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Automated Dog Feeder System Using Arduino Uno for Efficient and Timely Feeding

James Dalisay Baranggan, Haire Ato, Isaiah Smile B. Halik, Jennie Jorimocha, John Renwel Mauro, Rexel Gold D. Emuy, Judie L. Velasco
Carlos P. Garcia Senior High School
Juan Luna Street, Poblacion District, Davao City

Abstract- This project aims to develop a prototype that could potentially assist dog owners in managing feeding schedules more efficiently and inclusively. The functionality of the prototype was assessed based on the aptness of the object detection using an ultrasonic sensor, the accuracy of its real-time clock, the precision of its servo motor for kibble dispensing, the audibility of its voice recorder, the visibility of the neon signage for aging dogs, the braille integration for visually impaired owners, and its overall system reliability. The automated dog feeder was built using an Arduino Uno R3, an HC-SR04 ultrasonic sensor, RTC Module DS3231, PCB matrix, jumper wires, SG90 servo motor, LCD I2C screen, 12V AC adapter, MP3 player, speaker, acrylic, PVC elbow, and some recycled materials such as wood and PVC pipe. The data analysis was based on user feedback and system performance parameters. The results indicated that the prototype accurately dispensed kibble upon detection of the dog's presence, tracked and scheduled feeding times, and got favorable feedback on its overall functionality, usability, and inclusivity. The given results imply that the automated dog feeder has strong potential to assist diverse dog owners in maintaining regular feeding schedules, making it a more practical solution for busy homes.

Index Terms- automated dog feeder, dog owners, dog ownership, feeding schedule

I. INTRODUCTION

Dog ownership requires significant time management, particularly when it comes to maintaining a feeding schedule. A well-regulated feeding schedule is essential for the dog's wellness and well-being. However, in this modern time, balancing work, personal commitments, and time investment in dog ownership can be quite challenging, often leading to inconsistent feeding schedules. Understanding how to manage time effectively for feeding can help dog owners prevent health problems and behavioral issues in dogs, ensuring they receive the proper care and attention they need. As noted by Vink, et. al (2017), time investment and financial costs of dog ownership, along with longer work hours, can result in dogs being left unattended for extended periods, potentially leading to physical and behavioral issues.

Similarly, a study conducted by Wicaksono, et al. (2019) found that common concerns about owning pets include worries about pet care while traveling (34.6%), time investment (28.6%), and shelter considerations (28.3%). These findings suggest that many people are interested in pet ownership but are hesitant due to the long-term responsibilities involved.

This issue is also prevalent in the Philippines, where most Filipinos, often regarded as some of the hardest-working people, regularly work more than eight hours daily to meet living expenses.

According to Campanilla et al. (2022), domesticated animals that were once considered family pets are frequently abandoned on the streets when their owners can no longer afford to care for them which eventually contributes to the growing number of stray dogs roaming the country.

II. STATEMENT OF THE PROBLEM

This research aims to develop an automated dog feeder that dispenses food at specific times to assist dog owners in maintaining the dog's health and well-being, especially when they are not present. Specifically, it seeks to answer the following questions:

1. What is the percentage of successful trials of using an automated dog feeder in terms of:
- object detection using an ultrasonic sensor;
- real-time clock; and
- recorded recall reinforcement activation?

2. What is the percentage of success trials of the servo motor in terms of:

- 90 degrees rotation;
- 180 degrees rotation; and
- back to its original position?

3. What is the mass of the actual dog food dispensed by the automated dog feeder in terms of grams?

4. Is there a significant difference between the mass of the dog food set from the circular plate and the actual mass of dog food dispensed?

Hypothesis

- **Ho:** There is no significant difference between the mass of the dog food set from the circular plate and the actual mass of dog food dispensed.
- **Ha:** There is a significant difference between the mass of the dog food set from the circular plate and the actual mass of dog food dispensed.

Significance of the Study

The automated dog feeder system is significant in ensuring consistent and timely feeding for pets, especially when their owners are unavailable. By utilizing Arduino technology, the system automates portion control and feeding schedules, promoting healthier eating habits for pets and reducing the likelihood of overfeeding or missed meals. This system is particularly valuable for busy or frequently traveling pet owners, providing convenience and peace of mind while improving the overall well-being of their pets. Additionally, the system's real-time notifications enhance monitoring and control, making it a reliable solution for pet care.

