease management sectors of the industry.

Health monitoring and diagnostics

Maintaining the well-being and welfare of horses depends on effective disease management. AI has a significant impact on early illness identification, prevention, and treatment. AI can detect trends and forecast the possibility of disease outbreaks by evaluating vast volumes of data from numerous sources, including veterinarian documentation, variations in the weather, and horse movement. This allows for proactive disease control techniques. Furthermore, early disease and abnormality detection might help veterinarians treat patients more quickly and possibly increase survival rates. powered by AI imaging or diagnostic tools can help with this process. AI is used in tools and systems that track vital signs, evaluate gait, and show early indicators of disease or damage. Additionally, by using these tools, veterinarians may be able to diagnose patients more precisely, schedule treatments on time, and even produce better results.

In cases of subpar performance, for instance, body-mounted inertial sensors can gather movement data from many reference locations and analyze it to supply recommendations for additional lameness inquiries. Additionally, AI can be used to create customized treatment programs that consider each horse's unique condition, medical background, and responsiveness to medicine (Reed *et al*., 2020).

Nutrition and feeding

AI systems can analyze information about individual horses and produce personalized feeding schedules that consider variables like age, activity level, and dietary needs.

Breeding and genetics

AI can process enormous amounts of data about individual horses and their ancestry to properly estimate their genetic potential through the application of sophisticated algorithms and machine learning. By using this knowledge, breeding decisions may be made more effectively, and the likelihood of generating faster, stronger, and healthier horses may increase. AI is also useful in the analysis and interpretation of genomic data, which aids in the identification of genes linked to favorable characteristics like athletics, temperament, and resilience to disease. By using this knowledge, breeders can increase the overall quality of the horses they produce by making better educated decisions. AI-driven technologies are used to evaluate performance, genomic, and pedigree data to forecast offspring potential and enhance breeding initiatives (Hill *et al*., 2010).

Training and performance optimization

AI can assist trainers in developing individualized training programs, tracking results, and pinpointing areas in need of development. Motion capture technologies and biomechanics analysis can also offer insightful information about a horse's gait, enhancing performance and lowering the risk of injury (Marlin *et al*., 1999).

Race prediction and betting

AI can improve betting systems, optimize race plans, and guide training regimens. To create customized training plans and racing tactics, machine learning algorithms may examine enormous volumes of data on a single horse's performance, including training schedules, past race results, and environmental circumstances (Benter, 2008).

AI in livestock farming

Another sector that has experienced an AI revolution is agriculture. AI has greatly benefited livestock raising, in particular, in a number of ways. This technology could improve productivity, support sustainable farming methods, and improve the welfare of animals.

Current applications of AI in livestock farming

Precision livestock farming: Employing AI and sensor technology, personalized livestock farming (PLF) keeps an eye on and manages each individual animal. By gathering and analyzing data on animal behavior, development, health, and reproduction, these technologies help farmers increase productivity by empowering them to make well-informed decisions. The goal is to develop management systems that are predicated on the ecological effects of livestock production, livestock welfare and health, and continuous automated oversight and oversight of output (Berckmans, 2014).

Examples include

Automated milking systems are machines that milk cows using robotics and artificial intelligence (AI), saving labor expenses, and guaranteeing regular milking schedules. Animals are fitted with wearable gadgets that check their body temperatures, heart rates, and levels of activity. After that, any irregularities are found through analysis, which enables the early diagnosis of stress or disease as well as the prediction of cattle oestrus. Systems for computer vision: AI-enabled cameras can track the behavior, mobility, and physical state of livestock, giving valuable information about their welfare. For instance, lameness affects up to 25% of dairy cows in the modern era, making it a serious welfare issue. When dairy cows approach a milking robot, automatic camera video is analyzed to show lameness issues and give a warning to the farmer. instance, lameness affects up to 25% of dairy cows in the modern era, making it a serious welfare issue. When dairy cows approach a milking robot, automatic camera video is analyzed to show lameness issues and give a warning to farmer.

