International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; 10(1): 368-378
www.biochemjournal.com
Received: 14-11-2025
Accepted: 18-12-2025

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Cutting-edge potential of Artificial Intelligence: A paradigm shift in canine clinical practice

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DOI: https://www.doi.org/10.33545/26174693.2026.v10.i1e.6956

Abstract
Artificial intelligence (AI) is transforming our everyday life at an unprecedented pace. The emergence of technological advancement in AI aimed to bring together transparent solutions to tackle various global health challenges, including broad scientific space in veterinary research and canine clinical practice.AI has elicited profound impact on real world applications in animal disease detection and diagnosis with unprecedented accuracy and efficiency. The basic tenets of AI encompasses various technical understanding, including three major knowledge applications in machine learning (ML), natural language processing (NLP), and computer vision (CV) to assist disease detection, image classification, predicting outcomes, and tailor personalized treatment plans in canine practice. Critical language texts gleaned from uncategorized medical records, clinical notes, and textual data are transformed using NLP algorithm for relevant disease diagnosis and improved treatment outcomes. Moreover, image comparisons and scientific interpretation of digital images employing CV applications have potential to accurately pinpoint the binary classification task (diseaseds*vs.*healthy tissues). Here in this review, we explore the current knowledge of algorithms and networks that can offer numerous benefits to clinical decision-making in canine patient care, including highly precise treatment options and data-driven insights for veterinarians and pet owners. However, the legal and ethical risks, unavailability of resources and technological anxiety are some of the barriers towards implementing this high throughput AI technology in canine practice need to be addressed before integration. The exponential developments in current transformative AI research corroborate its potential to enable a paradigm shift over canine clinical practice and veterinary medicine.

Keywords: Artificial intelligence, machine learning, veterinary medicine, canine clinical practice

1. Introduction

Artificial intelligence (AI) is a branch of computing systems that has broadly converged from various scientific and technological fields, including data science, applied mathematics, psychometrics, statistical genetics, genomics, cybernetics, econometrics and computer engineering.AI was first defined in 1955 by John McCarthy, since then the discipline has relentlessly expanded its application in wide spectrum of technologies, including automobile, financial, e-commerce, cyber security, manufacturing, education and health care industries [1-3] (Figure 1A). Veterinary medicine evolves from a diverse field encompassing vast knowledge of animal health and disease research, zoonotic disease monitoring, epidemiology and disease surveillance, animal production, and small and large animal clinical practice [4-6].Therefore, the convergence of these two discrete disciplines warrants remarkable technological possibilities to influence each other and advance the current landscape of clinical knowledge in animal health care industries. The global animal health care market employing AI technologies is expected to grow from 1.41 billion in 2024 to 8.23 billion in 2034 with an incremental compound annual growth rate (CAGR) of 19.3% in the next 10 years [5].

The current understanding of AI technology has broken our pervasive myths that a computer can only performs programmable solution to a problem as instructed by human inputs. However, with the qualitative and quantitative data inputs, it can overcome diagnostic challenges, automate clinical workflow and support rapid decision-making in a cost-effective manner.

The discipline of AI is broadly classified into three fundamental genre of computing systems: Natural language processing (NLP), computer vision (CV), and machine learning (ML) [7-9] (Figure 1B). The NLP tasks attempts to recognize relevant clinical information from unstructured documents (referred as SOAP notes creation; Subjective, Objective, Assessment Plan) of veterinary practitioner's notes or electronic health report (biochemical, radiological, or pathological), thereby ensures higher degree of accuracy and consistency in medical record keeping simultaneously transforming time management and efficiency in animal care [10], [11], [9]. In clinical practice NLP tasks have numerous potential applications that could leverage from two critical foundational components: The Unified Medical Language System (UMLS) that is used to minimize the ambiguity in the biomedical language text, and Semantic Medline Database (SemMedDB)-a semantic prediction extracted from PubMed citations revealing subject-predicate-object relationships [12-14].

The second subfield of AI is the computer vision that serves to analyse large number of relevant biomedical images using deep learning (DL)-based connecting nodes of neural networks [Artificial Neural Networks (ANN); Convoluted Neural Networks (CNN)] architecture that automatically extract complex features from raw data. DL utilizes ML methodologies for decision-making and is extensively recommended for predictive analysis in large imaging data set used in veterinary field, including clinical practice in dogs [15-17]. Application of DL through ANN and several CV algorithms have exhibited superior accuracy and sensitivity in veterinary diagnostic imaging [18-20]. The overgrowing availability of commercial CNN-based trained models along with lack of appropriate number of certified clinicians in this sub-speciality to determine and interpret 'blind spot' in a lesion from large number of radiograph, CT or MRI images are currently the driving force for adopting this cutting-edge technology in veterinary clinics and research [21-23].