Scope and Delimitation of the Study

This study focused on developing an automated dog feeder designed to dispense food at scheduled feeding times, aiming to assist busy dog owners in maintaining consistent feeding routines for their pets.

The prototype activated when the power supply was plugged in, calling the dog’s name. An ultrasonic sensor detected motion, triggering the automatic food dispensing mechanism and it will only dispense 250 grams each feeding time. After dispensing food, the feeder initiated an 8-hour timer before the next feeding, and this would also wait for the ultrasonic sensor to detect.

However, the prototype had notable limitations. It could only feed one dog and could not differentiate between dogs and other living beings. As a result, if it detects any motion, regardless of the source, it will dispense food and set the timer accordingly. This limitation could adversely affect the dog’s diet; for instance, if the dog fails to notice the food, it might eat too early, disrupting the recommended feeding interval of at least 8 hours.

Literature Review

This section contains the literature and empirical studies relevant to the study. These are selected for their relevance and significance to the topic under investigation. The discussion follows the following topics: automated dog feeders, the effectiveness of the automated dog feeder, and the effectiveness of the previous study about automated dog feeders.

Automated Dog Feeder

The automated dog feeder prototype is a dispenser device that delivers dog food at intervals, allowing dog owners to plan and control their dog's meals, guaranteeing that the dogs are fed on schedule. The features of the dog feeder prototype will include features such as an MP3 player and speaker that will call the dog’s name when the prototype is active, when the HC-SR04 detects motion, and when the delay timer is done. Additionally, an ultrasonic sensor will be added to the prototype that detects the presence of a dog near the feeder using ultrasonic sound waves, and an LCD I2C that displays a real-time clock using DS3231, and then displays “Next dispense in: (8 hours)” when HC-SR04 detects the motion of a dog near the feeder. The researcher chose an 8-hour delay because, according to Farmer, V. (2024, August 16), as referenced on the WebMD website, 'It's best to do it twice daily at 8 to 12 hour intervals.’ After the delay, the process will be repeated. These materials will assist in automating the dog feeder prototype, allowing owners to ensure their pet is fed on time, even when they are not around. Furthermore, the prototype will have a circular design that is controlled by a servo motor and is programmed in C++.

Effectiveness of the Automated Dog Feeder

The dog feeder prototype demonstrated significant effectiveness in making sure that pets are properly fed on time and providing pet owners with convenience, with the help of several components such as HC-SR04, DS3231, LCD I2C, servo motor, MP3 player, and speaker.

The MP3 player will send a signal to the speaker and then the speaker will call the dog’s name during the activation of the prototype and when the delay timer is done. This notifies the pet that the food is ready to be dispensed. The notification ensures that the pet is properly fed on time and provides pet owners with peace of mind. The MP3 player with speaker helps the dog understand that when the sound plays, it is time to eat, helping the dog link the sound with food and ensuring that the dog eats properly.

HC-SR04 detects motion within 100 cm to detect the presence of a dog near the feeder using ultrasonic sound waves. Once it detects motion, it will activate the servo motor, which rotates

to 90 degrees, to 180 degrees, and back to its original position of 0 degrees, and initiate the LCD I2C display "Next dispense in 8 hours." The detection of motion ensures that the servo motor rotates only at the right time, and the LCD I2C display initiates the message "Next dispense in: (8 hours)" and does not detect motion during that 8-hour delay, ensuring that the dog properly eats at the right time and prevents overfeeding.
The servo motor will be placed below in a circular plate and serve as the main foundation for the dispensing process of dog food to the food bowl. The servo motor will only be activated when the ultrasonic sensor HC-SR04 detects motion. When it is activated, it will perform three rotations: to 90 degrees, to 180 degrees, and back to its original position (0 degrees). This activation by motion ensures that the servo motor will rotate when the dog is near the feeder, allowing it to dispense dog food. This ensures that the dog properly eats at the right time and does not dispense food when it is not needed.

LCD I2C display will be placed in the front of the prototype design and serve as the timer for the dispensing process of dog food to the food bowl. The LCD I2C display will first display the real-time clock with the help of DS3231, then initiate the message "Next dispense in (8 hours)" when the ultrasonic sensor HC-SR04 detects motion. This message ensures that it does not dispense any more food, helping prevent overfeeding of dogs. This ensures that the dog properly eats the right amount of food.

DS3231 will be placed inside the prototype and will send real-time data to the LCD I2C display. This real-time data will be used by the LCD I2C to display the real-time clock. This ensures that consistent time and accurate time will be displayed by the LCD I2C display.

