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Review Article

Machine Learning in Animal Healthcare: A Comprehensive Review

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Abstract *- Observing and tracking diseases in animals is a matter of concern in the present-day scenario. Though several methods are available, yet there is a gap in the proper and early detection of animal diseases. The advanced technologies are applicable only to a few diseases that are too not known by most livestock owners. If known, sometimes it becomes inaccessible due to cost and distance. In the present review work, we have analyzed the various methods and machine learning algorithms used in animal healthcare with special reference to the future aspects of thosemethods. The observations of the study suggest that machine learning algorithms if employed properly, will be of great help in animal healthcare in the early detection of disease, work on big datasets, error-free results and real-time applications.*

Keywords *- Animal disease, Cattle disease, Foot and Mouth disease, Lumpy skin disease, Machine learning algorithms.*

1. Introduction

Animals have always been a vital part of the evolution of humans. Right from an early age, human depends on animals for food, transportation, agriculture, security, and recreational activities[1]. Therefore, animal activity recognition is one of the very important aspects of studying its well-being. Daily monitoring of animal activity can give insight into stress, disease symptoms and nutritional consumption. Animal husbandry, an essential component of Indian agriculture, provides a living for a significant number of rural people. In particular, cattle rearing is a popular activity among landless and marginal farmers during the lean agricultural season in India. There are three types of animal diseases prevalent in India. These mainly include (a) Viral diseases,(b) Bacterial Diseases, and (c) Parasitic diseases. The zoonotic diseases in animals may range from minor short-term illnesses to major life-changing illnesses. Various viral zoonotic diseases like the bird flu, swine flu, rift valley fever, Severe Acute Respiratory Syndrome (SARS), etc., were a matter of great concern, which created emergency-like situations internationally. Recently, the corona virus outbreak that shocked the whole world was also due to a bat. India, known as the world’s largest milk producer with a cattle population of around 192.5 million, witnessed the deaths of more than 97 thousand cattle in September 2022 due to lumpy skin disease[2]. The list of animal diseases and their harmful effects on both animals and humans continues and is an inevitable condition. The concern is the surveillance and prevention process. In most cases, diseases are detected at a later stage by the owner or farmers, where there is very little possibility to cure the disease. However, nowadays, a number of Machine Learning (ML) and Deep Learning (DL) approaches are being actively deployed to identify illnesses in their early phases to facilitate timely prevention. The ML is a branch of Artificial Intelligence (AI). It brings out the power of data in several new ways. The technology helps to learn and improve the accuracy of prediction in computer systems by experience. It is in use in almost every field nowadays, from voice recognition to signal processing, from search engines to social media handles, from banks to healthcare sectors, and the list goes on. The ML algorithms areused largely in medical fields for disease prediction and cures. In veterinary science also, ML is used in several applications such as disease diagnosis, predictive analytics, therapy optimization, real time monitoring and behavioural analysis[3][4][5]. The present study is a review of the various ML algorithms used in animal healthcare. ML algorithms are far way better than conventional methods in the animal healthcare sectors in the following ways as elaborated in Table 1.

Broadly, ML is divided into three categories: i) Supervised learning, ii) Unsupervised learning, and iii) Reinforcement method.

1.1 Supervised Learning

In this type of machine learning, the use of labelled datasets to train algorithms for precise data classification or result prediction is used. Upon obtaining input data, the model adjusts its weights until a satisfactory fit is attained. Supervised ML models are trained with labelled data sets, which allow the models to learn and grow more accurately over time. For example, when different labelled shapes are fed into the machine, it can identify the different shapes. The two main models of supervised machine learning are Regression analysis and classification[6]. The most common and widely used ML algorithms for animal disease detection are based on supervised learning, such as:

Table 1. Comparison of conventional methods versus machine learning based methods for animal healthcare

Aspects	Machine Learning	Conventional Methods	Sources
Data Handling	Can process large datasets efficiently, which is crucial for animal disease detection.	Dependent on manual processing and error-prone and time-consuming on large datasets.	[3], [5]
Model Flexibility	Models can be employed to do different tasks like regression, clustering, anomaly detection, etc, which can be helpful in various stages of disease detection.	Follows protocols which are rigid and specific to a certain condition.	[3]
Accuracy	It can achieve high accuracy in disease prediction through proper training, as it excels in recognizing complex patterns and identifying relationships between several patterns.	Accuracy depends highly on individuals collecting and analyzing data. The results may be affected by the quality of data and resources for diagnosis.	[4]
Speed	Can process data quickly, allowing real time analysis.	Delays in response and reporting as they are dependent on manual processes for data collection, analysis and reporting.	[5]
Scalability	In the machine learning process the scalability becomes easy due to parallel processing, feature reduction, cloud computing, etc technologies.	The manual processing limits the scalability as the volume of data increases. Also, scaling in conventional methods becomes costly as it requires investments in infrastructure, software and expertise.	[5][4]

1.1.1. Artificial Neural Network (ANN)

ANNs are designed to mimic the way the human brain works. These are systems with the capacity to alter their internal organization in response to a functional objective. The connections and nodes make up the fundamental components of an ANN. Every node has a distinct input through which it can communicate with other nodes and receive communication[7].

