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Design and Implementation of a Mobile-Controlled IoT Smart Pet Feeder for Busy Pet Owners

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ABSTRACT

Pet owners often struggle to maintain their pets' nutrition due to tight schedules and busy lifestyles, making it difficult to ensure pets receive adequate care. To address this issue, this paper proposes a system that integrates IoT technology, in the form of a smart pet feeder, with mobile applications. The system uses a mobile application as a remote control for the smart pet feeder, allowing owners to monitor food consumption and establish automated feeding schedules, ensuring pets are fed on time, even when the owner is away. The system consists of a mobile application and a smart pet feeder as the hardware component, enabling users to manage feeding remotely while offering real-time monitoring and scheduling features. A survey conducted among the IIUM community identified key features, such as automated feeding schedules and real-time monitoring, which were incorporated into the system's design. The system architecture was developed to illustrate the structure and operation of the solution. This work provides a comprehensive solution to the common challenges pet owners face, ensuring their pets' nutrition and well-being are maintained with greater convenience and reliability.

1. INTRODUCTION

The act of sharing or feeding food to the pets is a virtuous deed for all human beings especially as a Muslim. As a pet owner, it is a big responsibility to take care of beloved pets by feeding them on time. A solution to ease the process of pet feeding, even when not at home has been invented which is Integrated IoT Mobile Applications: Automation Smart Pets Feeding and Monitoring System named PawTector. The system combines smart feeding mechanisms with real-time monitoring capabilities, ensuring beloved companions receive optimal care and attention while enhancing the well-being of pets through the power of IoT innovation. [1], [2]. Additionally, a mobile application will be created to monitor the level of dispensers for food and drink. The discussion of this work has been published in [3].

1.1 Background of the problem

The development of PawTector is to meet the diverse needs and preferences of users. This approach is to maximize the user-friendly features and interfaces that cater to the users need to have real-time notifications and direct access to the Smart pets feeding and monitoring system [4]. This system is developed to cater to pet owners seeking the best solution for automatically monitoring and feeding pets. These people are typically busy and rarely at home to feed pets on time. Currently, traditional methods of feeding pets require manually putting the food or leaving a large amount of food in the pet food container when going out for a few days., as portrayed by Figure 1. The problem with this method is the lack of knowledge about the pet's well-being when the owner is away.

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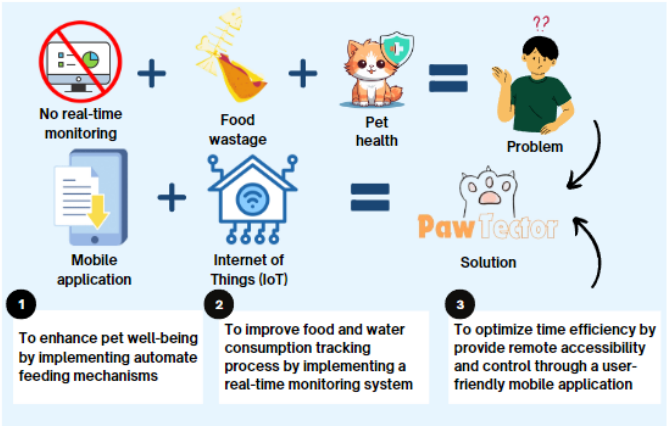

Fig. 1. Problem statements and objective of implementing the system.

The manual method of pet feeding has several downsides, which is that the food continuously exposed to the outside of the container leads to rapid spoilage due to environmental factors, posing a potential health risk to pets [5]. Additionally, there is a lack of real-time monitoring of the pet's well-being when leaving home. Lastly, manual handling of pet food without automated dispensing contributes to excessive food wastage and environmental impact, as larger portions may be left unused for prolonged periods. The aim of this work is to enhance pet well-being by implementing automated feeding mechanisms. Besides, the system is developed to improve food and water consumption tracking processes by implementing a real-time monitoring system and to optimize time efficiency by providing remote accessibility and control through a user-friendly mobile application [6].

The following is an overview of the different sections covered in a paper about the work which is Integrated IoT Mobile Applications: Automation Smart Pets Feeding and Monitoring System (PawTector). Section 1 covers the basics, including the background of the problem with the existing system or method. Section 2 gives an overview of the existing systems for benchmarking and highlights some main IoT components to be used in this work. Section 3 explains the project's methodology, including the system architecture, use case diagram for each subsystem and activity diagram illustrating the entire system process, related is the components and the arrangement of the component that will be used in the project. Section 5 suggests UI/UX design for the mobile application interface of the system for user accessibility. Section 6 concludes the paper.

