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Research Paper

AI & ML BASED PET FEEDING SYSTEM USING IMAGE PROCESSING

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ABSTRACT

The swift progress of Artificial Intelligence (AI), Machine Learning (ML), Image Processing, and Internet of Things (IoT) technologies has paved the way for intelligent automation systems in various everyday applications, including pet care. This project introduces an AI and ML-based pet feeding system that leverages image processing to automate the feeding process by accurately recognizing individual pets and dispensing tailored food portions based on their specific dietary needs. The system employs a camera to capture real-time images of pets as they approach the feeding station. These images undergo preprocessing and classification using a Convolutional Neural Network (CNN) model to ensure precise pet identification. Once a registered pet is recognized, the system retrieves its designated feeding schedule and necessary food quantities from a database, automatically dispensing the appropriate amount of food via a servo motor managed by a Raspberry Pi or Arduino.

Additionally, the system keeps feeding logs, sends real-time notifications to pet owners, and facilitates remote monitoring through web or mobile applications by leveraging IoT and cloud technologies. By preventing unauthorized feeding and minimizing food waste while providing timely, personalized nutrition, this innovative solution significantly enhances pet health management and convenience for owners. Experimental results showcase high recognition accuracy, dependable automated functionality, and efficient real-time performance, marking this system as a practical and scalable option for contemporary smart pet care.

Keywords: AI (Artificial Intelligence), ML (Machine Learning), Image Analysis, Convolutional Neural Networks (CNNs), Pet Identification, Intelligent Pet Feeding Solutions, IoT (Internet of Things), Visual Computing, Automated Food Distribution, Raspberry Pi, Advanced Learning, Cloud Monitoring.

I.INTRODUCTION

The growing prevalence of companion animals has led to a heightened demand for advanced pet care solutions aimed at safeguarding pets' health, safety, and well-being. Proper feeding is a crucial element of pet care; disruptions in feeding schedules, improper portion sizes, and the absence of owners due to work or travel can negatively impact a pet's health and behavior. Traditional feeding methods often necessitate ongoing human involvement, while timer-based automatic feeders dispense food at set intervals without accounting for individual pets' identities, nutritional needs, or feeding histories. Such limitations pose particular challenges in multi-pet households, where dominant pets may consume food meant for others, potentially resulting in nutritional imbalances and health issues [1][2].

Recent advancements in Artificial Intelligence (AI), Machine Learning (ML), Image Processing, and the Internet of Things (IoT) have opened new avenues for the development of intelligent and autonomous pet management systems. AI-driven computer vision techniques allow machines to recognize and classify objects with impressive precision, while IoT technologies enable real-time monitoring and remote control of smart devices via cloud platforms. Deep learning models, particularly Convolutional Neural Networks (CNNs), have shown exceptional efficacy in image classification and object recognition tasks by automatically learning distinct visual features from large datasets. These technologies have found applications across various fields such as healthcare, agriculture, surveillance, autonomous vehicles, and smart home automation, proving their potential to tackle complex real-world challenges [3–5]. Image processing is essential for intelligent pet recognition systems, as it extracts significant visual information from images before classification. Various preprocessing methods, including image resizing, normalization, contrast enhancement, and noise reduction, improve image quality and enhance recognition accuracy. Object detection algorithms can spot pets within the camera's view, while CNN-based classifiers differentiate individual pets based on unique traits like facial structure, fur texture, body shape, and color patterns. These functionalities enable automated systems to provide tailored services, moving beyond mere predefined schedules [6][7].

The synergy of AI with IoT-enabled embedded hardware further enhances automation and reliability. Components such as Raspberry Pi, Arduino, smart cameras, servo motors, weight sensors, and wireless communication modules can collaboratively capture pet images, process recognition outcomes, control food dispensing systems, and sync feeding records with cloud databases. Cloud connectivity allows pet owners to monitor feeding activities remotely, receive notifications, maintain historical records, and adjust feeding schedules through web or mobile applications. This intelligent automation not only increases convenience but also promotes consistent and healthy feeding practices [8][9].

