International Clinical and Medical Case Reports Journal
Research Article (ISSN: 2832-5788)

Artificial Intelligence: Transforming Animal Health and Management

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Citation: *Ninan Jacob, R J Padodara . Artificial Intelligence: Transforming Animal Health and Management. Int Clinc Med Case Rep Jour. 2025;4(8):1-24.*

Received Date: 01 August 2025**;** **Accepted Date:** 09 August 2025**;** **Published Date:** 13 August 2025

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1. ABSTRACT

Artificial Intelligence (AI) has developed as an interdisciplinary science based on computers and is concerned with building machines and equipment which use human intelligence to perform a particular task. Intelligence involves judgment, reasoning, understanding, acumen, insight, comprehension, sharpness, alertness, acuity and also intuition. It is basically a physiological trait present in varying degrees in different animals. The brain carries out cognitive learning and processing by performing combinations of various sort of information processes. Types of information processes are performed by different anatomical structures and instigated in physiology. The intersection of medicine and machine learning has the potential to transform healthcare. Physiology is a foundational discipline of medical training and practice with an upscale of quantitative history, clinical manifestation, diagnostic technics and treatments. The role of Artificial Intelligence is manifold in our day-to-day lives. The history of AI, its applications as software packages, simulation apps, and a list of various equipment used for analytical, clinical, and livestock farm purposes are detailed here. Veterinary practice management software which are commercially available in developed countries, especially for small animal practice, may not be beneficial in the Veterinary Dispensaries and Farms in India due to different conditions, animals and requirements. The AI has immense contribution in Veterinary and allied sciences and has made the diagnosis, treatment, and prognosis quicker, cheaper, and effective. AI is applicable in Antimicrobial Resistance (AMR) research, cancer research, drug design and vaccine development, epidemiology, disease surveillance, and genomics. Here, the authors have highlighted and discussed the potential impact of various aspects of AI in veterinary health and management, proposing this technology as a key tool for addressing pressing global health challenges across various domains.

2. KEYWORDS: Artificial Intelligence; History; Application; Data analytical software; Veterinary

3. BACK GROUND INTRODUCTION

Intelligence is defined as the ability to acquire and apply skills and knowledge. It relates to brainpower. How quickly, efficiently and also the manner in which an animal tackles a problem or adverse / favourable situation in its day-to-day life will define its intelligence and mental ability. Intelligence involves judgment, reasoning, understanding, acumen, insight, comprehension, sharpness, alertness, acuity, and also intuition. It is basically a physiological trait present in varying degrees in different animals.

Artificial Intelligence is using the intelligence (brainpower) of human beings to construct and run machines that are smart i.e. make machines do the work that humans need to do, but with greater precision, specificity, efficiency, and quickly. Ever since the time Humans invented the wheel, the wheels of scientific inventions and the development of machines have been turning at a faster rate much ahead of its time. Robotics has made medical science so advanced that the question now arises if robots will replace humans as doctors. The authors attempted to review the literature and probe into Artificial Intelligence in the field of Physiology and Animal Sciences [1]. A major breakthrough in AI came with the development of deep learning, which is a subset of machine-learning that uses artificial neural networks with multiple layers [2]. In other words, Artificial neural networks (ANN) – consisting of interconnected nodes organized in layers are fundamental components of Deep Learning (DL) – which process complex patterns within large data, and which in turn is an advancement of Machine Learning (ML) – which gives sense to machines, and is a subset of Artificial Intelligence (AI) – the replication of human intelligence [3]. Artificial Intelligence (AI) is considered as a future disruptive technology that involves the use of computerised algorithms to dissect complicated data [4]. Mahesh et al. [5] opined the foundation of AI models in healthcare have undergone a transformative journey, shedding light on the challenges, ethical considerations, and the vast potential they hold for improving patient outcome and system efficiency. Though initially there was relatively slow adoption of AI within the public sector of healthcare, at present the use of AI in healthcare is unparalleled, especially in the field of diagnosis. The impact of AI vibrates through diagnostic and intervention techniques positioning AI as the cornerstone of precision medicine. AI integrates 5G, IoMT, and blockchain, advancing remote healthcare through connected, data-driven innovations [6].

The brain carries out cognitive learning and processing by performing combinations of various sort of information processes. Types of information processes are performed by different anatomical structures and instigated in physiology. The information processes performed by different major anatomical structures of the brain (cortex, basal ganglia, thalamus, and cerebellum) are important, including their implementations in neuron physiology [7]. Hence, we can conclude that Artificial Intelligence (AI) is the development of computer systems that are able to perform tasks that normally require human intelligence [8]. AI is an umbrella term describing the mimicking of human intelligence by computers [9]. Gardner [10], the American development Psychologist classified intelligence, based on the soft skills possessed by humans, as follows in Table 1.

Table 1: Classification of Intelligence based on soft skills possessed

Soft Skill	Type of Intelligence
Nature smart	Naturalist
Sound smart	Musical
Number / Reasoning smart	Logical-Mathematical
Life smart	Existential
People smart	Interpersonal
Self-smart	Intrapersonal
Body smart	Bodily-Kinesthetic
Word smart	Linguistic
Picture smart	Spatial

4. INTRODUCTION TO ARTIFICIAL INTELLIGENCE

Artificial Iintelligence (AI) has developed as an interdisciplinary science based on computers and is concerned with building machines and equipment which use human intelligence to perform a particular task. It may have multiple approaches to a task involving the cognitive function and performance level of the human brain [11]. The intersection of medicine and Machine Learning (ML) has the potential to transform healthcare. Physiology, a foundational discipline of medical training and practice with an upscale of quantitative history, might be a start line for the development of a common language between clinicians and ML experts, thereby accelerating real-world impact [12]. AI-based systems have accurately predicted gender from retinal fundus images [13]. Artificial Intelligence has become an integral part of our lives and its involvement has evolved Veterinary Science with respect to quick diagnosis, treatment, and management of animals. AI- based algorithms help in speedier and accurate diagnosis of various conditions. Increased accuracy reduces misdiagnoses and ensures the patient receives correct treatment at the earliest [14]. By maintaining consistent accuracy, AI effectively counters the challenges posed by human fatigue and oversight, ensuring reliable interpretations regardless of external factors [15]. Hence, AI driven systems reduce the time-consuming nature of traditional manual measurements and reduce interobserver variability [16]. Artificial Intelligence (AI) serves as the key for transformation of health care, as globally healthcare systems face challenges in the form of escalating costs, limited access, and growing demand for personalized care [17]. The biggest advantage of AI in the Veterinary field lies in its potential to influence health care accessibility by addressing existing resource (material and personnel) constraints especially in the remote villages and providing timely care of the highest quality along with accurate diagnoses. In livestock farming AI has proved to be efficient for predicting production characteristics, individualizing animals, and can be used in breeding programs, especially, those which enhance decision-making in production systems [18].

5. HISTORY OFARTIFICIAL INTELLIGENCE

Various scientists over the years have contributed towards the development of Artificial Intelligence. A chronological list is presented in Table 2 to help the reader understand the progress and development of AI.

The first publication citing the use of computer intelligence in livestock farming was in 1998, and with the advance of automation systems, there has been a steady increase since 2015 in the number of publications.

Table 2: Chronological history of Artificial Intelligence

Year	Scientist / Originator	Event published/discovered or happened	Remarks
1943	Warren McCullough and Walter Pitts	Published paper "A Logical Calculus of Ideas Immanent in Nervous Activity."	Proposed the first mathematic model for building a neural network.
1949	Donald O. Hebb	Proposed the theory that neural pathways are created from experiences and that connections between neurons become stronger the more frequently they're used. Published book "The Organization of Behavior: A Neuropsychological Theory".	Hebbian learning continues to be a crucial model in AI.

