Low-Energy Machine Learning for Veterinary Medicine

A literature review on use cases, strategies, and challenges for low-energy machine learning in veterinary medicine

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Introduction

Even with constantly improving computer hardware and seemingly fully developed electricity grids in many parts of the world, the need for energy-efficient systems has not disappeared. In addition to economic factors, such as the need to reduce hardware and energy costs, there are other motivations for implementing devices and software that consume less energy. This is the case for veterinary medicine, a field with high interest in employing ML-powered devices operating close to animals where physical connections to the electrical grid are not guaranteed.

Domains

Veterinary medicine, like human medicine, is evolving. Treatments are becoming more complex, and the number of patients is rising. The use of machine learning is not yet popular, but there are numerous experiments showing the effectiveness of various smart systems in improving the quality of animal care.

Livestock Farming

In farming, automation is progressing at a rapid pace. One area that farmers would like to automate is the health and fertility monitoring of their livestock. Using sensors like GPS, accelerometers, and cameras, the behavior of individual animals can be analyzed, where irregularities could signal sicknesses or other conditions like eating disorders (Helwatkar et al., 2014, 1-2). Trained models can detect irregularities in the behavioral patterns and therefore assist farmers in providing better care for the animals and preventing the spread of diseases (Sharma et al., 2021, 4845).

Wildlife Animal Research

As with livestock, the behavior of wild animals can be analyzed using various sensors. However, the focus of most research is not directly related to health. With tags, the movements of individuals are followed, leading to new insights into social networks of wild animals and regional distributions (Valletta et al., 2017, 205). Another application of machine learning in this domain is automated wildlife data collection. Cameras with computing capabilities detect specific species entering the field of view and collect images (van Dijk, 2023, 5). The results are valuable datasets used for animal conservation (Trevathan et al., 2025, 101474).

Pet Care

The population of pets is increasing at a rapid pace, with a total population that has already surpassed 1 billion (HealthForAnimals, 2022). As a result, a pet care industry is emerging, producing numerous commercial products to aid owners in caring for these animals. A trending research topic is remote diagnosis and treatment using sensors and telecommunication, and automated diagnosis using fuzzy logic or machine learning (Raheja et al., 2018, 133). The methods applied include, among common sensors like GPS and motion sensors, creative health measurement techniques like measuring the pulling force of dogs with smart leashes (Nichols et al., 2024, 7).

Machine Learning Strategies

The examples mentioned above already provide some insights into the strategies applied for applying machine learning to veterinary medicine. These methods seem

popular: distribute the workload between IoT (Internet of Things) clients and servers, and they use specialized software and hardware for local inference.

Internet of Things

IoT is a perfect fit for low-energy requirements in veterinary care setups. Simple sensors connected to the internet are very energy efficient, and the total energy can be minimized by provisioning ideal hardware in the cloud.

One typical workload distribution looks like this:

- Sensor equipped with a microchip and internet module collects information and sends it to a remote server
- The remote server stores the information, transforms it into adequate formats, and performs ML model inference
- An interactive tool (web or mobile app) gives rich feedback with suggestions to the user (farmer, vet, pet owner, researcher, etc.).

Edge AI

Edge AI is the term describing software and hardware able to run machine learning algorithms with extreme compute and energy restrictions. Commercial products like edge AI cameras or single-board computer platforms support almost any kind of ML model (e.g., deep neural networks exported as TensorFlow Lite models), just with limitations regarding the model size (parameters, input size). Pretrained models are stored in the edge device, which continuously predicts some value using the incoming data from sensors.

Challenges

On-Device Model Training

Not a single one of the papers proposes training an ML model on remote devices. One reason for this is the absence of target values (what the model should predict) when collecting data. Only unsupervised methods (e.g., clustering, anomaly detection) work without labels, reducing the potential tasks the model can assist in.

Energy Constraints in Remote Locations

If there is no connection to the electrical grid, the energy constraints are extreme. Nature harvests limited energy (International Energy Agency, 2018), and it is difficult to sustain many forms of computing hardware over a long time. Therefore, pairing the energy-harvesting unit with a battery is essential. Additionally, turning on the devices only during data collection and prediction can significantly reduce overall energy consumption. The energy consumption of model inference is typically low and only a concern for large amounts of data like video (Desislavov et al., 2023, 100857).