ML is another subdivision of AI that relies on manual feature extraction of complex raw data and builds on four main models of supervised learning, semi-supervised learning, unsupervised learning and reinforcement learning. The supervised learning model is used extensively in the medical field for training larger set of labelled data with prior known features associated to the task or output. This is often applied in classification and regression analysis for disease diagnosis in dogs as well as to predict efficacy of drugs (ADMET). Whereas, unsupervised models of ML algorithm are employed to predict and validate the outcomes of unlabelled large datasets, based on unknown features and defined criteria for clustering and is potentially applicable to discovery of disease subtypes and drug targets. Growing evidence of AI applications in the healthcare industry suggests that implementation of ML algorithms and programmes have the potential to minimize cognitive biases, automation of responses, recognition of specific patterns (for example to identify and distinguish specific pattern from larger scale variable inputs that can be employed with high-speed and precision by ML algorithm systems),generate superior qualitative inferences, and surpassing human capability of decision-making [24, 25] (Table 1). These phenomenal features of AI/ML have set forth an unprecedented trend in global healthcare market, including pet care and animal industry. In this review we focused on available current literature pertinent to canine disease diagnosis, image analysis and discuss the application of AI in disease prediction and personalized treatment. We also discussed the potential risk factors, ethical and societal issues associated with implementation of AI/ ML models in pet care industry. *'Ethics declaration: not applicable.*

2. Benefits of AI in disease diagnosis and investigations

Increased use of AI tools to amplify the impact in canine disease diagnosis is an evolving area amongst veterinary clinicians and pet owners.AI systems not only improve the diagnostic accuracy of large complex dataset harnessed from electronic health records, imaging results, and biomarker profiling, but also analyze the data with unprecedented accuracy and precision. Processing and clinical validity of these dataset in real-time with enhanced efficiency to identify patterns are critical for early prediction and disease diagnosis.

2.1 Influence of AI-powered tools in therapeutic management

The pet wearable market is forecasted to grow at a striking rate of >15% CAGR between 2024 and 2034 with an enhance capability to monitor real-time health-associated biometrics and numerous vital sign data points (Table 2).Proposition has been made to commercially develop AI / ML-based DNN algorithms as cost-effective wearable pet collars for optimizing real-time monitoring and classification of disease severity in osteoarthritis (OA) (DAC. Digital Inc., Poland).These essential AI-driven gadgets are promising tool to improve the evidence-based diagnostic accuracy and early interventions of a particular diseased behavior, which are often difficult to interpret, biased and missed in a shorter consultation time at the clinics. The efficiency of advance computer system and a high-frequency multidimensional analyzer have been evaluated for pruritic behavior of scratching and head-shaking from 361 dogs with > 99% overall accuracy [26]. Continuous monitoring of intracranial electroencephalo-graphic (iEEG) data from epileptic seizure in dogs has been evaluated using ML-based training method, which provides invaluable forecasting of the disease behavior [27-29]. Predictive epidemiological risk with clinical prognostic outcomes of canine mammary gland tumors have been reported in a multicenter study using supervised ML tools with a significant level of diagnostic accuracy [30]. The power of data-driven insights lies in AI's ability to aggregate and analyze large datasets, uncovering trends in disease prevalence and treatment efficacy. Studies like SYMPLIFY demonstrates how AI can identifies high-risk cohorts for targeted cancer screening, a strategy applicable to canine populations [31]. Moreover, AI fosters standardization of protocols by reducing inter-clinician variability in cancer detection or behavioral disorder investigations. In particular, objective assessment of canine behavior employing ML algorithms has been reported to clinically validate pain-induced stress, anxiety, or neurological dysfunction using video images or wearable sensors, thereby addressing subjective interpretation over operator-based limitations with improved patient outcome [32, 33]. Collectively, these emerging applications of AI-powered algorithms foster an immense capability to lead early disease detections with précised accuracy and optimize the therapeutic interventions in-clinic.