2. LITERATURE REVIEW

The main purpose of this literature review is to identify the most suitable functionality or features for the PawTector mobile application which has the aim to enhance pet well-being by implementing automated feeding mechanisms [7], [8]. In this review, comparing and evaluating similar systems to the one will be the focus. From the evaluation, examining the advantages and disadvantages will be the potential chances and risks to avoid while developing PawTector.

Among the systems reviewed, the Raspberry Pi-based design [1] stands out for its versatility, allowing remote monitoring and control of the feeding mechanism via a web application. This capability is similar to the PawTector system, which also aims to provide remote management of food dispensing. However, the key difference lies in PawTector's use of the STM32 microcontroller for efficient data acquisition and integration with a mobile app, compared to the Raspberry Pi-centric design that primarily depends on a web interface.

In contrast, the Arduino Uno-based systems [9], [10] demonstrate more straightforward automation methods using weight sensors and scheduled dispensing mechanisms. These systems are advantageous for their simplicity and low-cost components, but they may lack the scalability and IoT integration offered by more advanced designs. The solar-powered system [10] introduces the potential for sustainable, off-grid usage, but its reliance on solar energy could present limitations in environments with inconsistent sunlight.

The IoT-based systems [11], [12] take advantage of real-time monitoring via mobile applications and camera modules. These systems align closely with PawTector's goal of providing live streaming capabilities, but they use different microcontrollers like NodeMCU or ARmega329P. While these setups offer a user-friendly interface, they may lack the precise data handling capacity provided by PawTector's STM32 and Raspberry Pi integration, which ensures seamless communication between hardware components and the mobile app.

Five mobile apps were chosen to be the source for the literature review: Smart Tiny Pet Feeder (Eyenimal) [13], Pet Zero [14], Petlibro LITE [15], Pet Marvel [16] and Xiaomi Home [17]. By comparing these mobile apps, the fundamental features or aspects of the pet monitoring system for mobile apps can be identified as shown in Table 1.

Table 1. Comparison of Similar Systems

Features	**Systems**					
	Eyenimal	*Pet Zero*	*Petlibro LITE*	*Pet Marvel*	*Xiaomi Home*	*PawTector (Our System)*
Sign up/Login		✓	✓	✓	✓	✓
Monitor food level Dashboard				✓		✓
Add Device	✓	✓	✓	✓	✓	✓
User Profile		✓	✓	✓	✓	✓
Pet Profile					✓	✓
Appointment Reminder			✓	✓		✓
Remote Control		✓	✓	✓	✓	✓

Automatic Feeding Schedule		✓	✓	✓	✓
Manual Dispense	✓	✓	✓	✓	✓
Setting	✓	✓	✓	✓	✓
Logout	✓		✓	✓	✓

Sign-up and login are the first crucial components of system adaptation, protecting user data and preventing unauthorized access. A dashboard for monitoring pet food levels will also be installed, enabling pet owners to check their pet's food levels from a distance using a mobile app. In addition, the system will feature user profiles and pet profiling, allowing users to input information about their pets' gender, weight, and health, including vaccination records for automated alerts. Users can plan automated food dispensing with remote-control capabilities and have the option to dispense food instantly via the app using a manual dispenser feature [9].

In this work, the IoT components that will be used are ultrasonic sensors, ESP8266 Wi-Fi module, servo motor and water pump which are the essential part in this project [18]. Incorporating ultrasonic sensors will equip the system with data logging capabilities, real-time tracking of food and water levels used to track the pet consumption behavior and the amount of food and water that are left in the tank [19]. Besides, integration of esp8266 into the system architecture facilitates the connection between other components where it receives the input from the ultrasonic sensors. Esp8266 transmits the data wireless to enhance the efficiency in controlling the smart pet feeder remotely [20]. Lastly, servo motor and water pump act as the output of the system where it will be triggered through a mobile application [21].

In the rapidly changing landscape of smart pet care technology, the PawTector system stands out by providing a comprehensive set of features that cater to both pet owners' convenience and pets' well-being. Unlike Eyenimal, which lacks key features such as a food-level monitoring dashboard, pet profiles, and appointment reminders, PawTector seamlessly integrates these, allowing users to manage their pets' feeding schedules remotely. Eyenimal's reliance on user presence and basic reminder functionality makes it less suitable for modern lifestyles.