1950	Alan Turing	Published "Computing Machinery and Intelligence".	Proposed the Turing Test, a method for determining if a machine is intelligent.
	Marvin Minsky and Dean Edmonds	Built Spatial-numerical association of response codes (SNARC).	The first neural network computer.
	Claude Shannon	Published paper "Programming a Computer for Playing Chess".	---
	Isaac Asimov	Published "Three Laws of Robotics".	---
1952	Arthur Samuel	Developed a self-learning program to play checkers.	---
1954	The Georgetown-IBM machine	A translation experiment was conducted which automatically translated 60 carefully selected Russian sentences into English.	---
1956	John McCarthy	The phrase artificial intelligence is coined at the "Dartmouth Summer Research Project on Artificial Intelligence."	The conference defined the scope and goals of AI. It is widely considered to be the birth of artificial intelligence.
	Allen Newell and Herbert Simon	Demonstrated Logic Theorist (LT), the first reasoning program.	---
1958	John McCarthy	Develops the AI programming language Lisp and published the paper "Programs with Common Sense".	The paper proposed the hypothetical Advice Taker, an entire AI system with the power to find out from experience as effectively as humans do.
1959	Allen Newell, Herbert Simon and J.C. Shaw	Develop the General Problem Solver (GPS), a program designed to imitate human problem-solving.	---
	Herbert Gelernter	Develops the Geometry Theorem Prover program.	---
	Arthur Samuel	Coins the term machine learning while at International Business Machines (IBM).	---
	John McCarthy and Marvin Minsky	Found the Massachusetts Institute of Technology (MIT) Artificial Intelligence Project.	---
1963	John McCarthy	Started the AI Lab at Stanford, CA, USA.	---
1966	The Automatic Language Processing Advisory Committee (ALPAC)	A report by the U.S. government details the shortage of progress in machine translations research, a serious conflict initiative with the promise of automatic and instantaneous	The ALPAC report results in the cancellation of all government-funded MT projects.

		translation of Russian.	
1969	Edward Feigenbaum, Bruce G. Buchanan, Joshua Lederberg, and Carl Djerassi, along with a team at Stanford, CA, USA	The first successful expert systems are developed in DENDRAL, a XX program, and MYCIN, designed to diagnose blood infections.	---
1972	Alain Colmerauer and Robert Kowalski	The logic programming language PROLOG is created.	---
1973	James Lighthill	The Lighthill report on "Artificial Intelligence: A General Survey" published.	It detailed the disappointments in AI research.
1974-1980	---	Major DARPA cutbacks in academic grants due to disappointment with AI development progress. Along with the earlier ALPAC report and "Lighthill Report," artificial intelligence funding dries up and research is stalled.	The period is understood as the "First AI Winter."
1980	John P. McDermott of Carnegie Mellon University (CMU) and Digital Equipme nt Corporati on (DEC)	Developed R1 (also known as XCON; eXpert CONfigurer), the first successful commercial expert system. Designed to configure orders for brand spanking new computer systems, R1 kicks off an investment boom in expert systems which will last for much of the last decade.	Brought an end to the 1st "AI Winter".
1982	Japan's Ministry of International Trade and Industry	Launches the ambitious Fifth Generation Computer Systems (FGCS) project.	The goal of FGCS was to develop supercomputer-like performance and a platform for AI development.
1983	The U.S. government	Launched the Strategic Computing Initiative.	Provided Defense Advanced Research Projects Agency (DARPA) funded research in advanced computing and artificial intelligence.
1985	Companies like Symbolics and Lisp Machines Inc.	Build specialized computers to run on the AI programming language Lisp.	Expenditure on expert systems increase manifold and the Lisp machine market industry sprang up to support them.

1987-1993	Improving computer technologies	As cheaper alternatives emerged the Lisp machine market collapsed in 1987.	The phase was considered as "Second AI Winter".
		Japan terminated the FGCS project in 1992 and DARPA ended the Strategic Computing Initiative in 1993 as it fell short of expectations despite heavy expenditure.	
1991	U.S. Military Forces in collaboration with BBN systems & Technologies (ISX corporation)	Deployed Dynamic Analysis and Replanning Tool (DART), an automated logistics planning and scheduling tool.	The usage of DART was made during the beginning of Operation Desert Storm.
1997	IBM's Deep Blue	Defeated world chess champion Gary Kasparov.	---
2005	Created by Stanford University Stanford Racing Team and Volkswagen Electronics Research Laboratory (ERL)	STANLEY, autonomous, robot-car, or a self-driving car, wins the DARPA Grand Challenge.	---
	Created by Boston Dynamics with Foster-Miller, the NASA Jet Propulsion Laboratory, and Harvard University Concord Field Station	Boston Dynamic's 'Big Dog' a robotic pack mule and iRobot's 'PackBot' were introduced	For bomb disposal, hazmat, search, reconnaissance, and other dangerous missions.
2008	Google App	Made breakthrough in speech recognition.	Introduced the feature in its iPhone app.
2011	IBM Watson	The computer system to answer questions on the quiz show Jeopardy!	Competed on Jeopardy! against champions Brad Rutter and Ken Jennings, winning the first-place prize of $1 million.
2012	Andrew Ng, founder of	Fed a neural network using deep learning algorithms 10 million YouTube videos as a training set.	Ushered breakthrough era for neural networks and deep learning funding (The neural network learned to recognize a cat without being told what a cat is).

	the Google Brain Deep Learning project		
2014	Google co.	Makes first self-driving car to pass a state driving test at Sans Francisco bay.	Later named “Waymo” - a new way forward in mobility.
2015	Google Deepmind	Achieved human parity by playing 29 Atari games.	Learned general control from video.
2016	Google co.	Google DeepMind's AlphaGo (a board game) defeats world champion Go player Lee Sedol.	The complexity of the traditional Chinese game was seen as a serious hurdle to clear in AI.
2020	Created by OpenAI, a San Francisco-based artificial intelligence research laboratory	Generative Pre-trained Transformer 3 (GPT-3) - an autoregressive language model that uses deep learning to produce human-like text.	It is the third-generation language prediction model within the GPT-n series.
	Google’s DeepMind	Developed AlphaFold 2 - an artificial intelligence program that predicts protein structure.	Led to disease understanding the medicine to be developed.
2021	Created by OpenAI	DALL-E (text to image model)	On being prompted by natural language text, DALL-E by generating realistic, editable images. The first model of DALL-E used a version of OpenAI’s GPT-3 model and was trained on 12 billion parameters.
2022	Created by OpenAI	Chat – GPT	It interacted with users in a far more realistic way than previous chatbots due to its GPT-3 foundation, which was trained on billions of inputs to improve its natural language processing abilities.
2023	Created by OpenAI	GPT – 4	GPT-4 generates far more nuanced and creative responses and can engage in an increasingly vast array of activities.

6. APPLICATION OF ARTIFICIAL INTELLIGENCE IN VETERINARY HEALTH AND MANAGEMENT

The application of Artificial Intelligence in Veterinary Science and health care is manifold. Deep Learning (DL) algorithms help medical imaging technology and support medical practitioners to identify abnormalities and detect diseases with a higher level of precision and speed than ever before, resulting in significant improvements in the accuracy of diagnosis, the efficiency of treatment, and the overall quality of patient care [4]. With AI-powered medical imaging (Table 3), diagnostic changes and applications (Table 4) will result in substantial benefits for the medical and veterinary practitioners and patients (Table 5,6).

AI-driven diagnostic tools (machine learning algorithms, deep learning, and image recognition systems) increase the accuracy and efficiency of disease detection and surveillance. AI also has immense potential to predict disease outbreaks and optimize treatment strategies. AI can also be used to strengthen and speed up the drug discovery and development process. By harnessing the capabilities of AI, healthcare systems can significantly improve their preparedness, responsiveness, and outcomes in the battle against infectious diseases [36]. Thus, AI provides a promising solution in analyzing intricate microbiological data quickly and accurately by providing sophisticated computational tools [37].

Various veterinary practice management software are commercially available in developed countries, especially for small animal practice. However, they may not be useful in the Veterinary Dispensaries in India as the reporting requirements and data obtained are different. Some useful tools for prediction of zoonotic diseases (Table 7).