Population disease detection and prevention

AI has made it possible to identify diseases in cattle early on, stop them from spreading, and reduce losses. Through the analysis of data from cameras, wearable technology, and other sensors, machine learning algorithms are able to spot patterns linked to particular diseases. With the use of this information,

producers are able to proactively safeguard their animals by treating, immunising, or placing them in quarantine. AI-powered systems, for instance, are able to recognise and categorise bird vocalisations in order to diagnose illnesses and stress in chickens. Similar to this, cough detection on pig farms helps to identify ventilation issues and initiate early treatment for infectious respiratory diseases.

Genetic selection and breeding

In livestock production, AI is becoming increasingly important in the selection of genes and breeding. AI systems are able to recognize animals that possess desired qualities, such as improved growth rates, disease resistance, or increased milk output, by examining enormous volumes of data. For instance, the genomic selection approach makes use of AI systems to forecast an animal's breeding value based on its genetic information (Hayes *et al*., 2009).

By using this information, farmers can improve the genetic make-up of their herds overall by making better breeding selections.

Nutritional optimization

It is possible to apply mathematical models to forecast the ideal feed for animals blend for an animal, such as the best proportion of cost, nutrients, and water (Saxena and Parasher, 2019).

Future developments in AI for livestock farming

AI-driven autonomous farming: As AI technology develops further, fully autonomous cattle farms may become a reality. To ensure a smooth, labor-free operation, these farms would incorporate a variety of AI-driven devices, including automated feeding, milking, and monitoring. This degree of automation has the potential to improve animal care, boost output, and drastically lower labor costs. Robotic milking and data analysis are already combined in automated milking systems to provide better herd management.

End to end technological solutions covering everything from breeding selection to optimal reproduction, feeding, and exercise to health monitoring and slaughter selection will not be far off.

China's towering pig farms, which have the capacity to process over a million pigs annually and are all automated system-fed and monitored, made headlines recently. This is being heralded as a big step forward to enhance cattle production in a country that struggles to feed its population. However, with this unprecedented degree of intensification, unavoidably, welfare considerations have been voiced (Anon., 2023).

AI in veterinary radiology

When it comes to the broad application of clinical tools, radiography is the area of human and animal medicine were AI is arguably most advanced. This gives veterinary radiology the chance and the responsibility to set the standard for morally ground-breaking AI research and implementation.

In recent years, the application of AI techniques in human radiography has grown significantly in popularity. In order to help radiologists analyse medical images more quickly, accurately, and efficiently, these technologies have been developed. Without a doubt, the increased demand for imaging services will greatly reduce the strain on radiologists if methods like these are implemented to veterinary radiology.

Examples of how AI is being used in radiology include

AI-driven systems for triage: By recognising high-priority cases and marking them for rapid attention, you may assist radiologists in managing workflow and case prioritisation. This can lessen delays and boost the radiology department's general effectiveness.

Computer-aided detection (CAD): This technique helps radiologists find areas that need more attention fast by analysing images and identifying suspicious radiological indications.

The technique of recognising and delineating particular structures in a picture, like organs or tumours, is known as image segmentation. In many image analysis activities, including radiation therapy planning, image-guided surgery, and image registration, this is a crucial step. This procedure can be automated using AI algorithms, which will increase its speed and accuracy.Image enhancement is the technique of making structures inside an image more visible.

This can be achieved by using filters that can draw attention to specific structures or by changing the image's brightness and contrast. This procedure can be automated with the assistance of AI algorithms, improving its consistency and efficiency. Medical

photos can be categorized using AI algorithms into distinct groups, such as healthy versus ill, benign versus malignant, and so forth. This aids radiologists in choosing a more sensible course of action for care and therapy. Image registration helps radiologists better comprehend how a condition changes over time by aligning and registering several images of one identical biological component. Radiologists can make better suggestions by using quantitative imaging, which is capable of helping extract data that is quantitative from medical pictures. Examples of this information include measurements of the density of tissues or volume.