Pet Zero, while offering basic features such as remote control and user profiles, falls short of automating feeding schedules and does not include appointment reminders. PawTector fills these gaps by providing automated feeding schedules based on individual pet needs, as well as a pet profile system and a food-level monitoring dashboard. This personalized and proactive approach ensures consistent and tailored feeding routines, which distinguishes PawTector from Pet Zero.

Though Petlibro LITE, Pet Marvel, and Xiaomi Home offer some advanced features, they fall short of PawTector's comprehensive capabilities. Petlibro LITE lacks a food-level dashboard and logout functionality, while Xiaomi Home and Pet Marvel are missing essential features such as appointment reminders and pet profiles. PawTector's unique combination of a food-level monitoring dashboard, pet profile management, and automated feeding schedules makes it a superior choice in the smart pet feeder market.

In addition to the unique features offered by PawTector, there are some similarities with other smart pet feeders, particularly in automated feeding and remote monitoring. However, the other systems often face the same limitations and weaknesses such as lack of precise reading on food dispensing, high dependency on internet connectivity and no sensors to prevent overfilling. Lack of precise reading on food dispensing can lead to inaccurate feeding amounts. To overcome the issues, PawTector includes a feature where users can set the exact portion size for automated dispensing ensures that pets receive the correct amount of food each time, eliminating the risks associated with inaccurate food measurements and providing a more controlled and reliable feeding experience.

Furthermore, a high dependency on internet connectivity might disrupt the smart pet's feeder to operate efficiently. In contrast, PawTector has implemented an automated feeding schedule that operates independently from wifi connection. User can preset the time interval and portion to dispense the food although there are no wifi connection to ensure pets are consistently fed. By reducing the reliance on wifi connection, PawTector has solved a significant problem faced by other smart pet feeders. While the other smart pet feeder has a common problem to ensure there is no overfilling, PawTector addresses this issue easily. PawTector is equipped with ultrasonic sensors that are designed to measure the level of food and water providing real-time data to users through the mobile application. By continuously monitoring the food level, PawTector ensures precise food management to make it more efficient in reducing the waste while maintaining the food's quality.

3. METHODOLOGY

A survey have been conducted among IIUM community to study features and functionality that enhance the user's experience. Based on the survey, 58% of respondents identify automatic feeding schedule could improve the user's experience in using smart feeder. Furthermore, 87% of respondents prefer a pet care solution that offers remote monitoring and control through a mobile application. The features significantly improve the real-time management from any location. PawTector consists of two parts which are mobile application as the remote control and hardware components.

3.1 System architecture

IoT-based systems combined with mobile applications can efficiently manage pet feeding processes. IoT communication architecture significantly enhances the control and monitoring of these processes [22]. The system architecture described achieves this by enabling request submission through a mobile app, ensuring a strong local network connection with the ESP8266 [23]. Figure 2 below referencing the architecture of the system for this project. The mobile app communicates with the database and Blynk to process these requests and send responses back, enabling users to view and control the system directly from their mobile devices.

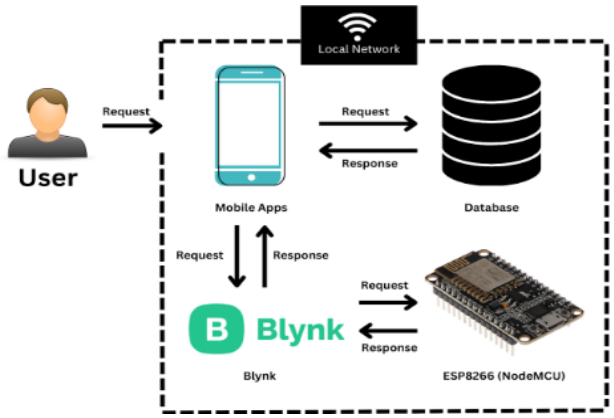

Fig. 2. System architecture of the system

3.2 Use case diagram

The use case diagrams show the features and key business actors that are involved within the system, contents in Figure 5, the use case diagram for the overall system. There are three actors which are end users (e.g., pet owner), database for storing the users and pet information and Wi-Fi module esp8266 that is responsible to receive the input from sensors and trigger the pet dispenser [24]. Firstly, 'login' use case is crucial in the system for securing users' information and data. For new users, account creation is required before logging in to the system. As illustrated in Figure 3, users can record their pet's details and health management such as vaccination appointment through the 'set pet profile', use case where users can set a reminder for the appointment date to notify users. Then, the use case as stated in Figure 4 is the 'automate feeding schedule' including 'manual dispense'. For this part, users will have two options to dispense the food either to set an automatic feeding schedule or manually dispense through mobile application, offering flexibility to the users [10]. In addition, users can monitor the level of food and water that are left in the container through 'monitoring food level' dashboard. These are the functional requirements collected from the users.