Summary and Future Work

The review of many different papers shows a large interest in IoT applications and remote computing for veterinary medicine use cases. Regarding the applied algorithms and models, there are no significant differences from other domains. The reviewed papers often propose using convolutional neural networks, as they are powerful for classifying and analyzing image and video data for animal species and individuals. Other mentioned model types are regression, support vector machines, and random forests for general prediction tasks and K-means for clustering.

There is a large potential for machine learning in real animal health and monitoring applications. The research done in the area of machine learning in natural environments is still sparse, and few fully developed systems are in professional use.

Model Training for Veterinary Medicine Tasks

Many of the papers advocate for greater engagement by the research community in the training of specialized models for veterinary medicine. Tools like efficient (edge) AI hardware as well as powerful model types and datasets exist, but still, few solutions are in productive use.

Unsupervised Machine Learning

Supervised learning methods are strongly favored by the veterinary medicine research community. They outperform unsupervised methods in various tasks when labeled data is available (Manohar et al., 2016, 156). Still, there are compelling reasons for doing further research on unsupervised methods for veterinary medicine because a lot of data collected in nature is unlabeled. Furthermore, unsupervised models could be deployed without training data and trained while in use.

References

Desislavov, R., Martínez-Plumed, F., & Hernández-Orallo, J. (2023). Trends in AI inference energy consumption: Beyond the performance-vs-parameter laws of deep learning. *Sustainable Computing: Informatics and Systems*, *38*, 100857. 10.1016/j.suscom.2023.100857

HealthForAnimals. (2022, 9). *Global Trends in the Pet Population - HealthforAnimals*. Health for Animals. Retrieved February 28, 2025, from

https://healthforanimals.org/reports/pet-care-report/global-trends-in-the-pet-population/

Helwatkar, A., Riordan, D., & Walsh, J. (2014). Sensor Technology For Animal Health Monitoring. *International Journal on Smart Sensing and Intelligent Systems*, *7*(5), 1-6. https://doi.org/10.21307/ijssis-2019-057

International Energy Agency. (2018, 7). *Energy Harvesting Technologies for IoT Edge Devices*. Energy Efficient End-use Equipment. https://www.iea-4e.org/wp-content/uploads/publications/2018/07/Energy_Harvesting_Final_Report.pdf

Manohar, N., Kumar, Y. H. S., & Kumar, G. H. (2016). Supervised and unsupervised learning in animal classification. *2016 International Conference on Advances in Computing, Communications and Informatics*, 156-161. 10.1109/ICACCI.2016.7732040

Nichols, C., Wu, Y., Gruen, M., Roberts, D. L., & Bozkurt, A. (2024). *Wireless Tension Sensors for Characterizing Dog Frailty in Veterinary Settings*. Association for Computing Machinery. 10.1145/3702336.3702337

pcoutlet. (2024, November 8). *How Much Electricity Does a PC Consume: Energy Usage Guide*. PC Outlet. Retrieved February 28, 2025, from https://pcoutlet.com/parts/power-supplies/how-much-electricity-does-a-pc-consume-energy-usage-guide

Raheja, J. L., Gupta, H., & Chaudhary, A. (2018, 1 1). Monitoring Animal Diseases in Remote Area. *Pattern Recognition and Image Analysis*, *28*(1), 133-141. 10.1134/S1054661818010145

Sharma, A., Jain, A., Gupta, P., & Chowdary, V. (2021). Machine Learning Applications for Precision Agriculture: A Comprehensive Review. *IEEE Access*, *9*, 4843-4873. 10.1109/ACCESS.2020.3048415

Trevathan, J., Tan, W. L., Xing, W., Holzner, D., Kerlin, D., Zhou, J., & Castley, G. (2025). A computer vision enhanced IoT system for koala monitoring and recognition. *Internet of Things*, *29*, 101474. 10.1016/j.iot.2024.101474

Valletta, J. J., Torney, C., Kings, M., Thornton, A., & Madden, J. (2017). Applications of machine learning in animal behaviour studies. *Animal Behaviour*, *124*, 203-220. 10.1016/j.anbehav.2016.12.005

van Dijk, N. (2023). *Advanced wildlife camera trapping using embedded AI machine vision*. University of Twente. http://essay.utwente.nl/96526/

Appendix

Usage of Generative AI

This report was written independently without the use of generative AI. QuillBot was used for grammar checking and rephrasing.