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Applications of Artificial Intelligence in Livestock Health and Its Future Research Approach

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***Abstract*—Artificial Intelligence (AI) is swiftly changing veterinary science by providing novel, data-oriented solutions. Solutions that improve diagnosis, disease monitoring, reproductive oversight, and research by utilizing machine learning (ML) and deep learning (DL), AI enhances diagnostic precision, accelerates vaccine progress and enhances studies in antimicrobial resistance (AMR) and cancer research. These technologies also support customized healthcare and analytics-based animal management. This demonstrates AI's capability to transform veterinary practice and public health. AI, a branch of computer science, enables machines to mimic cognitive abilities in humans including learning, reasoning, and making decisions. Although the concept originated in Since the 1950s, significant advancements have occurred only in recent decades because of powerful computers and extensive data collections, and enhanced algorithms. Currently, AI is crucial in numerous fields of veterinary and biomedical science, offering greater precision and effectiveness in animal health management. This assessment provides a summary of essential AI methods and their practical applications in veterinary medicine, including diagnostics, epidemiology, reproduction, and studies. It also examines existing constraints, ethical concerns, and future possibilities. Opportunities for AI within the One Health model.**

I. INTRODUCTION

Artificial intelligence (AI) is a field of computer science where computer systems are designed tointended to execute activities that replicate human intelligence (Appleby & Basran, 2022). This Artificial intelligence (AI) involves the development of smart machines, mainly software applications, through merging the finest elements of science and engineering. Although the concept came from the In the 1950s, the AI resurgence was truly experienced in the early 2020s, Presently in the middle of the AI revolution fueled by unmatched advancements in infrastructure, simultaneous excellence in human resources, along with computation and machine learning (ML) components, encompassing deep learning (DL), (Parija & Poddar, 2024) [23]. Currently, AI has nearly penetrated every field of human existence and is evolving to revolutionize the health-care industry (Jiang et al., 2017)

II. HISTORY OF ARTIFICIAL INTELLIGENCE TECHNOLOGY

Recent implementations of AI have emerged over the past ten years, with the underlying concepts, an idea having has existed for a minimum of 70 years. During the late 1940s and early 1950s, the initial ideas of AI were presented to the scientific community. Perhaps most renowned, British computer scientist Alan Turing was among the earliest to present the idea of computers carrying out intelligent activities. in 1950. The phrase artificial intelligence was created by John McCarthy in 1955 (Kaul et al., 2020). Several existing AI applications have been in development for the last decade; however, the implementation of certain concepts and ideas has occurred for at least 70 years. The initial concepts AI concepts were introduced to the scientific community during the late 1940s and early 1950s. Most notably, the British computer scientist presented the idea of machines capable of thinking in 1950 (Kaul et al., 2020). The term artificial intelligence was suggested by John McCarthy in 1955. (Kaul et al., 2020; Currie, 2022). The domain of artificial intelligence underwent significant studied during the latter part of the 20th century, yet progress was minimal concerning the extent of its application and usage due to restrictions in computer capabilities, Rise in computing power that happened since the beginning of the millennium and the widespread The gathering and digitization of data has led to a surge in AI (Tran et al., 2019; Kaul et al., 2020). In healthcare, information pertinent to artificial intelligence uses includes, but is not restricted to, diagnostic imaging like radiographs, CT scans and MRIs; microscopic images obtained from cytology and histopathology; along with details obtained from healthcare.

III. METHODS OF ARTIFICIAL INTELLIGENCE

AI consists of numerous sub domains and methods, one of which is machine learning (ML) (Chartrand et al., 2017). In spite of the extensive history of utilization of artificial neural networks, the domain of medical image interpretation has recently achieved considerable advancements due to developments in image processing and machine learning, comprising enhanced computing capabilities and availability of a larger volume of labeled images (Tsuneki, 2022). Numerous research investigations have had been carried out in this field, resulting in enhancements in activities like image categorization, object identification, and picture segregation. Assessing medical images is highly subjective and intricate process, it would be highly advantageous to automate the examination procedure utilizing deep learning and artificial methods of intelligence. There has been a lot progress in the area of human medical image examination in recent years, yet progress is also starting to occur in the field of veterinary medicine (Hennessey et al., 2022)