1.1.2. Decision Tree (DT)

A DT algorithm follows the same structure as that of a normal tree, which includes roots, branches and leaves. A root node is the topmost node; the internal node represents a decision or a test on a specific feature; each branch represents the outcomes of the decision; the leaf node represents the final decision 6].

1.1.3. K- Nearest Neighbour (KNN)

KNN is a well-liked approach for classification in supervised machine learning. It is a well-liked approach for classification in supervised machine learning. KNN considers the characteristics and labels of the training data to forecast a classification of unlabelled data. The KNN can perform classification tasks based on neighbour's number[6].

1.1.4. Naïve Bayes(NB)

The NB is a classification technique based on Bayes theorem within an assumption of independence among predictors[8]. This algorithm has been shown to be useful for real-world uses, including system performance management, medical diagnosis, and text classification**.** It is extensively used in text classification tasks. The NB depends on the conditional probability of happening and is mainly used for clustering and classification [8].

1.1.5. Support Vector Machines (SVM)

The SVM is mostly used to analyze data for classification and regression analysis[8]. The SVM has been made in reverse order in comparison to the development of neural networks. The kernal function used in SVM systematically finds support vector classifiers in higher dimensions. Out of the various kernels used in SVM, the polynomial, radial and linear kernels are widely used[6].

1.2. Unsupervised Learning

In unsupervised ML, a program looks for patterns in unlabelled data. Unsupervised ML can find patterns or trends that people are not explicitly looking for. The three basic types of unsupervised learning include clustering, association rules and dimensionality reduction. In this type of algorithm, no prior human intervention is needed[9].

1.3. Reinforcement

Reinforcement ML creates an incentive system in order to teach machines, via trial and error, how to arrive at the best possible decision. It is an autonomous, self-teaching system which learns by trial and error. By informing the machine when it made the proper choice, reinforcement learning can be used to teach models to play games or teach autonomous cars to drive. This allows the machine to learn what actions it must perform[10] gradually.

2. Application of ML in Animal Healthcare

2.1. Lumpy Skin Disease (LSD)

LSD is a disease caused by a lumpy skin disease virus. It is one of the most fatal pox viruses that mainly affects cattle, bulls, zebras etc. It is also be seen in giraffes, and water buffaloes.

It may affect animals of any age. The World Health Organisation (WHO) recognizes the LSD as a notable disease as it can spread quickly by sucking insects and can have economic concerns. The basic symptoms are mainly nodular lesions on the skin. It may appear on the head, neck, back, breast, etc. of the cow.

The development of skin nodules, enlargement of the lymph, fever, depression, and dysgalactia characterize the disease. It may lead to a decline in milk yield and infertility in bulls. Unfortunately, there is no specific drug available for the treatment of LSD. It can be treated only by proper care and by using sprays and medicines used for other skin diseases.

Rai *et al.*used Inception and VGG techniques in the detection of the disease[11]. Olaniyan *et al.* used a stacked ensemble and optimized ANN to predict LSD and found that both the models outperformed the existing ones with an accuracy of 97.69% and 98.89%, respectively[12].

2.2. Foot and Mouth Disease (FMD)

FMD is one of the serious and highly contagious diseases. It affects cloven-hoofed animals, including cattle, sheep, deer, pigs, goats, etc. An Aphthovirus of the family Picornaviridae causes it and is endemic in many countries. Even when the FMD virus accidentally infects a community, there might be unexpected economic loss. The basic symptoms of FMDV-infected animals include lesions on the tongue, oral cavity, muzzle eats and coronary bands.

Various other symptoms, such as repeated fevers, decreased appetite, weight loss, hypersalivation, and depression, among others, might persist long after the animal recovers from an illness. The following techniques can detect the FMD virus: a) Complement Fixation Test (CFT), b) virus isolation test, c) Virus Neutralization Test (VNT), and d) Enzyme-Linked Immunosorbent Assay (ELISA) [13]. ML algorithms such as Classification Trees (CT), Random Forests (RF), and Chi-Squared Automatic Interaction Detector (CHAID) are also explored and applied to detect the disease[14].