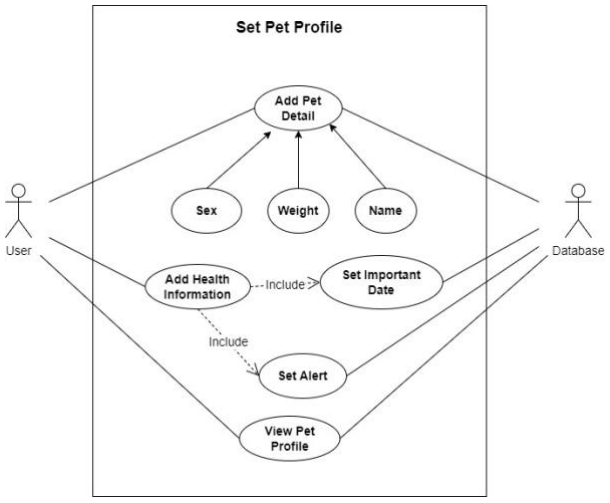

Fig. 3. Use case diagram for pet profile

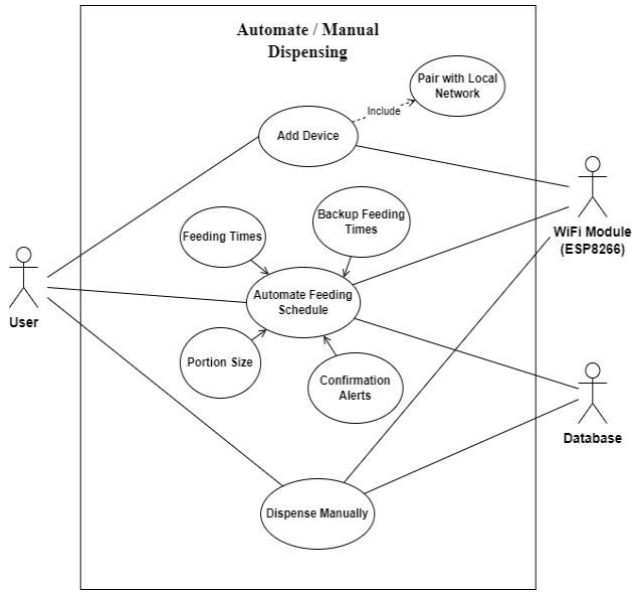

Fig. 4. Use case diagram for auto/manual dispense

Fig. 5. Use case diagram of the system

3.3 Activity diagram

The activity diagram shows how the mobile application will work through the system implementation, as depicted in Figure 6, The mobile application starts with the users required to register and login first into the application. This action is to secure the data that is contained in mobile applications and to enhance users' privacy [25], [26]. Then the system will bring the users to the homepage, the monitoring dashboard that measures water and food tank. There are three menu options that can choose which are view pet profile, connect device, and manage food scheduling. The pet profile feature enables the addition, deletion, and updating of pet and health information. It is also same with food scheduling, users can manage the schedule by add, delete and update the timing to dispense the food including the portion.