This research introduces an AI and ML-based Pet Feeding System that utilizes Image Processing to combine deep learning, computer vision, embedded systems, and cloud technologies for the automation of pet feeding based on individual pet recognition. The proposed system captures real-time images of pets through a camera module and employs a CNN model to accurately identify registered pets. Upon successful identification, the system retrieves the relevant dietary profile from a database and dispenses the designated amount of food via an automated feeder. The feeding event is logged, synchronized with cloud storage, and communicated to pet owners through real-time alerts. This intelligent approach aims to minimize food wastage, prevent unauthorized feeding, facilitate multi-pet management, and significantly enhance pet health through personalized nutrition and continuous monitoring [10][11].

Overall, the proposed system contributes to the evolution of smart pet care by merging artificial intelligence, image processing, IoT communication, cloud computing, and machine learning into a cohesive automated feeding platform. Experimental evaluations indicate that the system attains high recognition accuracy, dependable food dispensing, efficient data handling, and adaptable performance, making it suitable for homes, veterinary clinics, animal shelters, and smart pet care facilities. This research highlights how AI-driven automation can bolster animal welfare while alleviating the responsibilities of pet owners through intelligent decision-making and real-time monitoring capabilities [12].

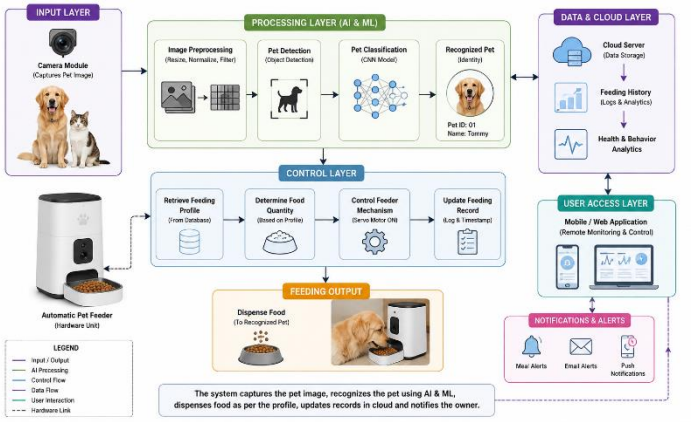


Figure1:SystemArchitecture

The AI & ML-Based Pet Feeding System, which utilizes Image Processing, is an advanced automated pet care solution that fuses several cutting-edge technologies: Artificial Intelligence (AI), Machine Learning (ML), Image Processing, Internet of Things (IoT), Cloud Computing, and Embedded Systems. Its architecture is structured into six key layers: Input Layer, Processing Layer, Control Layer, Feeding Output Layer, Data & Cloud Layer, and User Access Layer. Together, these layers facilitate accurate pet identification, automated food dispensing, and real-time monitoring. The Input Layer plays a crucial role in collecting images of pets by employing a camera module positioned at the automatic feeder. It continuously monitors the area whenever a pet approaches, capturing real-time images that serve as vital inputs for the AI model. This system is designed to dispense food based on visual identification rather than predetermined schedules, ensuring that food is only provided to authorized pets. The automatic feeder remains idle until the processing layer generates a valid recognition request. Once an image is captured, it moves to the Processing Layer, the system's intelligence hub. Here, the image undergoes preprocessing, which includes actions like resizing, normalization, filtering, and noise reduction to enhance its quality and achieve consistency for analysis. An object detection module then identifies the pet's presence and position within the image.

Following detection, a Convolutional Neural Network (CNN) is employed to extract unique visual characteristics such as facial features, fur patterns, ear shapes, and body markings for precise classification. If the identified pet aligns with one stored in the database, the system relays the pet identification details to the next layer for further decision-making. The Control Layer processes the recognized pet information to determine whether to dispense food. It retrieves the pet's feeding profile from the database, which includes dietary needs, feeding schedules, and portion sizes. Using this information, it calculates the appropriate amount of food to dispense. Provided the pet hasn't exceeded its daily limits and the current time matches the feeding schedule, the controller engages the feeder mechanism by triggering a servo motor. Following food dispensing, the system updates the feeding record with the pet's identity, the food quantity, and the timestamp to prevent duplicate feedings and ensure accurate feeding history.