AI-based models, in particular deep learning models, could act as effective supports in the evaluation of medical images for both specialized radiologists and general practitioners. Nevertheless, these technologies should not replace veterinary experience and knowledge. On the contrary, AI products have the potential to empower radiologists to deliver increased value in a more efficient way [39]. Some AI applications are also developed for exotic and wildlife animal health monitoring [40] shown in (Table 8).

Table 3: List of First Medical Imaging Applications used (adapted from Dias and Torkamani [8])

Sl. No.	Applications
1	Automated quantification of blood flow through the heart via cardiac MRI [19].
2	Determination of ejection fraction from echocardiograms [20].
3	Detection and volumetric quantification of lung nodules from radiographs [19].
4	Detection and quantification of breast densities *via* mammography [21].
5	Detection of stroke, brain bleeds, and other conditions from computerized axial tomography [22].
6	Automated screening for diabetic retinopathy from comprehensive dilated eye examination [23,24].

Table 4: Areas where AI is utilized in Veterinary Science and allied field

Area	AI utilized for
Teaching	• Simulators for the study of physiological functions of different systems, anatomical structures and dissection, clinical medicine (List given separately)
	• Virtual classroom
Research and Development	• Development of drugs
	• Simulators to study the effect of drugs
	• Vaccine development
	• Packaging and delivery of drugs
	• Efficacy and half-life of the drug
	• Biological potency and shelf life of drug
	• Digital balances and weighing machines
	• Automatic Inoculators
Treatment	• Tele-medicine (consultation, diagnosis, and advice)
Survey and mapping	• Radio tagging of animals and birds (collars, implants)
	• Drones fitted with digital cameras
Farm management	• CCTV
	• Drones (surveillance, water management, spraying of pesticides)
	• Milking machines, Rotary milking parlour
	• Infrared thermal imaging sensors
	• Pedometers
	• Facial recognition machine visual sensors

	• Species related application (cattle, sheep, goat, horse, swine, poultry)
	• Prediction of animal behaviour through accelerometers, magnetometers [25], optical sensors [26], or depth video cameras [27].
	• Sheep Pain Facial Expression Scale (SPFES) help to measure pain and discomfort in sheep [28].
	• Sensors that help estrus detection [29].
	• Machine that help estimate milk yield [30], Reproductive performance [31], Calving time [32].
	• Detection of mastitis through somatic cell count [33].
	• Oxygen saturator
	• Digital Weighing machine (animal weight)
	• Hatchery Unit-Automatic Egg candling machine with egg transfer system
	• Egg O meter (know internal temperature of an egg)
Agriculture	• Autonomous tractors (self-driven)
	• Robotic machines that control unwanted crops or weeds harvest crops with greater speed, help in picking and packing crops
	• Pest (grasshoppers, locusts) control through satellite and smartphones
	• Bailing of straw and hay
	• Identifying defects and nutrient deficiencies in soil (soil analysis)
	• Identifying plant pests and diseases
	• Detect defects in plants (by using image recognition-based technology)
	• Drone-based aerial imaging technique to monitor plant health, guide farmers regarding optimum planting and management of plants (Precision farming) [34].
Meteorology	• Weather forecasting – List given separately
	• Disaster management (Cyclones, Tsunamis, Heavy rainfall and floods, Cloud bursts, Draught, and famine)
Personal animal details	• Micro-chip implants (placed under animal skin and uses radiofrequency) and scanners
Disease prevention	• Sensors, Big Data, and Machine Learning help in predicting and preventing several diseases in a cost-effective and non-invasive manner [35].
Data Analytical Software	• Various software are listed below for data recording, storage, and analysis

	• Biological potency and shelf life of drug
	• Digital balances and weighing machines
	• Automatic Inoculators
Treatment	• Tele-medicine (consultation, diagnosis, and advice)
Survey	• Radio tagging of animals and birds (collars, implants)
	• Drones fitted with digital cameras
	• CCTV
	• Drones (surveillance, water management, spraying of pesticides)
	• Milking machines, Rotary milking parlour
	• Infrared thermal imaging sensors
	• Pedometers
	• Facial recognition machine visual sensors
	• Species related application (cattle, sheep, goat, horse, swine, poultry)

Farm management	• Prediction of animal behaviour through accelerometers, magnetometers [25], optical sensors [26], or depth video cameras [27]
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	• Sensors that help estrus detection [29]
	• Machine that help estimate milk yield [30], Reproductive performance [31], Calving time [32]
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Data Analytical Software	• Various software are listed below for data recording, storage, and analysis

Table 5: Software used in Veterinary medicine and clinical management

Name of software	Veterinary medicine and clinical management software
IDEXX, cornerstone vet software (AAHA)	Health network, data backup, payment portal
AVImark, Henry Schein vet solution	Electronic medical records, patient reminders dental charts, support paperless practices
IntraVet	Clinical services
Vetter	Electronic vet record tool that allows you to see consolidated patient record
eVetPractice	Electronic medical records
DVMAX	Practice management
Hippo manager software	Clinical appointments, reminders, SMS
ezyVet	Cloud-based management, clinical solutions
Equine Gait trax / canine gait trax	Motion analysis software (2D and 3D)
DMAS-6 and DMAS-DV motion capture suits	Motion analysis software (2D and 3D)
EMPRES-i	Global animal disease information system by FAO
Winepiscope 2.0	Epidemiological veterinary medicine software
VETport	Clouded-based practice management
Cassadol Equine	This is a simple software for Solo Equine Veterinarians featuring fast and easy medical records and billing
Qvet, VeterinaryGate Advanced, Bastet Win, Animal Hospital Management System, RxWorks, IntraVet	Veterinary practice management software

Table 6: Software used for image analysis of cells, tissues and microbes

Name of software	Image analysis for cells, tissues, microbes
QuPath, Cell profiler, Ilastik, Orbit, Icy	Image Analysis Software for cell and tissues
CellSens for deconvolution, automated high-content analyses, and quantitative image analyses	
AutoQuant for deconvolution and quantitative image analyses	
Imaris for 3D rendering and quantitative image analyses	
ImagJ / Fiji	For micrometry of cells

Table 7: Some examples of useful tools and available webservers dedicated to the prediction of zoonotic/veterinary diseases and monitoring [38]

Tool name	Year	Application / description	Website link
Blue Dot	2013	AI-powered platform employed in tracking and predicting the spread of infectious diseases. Reportedly predicted Zika virus spread to Florida in 2016 and the movement of the 2014 Ebola outbreak out of West Africa	https://bluedot.gl obal/
ZOV ER	2014	Database of zoonotic and vector-borne viruses which incorporates virological, ecological, and epidemiological data for better understanding of those pathogens	http://www.mgc.a c.cn/cgi-bin/ZOVER/main .cgi
P- HIPSTer	2019	(Pathogen-Host Interactome Prediction using STructurE similaRity) is an algorithm which utilizes sequence- and structure-based information to extrapolate interactions between pathogens and human proteins	http://phipster.org /
WIs H	2019	WIsH helps in predicting the prokaryotic hosts of phages by assessing their genomic sequences	https://github.co m/soedinglab/WI sH
IHB DP	2019,2022	The Integrated Health Big Data Platform compiles medical data from hospitals, e-health records, and vaccination records. Reportedly used in identifying Dengue and Tuberculosis (TB) patients	NA

VirH ostMatcher	2020	A network-based computational tool for predicting virus-host interactions. Specifically used in viral-host matching based on oligonucleotide frequency (ONF) comparison	https://github.co m/WeiliWw/Vir HostMatcher-Net
EPI WATCH	2020	AI-driven system harnessing vast, open-source data to generate automated early warnings for epidemics worldwide. Contains full language and geographic information system capability. Efficient in early identification outbreak signals	https://www.epiw atch.org/
VIDHOP	2021	VIDHOP is a virus-host predicting tool. It has been specifically used for Influenza A virus, rabies lyssavirus and rotavirus A predictions	https://github.co m/flomock/vidho p
FluS Pred	2022	Flu Spread Prediction is a machine learning-based tool which can predict human related Influenza viral strains by targeting their protein and genome sequences, accurately predicting the zoonotic potential of the viral strain	https://webs.iiitd. edu.in/raghava/fl uspred/index.html