2.2. Applications of AI-enabled automation in routine clinical task

The scope and applications of AI tools further falls under ubiquitous workflow of routine blood counts, blood smear examination, histopathological slide evaluation and assessments of parasitic disease burdening the clinics. Enhanced efficiency is achieved through automation of routine tasks and interpretation of imaging studies or lab results. For example, VETSCAN Imagyst system can be employed for automated fecal egg and oocyst counting in an unbiased manner, which minimizes different observer-intended traditional limitations without further requirements of specialized training [34-36]. Moreover, employing ML-based tools with logistical regression and tree algorithms coupled to blood smear hematology analyzer (ADVIA) data, superior and rapid screening of Babesia merozoites in dogs could be achieved with 95.7% specificity and 100% sensitivity [37]. Utilizing CNN algorithms and CV systems, rapid detection and classification of skin lesions have been used as a tool for feature extraction of images [38].Moreover, clinical presentations of chronic, non-infectious type of inflammatory and neoplastic diseases are often challenging because of worse prognosis and shortened survival time, thereby requires early diagnosis for better patient outcome. Based on clinic pathological data from routine blood counts and serum chemistry panels, ML algorithms have been robustly applied for differential diagnosis of chronic hypoadrenocortism (CHA) conditions in dogs from closely related other disorders, such as glucocorticoid deficiency, primary GI tract and chronic kidney diseases(CKD)or hepatic insufficiency [39]. Early diagnosis of CKD in canines using routine clinical data from electronic health records (EHR) have been developed and validated employing DL strategies and recurrent neural network (RNN) algorithms with 91.4% sensitivity and 97.2% specificity [40]. Additionally, DL-based network architecture has been extended with enhanced diagnostic capabilities for ultrasonography pathological grading of advanced CKD stages and sustained remissions. Therefore, careful and pertinent implementation of AI algorithms in canine clinical practice has substantial possibilities in advancing disease detection and assessment; with a better understanding of a patient predisposition to certain disease condition and personalizes therapy for better outcomes.

3. AI in disease prediction

Faster and accurate diagnoses are hallmarks of AI application, simultaneously processing the real-time data with rapid results.Clinical prediction engages AI with eight domains of medical practices, including diagnosis, assessment of risks, response to treatment, disease progression, risks associated with recurrence, and complication, prognosis of the disease, and mortality prediction[41].AI enables personalized treatment plans by tailoring therapies and has potential to accurately predict disease remissions and prognosis. By understanding an individual patient's disease trajectory, early intervention and treatments can be better tailored to their specific needs for improving efficacy and minimising adverse effects.Furthermore, AI-powered wearable sensors have potential to refine the treatment plans by monitoring outcome responses in real-time, which allows scalable adjustments of drug dosages and complete protocol remissions.

3.1 Influence of AI in canine oncology and personalized treatment

Based on known therapeutic outcomes from the standardized multi-agent chemotherapy as first-line of treatment (combination of Cyclophosphamide, Hydroxyduanomycin, Oncovin (Vincristine sulfate), and Prednisone-commonly referred as CHOP therapy), AI-based algorithms have been successfully employed for personalized prediction profiling of canine lymphoma and leukemia cases [42, 43]. A commercially available service from Imprimed Company provides AI-based therapeutic efficacy and accurate remission prediction of 13 anticancer drugs on live canine cancer cells [42, 44]. Multi-cancer early detection (MCED) tests adapted from human patients have been clinically applied and validated for dogs by liquid biopsy company PetDx to detect cancer at an early stage and predict the tumor aggressiveness [45-47]. Interestingly, the applications of AI-powered cytology methods demonstrate enhanced capacity to discriminate between fine-needle aspiration and conventional histopathology techniques for diagnosis of cutaneous masses [48, 49].

3.2 Potential application of AI in Point-of-Care facilities

Based on thermal properties, perfusion rate and metabolic activities of tumor tissues, ML-based decision-making algorithms of thermal imaging signals have been employed to distinguish between cutaneous and subcutaneous tumors noninvasively [50]. Therefore, development of ML program enables high degree of certainty in detecting subtle patterns to classify malignancies by thermal imaging or volatile organic compounds (VOCs) assessmentand minimizes the risk of false-positive cases [50], [51]. Moreover, ML-based application has been suggested for discrimination between diseased and sustainable remissions based on osteosarcoma-derived exosomal gene signatures as prognostic marker for canines [52].This approach enables refined applications of AI tools with muti-omics data in canine oncology research and disease intervention. Collectively, such tools outperform the traditional diagnostic and risk-predictive methods minimizing false positive cases, thereby unleashing the power of AI in early cancer detection and persistent remissions towards canine health improvement. Continuing interdisciplinary research and collaboration between AI experts and clinicians will entails to fine-tune and amplify the full potential of AI applications in personalized canine treatments.