IV. MACHINE LEARNING

Machine learning (ML), a branch of AI that educates algorithms to complete assignments by acquiring knowledge from data rather than through direct coding (Waljee & Higgins, 2010). Machine learning models can be developed in three methods: supervised. Education, unsupervised education, and semi-supervised education. In supervised learning, labeled datasets are utilized for training. Algorithms for categorizing data or predicting a value (Jiang et al. (2017). In supervised learning, the outcome of medical information understood prior to training the ML model to accomplish the task (labelled). In this type of ML, the algorithm needs two essential elements: a large quantity of information and the associated tags. Supervised learning refers to the process of teaching a model using labeled data. Dominant form of learning utilized by ML algorithms in healthcare since it produces the most straightforward clinical results important data (Jiang et al., 2017). However, unsupervised learning, where the ML algorithm generates its own standards for categorizing data or forecasting results might prove beneficial, especially when examining large datasets for where the characteristics that distinguish groups are not available (Jiang et al., 2017). In this category of machine learning, the algorithm is furnished with information that is free of any tags or established groupings. The objective in unsupervised learning is to attempt to create some understanding of the information by "filtering" it and observing if there are there any patterns or connections between persistence and attributes of patients that may hold clinical significance. Semi-supervised learning utilizes a mix of ensemble and could be beneficial in the context of algorithmic development when certain data lacks a clear conclusion (Jiang et al., 2017).

There are numerous sophisticated terms like 'assistance' vector machines, decision trees, logistic regression, and linear regression, which relies on supervised learning. However fundamentally, these are algorithms that merely provide a forecast, regarding a result determined by certain input data. Not supervised machine learning techniques, such as clustering and principal component analysis is utilized to investigate patterns and groupings in data without employing labeled results. At the at the core of these algorithms lies their ability to uncover patterns within data that function as a means to summarize information. These methods are known as conventional ML (Jiang et al., 2017)

V. ARTIFICIAL NEURAL NETWORKS:

Artificial intelligence (AI) is revolutionizing healthcare diagnostics by mimicking the structure and function of biological neural networks via artificial neural systems (ANNs) These systems are made up of interconnected layers. Nodes that handle information in a way influenced by the human brain (Currie, 2022), Similar to neurons, which send signals through intricate networks of input and output synapses, ANNs are created to obtain data, interpret it across various levels, and generate a comprehensible result. To more effectively understand the analogy, think about how both a person and AI system could identify pulmonary nodules in a healthcare setting picture. When a human specialist examines that type of image on a screen, light signals are detected by the retina, activating light receptors. These signals are subsequently transmitted through linked optic nerves to the brain, where a skilled veterinary radiologist analyzes them. The ultimate acknowledgment of "pulmonary nodules" stems from earlier training and continuous exposure, resulting in the formation of particular neural pathways able of associating shape and color patterns with that diagnosis.

In ANNs, a similar process takes place through computation. The medical image acts as the input, which is transmitted through concealed layers inside the network. These levels are implemented weighted filters throughout the training stage to enhance accuracy of predictions (Jiang et al., 2017). Although a straightforward ANN can have just a single hidden layer; the strength of AI resides. in deep learning, a type of machine learning that utilizes neural networks networks consisting of numerous (frequently exceeding ten) layers for analysis intricate data collections such as detailed medical imaging (Chartrand et al., 2017) A specific kind of artificial neural network referred to as a convolutional neural network (CNN) is commonly employed for analyzing medical images because of its ability to recognize spatial structures and derive characteristics from images. Regardless the redundant terminology, it's crucial to distinguish these ideas: AI encompasses the wider discipline, machine learning (ML) is a branch of AI, while deep learning represents a more focused area. a sector of ML that relies significantly on neural networks. a key benefit of AI is its capacity to reveal nuanced trends in data that might not be visible to human viewers.

Radiomics is an expanding area where artificial intelligence is applied to derive a variety of numerical attributes from imaging data, providing information on disease characteristics like cancer type (Bibault et al., 2020). This method shows potential for noninvasive diagnostic techniques and tailored treatment plans. Like defining a splenic mass or customizing treatment founded on distinctive imaging characteristics. Another important domain in AI pertinent to veterinary and human medicine is the processing of natural language (NLP). NLP enables machines to assess and extract significance from text and speech language, which is crucial since a significant portion of clinical Documentation is available in the form of unstructured text. Through the use of Linguistics-based ML methods allow for quick and efficient precise data retrieval from healthcare documents, aiding improved clinical decision-making and workflow effectiveness

VI. ARTIFICIAL INTELLIGENCE IN VETERINARY CLINICAL CARE

AI is transforming veterinary clinical care by enhancing diagnosis, treatment planning, and outcome forecasts. subarea of precision medicine referred to as radiomics utilizes mathematical analysis applied to medical images uncovers disease-specific processes that are not visible to the human eye as demonstrated Radiomics entails deriving quantitative characteristics obtained from imaging techniques such as MRI, CT, PET, and ultrasonography. This information, examined with statistical software, aid in tailored precision healthcare.