Table 8: AI Applications in Wildlife and Exotic Animal Health Management

Application	Description	Country & Year	Website link
Population Tracking	AI enabled GPS and satellite data systems to track animal movement and populations	Australia 2021	www.animalt racker.com
Behavioral Studies	AI tools are used to study animal behaviour patterns, aiding in the understanding of health indicators and social structures of exotic species	Canada 2021	www.behavio rtrack.com
Genetic Monitoring	AI to analyse genomic data from wildlife populations, enhancing breeding programs and tracking genetic diversity	USA 2021	www.genomi cwildlife.com
Conservation Efforts	AI models analyse environmental data to assist in habitat restoration projects, improving biodiversity conservation efforts	UK 2022	www.ecosyst emai.com
Wildlife Health Monitoring	AI aided image recognition to monitor wildlife populations, detect diseases, and track animal movement in remote areas	USA 2022	www.wildtec hai.com
Disease Detection	AI to detect early signs of disease in wildlife populations, helping researchers take preventive measures before outbreaks occur	South Africa 2023	www.wildlife healthai.com

7. ARTIFICIAL INTELLIGENCE IN ANIMAL MANAGEMENT

AI-Driven Animal Farming and Livestock Management System represents a pivotal advancement in agricultural technology, promising to revolutionize traditional farming practices by integrating Artificial Intelligence (AI) into livestock management (Table 9). The system's multifaceted capabilities, emphasizing its role in guiding animal farmers towards optimal livestock care, enhancing marketing strategies, and offering a suite of advanced functionalities. At its core, this system employs sophisticated AI algorithms like Natural Language Processing (NLP) and Convolutional Neural Networks (CNNs) to provide personalized guidance to animal farmers, ensuring they adhere to best practices in livestock care. Through real-time monitoring and data analysis, the system offers actionable insights into nutrition, health, and reproduction management, thereby maximizing the well-being and productivity of livestock. Furthermore, the System incorporates innovative features tailored to streamline marketing efforts. By analyzing market trends, consumer preferences, and supply chain dynamics, the system enables farmers to make informed decisions regarding product positioning, pricing strategies, and distribution channels, thereby enhancing market competitiveness and profitability [41]. The future of livestock technology is filled with opportunities to boost productivity, animal welfare, and sustainability in agriculture. Intelligent monitoring, like sensors and IoT devices paired with advanced analytics, provides real-time insights into animal health and environmental conditions. Precision livestock farming, powered by automation and AI, shows potential in optimizing feeding, health monitoring, and breeding [42].

Artificial Intelligence is used in many of the instruments that we use routinely in laboratories, clinics, and farms. Though the list is very exhaustive, the authors have attempted to tabulate some of the commonly used equipment (Table 10).

Table 9: Important AI application features in animal management and welfare [43]

Application	Function
Animal behavior recognition Animal nutrition	A novel face recognition model based on convolutional neural networks for recognizing pandas was developed by applying deep learning techniques [44].
	Predicting a cow's daily milk yield, composition and milking frequency by utilizing sensor machine learning [45].
	Identifying farrowing-related activity in sows using radar sensors [46].
	Intelligent robotic system applied to round the clock management for poultry house [47].
	Smart duck counting via AI detection of image data [48].
	Analyzing domestic shorthair cat facial image data by machine learning models for recognition in domestic cats [49].
	Intelligent detection of equine pain signals and diagnosis by training vision algorithms with computational classifiers via machine learning models [50].
	An intelligent learning model for collecting cow feed intake in automatic feeding systems to feeding schedules [51].
	An intelligent feeding system for controlling pet obesity [52].
Animal health	Predicting learning models for cow eye temperature, milk yield and quality [53].
	An intelligent diagnostic system for equine lameness [54].
	An intelligent system for animal health monitoring, animal tracking, milk quality and supply monitoring and safety [55].
	A machine learning model for a noninvasive video biometric system for intelligent health [56].
Animal ecology management	An intelligent real-time forecast for CO_2, SO_2, NO_2, $PM_{2.5}$ and PM_{10} levels [57].
	Monitoring system for temperature, CO_2 and wind speed in layer coops [58].
	An automatic monitoring and an adjustment system for livestock and poultry farming WiFi, LoRa wireless communication and IoT technologies [59].
Animal housing disinfection and cleaning system	Magnetic RFID-based navigation guided intelligent robots target the full range of disinfection large livestock farms [60]. Rapid disinfection strategy for livestock farms based on remote control of intelligent robots
	An AI based contactless biometric system for automated assessment of animal welfare on
Animalal disease diagnosis	transportation [62].
	An automated swine welfare indicator assessment system for the diagnosis of ear and tail lesions in slaughterhouses [63].
	Convolutional neural networks to improve the diagnostic accuracy of expert systems for fast and concise animal disease diagnosis [64].
	Computational models developed using penalized linear regression, random forests, gradient boosters and neural networks for helping farmers take evidence-based interventions before anticipated stressful environmental conditions occur [65].
Animal disease prediction	A fog-centered, IoT-based smart health care support system to monitor and control swine flu virus outbreaks [66].
	An IoT-based "LiveCare" framework for automated monitoring of the health of cows on large dairy farms [67].
	An IoT-based animal social behavior sensing framework for modeling the spread of mastitis in dairy cows and inferring the risk of mastitis infection in dairy cows [68].

Table 10: Some Instruments used in Veterinary Diagnostics

Physiograph	Ultrasonograph
Spirograph	Echocardiograph
Electrocardiograph	Colour Doppler
Electroencephalograph	Boyles Apparatus
Electroretinograph / Optical coherence Tomograph	Electro surgery unit
Kymograph	Cryosurgery unit
Bone densitometry / Dual Energy X-ray Absorptiometry (DEXA)	Perimetry (measurement of visual field function)
Digital Sphygmomanometer	Hemodialysis unit
Digital Thermoscan	X-ray machine
Digital Vernier Caliper	Magnetic Resonance Imaging
Digital Clinical Thermometer	Computed Tomography Scan
Mammography Machine	Nuclear Magnetic Resonance (NMR)
Diathermy machine	Muscle stimulator
Glucometer	Ventilator
Pulse Oximeter	Estrous detector (cow, ewe, doe, mare, sow)
Electronic / Digital / Telemedicine Stethoscope	Ovulation detector (bitch)
Oxygen Saturation Monitor	Pregnancy detector (bitch, sow, ewe, doe)

8. ARTIFICIAL INTELLIGENCE IN SIMULATORS

Simulation refers to the artificial representation of the actual process to achieve education through experimental learning. The Society for Simulation in Healthcare, termed simulation training as "the imitation or representation of one act or system by another" which is serves as "a bridge between classroom learning and real-life clinical experience". A list of some simulators which are used in veterinary health management is tabulated in (Table 11).

