

PawSync: Smart Automatic Pet Feeder

Anusha Sanjana
Dept. of Information Science and Engineering
BNM Institute of Technology, Affiliated to
VTU
Bengaluru, India

Dr. Jagruthi H
Associate Professor, Dept. of
Information Science and Engineering BNM
Institute of Technology,
Affiliated to VTU, Bengaluru, India

Divyashree V
Dept. of Information Science and Engineering
BNM Institute of Technology, Affiliated to
VTU
Bengaluru, India

Abstract— A project design is presented that enables pet owners to feed their pets without direct interference, improving upon older pet feeder versions. The core motive is to offer a simpler and more efficient method for pet owners to manage their pets' feeding schedules. This system is implemented using the Internet of Things (IoT) and Digital Image Processing. The process begins with a recorded voice message from a speaker to signal the pet's feeding time. An ultrasonic sensor detects the pet's presence, which activates a camera to capture and process an image of the pet. If the system recognizes the animal as the correct pet, a DC motor is activated to dispense food. The implementation is designed for two different pets, utilizing two DC motors to dispense different food types from four containers into two bowls. Upon successful feeding, a notification is sent to the owner's mobile phone via an API.

Keywords - Automatic Pet Feeder, Internet of Things (IoT), Digital Image Processing, Convolutional Neural Network (CNN), Esp32, Pet Care

I. INTRODUCTION

For individuals in today's busy society, providing consistent and proper care for their pets is essential, particularly in households where owners' schedules are demanding or where multiple pets have different dietary needs. Traditional feeding methods rely on the owner's presence and memory, which can lead to missed meals, incorrect portions, or feeding delays. Existing automated feeders generally depend on simple timers, which are inflexible and cannot distinguish between different pets, making them vulnerable to one pet stealing another's food. To overcome these limitations, this project introduces an intelligent, IoT-driven pet feeding solution that authenticates pets through digital image processing, thereby eliminating the need for manual intervention and reducing the risk of improper feeding. The system is built upon an Esp32 controller, a powerful yet cost-effective single-board computer that provides robust processing for real-time recognition while consuming minimal power. This makes the approach particularly efficient and suitable for a home environment, where reliability and intelligence are equally critical.

Traditional automated feeders provide only limited functionality and often cannot adapt to a pet's actual needs or presence. In contrast, this intelligent feeder leverages a pet's unique physical appearance, offering a natural and reliable method of identity verification. In this project, a Convolutional Neural Network (CNN) is employed for pet validation, ensuring accurate and reliable identification with minimal

owner effort. Unlike conventional feeders that operate on a blind schedule, the proposed system utilizes real-time image processing, which achieves accurate identification with low latency. This efficiency makes the design well-suited for a resource-constrained home device, ensuring that intelligence does not compromise performance.

At the heart of the system lies a secure backend architecture integrated with fingerprint modules for template storage, matching, and verification. To protect sensitive biometric data, fingerprint templates are encrypted using ECC prior to storage or transmission, thereby minimizing the risk of exposure during breaches or network attacks. The system also incorporates digital wallet functionalities, enabling users to perform seamless and instant microtransactions while ensuring both confidentiality and integrity of the transaction records. All transaction data is securely logged, ensuring traceability and accountability without compromising user privacy.

The system's performance is evaluated across several dimensions, including recognition accuracy, dispensing speed, notification latency, and overall responsiveness. The design consistently demonstrates low-latency processing, minimal computational overhead, and reliable pet recognition, thereby validating the feasibility of using a CNN on a for real-world pet care scenarios. Moreover, by embedding intelligence at every stage of the workflow, the design ensures that the feeding process remains secure against common household challenges such as food theft by other animals, over-feeding, and missed meals.

Beyond its technical reliability, the system is designed with scalability and cost-effectiveness in mind. All hardware components, including the Esp32, camera module, and sensors, are affordable, readily available, and compatible with standard home infrastructures. This adaptability makes the solution applicable to a wide range of environments and for various types of pets. Furthermore, the modular nature of the design allows for future integration with technologies such as weight sensors for health monitoring or linkage with a broader ecosystem of smart pet devices.