Effectiveness of the Previous Study about the Automated Dog Feeder
Previous studies on automated pet feeder using IoT (Internet of Things) have highlighted their effectiveness in managing timed feeding of pets and proper portion control. Research conducted by Kondapalli et al. in April 2019 discusses the effectiveness of integrating IoT into an automatic pet feeder in addressing two major challenges for pet owners: ensuring timely feeding of pets and controlling portion sizes to prevent overfeeding or underfeeding, highlighting the need for integrating the pet feeder into an IoT application that is controlled by a mobile application. The system is composed of materials such as an ultrasonic sensor and DC motor, water pump, relay, and NODEMCU. The purpose of having sensors in a system like this is to automate the feeding process completely with less human interference (Kondapalli et al., 2019). These systems allow the user to feed the pet whenever he wishes from anywhere through the internet and automatically dispense a predetermined amount of food and water to the bowls. This allows the user to feel secure that the beloved pet will be cared for and fed on time every time and ensures that the correct amount of food is dispensed at set intervals, contributing to healthier weight management and dietary control for pets, helping prevent overfeeding and stress. Additionally, the cost of pet sitters to feed our pets is too expensive compared to adopting pet feeders, which not only saves money but also provides great control in feeding times and portions, as demonstrated by Kondapalli et al. (2019) system, thereby improving the lives of both pets and owners by allowing the owner to reliably provide food to a pet at the time the owner wishes and keep the pet from reaching the food stored for later feedings.

III. METHOD

This section presents the research methodology which consists of four phases: Phase I - preparation and assembly of the automated dog feeder using Arduino Uno R3, primarily highlighting the mechanical and structural design; Phase II - sensor testing to verify if the system might achieve precise and reliable performance; Phase III - gathering and analysis of data regarding the system's performance; and Phase IV - Product Design.

Research Design
This research utilizes an experimental-quantitative approach to gather relevant data and information. To develop an automated dog feeder using Arduino Uno R3, this study aimed at maintaining consistent feeding schedules and promoting the well-being of dogs. The automation of the feeder was achieved through the integration of a servo motor, HC-SR04 ultrasonic sensor, DS3231 real-time clock (RTC), LCD I2C display, MP3 player, and a speaker. The servo motor rotates between 90 and 180 degrees and returns to its original position (0 degrees), triggered by the HC-SR04 sensor when it detects the dog's presence. An 8-hour timer, displayed on the LCD I2C screen and controlled by the DS3231, schedules subsequent feedings. The MP3 player would then send a signal to the speaker and would call the dog's name each time the system is activated. This automated feeding system provides convenience for pet owners by efficiently managing feeding routines and saving time.

Design Concept
Figure 1 shows the flowchart of the automated dog feeder. After the prototype is plugged into a power supply, the MP3 player will then send a signal to the speaker to announce the dog's name. After that, if the ultrasonic sensor detects a motion, it will make the servo motor move in a specified rotation. The servo motor can rotate about 90 degrees, 180 degrees, and back to its original position (0 degrees). If not, it will wait to detect any object that will approach the automated dog feeder before it will be able to proceed to the next step. Then, it will initiate an eight (8) hour timer that will be displayed in the LCD I2C. Finally, after the 8-hour timer, the

LCD I2C will display the real-time clock with the help of RTC DS3231.

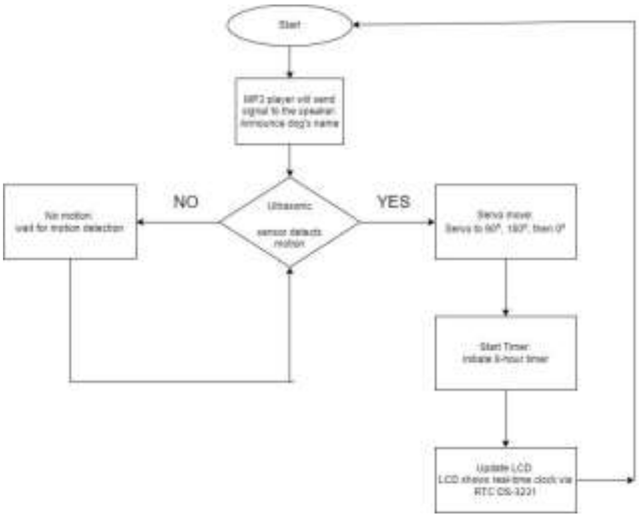

Figure 1. Flowchart of Automated Dog Feeder

Phase I. Designing and Assembling of the Prototype

Materials. The automated dog feeder system prototype will use an Arduino Uno R3, an HC-SR04 ultrasonic sensor, RTC Module DS3231, PCB matrix, jumper wires, SG90 servo motor, LCD I2C screen, 12V AC adapter, MP3 player, speaker, acrylic, PVC elbow, and some recycled materials such as wood and PVC pipe.

