AN EMBEDDED AI SYSTEM FOR RECOGNIZING PET ACTIVITIES AND MANAGING THEIR NUTRITION

Ravindran K

Lecturer in Electronics Engineering

Department of Electronics Engineering, Government Polytechnic College, Palakkad

Kerala 678551, India

ABSTRACT

An AI system built into devices for pet activities and nutrition uses hardware like sensors and cameras along with machine learning to understand what a pet is doing and suggest the right amount of food. These systems can track how active a pet is using accelerometers, identify the pet through cameras to offer personalized meals, check how much food is eaten, and change the portion sizes based on things like age, weight, and activity. This tech is used in smart feeders, trackers, and cameras to help pets stay healthier and make it easier for owners to care for them. This paper talks about an AI system that runs on low power and is made to work in real time for recognizing what pets are doing and giving them proper nutrition. It uses a 3-axis accelerometer to measure movement and takes data from that using a 512-point FFT. Then it uses an improved MLP model on a Seed XIAO nRF52840 microcontroller. The system identifies activity levels and sends the results through Bluetooth Low Energy to a mobile app. It also saves data on a microSD card. GPS data helps track the actual speed of the pet to label and train the model accurately. As more people own pets worldwide, there's a growing need for new ways to improve how we take care of them, especially dogs and cats. Like in other areas, AI is offering a new way to address this need. There's a big shift happening in how we manage pet care with the use of advanced AI and machine learning techniques. This review explores how AI can change the pet industry in two main ways. The system works well, accurately identifying activities (94.3% accuracy), responding quickly (16 ms latency), and using resources efficiently. This makes it great for use at home, in vet clinics, and with pet insurance companies.

Keywords: - *Artificial intelligence (AI); Machine learning (ML); Pets; Monitoring Welfare.*

INTRODUCTION

Animals are important to our environment and live with us in a complex web of life [1]. As thinking creatures, they need not only respect but also careful attention to their well-being. The idea of treating animals well has become more popular in recent years as we face ethical and moral questions about how we treat them [1-3]. Whether they are farm animals, pets, wild animals, or subjects in research, making sure they are treated well is now very important in today's world [4, 5].At the same time, the field of Artificial Intelligence (AI) has made big progress, including machine learning, deep learning, and neural networks, showing great potential in many areas [6, 7]. One exciting and important use of AI is in helping improve the well-being of animals [8]. Using AI

tools can change how we watch over, manage, and improve the lives of animals in different situations [9].

Because pets are so important in many areas of life, they have a big impact on how people live and interact. However, even though these animals are very important to us, there are still big differences in how we see and treat them. A lack of good management options leads to the killing of millions of pets each year in shelters around the world. In recent years, fast-paced research has led to new solutions like using AI to improve pet well-being [7].

In recent years, AI has made a big difference in the lives of pets, especially dogs and cats. The start of this wide-ranging effort came with the use of AI in wearable devices that track important health signs and activity levels, helping to detect health problems early and create personalized care plans. As this field expanded, AI began being used to monitor pet behavior by analyzing data like movement, sounds, eating and drinking habits, and sleep patterns, which helps improve the well-being of pets [5].

Additionally, by using individual pet health information, AI is helping to improve digital feeding systems by offering better dietary advice. For people with allergies, limited time, or small living spaces, AI-powered robotic, virtual, and artificial pets provide a low-maintenance option. These pets offer companionship, emotional support, and can even help with education or therapy [5-6].

It is also important to note that many mobile apps now use AI to offer real-time health updates, track pet behavior, and connect pet owners with veterinary advice, making pet care more accessible and informed.

Even though AI technology can be complex, veterinarians don't need to know advanced computer programming to use it in their work[9]. However, having a basic understanding of AI algorithms and machine learning tools is important to recognize their benefits and use them effectively in veterinary care. This review gives a detailed look at key areas of AI and how they are being used in various aspects of pet care to help achieve the best possible results. The focus is on AI-based solutions that support both pet owners and veterinarians, including health monitoring, behavior tracking, feeding systems, parasite detection, artificial and robotic pets, veterinary care, and mobile phone applications (Figure 1) [4-6].

While AI brings exciting new possibilities to pet care, fully using it requires solving many different challenges.