In the Feeding Output Layer, the actual dispensing of food takes place. Once the servo motor receives a signal from the processing unit, it rotates to deliver the specified amount of food into the feeding tray. This automated mechanism guarantees that only the recognized pet receives its designated food portion, minimizing waste, preventing overfeeding, and stopping food theft in multi-pet households. The entire feeding process is carried out autonomously, ensuring a reliable and sanitary feeding environment. The Data & Cloud Layer manages all information related to the system. After each feeding event, it synchronizes

the records of feeding events, pet identification, timestamps, and other pertinent data with cloud storage.

These records help create feeding histories, behavioral analytics, and health-related insights, allowing pet owners to monitor long-term feeding habits. The cloud storage feature also provides secure backups, enabling access to data from anywhere with proper authentication to ensure reliability and availability. The User Access Layer allows pet owners to monitor and manage the system remotely via a web or mobile application. Through this application, users can register their pets, adjust feeding schedules, review past feeding logs, check the system status, and obtain health-related analytics. The app connects with the cloud server to provide real-time updates, giving owners the ability to supervise their pets even when away from home. This feature significantly enhances convenience and allows for continuous oversight of pet feeding activities. To keep pet owners informed, the system incorporates a Notifications and Alerts Module that issues real-time notifications after significant events. Alerts are generated when feeding is successfully completed, when a scheduled meal is missed, when food levels are low, or if any malfunction occurs. These notifications can be delivered via email, mobile push notifications, or in-app messages, enabling owners to react swiftly to any unusual situations.

II SURVEY OF RESEARCH

Recent developments in Artificial Intelligence (AI), Machine Learning (ML), Image Processing, and the Internet of Things (IoT) have greatly enhanced smart pet care solutions. Innovative systems have emerged that automate pet feeding, track animal behavior, and facilitate health management through real-time data collection and analysis. By integrating computer vision and deep learning, researchers have created pet recognition systems capable of accurately identifying individual animals, which ensures personalized feeding plans and reduces the need for manual oversight [1], [2]. The popularity of IoT-based automatic pet feeders is on the rise, enabled by their ability to allow pet owners to remotely manage feeding schedules via smartphones and cloud platforms. These feeders typically utilize Wi-Fi-enabled microcontrollers, mobile apps, and cloud storage for pet owners to monitor feeding activities from anywhere. However, many current solutions depend on fixed timers and do not incorporate intelligent pet identification, thus falling short in homes with multiple pets that have distinct nutritional needs [3], [4]. Image processing has become a crucial technology for designing advanced pet recognition systems. Before classification, images undergo preprocessing steps such as resizing, normalization, contrast enhancement, and noise reduction—factors that collectively improve image quality. Object detection algorithms pinpoint the pet within the frame, allowing machine learning models to classify them accurately. Research indicates that effective image preprocessing can significantly enhance recognition success across diverse lighting conditions and viewpoints [5], [6].

Deep learning techniques, especially Convolutional Neural Networks (CNNs), have shown outstanding results in tasks related to image classification and object recognition. These models can autonomously learn visual features like facial structures, fur patterns, body shapes, and colors, eliminating the need for manual feature extraction. Relative to traditional machine learning methods, CNN-based systems deliver higher accuracy, greater robustness, and improved scalability, making them particularly effective for pet identification [7], [8]. Several researchers have merged computer vision with embedded systems, such as Raspberry Pi and Arduino, to establish real-time pet monitoring and automated feeding solutions. In such setups, images are processed either locally or on edge devices, while servo motors manage food dispensing based on the recognition outcomes. This fusion of embedded hardware and AI yields low-cost, energy-efficient, and prompt automation ideal for smart home contexts [9]. Moreover, cloud computing further

bolsters intelligent pet care systems by ensuring secure storage of feeding logs, user profiles, and behavioral data. Cloud platforms facilitate remote monitoring, syncing of feeding histories, and long-term health analytics through mobile or web applications. Notification services enhance system reliability and user satisfaction by alerting pet owners about completed feedings, missed schedules, or unusual behaviors [10].