4. Influence of AI in canine diagnostic imaging

Transformative impact of AI-powered algorithms have improved our understanding to extract, quantify and analyze large amount of medical images evolving from Radiomics research studies and apply them for disease phenotyping and diagnosis. The clinical use of digitalized data curated from radiographs, CT scans, MRI, PET, and ultrasound images in veterinary diagnostic have significant promise to further analyze, detect artifacts, apply segmentation, and assign the associated image reports for disease prediction and accurate stage-classification (Table 3). For example, several canine radiograph images have been analyzed so far by employing CNN-based algorithm and DL method extraction features, such as-age determination from bones, components of joints and abnormality identification, fracture categorization followed by comparing the results with expert radiologist for validation [53-55]. These novel algorithms reveal high accuracy, sensitivity, and specificity for all the assigned tasks and performs > 80% match with radiologist-determined reports and classification. The commercially available AI-based software (Vetology Innovations Inc, San Diego, CA, USA) have successfully been employed in determining normal and abnormal canine thoracic and extra-thoracic radiograph images with higher positive predictive values [56-58]. Implementing CNN-based AI tools, canine corneal ulcerative images have been optimized, validated, and categorized based on severity of the disease with superior accuracy and sensitivity [59].

4.1. Application of AI on digital images in-clinic

Furthermore, to pin-point the diagnostic accuracy and binary classification of degenerative (*vs*. non-degenerative) liver diseases in dogs, ML tools have been developed from pre-trained deep neural networks (DNN) using ultrasound images. The study reveals superior resultant DNN data accuracy over conventional cytological and biochemical determinants with 100% sensitivity and > 82% specificity (AUC 0.91) for detection of degenerative canine liver diseases [60]. Similar ML application and DL methodology have been opted for better signal analysis and enhancing diagnostic capabilities of computer tomography (CT) scan images [22, 61, 62]. Using ML-based feature engineering of CT image modalities, AI can narrow the decision making window of canine diagnostic imaging in different disease classification, lesion detection, and tumor segmentation[63], [64], (65,66). Implementation of sophisticated ML pipelines on MRI images exhibited précised diagnostic accuracy indistinguishing different stages ofcanine inflammatory or neoplastic brain diseases [67],[68].Using texture analysis feature of MRI images non-infectious inflammatory meningioencephalitis could be clinically distinguished from the overlapping images of canine glial cell neoplasia. Although the subjective radiological differentiation seems arduous, random forest algorithm enabled featured engineering application provides plausible solution to distinguish between gliomas grades and inflammatory subtypes (granulomatous meningioencephalitis; GME, necrotizing meningioencephalitis; NME, and necrotizing leukoencephalitis; NLE) [67]. Difficult to diagnose MRI images fromcanine skull and cranial cervical vertebrae disorder (syringomyelia and pain associated Chiari-like malformation) in Cavalier King Charles Spaniel (CKCS) breed have been successfully adopted for neuromorphological characterization using ML tools [69]. In the latest study, CNN-based algorithms have been shown to distinguish between intervertebral disc protrusions from extraction (IVDP *vs.* IVDE) with higher degree of accuracy (> 95% specificity, and > 90% sensitivity) in canine spinal cord disease detection [70]. Moreover, DL-based novel algorithms have been developed to minimize the timeframe with increased quality of compressed-sensing associated MRI image acquisition and reconstruction [71, 72]. Collectively, these findings demonstrate that integration of AI tools have unmet potential to eliminate observer-based decision making errors, there by facilitating the diagnostic imaging accuracy and treatment outcomes in canine clinical practice.

5. Ethical, legal and societal implications of AI in canine practice:

The integration of artificial intelligence (AI) and big data analytics into veterinary medicine heralds a transformative era in animal healthcare, marked by innovations in diagnostics, personalized treatment, and operational efficiency. However, these advancements are inextricably linked to ethical, legal, and societal challenges that demand interdisciplinary collaboration to ensure equitable and responsible adoption by the professionals and pet owners.