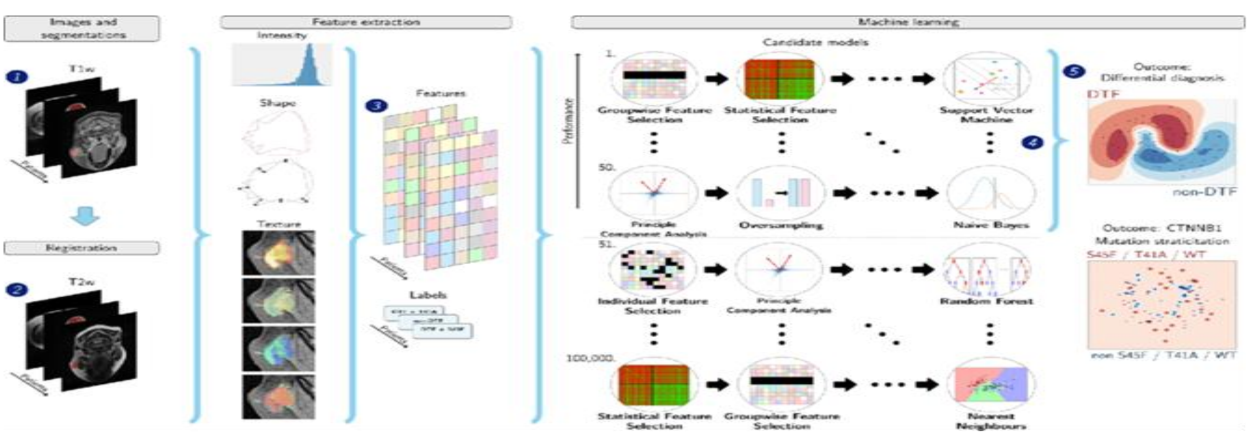

Fig.Differential diagnosis and mutation stratification of desmoid-type fibromatosis on MRI using radiomics: Schematic overview of the radiomics approach: adapted from [24] 24-Processing-steps-include_fig1_344381457 [accessed 24 Dec 2025] Processing steps include segmentation of the tumor on the T1-weighted (T1w) MRI (1), registration of the T1w to the T2-weighted (T2w) MRI to transform this segmentation to the T2w-MRI (2), feature extraction from both the T1w-MRI and the T2w-MRI (3) and the creation of machine learning decision models (5), using an ensemble of the best 50 workflows from 100,000 candidates (4), where the workflows are different combinations of the processing and analysis steps. DTF, desmoid-type fibromatosis.

Machine learning (ML), an essential part of AI, develops models that forecast outcomes based on past data. In contexts related to veterinary medicine, AI aids in understanding host-pathogen interactions, creating targeted treatments, and enhance predictive epidemiology. Artificial Intelligence improves diagnostic precision, suggests treatment strategies, recognizes risk factors and promotes the creation of focused treatments (Bibault et al., 2020, Ezanno et al., 2021). Diagnosis of Disease Prompt identification of illnesses is crucial for effective therapy. Artificial Intelligence assists in examining extensive clinical and imaging datasets, enhancing diagnostic accuracy and facilitating ongoing wellness tracking. For instance, (Reagan et al., 2020) utilized ML algorithms for diagnosing chronic hypoadrenocorticism (CHA) in canines from standard blood tests. In the same way, Texture Analysis (TA) has identified inflammatory canine glial neoplasia leading to meningoencephalitis, surmounting restrictions of traditional image analysis (Bouhali et al., 2022) Radiomics and artificial intelligence are utilized integrated into standard diagnostics to enhance sensitivity, precision and consistency (Bohr & Memarzadeh, 2020)

VII. SURVEILLANCE OF ZOONOTIC DISEASES

Artificial intelligence holds great potential for monitoring zoonotic diseases. Combining machine learning with conventional disease control techniques allow for risk forecasting, timely identification, and intervention (Agrebi & Larbi, 2020, Guo et al.,2023). Models such as Word2vec and VIDHOP forecast the range of viral hosts. from nucleotide sequences (Bartoszewicz, 2022). FluSPred utilizes protein and genomic information to evaluate the human infection capability of influenza variants (Roy et al., 2022).