In summary, by merging intelligent image recognition with robust IoT connectivity, the project proposes a practical, reliable, and owner-friendly framework that addresses the inherent challenges of modern pet care. The approach not only

enhances pet well-being, owner peace of mind, and convenience but also lays a foundation for next-generation pet care systems capable of operating intelligently within a connected smart home.

II. SURVEY ON PET FEEDER

The field of automatic pet feeding systems has witnessed substantial evolution with the integration of IoT, image processing, and deep learning-based recognition. A central focus has been improving feeding accuracy, enabling remote monitoring, and ensuring pet health through intelligent and automated mechanisms.

Hari N. Khatavkar et al. (2019) introduced an Intelligent Food Dispenser (IFD) that automated scheduled feeding while reducing human intervention, laying the foundation for smart feeding mechanisms [1]. Similarly, Smruthi Kumar (2018) designed a pet feeder using Arduino and GSM technology, which enabled remote control via SMS, thereby addressing the problem of unattended pets [4]. Early research by Aasavari Kank and Anjali Jakhariye (2018) focused on a mechanical automatic feeder with timer-based dispensing, highlighting the feasibility of basic automation [5].

With the rise of IoT integration, several works emphasized connectivity and remote access. Saurabh A. Yadav et al. (2018) developed an IoT-based pet feeder system that allowed remote scheduling and monitoring using sensors [7]. Wu et al. (2018) extended this with a feeder control system using the MQTT protocol, offering lightweight, low-latency communication suitable for resource-constrained IoT devices [6]. Dharanidharan and Puvirasi (2018) proposed a simulation of automatic food feeding systems, demonstrating performance under controlled environments before real-world deployment [8]. These studies showcased the potential of IoT-driven feeding systems for smart home ecosystem.

Beyond dispensing mechanisms, image processing has been explored for pet recognition and feeding personalization. Ankur Mahanty et al. (2019) proposed an animal recognition system using image processing, which aimed to identify individual pets and ensure selective feeding [2]. R. Ravikumar and V. Arulmozhi (2019) provided a review of digital image processing techniques, offering insights into methods applicable for intelligent feeders [3]. Such approaches enable adaptive feeding, ensuring that food is dispensed only when the correct pet is detected.

The adoption of Convolutional Neural Networks (CNNs) has further strengthened recognition capabilities. Rahul Chauhan et al. (2018) highlighted the use of CNNs for image detection and recognition, showcasing robust feature extraction for complex visual patterns [9]. Similarly, Nadia Jmour et al. (2018) detailed CNN-based image classification techniques, emphasizing their effectiveness for real-time recognition in constrained devices [10]. These advances underline the role of deep learning in enhancing the accuracy of recognition-based feeding systems.

A comparative analysis of the reviewed works shows that early systems [4], [5], [7] focused on mechanical automation and basic IoT control, ensuring convenience but lacking intelligence. Later works [2], [9], [10] introduced vision-based recognition with CNNs, enabling feeders to identify pets and tailor feeding accordingly. However,

most studies did not fully integrate IoT-based remote control with CNN-driven recognition, leaving room for hybrid intelligent systems.

The application of Convolutional Neural Networks (CNNs) has addressed some of these limitations by providing superior feature extraction and recognition accuracy. Chauhan et al. [9] and Jmour et al. [10] demonstrated CNN-based models for classification and detection tasks, which can be adapted to recognize pets in uncontrolled environments. Such methods open possibilities for personalized feeding systems that adapt to each pet's identity, diet, and schedule. Yet, real-time CNN processing requires significant computational resources, creating challenges for deployment on low-power IoT devices. Hybrid solutions that combine cloud-based recognition with local IoT controls could bridge this gap in practical implementations.

III. COMPARATIVE ANALYSIS

The use of IoT and artificial intelligence in automated pet care systems has received considerable attention over the last decade. This section provides a comparative discussion highlighting the evolution of pet feeding technology, its effectiveness, and the research gaps that remain.