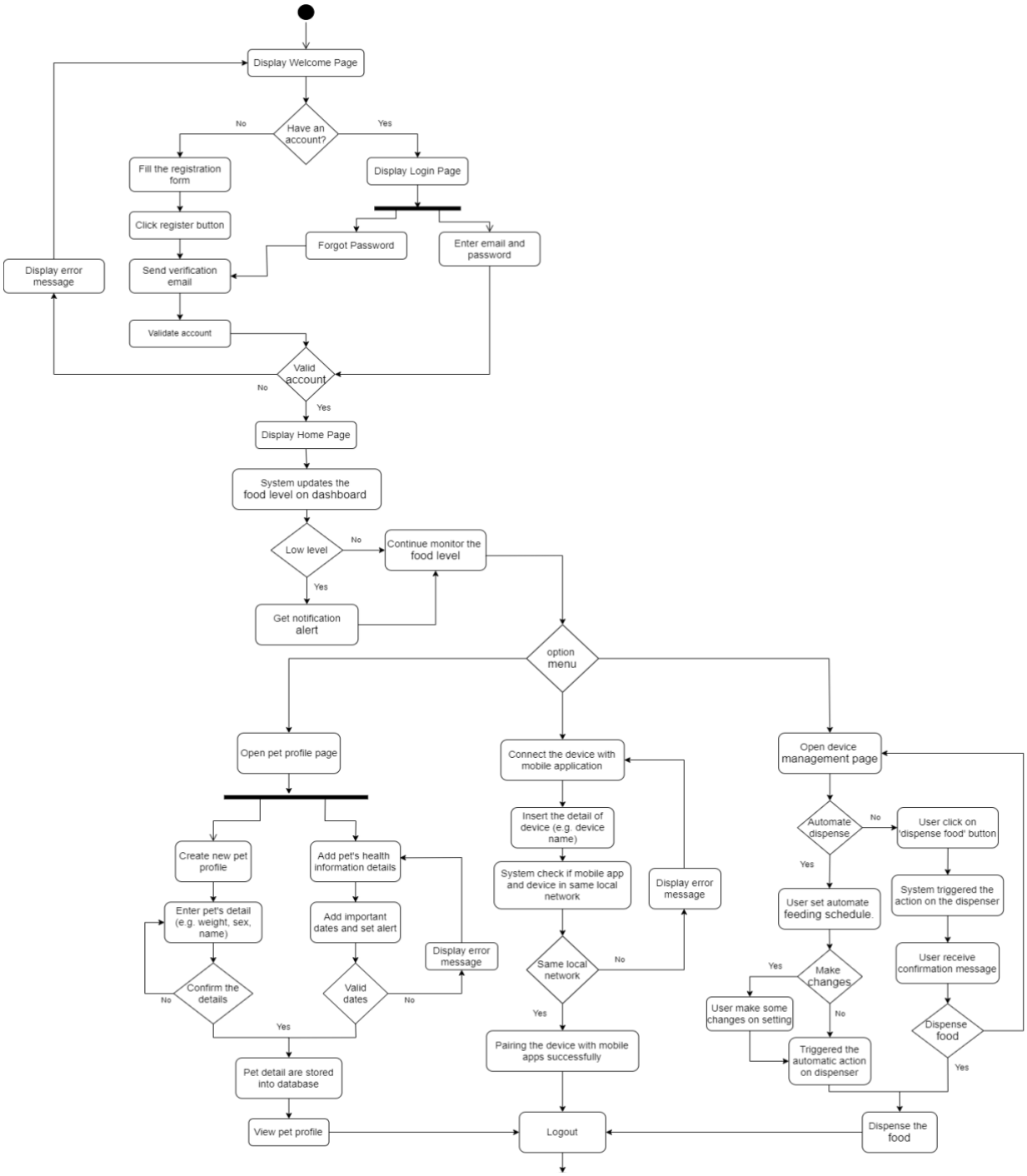

Fig. 6. Activity diagram of the system

3.4 System wiring and diagram overview

The integrated IoT mobile application for PawTector integrates real time detection features that allow users to receive instant alert and measurements via mobile phone. As shown in Figure 7, the system begins with ultrasonic sensor that function to measure the food and water level. The system then uses ESP 8266 NodeMCU as the main micro controller as the processor of the system, link the sensor and other component via Wi-Fi. The system is connected with servo motor and water pump used to dispense the food and water including buzzer and red LED as the alert features. The data is transmitted to Blynk, where it is stored and displayed in real-time within the mobile application. Figure 8 is the schematic diagram detailing the ESP8266 connections with the components that are involved. Figure 8 illustrate a logical connection between electrical components.

4. PROTOTYPE: MOBILE APPLICATION INTERFACES

4.1 UI/UX

Figure 9 to Figure 12, these Figures provide visual representation of the project when operates by using a mobile phone, interactions of the user with the system from the home

page, pet profile page and automate feeding schedule page where the user set the feeding time for the pets. The automated feeding schedule page also has manual dispense button, offer a flexibility for users in managing their pets feeding time. The manual dispense page shows the user interactions when click the buttons, where it displays the number of portions, a method to cancel in case of a miss click and a dispense button to confirm the action.