Table 11: Simulation Apps used in Veterinary Health Management

Simulation App and Utility		References
Simulator for digital rectal examination, detect prostate cancer.		Kuroda et al. [69].
Virtual haptic back – for training osteopathic students.		Williams et al. [70].
Haptic Cow – for teaching bovine rectal palpation to identify pelvic structures, cervix, and uterus.		SensAble Technologies [71].
Horse Ovary Palpation Simulator (HOPS) – number, shape, size of follicles can be felt and altered.		Crossan [72].
Haptic simulators – developed as a palpation-based simulator where touch is the primary sensation available to Veterinarians.		Baillie [73].
Endoscopy Simulator		
Laparoscopic Simulator		
Neurosurgery Simulator		
Ultrasound Simulator	SonoSim	
vSim		
Emergency Simulator	Virtual simulation - an interactive, personalized simulation experience for evidence-based, psychiatric patient scenarios	https://www.healthysimulation.com/5689/free-medical-simulation-scenarios/
Farm Animal related Simulators		
Bovine Breeder Artificial Inseminator Simulator	Teaches correct cervix manipulation, AI gun positioning, and pregnancy palpation. Students can see inside the reproductive tract to identify the reproductive system and learn correct techniques for delivering semen	

Bovine Injection simulator	Teach all type of injections and infusions in a different layer of skin and muscles	www.realityworks.com
Bovine milking udder simulator	Teach proper udder care, milk diseases, and infection treatment and prevention. Also, teach proper California Mastitis Test performance and udder anatomy	
Exercise physiology virtual lab	Supervise a clinical trial to investigate the acute and chronic physiological effects of high-intensity sprint interval training (SIT) on a sedentary lifestyle	https://www.labster.com/

Table 12: Equipment used in Environment Physiology to determine Heat Stress

Lux meter	Digital weather station
Anemometer	Radiosonde
a) Wind Hall effect anemometer	
b) Hot wire anemometer	
Temperature and Humidity recorder	Transmissometer
a) Tinytag Plus 2 logger	
b) HOBOPro sensor	
Automatic Rain gauge	Weather balloons
Noise recorder	Weather satellite
Seismograph	Digital Barograph
Refractometer	Snow gauge
Hygrometer	Pan evaporimeter with digital water level recorder
Telemetry	Thermo-hygrograph (digital)
Spectroscope	Lightning detector
Pyregeometer	Digital rain gauge
Pyrradiometer	Digital Cup anemometer
Pyranometer / Lucimeter (Solar radiation)	Digital Wind Vane
Automated Weather stations	Portable weather station
Livestock Heat Stress Monitor (Kestrel DROP D2AG)	Environmental Chamber

9. ROLE OF AI IN DETERMINING HEAT STRESS IN ANIMALS

Livestock encounter various stressors throughout their production cycle, with temperature fluctuations being among the most challenging to manage [74]. Heat stress negatively affects dairy cow performance across all production phases, leading to decreased growth, reproduction, and increased disease susceptibility, ultimately delaying lactation initiation [75]. Instruments used for determine environment stress in animals are listed in Table 12. Determination of Heat stress in animals plays an important role in animal management and animal welfare.

A. Non-invasive methods

Non-invasive methods for heat stress determination are beneficial as it prevents further stress to the animals. The various methods used to determine heat stress in animals are listed below.

i) Infrared Thermography – Evaluation of heat stress responses in Murrah buffaloes, crossbred cattle, and Vechur cattle was done using inner canthus infrared thermography as a non-invasive tool at Silent Valley Farm, Kerala [76]. In Hair sheep the eye temperature was found to have a strong correlation with both vaginal and rectal temperature [77]. However, a variation was found in the degree of correlation between different body regions and ambient temperature when using Indirect Reflective Thermometry (IRT) to measure body temperature accurately [77,78]. It was observed that in cattle, the forehead IRT showed the strongest correlation with both rectal temperature and THI, which was followed by the flank regions on the right and left [78]. Further, Age, physical condition, lactating stage, and reproductive status of the animals should also be taken into account as a determining factor for IRT readings [79].

ii) Accelerometers – Small, light devices that have minimal impact on animal's normal grazing behavior [80]. Along with the accelerometer Activity collars are fitted on the animal's neck, which help in detecting the animals breathing pattern. Increased and labored breathing indicates heat stress.

iii) Bioclimatic indices – Bioclimatic indices are the most preferred to measure or predict heat stress in animals. The various indices are listed below

a) Temperature Humidity Index – Black Globe Temperature Humidity Index [81]

BGHI = BGT + 0.36tdp + 41.5

Where, BGT: black globe temperature (°C) and tdp: dew point temperature (°C)

BGHI below 70 units does not cause discomfort to dairy cow, but decrease in feed intake is observed when BGHI crosses 75 units.

b) Calculated indices include – Heat Load Index [82], Index of Thermal Stress for cows [83], Comprehensive Climate Index [84].

iv) Mobile applications – Nedap Now Herd app can be used to obtain real time thorough summary of the heat stress levels in the sheds. This feature is compatible with IFER(P)4 and IFER(P)9 tags from 2021 and later, requiring the latest Velos version [84]

v) Feed intake as an indicator of stress. Feed intake can be recorded using automated systems like Insentec feed bins (Roughage Intake Control system, Insentec B.V.) [85].

vi) Milk Yield – In heat stressed dairy cows, variation in milk yield are indicators of herd problems. Milk analyzers like the FT120 (Foss Electric, Hillerod, Denmark) represent a source to automatically highlight variations in milk yield and milk constituents [86].

vii) Behavioral patterns – Shifts in behavioral pattern serve as the first indicator of heat stress and can be detected using mechanized systems which are useful aids to record the behaviour of individual animal [87].

B. Invasive methods

Invasive methods are accurate and reliable but can be uncomfortable, risky, and are not used regularly or for continuous monitoring.

i) Ear tag sensors – A RFID temperature biosensor (LifeChip Microchip) can be inserted on the rear of the ear base to monitor and record subcutaneous temperature. Subcutaneous temperature sensor is more reliable as it is minimally affected by heat waves and water sprinkling on the body [88].

ii) Rumen Reticulum bolus sensors – They are placed in the reticulum and monitor rumen temperature and pH throughout the day and can wirelessly transfer the data. Names of some Apps that used – SmaXtec classic, Moow Rumen Bolus, LiveCare, Smartstock, Herdstrong.

9. ADVANTAGES OFARTIFICIAL INTELLIGENCE IN VETERINARY MEDICINE

i) Physiological activities like respiratory, perspiratory, cardiovascular responses can be analysed through thermal imaging channels (Thermography) without contact with the individual [89, 90, 91].

ii) With the help of simulators help in experimental learning in laboratories and classrooms, of the actual process without the animal [92].

iii) Physiology based medical diagnosis systems are gaining importance in recent years, as they are reliable, accurate, and specific [93].

iv) Artificial Intelligence has made diagnosis cheaper, faster, and easier and helps to recognize the pattern of medical and veterinary complications [94,95].

v) Artificial Intelligence helps to record and store medical information of the individual animal and other animals coming to the clinic.

vi) Diagnostic Apps are developed which use Hybrid Artificial intelligence (Artificial intelligence along with the experience of the Veterinarian) to diagnose ailments through video recordings.

vii) Apps are also developed which read the Veterinarian's notes and suggest the diagnosis and treatment.

viii) Apps are developed to detect Addison’s disease in canines [96].

ix) Artificial intelligence could help a farmer understand if his animal has an emergency and needs treatment. ‘Smart Farms’ can also be developed, which may automatically diagnose sickness and administer remedies/cures to the affected animal (as part of its feed), without any human involvement [97].

x) Artificial Intelligence removes human bias in diagnosis and treatment, thus improving the skill and efficiency of veterinarians.

xi) Artificial Intelligence will help in automation of tedious tasks on the farm.

xii) The integration of AI into medical education will prepare future health care professionals for the data-driven, technologically advanced health care landscape while fostering a deeper understanding of AI applications and related ethical implications [98].

xiii) Artificial Intelligence applications are used in determining the Heat stress that an animal is exposed to.

xiv)Artificial Intelligence has made significant progress in Genomics which help in early disease detection. The analysis of vast amounts of genomic data helps to identify genetic mutations that increase the risk of diseases such as cancer, cardiovascular conditions, and hereditary disorders [99].

xv) A wide range of analytical tools (biomarkers) to study biological parameters have been developed to improve animal health and production. It has been established that blood-based biomarker assays aid in the diagnosis of preclinical cardiomyopathy [100].

xvi) In the field of companion animal care aspects such as health and behavior monitoring, feed and feeding systems, parasite detection, artificial, virtual, and robotic pets, and veterinary care and support, have been efficiently improved [3].

xvii) However, Artificial Intelligence cannot replace a Veterinarian and only assists in accurate and speedy teaching, management, diagnosis and treatment.