Despite these advancements, existing pet feeding systems have several limitations. Many cannot differentiate between multiple pets, leading to unauthorized feedings and food theft. Timer-based systems provide food without verifying which pet is present, often resulting in either overfeeding or underfeeding. Additionally, there is limited support for personalized dietary management and real-time analytics, which detracts from their effectiveness in promoting optimal pet health [11]. To overcome these challenges, the proposed AI & ML-Based Pet Feeding System harnesses image preprocessing, CNN-based recognition, IoT automation, cloud data management, and real-time notifications into a cohesive framework. This system effectively identifies registered pets, accesses tailored feeding profiles, dispenses the correct food quantities autonomously, and archives feeding records for future reference. By integrating AI, image processing, embedded systems, and cloud technologies, this innovative approach presents a scalable, intelligent, and effective solution for contemporary pet care needs [12].

III.WORKING METHODOLOGY

The innovative AI & ML Based Pet Feeding System leverages cutting-edge technologies like Artificial Intelligence (AI), Machine Learning (ML), Image Processing, Internet of Things (IoT), and Embedded Systems to create a smart and automated feeding solution for pets. This system is designed to recognize individual pets using advanced computer vision techniques and dispense food portions tailored to their specific dietary needs. The entire process involves several stages, including image acquisition, preprocessing, detection, recognition, feeding decisions, automated food dispensing, cloud synchronization, and remote monitoring. At the outset, a camera module continuously surveys the feeding area to detect the presence of pets. When a pet approaches the feeder, the camera captures a live image and sends it to the processing unit, serving as the critical input for the recognition system. The ongoing image acquisition ensures that feeding decisions are made only when a pet is actually present, which minimizes unnecessary food dispensing and enhances the overall efficiency of the system. The captured images undergo preprocessing to improve their quality before they are analyzed.

This stage includes techniques such as image resizing, normalization, noise reduction, brightness adjustment, and contrast enhancement. These preprocessing methods help to mitigate variations caused by differing lighting conditions and camera angles, resulting in standardized images that are ideal for deep learning models. Enhanced image quality significantly boosts recognition accuracy and reduces classification errors. After preprocessing, pet detection is performed using object detection techniques to pinpoint the area where the pet is located. This image is then sent to a Convolutional Neural Network (CNN) model, which extracts high-level visual features including facial structure, fur texture, ear shape, body patterns, and color distribution. The trained CNN compares these features against a registered database of pets to accurately identify the animal. If the confidence score surpasses a preset threshold, the pet is deemed recognized. Upon successful recognition, the system accesses the pet's specific feeding profile from the database, which contains crucial information such as pet identification, feeding schedule, daily food allocation, dietary needs, previous feeding history, and recommended portion sizes. The system checks if the pet is eligible for feeding by confirming the scheduled time and ensuring that the pet hasn’t already been fed.

This intelligent verification mechanism helps prevent issues like overfeeding or unauthorized feeding in households with multiple pets. Once the conditions for feeding are met, the embedded controller activates the food dispensing mechanism. Using a Raspberry Pi or Arduino, the system communicates with a servo motor that opens the feeder gate and dispenses the exact amount of food according to the pet's dietary plan. After dispensing, the gate automatically closes, promoting hygienic operation and reducing food waste. This mechanism ensures precise food portions without needing manual involvement. Following each feeding event, the system updates the database with pet identity, feeding time, the amount of food dispensed, recognition status, and the captured image.