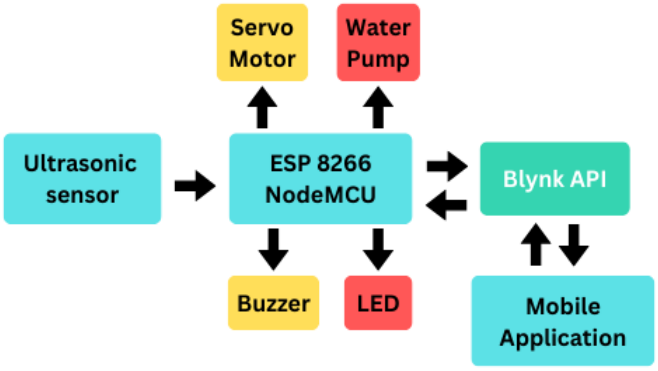

Fig. 7. Block diagram of the system

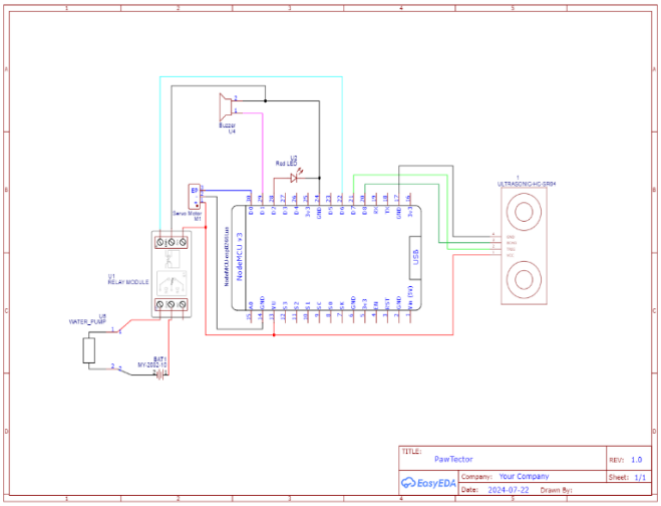

Fig. 8. Schematic diagram of the system

5. CONCLUSION

The mobile applications are built to facilitate users in remotely controlling the automated smart pet feeder. Implementing automation scheduling feeding mechanisms and real-time monitoring capabilities, the system addresses familiar challenges faced by busy pet owners, such as irregular feeding schedules and the lack of real-time insights into their pets' well-being [27], [28]. Lastly, the significance of this work lies in the potential to provide peace of mind, save time, and enhance the nutrition consumption of pets through innovative IoT-based solutions.