5.1. Resource inequity and access barriers

The promise of AI-driven veterinary care is tempered by disparities in overall usage of systemic resources, particularly in rural and underserved regions. Urbanized clinical practice increasingly deploys AI tools, including DL algorithms and thermal imaging systems for cancer detection and enhanced diagnostic precision [51]. In contrast, canine practice in rural regions often lacks the financial and infrastructural capacity to adopt these technologies, including high-speed internet and advanced computing hardware [5]. For example, there are >40% inaccessibility to AI-based model adoption and computer utilization for appendicular bone neoplasia detection and screening in low-income regions. Although technological access drives better animal care and quality, the demographical disparities in clinical practice entrench risks of two-tiered healthcare system. Addressing the division demands policy interventions, such as subsidized AI platforms, infrastructure grants, and public-private partnerships to democratize access for all [31].

5. 2 Ethical and legal challenges in big data Governance

The ethical integration of AI and big data in veterinary medicine hinges on equitable access to transparent governance and preservation of clinical judgment. Policymakers must prioritize infrastructure investments for underserved regions, enforce algorithmic accountability, and modernize data protection laws. The proliferation of big data in veterinary medicine raises unresolved ethical dilemmas, particularly regarding privacy, ownership, and algorithmic bias. In accordance with the current medical health care sector, the US Food and Drug Administration (FDA), the Medicines and Health care products Regulatory Agency (MHRA) of United Kingdom and Health Canada have jointly identified 10 guiding principles for development of Good Machine Learning Practice (GMLP) [73],[74]. These guiding principles includes, inclusion of multi-disciplinary expertise throughout the AI/ML methods and systems, implementing good software engineering and security practices, applications of software in clinical scenario should represents the data set of the intended population. In addition, the datasets in veterinary medicine initiate various sensitive information from genomic profiles, treatment histories, and owner demographics, thereby requires regulatory framework and compliance of General Data Protection Regulation (GDPR) and Health Insurance Portability and Accountability Act (HIPAA) to address specific issues [75]. Moreover, pet owners frequently lack awareness of how their data is monetized and shared with third parties, underscoring the need for informed and transparent consent management system [76]. Regulatory mandates for algorithmic audits and equity assessments are critical to ensure AI outputs align with diverse clinical practice [77].

5.3 AI-driven decision-making and autonomy in clinics

The ascendancy of AI in clinical workflows challenges clinical autonomy and trust. While AI reduces diagnostic errors by 15-20% in thoracic lesion evaluations, there are chances of over-reliance on algorithms that compromises clinical judgment and animal welfare [78]. In practice, expertise in contextualizing patient history, behavior, and owner preferences remains irreplaceable, particularly in complex cases where empathy over nuanced decision-making is required [79].Considerable amount of ambiguity exist amongst stakeholders, clinicians and academic institutions over the usage and interpretation of black box (or heuristic algorithm) ML models that affects safety, ethics, and regulations which compounded distrust in healthcare applications [80, 81]. To reconcile these ambiguities, AI must function as an augmentative tool with veterinarians retaining their ultimate clinical authority. Concurrently, educational reforms must cultivate the digital literacy and training to empower codes of ethical practice for AI output evaluation.

5.4 Societal trust and companion relationship

The AI's pivotal role in accelerating veterinary science and animal health care industry are forthcoming. The goal of model design should be tailored on available data or training data sets that are independent of test sets and provides transparent clinically relevant information to the users. However, the full spectrum of AI/ML adoptability and its clinical application in veterinary practice possess higher risk of algorithm transparency, data privacy and sharing with ethical, legal and societal complications and acceptance. These consistent developments and challenges of cutting-edge technologies will continue to shape the future of animal care industry in twenty first century. The societal implications of AI adoption extend beyond clinical settings, impacting public trust and the human-animal relationship. Pet owners increasingly expect transparency in AI-driven diagnoses; however, the existing opaque systems risk eroding confidence in animal care and clinical practice [82]. There are possibilities of misdiagnoses attributed to AI tools without clear explanations, which deter owners from pursuing critical treatments [80]. Therefore, preserving trust is entitled and requires explainable AI (XAI) frameworks to demystify algorithmic decisions ensuring informed consent policies for data security [75].

6. Collaboration and future perspectives

By making complete and intelligent use of the technology to subjugate and transform vast clinical information-pet-practitioners, owners, and researchers along with national and international authorities should be tasked with delivering a quantum leap forward for development and use of this new knowledge in animal welfare. Simultaneously, the veterinary profession must champion the irreplaceable role of human expertise, ensuring technology amplifies-rather than supplants-the human-animal bond. By fostering collaboration among clinicians, technologists, and policymakers, the field can harness AI's full potential while safeguarding ethical integrity and societal trust.