10. CHALLENGES POSED BY AI

The use of AI presents various challenges in the veterinary field with regard to disease detection, diagnostics, treatment, production and management (adapted from [3,101,102]).

i) The major concern is the quality and representativeness of the data used to train AI models. AI systems that are trained on biased or incomplete datasets, will may produce inaccurate or unreliable results, especially for underrepresented populations.

ii) Another major concern is regarding data privacy and security, as AI relies on large amounts of sensitive data (In Veterinary Science, data pertaining to animals and owner).

iii) The third concern is regarding the compliance of ethical standards and regulations, which is crucial for maintaining patient trust and ensuring equitable access to AI-driven diagnostics.

iv) Inherent challenges are posed related to the accessibility of AI-based tools, adaptability, efficiency and flexibility of AI models in veterinary sector under different environment conditions.

Hence, AI should be seen as a tool to assist veterinary professionals rather than replace them. Even as AI gains wider use in Veterinary field, the human elements of empathy, communication, and ethical judgment should remain paramount during treatment and diagnosis.

11. CONCLUSION

Veterinary informatics can forge new possibilities within veterinary medicine and between veterinary medicine, human medicine, and One Health initiatives [103]. The integration of AI across these diverse healthcare domains reflects its transformative potential in revolutionizing the landscape of medical research and application. There are a number of challenges inherent in veterinary diagnostic imaging data sets. Artificial

Intelligence has made deep inroads into Veterinary Medicine. It has become an essential and irreplaceable component and helped evolve Veterinary Science. It is certain that at any point in time, AI may not replace veterinarians, but veterinarians who get trained and wilfully embrace AI will probably surpass those who do not. It is the need of the hour to provide a common platform for inter-disciplinary research for which AI generative techniques are needed.

12. REFERENCES

1. Jacob N, Sai Kumar BAA., Padodara RJ. A Glimpse into Artificial Intelligence in Animal Physiology and Allied Sciences. Animal Reproduction Update. 2022;1(2):72-81.
2. Erickson BJ, Korfiatis P, Akkus Z, Kline L. A brief history of imaging informatics. Journal of Digital Imaging. 2015;28(6):613-27.
3. Arshad MF, Ahmed F, Nonnis F, Tamponi C, Scala A, Varcasia A. Artificial intelligence and companion animals: Perspectives on digital healthcare for dogs, cats, and pet ownership. Res Vet Sci. 2025;193:105776.
4. Valavanidi A. Artificial Intelligence in Medical Diagnostics and Imaging. Applications that will revolutionize the fields in biomedical research and healthcare. 2023.
5. Mahesh N, Devishamani CS, Raghu K, Mahalingam M, Bysani P, Chakravarthy AV, et al. Advancing healthcare: the role and impact of AI and foundation models. Am J Transl Res. 2024;16(6):2166-79.
6. Chaturvedi U, Chauhan SB, Singh I. The impact of artificial intelligence on remote healthcare: Enhancing patient engagement, connectivity, and overcoming challenges. Intelligent Pharmacy. 2025.
7. Coward L A. Brain anatomy and artificial intelligence. In International Conference on Artificial General Intelligence. 2011; Springer, Berlin, Heidelberg, pp-225-68.
8. Dias R, Torkamani A. Artificial intelligence in clinical and genomic diagnostics. Genome Medicine. 2019;11:70.
9. Hunter B, Hindocha S, Lee RW. The Role of Artificial Intelligence in Early Cancer Diagnosis. Cancers. 2022;14(6):1524.
10. Gardner H. Multiple intelligences. 1983.
11. Anonymous. What is Artificial Intelligence and how does AI work? 2021.
12. Sarma GP, Reinertsen E, Aguirre A, Anderson C, Batra P, Choi SH, et al. Physiology as a Lingua Franca for Clinical Machine Learning. Patterns. 2020;1(2):100017.
13. Poplin R., Varadarajan AV, Blumer K, Liu Y, McConnell MV, Corrado GS, et al. Prediction of

cardiovascular risk factors from retinal fundus photographs via deep learning. Nature Biomedical Engineering. 2018;2(3):158-64.

14. Srivastav S, Chandrakar R, Gupta S, Babhulkar V, Agrawal S, Jaiswal A, et al. ChatGPT in radiology: the advantages and limitations of artificial intelligence for medical imaging diagnosis. Cureus. 2023; 15(7):e41435.
15. Kundisch A, Hönning A, Mutze S, Kreissl L, Spohn F, Lemcke J, et al. Deep learning algorithm in detecting intracranial hemorrhages on emergency computed tomographies. PLoS One.2021;16(11): p.e0260560.
16. Noble JA, Boukerroui D. Ultrasound image segmentation: a survey. IEEE Transactions on Medical Imaging. 2006;25(8): 987–1010.
17. Varnosfaderani SM, Forouzanfar M. The Role of AI in Hospitals and Clinics: Transforming Healthcare in the 21st Century. Bioengineering (Basel). 2024;11(4): 337.
18. Castro DPD, Diniz FDA, Lima FA, Silva TDS, Silva APSE, Nolêto RMA, et al. Artificial intelligence applied to animal production. Ciência Rural. 2025; 55(7): e20230520.
19. Retson T A, Besser AH, Sall S, Golden D, Hsiao A. Machine learning and deep neural networks in thoracic and cardiovascular imaging. Journal of Thoracic Imaging. 2019;34:192–201.
20. Asch FM, Abraham T, Jankowski M, Cleve J, Adams M, Romano N, et al. Accuracy and reproducibility of a novel artificial intelligence deep learning based algorithm for automated calculation of ejection fraction in echocardiography. Journal of the American College of Cardiology. 2019;73(9S1):1447.
21. Le EPV, Wang Y, Huang Y, Hickman S, Gilbert FJ. Artificial intelligence in breast imaging. Clinical Radiology. 2019;74:357-66.
22. Majumdar A, Brattain L, Telfer B, Farris C, Scalera J. Detecting intracranial hemorrhage with deep learning. Conference Proceedings IEEE Engineering in Medicine and Biology Society. 2018;583-7.
23. Gulshan V, Peng L, Coram M, Stumpe MC, Wu D, Narayanaswamy A, et al. Development and validation of a deep learning algorithm for detection of diabetic retinopathy in retinal fundus photographs. Journal of the American Medical Association. 2016;316(22):2402-10.
24. van der Heijden AA, Abramoff MD, Verbraak F, van Hecke MV, Liem A, Nijpels G. Validation of automated screening for referable diabetic retinopathy with the IDx-DR device in the Hoorn diabetes care system. Acta Ophthalmology. 2018;96:63-8.
25. Dutta R, Smith D, Rawnsley R, Bishop-Hurley G, Hills J, Timms G, et al. Dynamic cattle behavioural classification using supervised ensemble classifiers. Computers and Electronics in Agriculture. 2015; 111:18-28.
26. Pegorini V, Zen Karam L, Pitta CSR, Cardoso R, Da Silva JCC, Kalinowski HJ, et al. In vivo pattern classification of ingestive behavior in ruminants using FBG sensors and machine learning. Sensors. 2015; 15(11):28456-71.
27. Matthews SG, Miller AL, PlÖtz T, Kyriazakis I. Automated tracking to measure behavioural changes in pigs for health and welfare monitoring. Scientific Reports – Nature. 2017;7(1):1-12.
28. McLennan KM, Rebelo CJB, Corke MJ, Holmes MA, Leach MCF. Constantino-Casas. Development of a facial expression scale using footrot and mastitis as models of pain in sheep. Applied Animal Behavior Science. 2016;176:19-26.