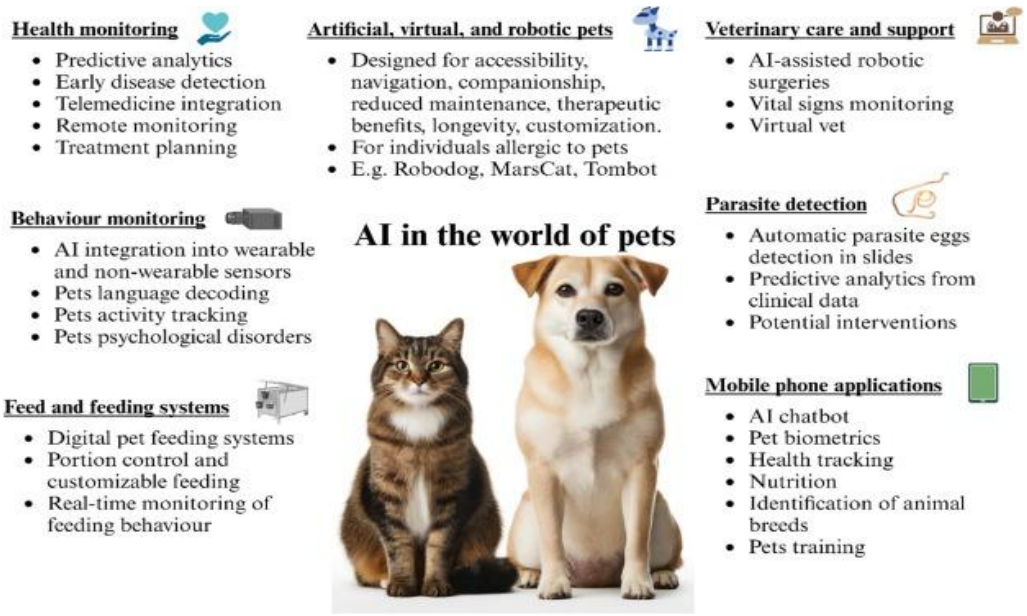

Figure 1: A variety of AI-powered innovations are changing the way we take care of pets. These include advanced systems for monitoring health and behavior, automatic detection of parasites, digital feeding solutions, artificial and robotic pets, support for veterinary care, and mobile phone apps all of which make pet care easier and improve their well-being[1].

KEY COMPONENTS AND TECHNOLOGIES

Sensors: These include a 3-axis accelerometer and other tools like cameras that gather data about how pets move and behave [1].

AI and Machine Learning:

❖ Special algorithms look at the data from the sensors to tell what a pet is doing, like walking, running, or resting [2].
❖ Computer vision and facial or body recognition can tell apart different pets, especially when there are multiple pets in the same home.
❖ Machine learning models can tell what kind of pet is in a photo, helping to give specific nutrition advice [2].

Hardware:

❖ **Wearables:** Collars with sensors and processors track a pet's activity and send alerts if something is wrong, like if a pet isn't moving much or isn't drinking enough water [2].
❖ **Smart feeders:** These devices have cameras and sensors that automatically give food and can tell which pet is eating.
❖ **Connectivity:** Wireless technologies like Wi-Fi or Bluetooth let the system send information to a mobile app and allow for remote control [1].

Functionality

❖ **Activity recognition:** The system tracks how much a pet is moving, which can help manage their diet and identify health problems [1].
❖ **Personalized nutrition:** Using information like the pet's species, age, weight, and activity level, the AI gives feeding suggestions and helps control portion sizes.
❖ **Smart feeding:** In homes with multiple pets, the system can tell which pet is eating and make sure they get the right food and amount [2].

Health monitoring:

- Keeps track of how much food and water a pet is eating and what their eating habits are.
- Creates health reports based on feeding and activity data [2].
- Sends real-time alerts if there are sudden changes, like a drop in activity or food intake.

Remote access: Pet owners can check on their pet's activity and feeding and change settings using a mobile app from anywhere [1].

Benefits

❖ **Improved pet health:** Tailored feeding based on each pet's needs helps keep them at a healthy weight and supports their overall health[2].
❖ **Convenience for owners:** The system handles feeding schedules and gives insights into a pet's health without requiring much manual work [3].
❖ **Precise nutrition:** By connecting activity and eating data, the system ensures more accurate portion control, helping to prevent over- or under-feeding [3].