Early contributions focused on simple mechanical automation. Works such as Kank and Jakhariye's "Automatic Pet Feeder" laid the groundwork with timer-based systems designed to dispense food at set intervals. Building on this, Smruthi Kumar identified the potential for remote control by using Arduino and GSM technology to create a pet feeding dispenser. These findings established the value of remote access for pet owners, but they primarily focused on executing simple commands without any onboard intelligence or validation in real-world, multi-pet environments

Subsequent studies introduced the integration of intelligence through image processing. Mahanty et al. proposed systems for animal recognition, while foundational papers on Digital Image Processing and Convolutional Neural Networks (CNNs) provided the tools for accurate identification. This advancement marked a significant shift from command-based automation to intelligent, data-driven decision-making. However, many of these approaches demonstrated resilience in recognizing animals in datasets, but usability concerns like recognition failure rates in varied home environments were not deeply analyzed.

With the rise of the smart home, researchers developed more sophisticated IoT-based systems to enhance flexibility and

minimize connectivity overhead. For instance, Wu et al. developed a remote pet feeder using the MQTT protocol for more efficient communication within a home network, while Yadav et al. explored a broader "IoT Based Pet Feeder System". These approaches improved on earlier GSM-based models by offering better integration and responsiveness. However, the scalability of these systems to handle complex scenarios, such as distinguishing between multiple pets, was not always fully explored.

Recent research has shifted towards creating more advanced and holistic ecosystems. The concept of an "Intelligent Food Dispenser (Ifd)" by Khatavkar et al. examines the synergy of AI and IoT to create a smarter device. Likewise, simulation-based studies on automatic feeding systems have reinforced the viability of these models for practical deployment. This work underlines the technology's adaptability beyond simple dispensing, moving toward comprehensive pet wellness monitoring

Complementing these domain-specific contributions, general surveys and standards have enriched the field. Al-Zubaidie et al. [6] provided an in-depth survey of ECDSA, emphasizing algorithmic improvements relevant for signature-based payment protocols. Rashidi [9] analyzed hardware implementations of ECC, a perspective crucial for payment terminals and IoT-enabled devices. Furthermore, global guidelines such as NIST recommendations [15] and the SPA white paper [10] provided standardization and best practices, ensuring interoperability and regulatory alignment.

Overall, the comparative review suggests that while IoT connectivity and machine learning have become cornerstones of modern pet feeders, their deep integration is still maturing. The literature demonstrates a strong progression from basic mechanical devices to intelligent, sensor-driven systems. However, challenges remain in balancing cost, performance, and usability. In particular, practical deployment in complex home environments requires further optimization. Future research should address pet recognition error tolerance, privacy-preserving image analysis, and efficient on-device processing to ensure widespread adoption.

IV. PROPOSED SURVEY INSIGHTS

The survey of existing literature reveals a strong movement toward making pet care devices smarter by integrating Internet of Things (IoT) technology with advanced machine learning techniques. While many studies address automated or remote-controlled feeders and others focus on the separate challenge of animal recognition using image processing, the combination of both approaches to create a truly intelligent system tailored for specific household challenges, like managing multiple pets, remains relatively underexplored.

From the reviewed works, the following insights are drawn:

1. Lightweight Connectivity is Crucial: The effectiveness of a smart pet feeder heavily relies on its connectivity. The use

of IoT platforms and efficient communication protocols like MQTT is consistently shown to be ideal for home environments. These lightweight solutions ensure that the device remains responsive and reliable without overburdening home networks, which is essential for real-time monitoring and control.