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Fig. 9. Home Page

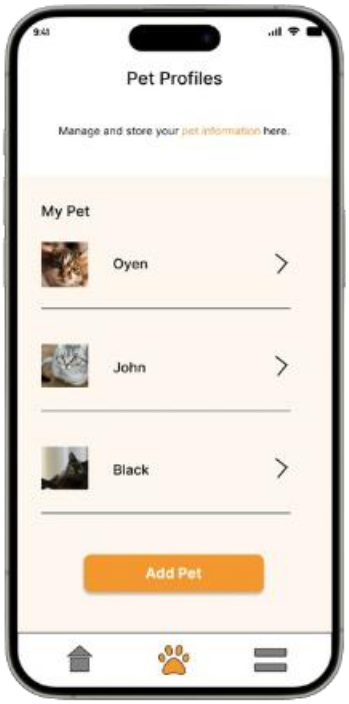

Fig. 10. Pet Profile Page

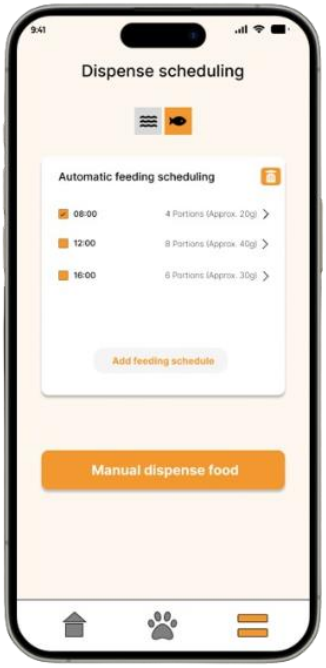

Fig. 11. Automate Feeding Schedule Page

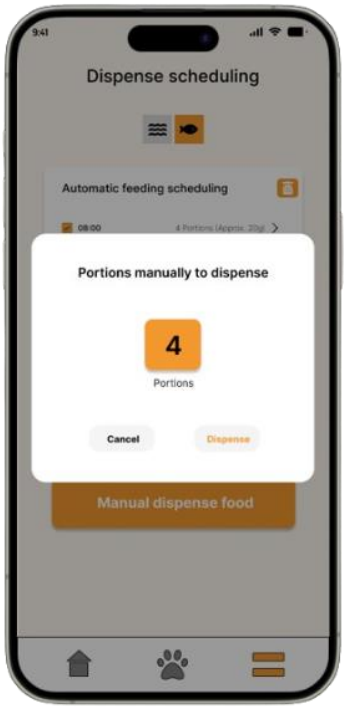

Fig. 12. Manual Dispense Page

REFERENCES

[1] H. Che Hasni and S. Suhaimi, "Pet Feeding System," International Journal of Recent Technology and Applied Science, vol. 4, no. 2, pp. 112–119, Sep. 2022, Doi: 10.36079/lamintang.ijortas-0402.400.

[2] V. Kale, M. Malaiya, U. Bagwan, and Prof. M. A. Kamthe, "Smart Pet Monitoring and Parenting System," IJRASET, vol. 11, no. 5, pp. 5651–5656, May 2023, doi: 10.22214/ijraset.2023.52939.

[3] Sivaraman, S., Zainuddin, A. A., & Subramaniam, K. (2021, July). Advances in Technology for Pet Tracker Sensing Systems. In 2021 International Conference on Green Energy, Computing and Sustainable Technology (GECOST) (pp. 1-4). IEEE.

[4] A. Y. Majid, R. F. Nurmansyah, M. L. A. Pratama, H. Susanti, and N. Prihatiningrum, "IoT-Based Cat Feeding and Monitoring System," in 2023 8th International Conference on Instrumentation, Control, and Automation (ICA), Jakarta, Indonesia: IEEE, Aug. 2023, pp. 160–165. doi: 10.1109/ICA58538.2023.10273126.

[5] M. V. R. Durga Prasad, M. Anita, and T. Malyadri, "An Iot-Based Smart Pet Food Dispenser," in Intelligent Manufacturing and Energy Sustainability, vol. 213, A. N. R. Reddy, D. Marla, M. N. Favorskaya, and S. C. Satapathy, Eds., in Smart Innovation, Systems and Technologies, vol. 213., Singapore: Springer Singapore, 2021, pp. 147–163. doi: 10.1007/978-981-33-4443-3_15.

[6] S. R, A. M T, A. K, S. C, A. K, and V. Balamurugan, "Real-Time Utilities Consumption Monitoring System Using ESP32," JOCSACI, vol. 9, no. 2, pp. 1–9, Jun. 2023, doi: 10.46610/JOCSACI.2023.v09i02.001.

[7] D. Dhakshayeni and Dr. S. Rathinavel, "Automated food feeder for dogs using embedded device," Int. J. Res. Publ. Rev., vol. 5, no. 4, pp. 1074–1077, Apr. 2024, doi: 10.55248/gengpi.5.0424.0933.

[8] M. J. Downes, C. Devitt, M. Downes, and S. J. More, "Understanding the context for pet obesity; self-reported beliefs and factors influencing pet feeding and exercise behaviour among pet owners." Dec. 18, 2014. doi: 10.7287/peerj.preprints.715v1.

[9] M. S. Z. M. Suffian, A. N. H. A. Zaini, A. Jamali, S. Mohamaddan, and M. F. Ashari, "Reliable Smart Pet Feeding Machine Using Arduino Uno Starter Kit," IOP Conf. Ser. Mater. Sci. Eng., vol. 1101, no. 1, p. 012033, Mar. 2021, doi: 10.1088/1757-899X/1101/1/012033.

[10] W. S. Woo, S. O. A. Ling, and F. L. A. Fang, "Automatic solar-based pet food dispenser system," E3S Web Conf., vol. 479, p. 07032, 2024, doi: 10.1051/e3sconf/202447907032.

[11] Sunil, K., Vishwanath, S., Vikas, T., Avinash, K., & Jagadish, J. (2022). IOT based dog day-care robot. International Journal of Advanced Research in Engineering and Technology, 4(7), 182-187.