7. Conclusions

The transformative impact of AI in the field of veterinary medicine surpasses the limitation of clinical documentation, record keeping, rapid point-of-care testing, differential disease diagnosis, and tailoring personalized medical plans, thereby promise a new dimension of technological integration that encompasses every facet of canine practice (Figure 2). As AI technology rapidly evolves, AI-assisted algorithms and novel tools will be invaluable to assist veterinarians for a better understanding of the disease process, providing much better service and more promising outcomes. The unification of data-driven AI application across the diverse fields of veterinary clinical practice reflects an innovative shift towards greater operational efficiency revitalizing the work force culture with accurate diagnostic tools and enhanced animal welfare. However, despite this emerging inquisitiveness and research efforts, successful implementation and adoption of AI tools in pet clinics and hospitals warrants interdisciplinary collaboration, clinical validity, large infrastructure to manage and employ big data sets and deployment of trained personnel and technicians.

8. Conflict of Interest

All authors have read and approved of the manuscript and do not have any conflicts of interest to declare. The authors declare that the review materials in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

9. Author Contributions

All the authors contributed to the study conception and design. D.C., N.M, S.N., R.B., and A.M. collected the literature and drafted the manuscript; A.M generated the images and supervised the writing of the manuscript. A.M. and N.S. conceived the idea and edited the manuscript to its current version.

10. Funding and Acknowledgements

Open access funding provided by Siksha 'O' Anusandhan (Deemed to be University). We thank Siksha-O-Anusandhan University (Deemed to be University) for institutional support and advice. The content is solely the responsibility of the authors and does not necessarily represent the official views of the University.

11. Availability of data

Data sharing does not apply to this article as no new data were generated or analysed in this study.

12. Figure Legends

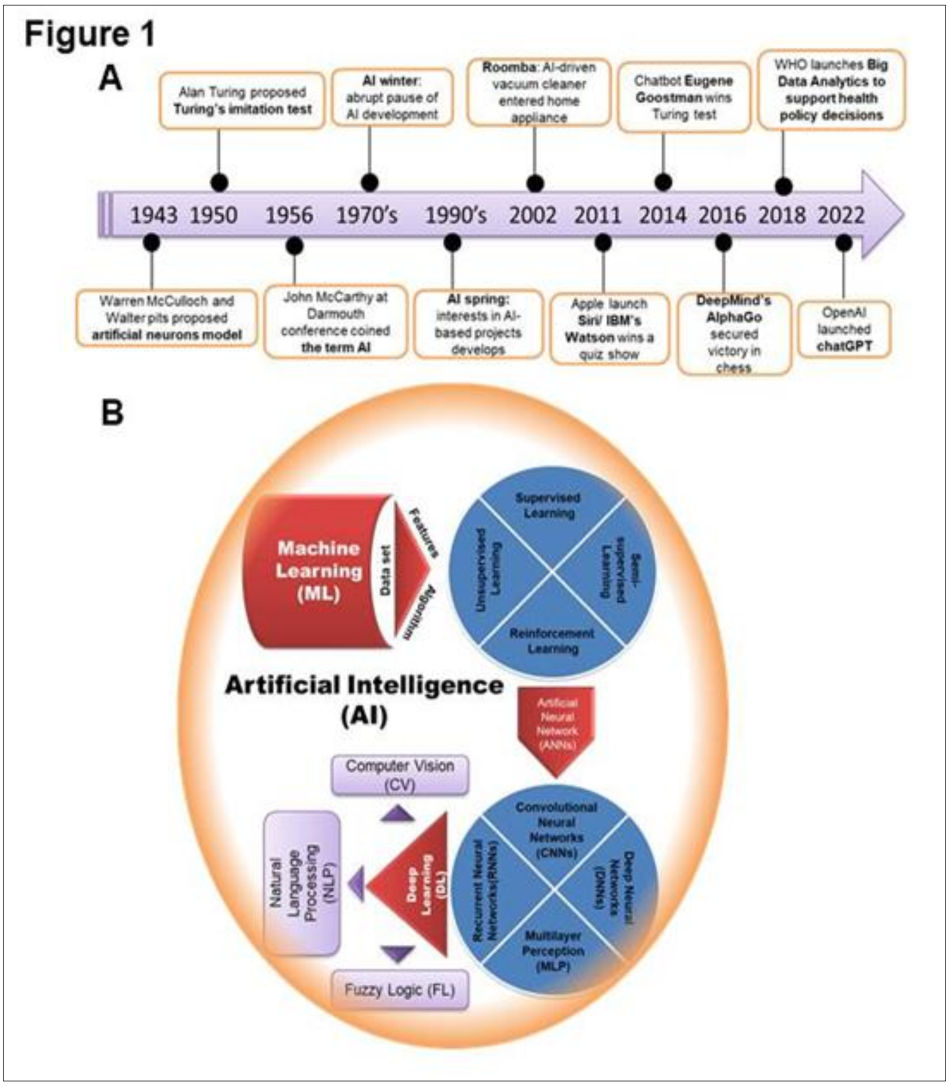

Fig 1: A) Evolution of artificial intelligence (AI) B) Ecosystem and interrelationship between AI, Machine Learning (ML), and Deep Learning (DL) with other relevant algorithms and networks.