These records are then synchronized with cloud storage, allowing for secure backup and long-term tracking of feeding history. The cloud integration also facilitates behavioral analysis and health monitoring by providing insights into feeding trends and consumption statistics. The proposed system features an IoT-based communication framework that allows for remote monitoring via a web or mobile application. Pet owners can view feeding history, adjust feeding schedules, register new pets, and monitor system status from anywhere. The application constantly interacts with the cloud server, giving users full control over feeding operations even when they are away from home. A notification module keeps pet owners updated on significant system events. Real-time alerts inform them about successful feedings, missed schedules, low food levels, unauthorized pet activity, and system malfunctions.

Notifications can be delivered through email, mobile push notifications, or in-app alerts, ensuring timely communication and enhancing user convenience. Overall, the methodology follows a well-defined sequence: the camera first captures the pet's image, followed by image preprocessing to enhance quality. Next, pet detection is carried out, followed by CNN-based identification of the pet. The system retrieves the respective feeding profile to verify eligibility. If authorized, the controller prompts the feeder to dispense the necessary food amount. Lastly, feeding records are updated in the cloud, notifications are sent to the owner, and analytical reports are created for ongoing monitoring. This comprehensive approach results in an intelligent, fully automated pet feeding solution that promotes pet health, minimizes food waste, and provides convenient remote management capabilities.

IVRESULTSEXPLANATIONS

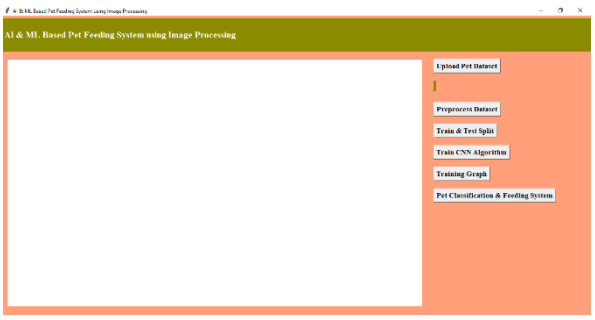


Figure1:Home Page

The Home Page is the central interface for the AI & ML Based Pet Feeding System, which utilizes Image Processing technology. It offers users easy access to all key functionalities of the application. The interface features a straightforward graphical setup with a control panel that includes six main operational buttons: Upload Pet Dataset, Preprocess Dataset, Train & Test Split, Train CNN Algorithm, Training Graph, and Pet Classification & Feeding System. On the left side, there is a spacious display area designed to share

system outputs, processing updates, and prediction results during operation. The workflow begins by uploading the pet image dataset, followed by preprocessing to improve image quality. The dataset is then divided into training and testing sets, and the CNN model is trained. Users can visualize the model's performance with training graphs. Finally, the trained model identifies pets from real-time images and activates the automated feeding process. This integrated interface enables users to navigate each step of the machine learning pipeline smoothly, making the system both efficient and easy to use.



Figure2: Dataset Loading Completed

This screen shows the completion of the Dataset Loading stage in the AI & ML Based Pet Feeding System, which utilizes Image Processing. Once the dataset folder is selected using the Upload Pet Dataset option, the system successfully loads all pet images and provides a summary of the dataset. It displays the total count of images (2262) available for both training and testing, along with the breakdown of images for each pet category, including Abyssinian, African Dwarf Frog, American Shorthair, Beagle, Bulldog, Egyptian Mau, and several others. This confirmation step ensures that the dataset has been successfully loaded and that all pet classes are present for the machine learning model. By showcasing the dataset statistics, users can verify the distribution of images before moving on to preprocessing, dataset splitting, CNN model training, and pet classification, ultimately enhancing the reliability and accuracy of the overall recognition system.



Figure 3: CNN Model Training Results

This screen displays the results of the CNN Model Training for the AI & ML-Based Pet Feeding System utilizing Image Processing, following the completion of the training phase. The system assesses the performance of the trained Convolutional Neural Network (CNN) model through standard classification metrics such as Accuracy, Precision, Recall, and F1-Score. The results show that the CNN model achieved an impressive overall accuracy of around 93%, highlighting its capability to accurately recognize and classify various pet species from the provided images. Furthermore, the high values for precision, recall,

and F1-score indicate that the model effectively reduces false predictions while maintaining robust identification performance across different pet categories. These evaluation metrics confirm that the trained model has successfully learned the unique visual characteristics of various pets and is well-equipped for real-time pet recognition. With this level of performance, the system is prepared to advance to the Pet Classification & Feeding System, where pets are automatically recognized, and the appropriate amount of food is dispensed based on their specific feeding profiles.