Imaging that is done autonomously

using AI algorithms to manage the imaging procedure and choose which images to acquire. This can involve making modifications to the radiation dosage, choosing the best imaging method, or fine-tuning the imaging variables for a particular clinical purpose.

Radiomics

The process of identifying quantitative characteristics in medical images and applying them to forecast various patient outcomes, including survival, tumour growth, and response to treatment. In order to accomplish this, AI algorithms are used to evaluate the photos and extract important information that is hidden from view.

Information

The availability, calibre, and volume of data in the veterinary and human sciences differ significantly.

Quantity: Millions of photos and the clinical data that goes with them are among the massive amounts of standardised data that are available in human radiology. The range of breeds and species in veterinary radiology results in increased anatomical variance and a considerably smaller volume of data.

Because of this, training AI algorithms to reach the same degree of accuracy as human radiology becomes more challenging.

Quality: Veterinary radiology has far more variable quality control over picture acquisition and manufacturing, including location, exposure, and labelling, than does human radiology.

Availability: Stricter laws and concerns regarding privacy, such HIPAA(Health Insurance Portability and Accountability Act) in the United States), apply to human medical data.

Accessibility: Accessing and compiling big data sets might be difficult because veterinary data is frequently localised inside certain clinics or hospitals. In human medical systems, data may be less available due to data protection rules, but it may be more accessible in terms of huge, standardised data pools (like the National Health Service in the U.K.).

Conclusions and Recommendations

AI is now a part of daily life and affects us in ways we may not even be completely aware of. This increasingly sophisticated non-human "brain" offers a vast resource that sees the information it receives through a whole new algorithmic prism, going beyond the capacities and functioning of our own biological neural networks. The adage "Two heads are worth more than one" has recognized the benefits of improved problem-solving ability and a broader viewpoint for millennia.

But there's also the proverb Ask two doctors, get two opinions. So, who gets the last say a machine or a man? Artificial intelligence's real strength comes from enhancing human comprehension and freeing up more human resources for social and relational tasks that AI is not going to replace.

While AI may be superior at the scientific side of veterinary care, humans are still necessary to apply knowledge in the sensitive clinical context; it is unlikely that robots will ever totally replace the "art" of being a veterinarian. Similar to how we study cell-based biochemistry to understand the impact of treatments on whole body systems, we need to give our veterinary medicine society background knowledge of how artificial intelligence (AI) applications are developed in order to enable professionals to apply the results of artificial intelligence confidently and correctly. In addition to improving our proficiency with AI technologies, we also need to employ critical thinking and well-informed questioning to identify biases and mistakes.

AI needs to be viewed as a separate medical field in and of itself. This is because of the data it is given during development, the questions it is asked, the algorithm's mechanics and capacity for self-learning, continuous

quality improvement, and, most importantly, what its outcomes can and cannot tell humanity and when they might be inaccurate. Regulation and/or the implementation of strict standards, such as those suggested by the MHRA regarding computer software and AI as medical devices, including guidelines for machine learning in medical devices, are necessary to provide safeguards against dangers.

Novelty Statement

With artificial intelligence (AI) emerging as a potent ally, a disruptive tsunami is sweeping throughout the veterinary practice environment. This review explores new ground by negotiating the intersection of state-of-the-art technology with the complex field of veterinary ailments and procedures. By means of an exhaustive investigation into the application of AI, we unveil new avenues in which machine learning not only enhances but transforms diagnosis, therapeutic approaches, and overall health results for our animal friends.By dissecting the innovative fabric, this review aims to reimagine veterinary care in the future, where the combination of AI and therapeutic knowledge promises previously unheard-of breakthroughs and a revolution in how we protect the health and welfare of our beloved animal companions.

Author's Contribution

M.W.Gulzar conceptualized and designed the study plan, developed the search query and conducted the literature search, compiled the data,proof reading , file uploads and submissions.
J.Hussain screened the articles, wrote reviewed,prepared and approved the final draft of the manuscript writing prior to submission.
Both Authors revised and accepted the final version of the article for publication.

Conflict of interest

The authors have declared no conflict of interest.

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