29. Riaboff L, Poggi S, Madouasse A, Couvreur S, Aubin S, Bédère N, Goumand E, et al. Development of a methodological framework for a robust prediction of the main behaviours of dairy cows using a combination of machine learning algorithms on accelerometer data. Computers and Electronics in Agriculture. 2020;169:105179.
30. Gianola D, Okut H, Weigel KA, Rosa GJM. Predicting complex quantitative traits with Bayesian neural networks: a case study with Jersey cows and wheat. BMC Genetic Data. 2011;12(1):87.
31. Shahinfar S, Page D, Guenther J, Cabrera V, Fricke P, Weigel K. Prediction of insemination outcomes in Holstein dairy cattle using alternative machine learning algorithms. Journal of Dairy Science. 2014; 97(2):731-42.
32. Borchers YM, Chang KL, Proudfoot BA, Wadsworth AE, Stone JM, Bewley. Machine learning-based calving prediction from activity, lying, and ruminating behaviors in dairy cattle. Journal of Dairy Science. 2017;100(7):5664-74.
33. Dhoble AS, Ryan KT, Lahiri P, Chen M, Pang X, Cardoso FC, et al. Cytometric fingerprinting and machine learning (CFML): a novel label-free, objective method for routine mastitis screening. Computers and Electronics in Agriculture. 2019;162:505-13.
34. Bisen Vikram Singh. How AI can help in agriculture – five applications and use cases. Tech News Info, updates and free tips. 2019.
35. Suresh N. The role of sensors, big data and machine learning in modern animal farming. Sensing and Bio-sensing Research. 2020;29:100367.
36. Srivastava V, Kumar R, Wani MY, Robinson K, Ahmad A. Role of artificial intelligence in early diagnosis and treatment of infectious diseases. Infectious Diseases. 2024; 57(1): 1–26.
37. Alsulimani A, Akhter N, Jameela F, Ashgar RI, Jawed A, Hassani MA, et al. The Impact of Artificial Intelligence on Microbial Diagnosis. Microorganisms. 2024;12(6):1051.
38. Akinsulie OC, Idris I, Aliyu VA, Shahzad S, Banwo OG, Ogunleye SC, et al. The potential application of artificial intelligence in veterinary clinical practice and biomedical research. Frontiers in Veterinary Science. 2024;11:1347550.
39. Burti S, Banzato T, Coghlan S, Wodzinski M, Bendazzoli M, Zotti A. Artificial intelligence in veterinary diagnostic imaging: Perspectives and limitations. Research in Veterinary Science. 2024;175:105317.
40. Nair SS. Transforming Veterinary Practice with Artificial Intelligence (AI): A Comprehensive Review of Applications for Veterinary Practitioners. Journal of Indian Veterinary Association. 2024;22(3):36-52.
41. Kazembe I, Mkandawire M. AI driven animal farming and livestock management system. International Journal of Advanced Research in Science, Communication and Technology. 2024;23.
42. Vlaicu PA, Gras MA, Untea AE, Lefter NA, Rotar MC. Advancing livestock technology: intelligent systemization for enhanced productivity, welfare, and sustainability. AgriEngineering. 2024;6(2):1479-96.
43. Zhang L, Guo W, Lv C, Guo M, Yang M, Fu Q, et al. Advancements in artificial intelligence technology for improving animal welfare: Current applications and research progress. Animal Research and One Health. 2024;2(1):93-109.
44. Hou J, He Y, Yang H, Connor T, Gao J, Wang Y, et al. Identification of animal individuals using deep

learning: A case study of giant panda. Biological Conservation. 2020;242:108414.

45. Ji B, Banhazi T, Phillips CJ, Wang C, Li BA machine learning framework to predict the next month's daily milk yield, milk composition and milking frequency for cows in a robotic dairy farm. Biosystems Engineering. 2022;216:186-97.
46. Manteuffel C. Parturition detection in sows as test case for measuring activity behaviour in farm animals by means of radar sensors. Biosystems Engineering. 2019;184:200-6.
47. Park M, Britton D, Daley W, McMurray G, Navaei M, Samoylov A, et al. Artificial intelligence, sensors, robots, and transportation systems drive an innovative future for poultry broiler and breeder management. Animal Frontiers. 2022;12(2):40-8.
48. Jiang K, Xie T, Yan R, Wen X, Li D, Jiang H, et al. An attention mechanism-improved YOLOv7 object detection algorithm for hemp duck count estimation. Agriculture. 2022;12(10):1659.
49. Feighelstein M, Shimshoni I, Finka LR, Luna SP, Mills DS, Zamansky A. Automated recognition of pain in cats. Scientific Reports. 2022;12(1):9575.
50. Lencioni GC, de Sousa RV, de Souza Sardinha EJ, Corrêa RR, Zanella AJ. Pain assessment in horses using automatic facial expression recognition through deep learning-based modeling. PLoS One. 2021; 16(10):e0258672.
51. Saar M, Edan Y, Godo A, Lepar J, Parmet Y, Halachmi I. A machine vision system to predict individual cow feed intake of different feeds in a cowshed. Animal. 2022;16(1):100432.
52. Ravi G, Choi JW. Data-driven intelligent feeding system for pet care. In 2022, 22nd International Conference on Control, Automation and Systems (ICCAS). 2022; Pp.2013-8.
53. Fuentes S, Gonzalez Viejo C, Tongson E, Lipovetzky N, Dunshea FR. Biometric physiological responses from dairy cows measured by visible remote sensing are good predictors of milk productivity and quality through artificial intelligence. Sensors. 2021;21(20):6844.
54. Feuser AK, Gesell-May S, Müller T, May A. Artificial intelligence for lameness detection in horses—A preliminary study. Animals. 2022;12(20):2804.
55. Gehlot A, Malik PK, Singh R, Akram SV, Alsuwian T. Dairy 4.0: Intelligent communication ecosystem for the cattle animal welfare with blockchain and IoT enabled technologies. Applied Sciences. 2022; 12(14):7316.
56. Fuentes S, Viejo CG, Tongson E, Dunshea FR., Dac HH, Lipovetzky N. Animal biometric assessment using non-invasive computer vision and machine learning are good predictors of dairy cows age and welfare: The future of automated veterinary support systems. Journal of Agriculture and Food Research. 2022;10:100388.
57. Almalawi A, Alsolami F, Khan AI, Alkhathlan A, Fahad A, Irshad K, et al. An IoT based system for magnify air pollution monitoring and prognosis using hybrid artificial intelligence technique. Environmental Research. 2022;206:112576.
58. Li H-L, Yang X-J, Li J-Y, Zhan K, Li M, Gao H-Y, et al. Design and application of intelligent monitoring system for laminated henhouse with six overlap tiers cages. In 3rd International Conference on Wireless Communication and Sensor Networks (WCSN 2016). 2016; Pp. 345-8.
59. Sun H, Palaoag TD, Quan Q. Design of automatic monitoring and control system for livestock and poultry house environment based on Internet of Things robot. In Proceedings of the 2022. 4th Asia Pacific Information Technology Conference. 2022; Pp. 224-30.

60. Qingchun F, Xiu W, Quan Q, Chunfeng Z, Bin L, Ruifeng X, et al. Design and test of disinfection robot for livestock and poultry house, Smart Agriculture. 2020;2(4):79.

61. Feng QC, Wang XJPCS. Design of disinfection robot for livestock breeding. Procedia Computer Science. 2020;166:310–4.

62. Fuentes S, Gonzalez Viejo C, Chauhan SS, Joy A, Tongson E, et al. Non-invasive sheep biometrics obtained by computer vision algorithms and machine learning modeling using integrated visible/infrared thermal cameras. Sensors. 2020;20(21):6334.

63. Blomke L, Volkmann N, Kemper N. Evaluation of an automated assessment system for ear and tail lesions as animal welfare indicators in pigs at slaughter. Meat Science. 2020;159:107934.

64. Mohan A, Raju RD, Janarthanan P. Animal disease diagnosis expert system using convolutional neural networks. In 2019, International Conference on Intelligent Sustainable Systems (ICISS). 2019; Pp. 441-6.

65. Gorczyca MT, Gebremedhin KG. Ranking of environmental heat stressors for dairy cows using machine learning algorithms. Computers and Electronics in Agriculture. 2020;168:105124.