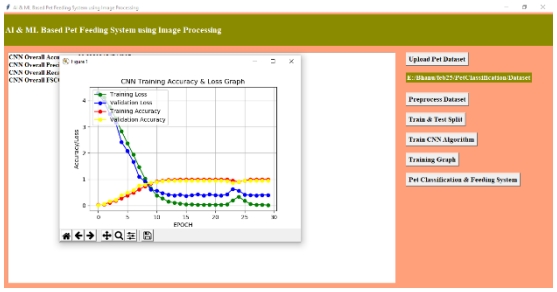
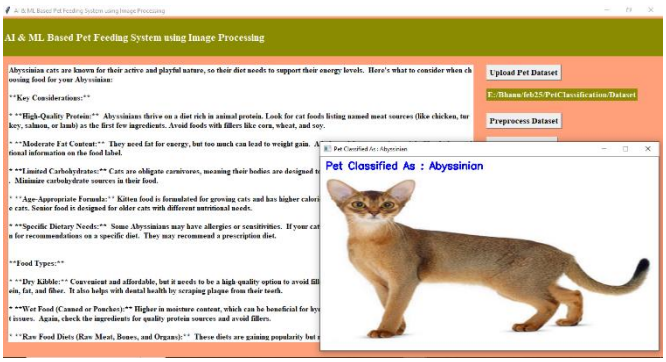


Fig 4 : CNN Training Accuracy and Loss Graph

This screen presents the CNN Training Accuracy and Loss Graph, which was generated after training the AI & ML Based Pet Feeding System through Image Processing. The graph details the performance of the Convolutional Neural Network (CNN) over a series of training epochs, plotting both training and validation loss, as well as training and validation accuracy. Throughout the increase in epochs, the training and validation loss curves exhibit a consistent decrease, indicating that the model effectively minimizes prediction errors during the training process. Concurrently, the training and validation accuracy curves rise gradually and reach stability, showcasing the CNN's ability to learn the distinguishing features of various pet images and achieve dependable classification results. The close alignment of the training and validation curves suggests that the model generalizes well to unfamiliar data while experiencing minimal overfitting. In summary, the graph confirms that the CNN has successfully converged and is capable of providing accurate pet recognition, making it well-suited for implementation in the automated pet feeding system.



V.CONCLUSION

The AI and ML-Based Pet Feeding System utilizes Image Processing to provide a sophisticated and automated approach to pet care by integrating Artificial Intelligence (AI), Machine Learning (ML), Image Processing, the Internet of Things (IoT), and Embedded Systems. This system can accurately recognize individual pets through a Convolutional Neural Network (CNN) and dispense tailored food portions based on specific dietary needs. Utilizing advanced image preprocessing and deep learning techniques, it minimizes the chances of false identifications and unauthorized feeding incidents. With the integration of

cloud storage and IoT, pet owners can enjoy features such as real-time monitoring, feeding history management, and remote access via web or mobile applications, significantly enhancing convenience. This system effectively overcomes the limitations of traditional manual and timer-based feeders by preventing overfeeding, reducing food wastage, accommodating households with multiple pets, and maintaining a comprehensive log of feeding records. Testing shows that the CNN model achieves high accuracy in recognizing pets, demonstrating reliable precision, recall, and F1-score, making it well-suited for real-world applications. In conclusion, this smart pet feeding solution is scalable, cost-effective, and user-friendly, promoting better management of pet health while reducing the need for constant human intervention. Future improvements, such as health monitoring sensors, behavioral analysis, and advanced AI-driven dietary recommendations, could further enhance the system's capability and intelligence.

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