TECH CHALLENGE

1) The conversation between the caregiver and the pet should be quick and smooth, like talking with a real person. The system needs to process the caregiver's words, generate replies, and choose the right response quickly [1].
2) The voice used should sound natural, expressive, and emotional, matching the voice of the actor the user has selected.
3) The system should only start working when it hears the pet's name. To save battery, it uses very few examples of the user's voice that are collected during setup [2].
4) The system should understand speech clearly even when there is a lot of background noise. Since the collar is often used outside, and a dog's collar can pick up sounds like breathing, movement, or barking, the system must work well in noisy conditions [3].
5) The system needs to recognize different sounds made by the pet. This was difficult because there weren't enough open-source audio examples of pet sounds. Special data had to be collected and features had to be carefully extracted to pick up high-pitched sounds common in dogs [4].

6) The system can understand the emotions of both the pet and the caregiver. It uses sounds and the text of what is being said to feed into a trained neural network, helping to understand the feelings and context of the interaction [5].
7) The system uses motion sensors (IMUs) to detect what the pet is doing, like resting, running, or jumping. These activities should trigger events that help track the pet's health. This needs a model trained on IMU data and a system to collect and prepare the sensor data.
8) Collecting and labeling data was a big challenge. It involved getting specific sounds made by the pet and sensor data from the IMU [3].
9) The system needs to run machine learning models quickly, so predictions can be made in milliseconds. It must handle many requests at the same time, which requires using efficient computing resources and building scalable, reliable services [5].
10) The system should send alerts to the caregiver based on events and predictions, like changes in nutrition, signs of dehydration, lack of activity, sleep issues, or possible dangers to the pet [4].

KEY AI AREAS

AI is a general term that includes areas like machine learning (ML), deep learning (DL), and artificial neural networks (ANNs) (Figure 2). The key part of AI is machine learning, and deep learning is a type of ML. Deep learning includes different kinds of neural networks, especially those that have many layers, which is why it's called "deep" learning [6].

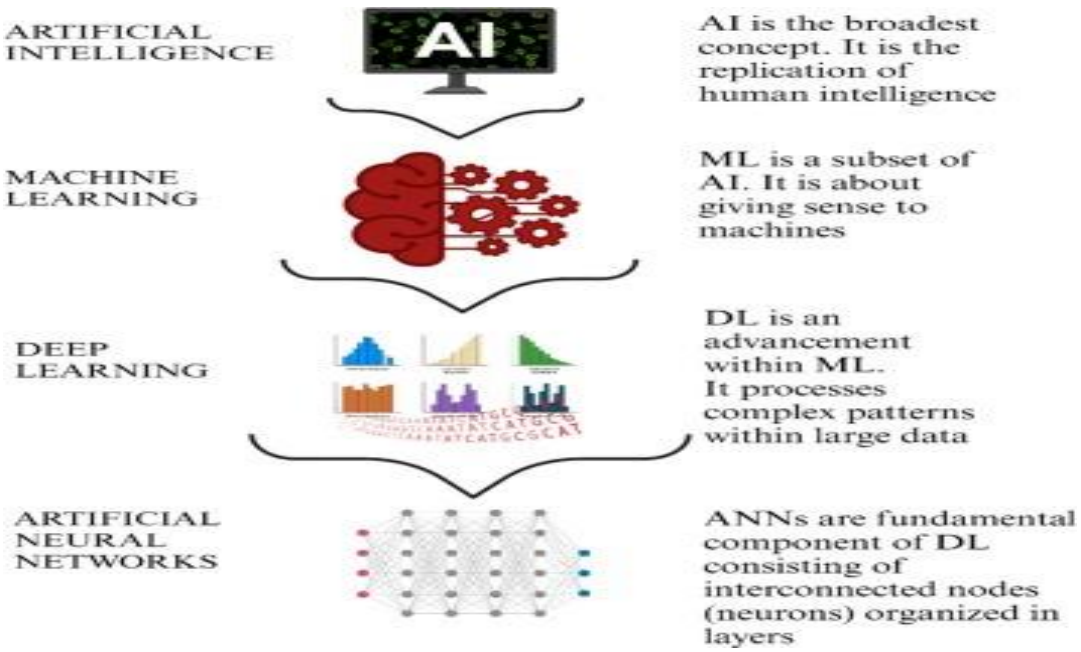

Figure 2: shows the hierarchical structure of AI technologies. AI includes machine learning, which is made up of deep learning methods. Deep learning is based on artificial neural networks, which are inspired by how the human brain is structured and works [5].