66. Singh PD, Kaur R, Singh KD, Dhiman G, Soni M. Fog-centric IoT based smart healthcare support service for monitoring and controlling an epidemic of Swine Flu virus. Informatics in Medicine Unlocked. 2021; 26:100636.

67. Chatterjee PS, Ray NK, Mohanty SP. LiveCare: An IoT-based healthcare framework for livestock in smart agriculture. IEEE Transactions on Consumer Electronics. 2021;67(4):257–65.

68. Feng Y, Niu H, Wang F, Ivey SJ, Wu JJ, Qi H, et al. Social Cattle: IoT-based mastitis detection and control through social cattle behavior sensing in smart farms. IEEE Internet of Things Journal. 2021;9(12): 10130–8.

69. Kuroda Y, Nakao M, Kuroda T, Oyama H, Komori M. Interaction model between elastic objects for haptic feedback considering collisions of soft tissue. Computer Methods and Programs in Biomedicine. 2005;80(3):216-24.

70. Williams RL, Srivastava M, Howell JN, Conatser RR, Eland DC, Burns JM, et al. The Virtual Haptic Back for Palpatory Training. In Sixth International Conference on Multimodal Interfaces, State College, PA, USA. 2004; Pp-191-7.

71. SensAble Technologies. Cited from http://www.sensable.com. 2021.

72. Crossan A. The Design and Evaluation of a Haptic Veterinary Palpation Training Simulator. Ph.D. Thesis, University of Glasgow. 2004.

73. Baillie S. Utilisation of simulators in veterinary training. Cattle Practice. 2007;15(3):224.

74. Ninan J. Different Adaptative mechanisms exhibited by dairy cattle when exposed to heat stress. In Capacity Building for adaptation of Technology (Cat) Program on Summer management of heat stress associated diseases and sustained dairy cattle production, Raghy, R, George, D, Silpa, M.V. Rajaganapathy, V. and Sejian, V. (eds). Published by RIVER- Puducherry and NABARD. 2024; Pp 70-80. ISBN: 978-81-920883-5-8.

75. Ilavarasi G, Ninan J, Sejian V. Impact of Environmental Factors on Blood Disorders in Animals. International Journal of Environment and Climate Change. 2025; 15(6): 233-49.

76. Singaravadivelan A, Prasad A, Balusami C, Harikumar S, Beena V, Gleeja VL, et al. Non-invasive heat stress assessment in Murrah buffalo, crossbred (Bos taurus × Bos indicus) cattle and Vechur cattle using

inner canthus infrared thermography. Tropical Animal Health Production. 2025;57:285.

77. George WD, Godfrey RW, Ketring RC, Vinson MC, Willard ST. Relationship among eye and muzzle temperatures measured using digital infrared thermal imaging and vaginal and rectal temperatures in hair sheep and cattle. Journal of Animal Science. 2024;92:4949-55.
78. Salles MS, Da Silva SC, Salles FA, Roma LC, ElFaro L, Lean BMPA. Mapping the body surface temperature of cattle by infrared thermography. Journal of Thermal Biology. 2016;62:63-9.
79. Stone W. Nutritional approaches to minimize subacute ruminal acidosis and laminitis in dairy cattle, Journal of Dairy Science. 2004; 87: E13-26.
80. Yang CC, Hsu Y L. A Review of Accelerometry-Based Wearable Motion Detectors for Physical Activity Monitoring. Sensors. 2010;10:7772-88.
81. Buffington DE, Collazo-Arocho A, Canton GH, Pitt D, Thatcher WW, Collier RJ. Black Globe-Humidity Index (BGHI) as Comfort Equation for Dairy Cows. Transactions of the ASAE. 1981;24:711-4.
82. Gaughan JB, Mader TL, Holt SM, Lisle A. A new heat load index for feedlot cattle. Journal of Animal Science. 2008;86(1):226-34.
83. Da Silva RG, Maia ASC, de Macedo Costa LL. Index of thermal stress for cows (ITSC) under high solar radiation in tropical environments. International Journal of Biometeorology. 2015; 59(5):551-9.
84. Dixit S, Sirohi R, Singh Y, Mamta Ajay K, Gaur VS, Chelani L, et al. Different Methods of Monitoring Heat Stress in Dairy Animals. International Journal of Science, Engineering and Technology. 2025;13: 2.
85. Wang F, Shao D, Li S, Wang Y, Azarfar A, Cao, Z. Effects of stocking density on behavior, productivity, and comfort indices of lactating dairy cows. Journal of Dairy Science. 2016; 99: 3709-17.
86. Kendall P, Nielsen P, Webster J, Verkerk G, Littlejohn R, Matthews L. The effects of providing shade to lactating dairy cows in a temperate climate. Livestock Science. 2006; 103: 148-57.
87. Herbut P, Hoffmann G, Angrecka S, Godyń D, Vieira FMC, Adamczyk K, et al. The effects of heat stress on the behaviour of dairy cows - a review, Annals of Animal Science. 2021;21(2).385-402.
88. Chung H, Li J, Kim Y, Van Os JMC, Brounts SH, Choi CY. Using Implantable Biosensors and Wearable Scanners to Monitor Dairy Cattle's Core Body Temperature in Real Time. Computers and Electronics in Agriculture. 2020;174:105453.
89. Garbey M, Sun N, Merla A, Pavlidis I. Contact-Free Measurement of Cardiac Pulse Based on the Analysis of Thermal Imagery. IEEE Transactions on Biomedical Engineering. 2007;54:1418-26.
90. Pavlidis I, Tsiamyrtzis P, Shastri D, Wesley A, Zhou Y, Lindner P, et al. Fast by nature-how stress patterns defines human experience and performance in dexterous tasks. Scientific Reports – Nature. 2021;2(1): 1-9.
91. Cho Y, Julier SJ, Bianchi-Berthouze N. Instant Stress: Detection of Perceived Mental Stress through Smartphone Photoplethysmography and Thermal Imaging. JMIR Mental Health. 2019;6:e10140.
92. Gadariya GM, Kumar V, Sharma A, Padodara R, Bhatt RH. Artificial intelligence-a valuable complementary tool for teaching and learning veterinary anatomy. International Journal of Biology Sciences. 2025;7(7):139-45.
93. Shuaib A, Arian H, Shuaib A. The Increasing Role of Artificial Intelligence in Health Care: Will Robots Replace Doctors in the Future? International Journal of General Medicine. 2020;13:891-96.

94. Suresh KP, Hemadri D, Kruli R, Dheeraj R, Roy P. Application of artificial intelligence for livestock disease prediction. Indian Farming. 2019;69(3):60-2.
95. Ahuja AS. The impact of artificial intelligence in medicine on the future role of the physician. PeerJ. 2019;7:e7702.
96. Michael N. How Artificial Intelligence is changing the Veterinary Industry. 2020.
97. Muhammad Ali I. Artificial Intelligence in animal health and veterinary sciences. 2020.
98. Topol EJ. High-performance medicine: the convergence of human and artificial intelligence. Nature Medicine. 2019;25(1):44-56.
99. Namaganda G. The Role of AI in Early Disease Detection and Diagnostics. Journal of Biochemistry and Biotechnology. 2024;7(6):239.
100. Rebez EB, Ninan J. Biomarkers in the cardiovascular system of animals: A review. Indian Journal of Animal Health. 2024;63(1):22-8.
101. Obermeyer Z, Emanuel EJ. Predicting the future—big data, machine learning, and clinical medicine. The New England Journal of Medicine. 2016;375(13):1216-9.
102. Luo L, Wang X, Lin Y, Xiaoqi M, Tan A, Chan R, et al. Deep learning in breast cancer imaging: A decade of progress and future directions. IEEE Reviews in Biomedical Engineering, 2024.
103. Lustgarten JL, Zehnder A, Shipman W, Gancher E, Webb TL. Veterinary informatics: forging the future between veterinary medicine, human medicine, and One Health initiatives—a joint paper by the Association for Veterinary Informatics (AVI) and the CTSA One Health Alliance (COHA). JAMIA open. 2020;3(2):306-17.