2.3. Disease in Pigs

Since animals communicate their well-being through eating, drinking, social conduct, and other behaviours, the changes in their behaviour may be an early symptom of sickness. Although daily monitoring of such signs is not possible, however parameters like coughing patterns, restlessness, tail patterns, feeding patterns etc., were monitored in various studies[15].

2.4. Skin Disease in Dogs

Dogs are considered to be “Man’s best companion”. Dogs provide mental and emotional health benefits to their owners[16]. However, at the same time, they may be the source of several zoonotic diseases.

Dissanayaka *et al.* tested various ML algorithms but got good accuracy using KNN, SVM and Linear Regression algorithms for developing a mobile application to diagnose dogs’ disease and provide feedback for possible treatments by users. Once the disease was confirmed by the application, remedies and treatments were predicted by AI and Natural Language Processing (NLP) [17].

2.5. Lameness

Lameness in dairy cows is a matter of concern from an economic point of view, as it hampers not only the farmers but also the animal welfare of milk production globally. It is considered to be one of the costliest health diseases of dairy cows after mastitis and diminished fertility. Lameness can be recognized by a change in locomotion, usually associated with lesions of the pelvic limbs. Fever, anorexia, reduced milk yield, pain, swelling, and loss of mobility are the basic symptoms of lameness[18]. In most cases, the farmers fail to detect the disease in cows of their herd until it is too late and the time to treat the disease becomes less. So, a quick and easy method to find whether or not a cow is lame has been proposed by many research proposals, as in Table 2 below.

3. Related works and discussions

The various results obtained by applying ML algorithms are summarised in Table 3 below:

Additionally, it has been noted that multiple distinct conditions may be identified using ML techniques, like postpartum disease in cows, which can be detected using the random Forest algorithm of ML, taking into consideration the lactose yield, protein production and milk yield. In a few cases, the theoretical value was compared to the observed data to generate an anomaly signal in disease detection. The use of sensors is indispensable in such domains, as we have seen in most cases that the sensor’s application and ML algorithms went hand in hand. In the present review, we have inferred the results based on only the Accuracy of the algorithms, the formula for which is:

$$Accuracy = \frac{(TP + TN)}{(TP + TN + FP + FN)}$$

Where TP = True Positive, TN = True Negative, FP = False Positive and FN = False Negative.

Table 2. Various methods of detection of lameness

Papers	Techniques used for the detection of lameness	Year
[19]	Infrared Thermography	2018
[20]	Touch and release angles	2011
[21]	Back Curvature posture	2012
[22]	3D camera to analyze cattle gait asymmetry	2016

Table 3. The outcomes of several research works related to cattle disease detection using ML

Diseases	Algorithms	Techniques	Outcome
Lumpy skin disease in cattle	Segmentation	Image Processing[23]	99.9% training accuracy and 95.7% testing accuracy.
	ANN	Inception V3[11]	92.5% accuracy
	Logistic Regression	VGG-16[11]	87.9% accuracy
	Naïve Bayes	VGG-19	88.2% accuracy
	Optimized ANN	-	98.89 accuracy[12]
Lameness in cattle	Fog Computing, XGBoost, Regressive Tree (CART)	Image Data Leg and neck movement [18], [24], [25]	86% AUROC and 81% F-Measure With a 2% error. Boosting proved better than fog computing.
Foot and Mouth disease in cattle	CT, RF and CHAID	Comparison of predictive performance[14]	Highest accuracy with Random Forest algorithm.
Skin disease in dogs	KNN, SVM, Linear Regression	Image Processing[16], [17]	98.79 using NLP and AI
Disease in pigs	XGboost	Feature Extraction[15]	80% accuracy

4. Conclusion

After reviewing the existing research works, it is observed that machine learning techniques are useful in the animal healthcare sector, enabling early detection and easy treatment. The random forest algorithm is the technique, which yields the highest accuracy in most of the cases. It is noteworthy to mention that, the process of early detection of cattle diseases is yet to be institutionalized in India. Consequently, poor farmers are unable to access treatment during the initial phase of animal diseases. In the case of animal skin disease, there was difficulty because of animal fur, which does not occur in humans. While studying the feeding and living patterns of pigs, the researchers sometimes could not differentiate between the sick and well pigs, as there was not much difference between the feeding pattern on the unhealthy and healthy ones.

The massive use or application of ML algorithms may be very helpful in detecting animal diseases in the very early stage, which will not only help the farmers on the economic front but also reduce the risks of any outbreak. Although several automated ML techniques have been developed and employed, the concept is not free from limitations such as cost, performance, longevity and farmer's perception.

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