VIII. EPIDEMIOLOGY AND MONITORING

AI aids in early identification of diseases and the efficient use of resources. in animal health epidemiology. Platforms such as PADI-web combine Algorithms in machine learning for identifying new diseases. Artificial intelligence is capable of ranking. samples based on the probability of testing positive, prioritize cases, and enhance monitoring effectiveness in food borne and animal diseases (Guitian et al., 2023) Artificial Insemination AI improves reproductive efficiency by analyzing data and visual identification. Predictive models determine best breeding periods; evaluate fertility, and direct insemination scheduling. CASA and flow cytometry provide accurate semen evaluation, enhancing sire choice (Zuidema et al., 2021) AI tools observe signs of oestrus, behavior, and reproductive activity. wellness from visual and imaging information, facilitating accuracy reproducing and enhancing mating success rates.

IX. EVALUATION, TREATMENT, AND ASSESSMENT OF PATIENTS

AI facilitates customized treatment strategies through integration genetic makeup, health background, and clinical information. It aids in medication choosing, dosage, and modifying treatment. In dairy, machine learning detects mastitis (Dhoble et al., 2019) [12], limping, forecasts calving, and predicts milk production (Shine & Murphy, 2021). Artificial Intelligence also aids in the surveillance of antimicrobial resistance (AMR), monitoring resistant bacteria, patterns of antibiotic usage, and epidemics (Rabaan et al., 2022) AI in Veterinary and Biomedical Studies

X. INVESTIGATING ANTIMICROBIAL RESISTANCE (AMR)

AI monitors AMR patterns, forecasts resistance, and aids new development of antibiotics. Algorithms such as Naïve Bayes, decision trees and support vector machines help in prediction of resistance and antibiotic formulation (Elalouf et al., 2025). AI shortens the duration of drug development and enhances efficiency. Monitoring, and detects resistance genes within food systems.

XI. RESEARCH ON CANCER

AI enhances cancer detection, treatment strategies, and medication development, exploration. It streamlines cancer detection, forecasts medication. Effectiveness and harmfulness, while tailoring therapy through evaluation genomic and proteomic information (AlZaabi et al., 2024) Instruments similar to Sybil, assess lung cancer risk from just one LDCT scan, facilitating effective assessment (Mikhael et al., 2023)

XII. DEVELOPMENT OF VACCINE

AI hastens vaccine development by pinpointing immunogenic aspects. antigens, forecasting epitope binding, and enhancing adjuvants. It allows for the choice of candidates with great potential. prior to trials, enhancing vaccine effectiveness and safety (Sharma et al., 2022). Artificial intelligence is transforming the way vaccines are created by enhancing the efficiency of the process and accurate. Through the analysis of extensive collections of genomic, proteomic, and immunological information, AI assists in swiftly recognizing promising Vaccine focuses on and streamlines candidate selection. These instruments enhance the intelligent formulation of vaccines for improved effectiveness, consisting of individualized and cross-protective compositions. Artificial Intelligence also supports immediate tracking of vaccine effectiveness, enhancing safety and reactivity while in operation. Furthermore, it promotes global collaboration via data exchange and shared platforms, accelerating worldwide vaccine creativity. In general, AI acts as a powerful driver for creating advanced vaccines and addressing emerging public health issues (Olawade et al., 2024)

XIII. RESEARCH ON PHYTOMEDICINES AND PHARMACEUTICALS

AI simplifies the process of discovering drugs from natural sources, assesses treatment effectiveness and forecasts side effects (Blanco-Gonzalez et al., 2023). It assists customized medicine, enhances clinical trial design, and decreases failure rates in drug development research.

XIV. FUTURE CHALLENEGES

As artificial intelligence is becoming more deeply integrated into veterinary In the realm of science, several obstacles remain to be tackled. Access to extensive, high-quality datasets is essential for developing strong algorithms. Many veterinary datasets lack standardized or comprehensive, creating efficient model progress challenging. Secondly, the "black-box" characteristic of most AI models limit transparency and possibly reduces clinician confidence (Burti et al., 2024) Ethics and regulatory structures must be created that can guide the responsible use of AI technologies in animal well-being (Ezanno et al., 2021) [14]. This involves addressing issues concerning algorithmic bias, data confidentiality, and responsibility for AI-assisted choices. Data proficiency and artificial intelligence resource education of veterinary practitioners will benefit

XV. CONCLUSION

Artificial Intelligence is quickly becoming an essential element of modern veterinary science. Please provide the text you would like me to paraphrase. Improving disease detection to epidemic forecasting and accelerating the development of drugs and vaccines, AI technologies possess instruments that can greatly enhance the well-being of creatures. However, meticulous execution is essential. This entails allocating resources towards data infrastructure, enhancing skills experts, and establishing ethical standards that govern AI deployment in veterinary clinics (Shah et al., 2024). This tool connecting technological advancement with moral responsibility and clinical significance, AI has the potential to transform veterinary practice, but also enhance the broader field of One Health, in where human, animal, and environmental health intersect.

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