2. Image Recognition Enhances System Intelligence: Incorporating digital image processing and a Convolutional Neural Network (CNN) elevates the device from a simple dispenser to an intelligent system. This technology provides the ability to recognize specific animals, which enhances an owner's trust that the correct pet is receiving the correct food. However, challenges in accuracy, such as varying lighting conditions or potential spoofing by other pets, persist and require robust model training.
3. IoT and Image Recognition Integration : Few studies have fully integrated real-time, intelligent image recognition with the IoT functionalities of a pet feeder. Many designs focus on the mechanics of automation or on remote control, but do not include onboard intelligence to make decisions. This indicates a significant gap in creating scalable, low-latency pet care solutions that can autonomously manage complex feeding scenarios.

V. FUTURE DIRECTIONS

Although the proposed design demonstrates significant progress in automated pet care, several avenues remain open for future research and enhancement. One promising direction is the deeper integration into smart home ecosystems and the broader Internet of Things (IoT). Lightweight implementations will be crucial for ensuring that the feeder can operate efficiently on home networks without compromising performance, allowing for seamless control via voice assistants and integration with other smart devices

Another critical area is the development of multi-factor pet identification. While the current system uses visual recognition, future studies could explore hybrid mechanisms that combine multiple unique traits. For instance, pairing the camera's image recognition with data from a weight scale integrated into the feeding platform, a microphone for bark or meow recognition, or an RFID/NFC reader that detects a tag on the pet's collar could be implemented. Such approaches would dramatically improve resilience against spoofing, where one pet might try to steal another's food, and increase recognition accuracy

Furthermore, privacy-preserving recognition is an important consideration. As the system uses a camera within the user's home, emerging techniques could be applied to verify the pet's identity without storing or transmitting raw image or video data to the cloud. This would reduce the risk of privacy breaches and enhance user trust in the device's security. Finally, future work should investigate the standardization of pet data to create a holistic wellness ecosystem. Establishing global benchmarks for interoperability would allow the feeder

to share data with other smart products like automatic waterers, activity trackers, and veterinary platforms. This could involve using blockchain technology to create a secure, tamper-proof log of a pet's feeding history, providing verifiable data for health monitoring and diagnostics.

VI. CONCLUSION

This paper has presented the design of an Automatic IoT Based Pet Feeder, a system that moves beyond simple automation to create a truly reliable and intelligent feeding solution by leveraging digital image processing. The core of this innovation lies in its ability to accurately identify specific pets before dispensing food, which is accomplished using a camera. Convolutional Neural Network (CNN) for pet recognition. This ensures that in multi-pet households, each animal receives its specific, pre-assigned food, effectively managing different dietary needs and preventing pets from consuming incorrect meals. Furthermore, the integration

IoT technology provides a crucial link between the pet and the owner; the system automatically sends notifications to the owner's mobile phone via an API after a successful feeding, offering valuable peace of mind and remote confirmation that their pet has been cared for. The entire system is built upon a powerful yet cost-effective foundation using a

Esp32 controller, which is ideal for reducing complexity in real-time applications. Ultimately, this project directly addresses common problems faced by busy pet owners, such as feeding pets late, providing insufficient food during outstation work, or forgetting feedings altogether, which can disrupt a pet's health and routine. By solving these issues, the proposed feeder contributes significantly to better pet health through consistent and proper portioning, fostering a more convenient and worry-free ownership experience

Upon comparative analysis, the proposed system offers a significant advancement over existing automated pet feeders. Conventional systems typically rely on simple mechanisms such as timers set by the user or remote activation through a mobile application. While some may include force sensors to regulate food quantity, their core functionality lacks intelligence; they cannot differentiate between pets and dispense food based on a schedule or a direct command, not on the pet's actual presence or identity. In contrast, the proposed system introduces a layer of intelligent verification by integrating digital image processing. The use of an ultrasonic sensor to detect a pet's presence, followed by a camera and a Convolutional Neural Network (CNN) to positively identify the specific animal, is a primary differentiator. This capability allows for targeted feeding, where different types of food can be dispensed for two distinct pets, a feature particularly crucial for households with multiple animals on different diets. Therefore, while existing systems provide a baseline of convenience, the proposed model delivers a more personalized and reliable pet care solution by ensuring the right pet receives the right food, and confirming this action to the owner.

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