[12] Kulaikar, J., Kurade, D., Sawant, A., Sthawarmath, P., & Chaurasia, A. (2023). IoT based automatic pet feeding and monitoring system. International Journal of Mechanical and Design Engineering and Systems (IJMDES), 2(4), 24–27. https://journal.ijmdes.com/ijmdes/article/view/125

[13] Retrieve from Bandou. (2024). Feeder [Mobile application software]. Google Play Store. https://play.google.com/store/apps/details?id=com.bandou.app.feeder

[14] Retrieve from KKPetFeeder. (2024). PetZero [Mobile application software]. Google Play Store. https://play.google.com/store/apps/details?id=com.kkpetfeeder.petzero.android

[15] Retrieve from Shenzhen DaLong Information Technology Co., Ltd. (2024). Petlibro [Mobile application software]. Google Play Store. [https://play.google.com/store/apps/details?id=com.dl.petlibro

[16] Retrieve from Ningbo Newthink Motor Inc. (2024). PetMarvel [Mobile application software]. Google Play Store. https://play.google.com/store/apps/details?id=com.nyhx.petmarvel

[17] Retrieve from Xiaomi Inc. (2024).Mi Home [Mobile application software]. Google Play Store. https://play.google.com/store/apps/details?id=com.xiaomi.smarthome

[18] Vaddeswaram, Guntur, India et al., "IoT Based Automatic Soil Moisture Monitoring System using Raspberry PI," Int. J. Innov. Technol. Explor. Eng., vol. 9, no. 2, pp. 4375–4379, Dec. 2019, doi: 10.35940/ijitee.B9002.129219.

[19] Salvaña, J. S. (2023). Simultaneous Measurement of Fluid Level and Flow in Gravity Tanks using Ultrasonic Sensors. Cognizance Journal, 3(4), 32–38.

[20] Birha, P., Ingle, R., Tajne, S., Mule, P., Pandey, A., Kukekar, S., & Kadu, A. (2022). Design and Development of IOT Based Pet Feeder. International Journal of Innovations in Engineering and Science, 7(8), 137–140.

[21] R. Tasnim et al., "IoT and GSM Integrated Automated Water Pump Controlling System for Prevention of Water Wastage," in Proceedings of the International Conference on Industrial Engineering and Operations Management, Dhaka, Bangladesh: IEOM Society International, Dec. 2023. doi: 10.46254/BA06.20230106.

[22] Quiñonez, Y., Lizarraga, C., Aguayo, R., & Arredondo, D. (2021). Communication architecture based on IoT technology to control and monitor pets feeding. Journal of Universal Computer Science, 27(2), 190-207.

[23] I. Riadi and R. Syaefudin, "Monitoring and Control Food Temperature and Humidity using Internet of Things Based-on Microcontroller," J. Ilm. Tek. Elektro Komput. Dan Inform., vol. 7, no. 1, p. 108, Apr. 2021, doi: 10.26555/jiteki.v7i1.20213.

[24] A. E. Shafee and K. A. Hamed, "Towards a WiFi Based Home Automation System," Int. J. Comput. Electr. Eng., pp. 803–808, 2012, doi: 10.7763/IJCEE.2012.V4.609.

[25] Q.-A. Arshad, F. Azam, W. Z. Khan, M. K. Khan, and M. Raza, "Blockchain based Decentralized Trust Management in IoT: Systems, Requirements and Challenges." Mar. 21, 2022. doi: 10.36227/techrxiv.19351892.v1.

[26] C. Li and B. Palanisamy, "Privacy in Internet of Things: From Principles to Technologies," IEEE Internet Things J., vol. 6, no. 1, pp. 488–505, Feb. 2019, doi: 10.1109/JIOT.2018.2864168.

[27] D.M.M.P Gunaratne, S.M.D.S Bandara, H.M.T.S Sooriyabandara, M.G.D.P.M.B Chandrarathna, D. I. De Silva, and H.M.P.P.K.H Samarasekara, "Implementation of a Pet Care Management System," Int. J. Eng. Manag. Res., vol. 12, no. 5, pp. 157–163, Oct. 2022, doi: 10.31033/ijemr.12.5.19.

[28] R. Bhagat, "Review on Automatic Pet Feeding System," Int. J. Res. Appl. Sci. Eng. Technol., vol. 12, no. 3, pp. 322–325, Mar. 2024, doi: 10.22214/ijraset.2024.58684.