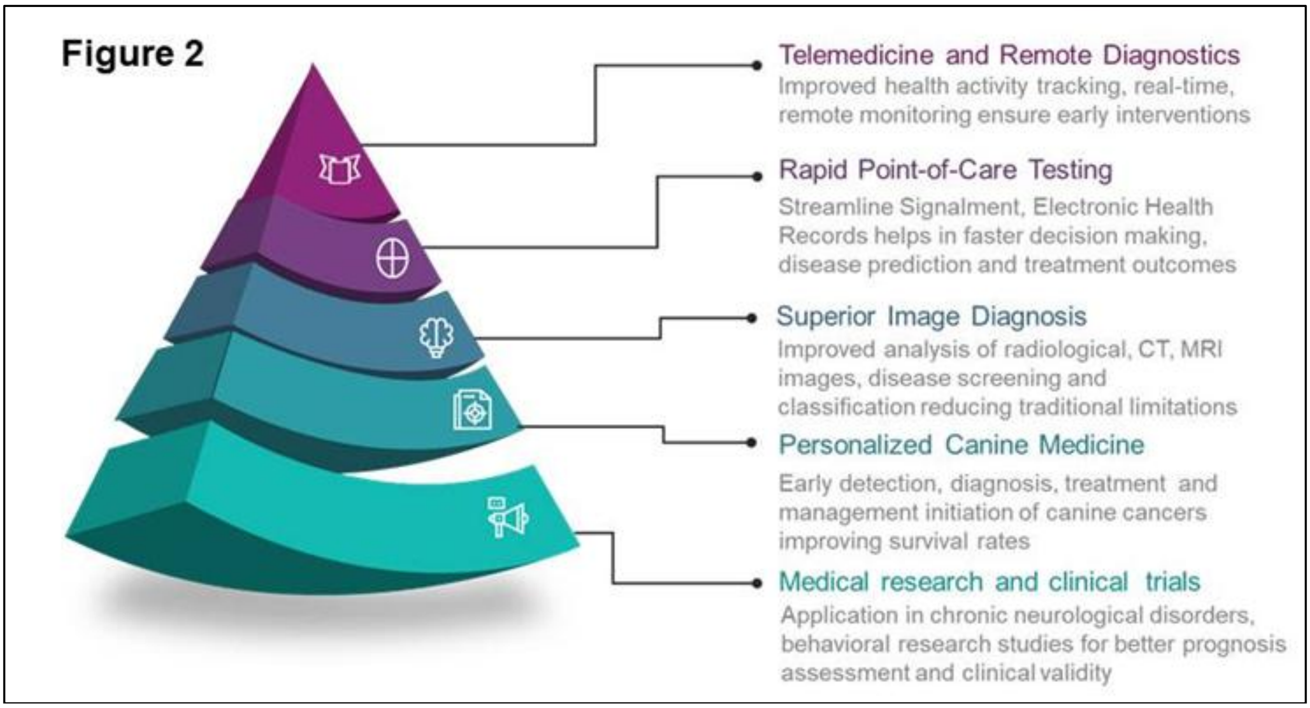

Fig 2: Scope of AI application on different facets of canine clinical practice

Table 1: Commonly used Machine Learning (ML) and Deep Learning (DL) algorithms in veterinary medicine and research