The success of machine learning and deep learning models depends a lot on the data they're trained on. A training dataset is a carefully gathered set of labeled or organized information that helps teach AI systems to spot patterns and do specific jobs, like classifying images, understanding language, or making predictions [9]. In the pet care industry, this data could include things like X-rays, electronic health records, data about how pet owners behave, or videos with labels. These datasets can come from inside a company or be available to the public. Internal datasets are usually collected and kept by places like vet clinics, research groups, or companies that use AI for diagnostics [4-6]. These sets are often very well organized, focused on a specific area, and high quality, and they might be made with help from vets or specialists to make sure the information is accurate and useful for real-world situations. On the other hand, public datasets or those collected automatically from the web might cover a wider range of topics, but they can vary in how good the data is, how it's structured, and they might have issues with ethics or laws [7]. It's important to know where the data comes from and what kind of data it is because the quality of the data affects how well the models work, how well they can be used in different situations, and how helpful they are in a real clinical setting.

HOW AI IS REVOLUTIONIZING THE WORLD OF PETS

Health monitoring

The use of AI in veterinary medicine is wide and significant, especially in the development of AI-based diagnostic tools. These tools can process a lot of data, like medical records, images, and lab results, helping vets make better and more accurate diagnoses. So far, the biggest use of AI in veterinary care is to find new information from large animal databases to improve diagnosis and treatment [6]. AI can help vets make smart decisions and plan treatments by looking at past disease data from pets. An example of this is Laika, a tool created by AITEM, which lets vets enter clinical data and symptoms of their animal patients for records and diagnosis support. The platform can take in clinical information from uploaded PDF files, making it easier for vets to provide quick diagnosis support [5].

Behaviour monitoring

Besides vets and other animal care professionals, the general public is not very aware of pet health issues. Since changes in a pet’s behavior and body posture can signal their health, it's important to have a good way to monitor these behaviors so that timely action can be taken. This can be done with AI-based systems that use wearable sensors in an intelligent setup to identify and classify behavior and body posture [4]. This automatic behavior classification system is much better than old video cameras, where the pet owner has to watch the screen constantly to spot any unusual behavior. AI tools use common wearable sensors like gyroscope, accelerometer, and magnetometer for automatic, accurate behavior detection, welfare checks, and remote monitoring. For instance, triaxial accelerometers are used on cats, while accelerometers and gyroscopes are

used on dogs [9]. In some cases, AI can also use data from non-wearable systems like depth-based tracking, which uses cameras or lasers. Animal tracking data is processed by AI to monitor and predict any changes in behavior. Such systems are useful when wearable devices are hard to use [6-7].

Feed and feeding systems

The biggest cost of taking care of pets is their food, and it's important to give them the right amount at the right time. However, pet owners often face unexpected events that make it hard to care for their pets. This highlights the need for AI-based automatic feeding systems that can assess each animal's needs in real-time and provide the correct portion of food. These systems can also help reduce obesity and related health problems by adjusting the food amount based on the pet's health factors [6-7]. These factors include body weight, temperature, behavior, heart rate, eating habits, activity level, sleep patterns, and urine pH. Analyzing the gut microbiome of pets is important for understanding their health. In one study, machine learning was used to analyze large datasets to explore how diet, sex, and the makeup of the fecal microbiome are connected. The study used fecal microbiome data from 132 dogs and found that there is a complex, two-way relationship between the microbiota and the host's characteristics. The results showed the potential of machine learning in finding hidden patterns in the data [6].

Parasite detection

Parasitic worms are among the most successful pathogens, using clever strategies to affect their hosts. Many of these worms can infect both pets and humans. These widespread zoonotic infections require better tools for identifying parasites, regular monitoring, and tracking. In cats and dogs, common methods for parasite detection include fecal floatation and Baermann tests [6-7]. The final and most sensitive step in these methods is looking at and identifying the type of parasite egg or larvae on a glass slide under a microscope. This process is time-consuming and the accuracy can be affected by the experience of the person doing the test and how the samples are prepared. These issues can be improved by using AI-based algorithms that increase accuracy and speed up the process of reading slides, identifying parasites, and counting them [6-7].

Veterinary care and support

New technology is becoming easier to use and more affordable, which opens up better options for taking care of pets. There has been big progress in telehealth, which makes it easier and more convenient to get veterinary care. Many AI-based services are being developed to help with veterinary care and support [6]. Veterinarians are starting to use these tools, such as AI-powered robotic surgeries, devices that monitor vital signs, and other similar technologies. One example is the AliveCor ECG device, which lets smartphone users record their heart rate and rhythm to create an electrocardiogram (ECG) [10]. Studies have looked at using this in dogs and cats. With this technology, dog owners can check their pets' health and ECGs at home using their phones and

send the information to a vet. This can help diagnose heart rhythm problems and other conditions in dogs right at home [10].

CONCLUSIONS

In summary, using AI has a lot of potential to improve the well-being of animals. By using its benefits, solving its challenges, and exploring new ways to use it, we can make big progress in this area. AI has already started to change how we care for our animal friends. Research is moving quickly to make the most of different AI techniques like machine learning, deep learning, convolutional neural networks, and large language models. Many areas of pet care, including health monitoring, behavior tracking, feeding systems, parasite detection, virtual and robotic pets, and veterinary support, have already improved thanks to AI. In the future, AI is expected to help with better predictions, leading to more personalized care plans. It will also help understand a wide range of pet behaviors, making the bond between pets and their owners stronger. Additionally, robotic pets may serve as alternatives to real pets for people with special needs. However, there are still challenges, such as making sure AI tools are easy to use, adapting them to the veterinary field, making AI models work efficiently, needing large amounts of data, and ensuring they can function in different environments. Overall, future developments in this area are expected to greatly improve the lives of both pets and their owners.

REFERENCES

Bhattacharyya, J., & Slocombe, S. (2017). Animal agency: Wildlife management from a kincentric perspective. *Ecosphere, 8*(10), e01978. https://doi.org/10.1002/ecs2.1978

Eli-Chukwu, N. C. (2019). Applications of artificial intelligence in agriculture: A review. *Engineering, Technology & Applied Science Research, 9*(4), 4377–4383. https://doi.org/10.48084/etasr.2756

Farooq, M. S., Riaz, S., Abid, A., Abid, K., & Naeem, M. A. (2019). A survey on the role of IoT in agriculture for the implementation of smart farming. *IEEE Access, 7*, 156237–156271. https://doi.org/10.1109/ACCESS.2019.2947235

Humer, E., Aschenbach, J. R., Neubauer, V., Kröger, I., Khiaosa-Ard, R., Baumgartner, W., & Zebeli, Q. (2018). Signals for identifying cows at risk of subacute ruminal acidosis in dairy veterinary practice. *Journal of Animal Physiology and Animal Nutrition, 102*(2), 380–392. https://doi.org/10.1111/jpn.12896

Kamat, Y., & Nasnodkar, S. (2018). Advances in technologies and methods for behavior, emotion, and health monitoring in pets. *Applied Research in Artificial Intelligence & Cloud Computing, 1*(1), 38–57. *(DOI not found)*

Liakos, K. G., Busato, P., Moshou, D., Pearson, S., & Bochtis, D. (2018). Machine learning in agriculture: A review. *Sensors, 18*(8), 2674. https://doi.org/10.3390/s18082674

Navulur, S., & Prasad, M. G. (2017). Agricultural management through wireless sensors and Internet of Things. *International Journal of Electrical and Computer Engineering, 7*(6), 3492–3499. https://doi.org/10.11591/ijece.v7i6.pp3492-3499 IJECE

Reith, S., & Hoy, S. (2018). Behavioral signs of estrus and the potential of fully automated systems for detection of estrus in dairy cattle. *Animal, 12*(2), 398–407. https://doi.org/10.1017/S1751731117002251

Sharma, B., & Koundal, D. (2018). Cattle health monitoring system using wireless sensor network: A survey from innovation perspective. *IET Wireless Sensor Systems, 8*(4), 143–151. https://doi.org/10.1049/iet-wss.2018.5089

Yuan, Z., Ji, J., Sheng, H., Jiang, S., Chen, T., Liu, X., … Zhang, L. (2019). Animal-based diets and environment: Perspective from phosphorus flow quantifications of livestock and poultry raising in China. *Journal of Environmental Management, 244*, 199–207. https://doi.org/10.1016/j.jenvman.2019.04.101