		Algorithm	Brief description	Application in Veterinary Medicine
Machine Learning (ML)	Supervised Learning	Support Vector Machine (SVM)	Split the learning data into classes and sort out hierarchical classification and regression problems	In predictive analysis and early disease detection and classification.[83]
		Bayesian networks (BN)	Probability distribution with graphic model illustrating a set of arbitrary variable	Used in veterinary epidemiological data for risk factor analysis.[84]
		K-nearest neighbors (kNN)	Classifies a point depending on known classification of other points	Used in disease classification and analysis. [85]
		Relevance Vector Machine (RVM)	Probability-based algorithm includes Bayesian extension and SVM	Real-time prediction of variables in animal research [86]
		Decision Tree (DT)	Rule-based graphical model predicting end-nodes and leaves	Used in disease prediction and diagnostic analysis.[87]
	Unsupervised Learning	Fuzzy C Means (FCM)	Partitioning-based algorithm that measure the distance between cluster center and each data point	Analysis and clustering of big data in disease progression and prognosis. [88]
		K-Means	Type of clustering algorithm	Used in clustering analysis of canine behavioral research studies [87]
Deep Learning (DL)	Multilayer Perception (MLP)		Basic unit (perception) comprising multiple layers that allows backward propagation with learning algorithm	Analysis and determination of various disease variables for automation. [89]
	Convolutional Neural Networks (CNNs)		MLP applies to a 2D matrices by a convolution operation	Used for image analysis and Computer Vision (CV) task. [16]
	Recurrent Neural Networks (RNNs)		Time-lapse or sequential data linked to loops between layers	Automation of medical text narratives and voice recognition used in Natural Language Processing (NLP) [90]
	Long short-term Memory (LSTM)		Extended version of RNNs that stored information for longer time	Used for improving detection, performance for different biomedical devices, images and signals.[91]

Table 2: Examples of commercially available AI-driven tools available for canine clinical management and practice

Tools available In market	Type of software/ device	Technical benefits	Software source/ Ref
PetDesk	Veterinary Client communication software	Automated appointment scheduling, communication and reminders	PetDesk
Vetter Software	Cloud-based management system	In clinic administration, electronic health record organization, medication inventory management	DaySmart Vet
VetSOAP	Intuitive interface software	Generates seamless clinical SOAP notes from audio recordings focusing on patient care	VetSOAP
Semantics of dogs vocalization	ML-based dog bark decoding	Analyze and detect animal sounds to alert stress and illness	[92]
Instinct EMR system	Instinct EMR	Manage full electronic records and help in and out-patient treatment, communicate with clients	Instinct Science
FitBark	Activity GPS and RFID tracker	Monitors health and wellness management and disease prevention	FitBark
Petnow	Facial recognition	Biometric and animal tracking	Petnow
Companion AI	Behavior study device	Monitor anxiety and suggest behavioral well-being	Companion
InvoxiaMinitailz Smart Pet Tracker	Pet wearable device	Monitor biometrics along with AI-based respiratory and heart rate vitals including atrial fibrillation	Invoxia
High-tech sensor	ML-driven collar device	Detection of osteoarthritis (OA) in dogs	DAC. digital
Pawgnosis	Computer vision enabled application	Detection of canine pododermatitis and paw neoplasia from digital images	[16]
Imagyst	5-in-1 single analyzer	Use for clinical analysis and disease identification of intestinal parasites and skin from digital cytology, faeces, blood smears and urine sediment samples	Vetscan

Table 3: Seminal applications of AI-based algorithms in canine diagnostic imaging

Anatomical/ lesion area	Type of images	Task to determine	AI-model system used	Results	Ref
Abdominal	Radiographs	hip dysplasia	DL	PPV> 90%	[53]
Thorax	Radiographs	cardiogenic pulmonary edema	Vetology software	> 90% accuracy, sensitivity, and specificity	[58]
Thorax	Radiographs	Pleural effusion	Vetology software	>90% sensitivity < 85% accuracy and specificity	[57]
Cardio-thoracic	Radiographs	Left atrial enlargement	DL	> 80% accuracy and specificity	[93]
Abdominal	CT scans	Classification of focal lesions in spleen	ML	67% overall accuracy	[22]
Pulmonary	CT scans	Thromboembolism detection	SVM-based supervised ML	> 94% sensitivity and specificity	[63]
Abdominal	CT scans	Heterogeneity in hepatic carcinoma	ML	> 73% accuracy	[94]
Brain	MRI	Inflammatory *vs.* neoplastic	DL	> 85% accuracy	[67]

		lesions			
Brain	MRI	Neuromorphological characterization of Chiari-like malformation	DL	>90%sensitivity69% specificity	[69]
Intracranial	MRI	Distinguishing meningiomas from gliomas	DL	80% accuracy	[95]
Spinal cord	MRI	Spinal cord injury	DL	> 95% specificity	[70]
Abdominal	Ultrasound	Degenerative liver disease	DNN based transfer learning method	> 80% specificity and 100% sensitivity	[60]

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