Building System Sensors

The first step in designing and assembling the wiring system involves the Arduino Uno R3 and a PCB matrix. The VCC is connected to the PCB matrix where it is in a column with 5V from the Arduino, while the ground (GND) is connected to the PCB where GND from the Arduino is connected in a column. Then, connect the analog inputs and digital pins to their corresponding rows on the PCB matrix to ensure proper wiring for each component.

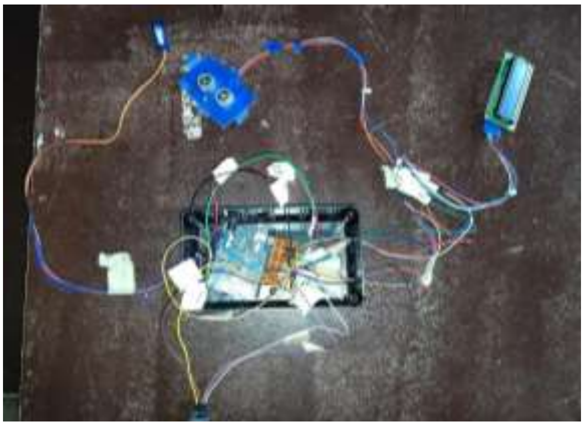

Figure 2. Wiring System

Building Up of Prototype Design

Figure 2 shows the interior design of the prototype. Inside the PVC pipe, a circular platform supports the servo motor, which controls the dispensing mechanism through three specific rotations, ensuring precise food release.

Figure 3. Interior Prototype Design

Building Up of Food Storage

Figure 3 shows the exterior design of the prototype, featuring a plastic container for the dog feeder. The container is designed to fit securely at the top of the PVC pipe, which facilitates the food dispensing process. The storage's maximum capacity can be held for up to 1 week.

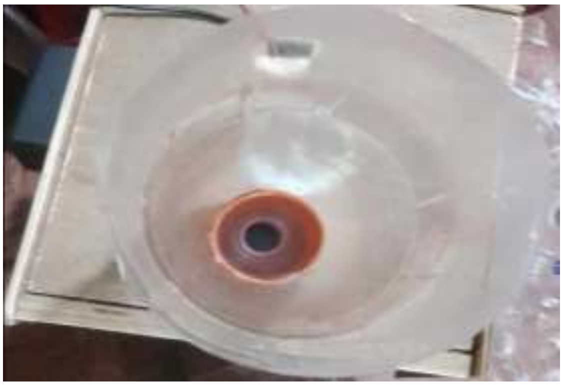

Figure 3. Exterior Prototype Design

Assembling of the System Wirings to the Prototype Design

The assembling of the system wiring to the automated dog feeder prototype involves connecting essential components to ensure proper functionality. The Arduino Uno R3 microcontroller is connected to the HC-SR04 ultrasonic sensor for motion detection, the DS3231 module for real-time clock display, and the servo motor for controlling the food dispensing system. Wires from the LCD I2C display, and the MP3 player are also connected to the PCB matrix and microcontroller. Careful arrangement and secure wiring ensure that all components communicate effectively, allowing the system to function as designed for automated feeding.

Coding

Presented in Figure 4 is the circuit design of the automated dog feeder prototype. The system was programmed using Arduino IDE software. The Arduino microcontroller in the dog feeder prototype will give instructions to the components of the dog feeder prototype. The system of the dog feeder prototype uses an LCD I2C display, HC-SR04, DS-3231, servo motor SG90, MP3 player, and speaker to automate the dog feeder. The servo motor will perform three specified rotations: one to 90 degrees, one to 180 degrees, and 0 degrees (original position). The servo motor will be activated in one condition: HC-SR04 detects a motion within 100 cm. If it does not follow the condition, the servo motor won't activate. The MP3 player will send a signal to the speaker and then the speaker will call the dog's name when the prototype is active. The LCD I2C will first display a real-time clock, then it will display a timer when the HC-SR04 detects a motion within 100 cm and after it dispenses food.

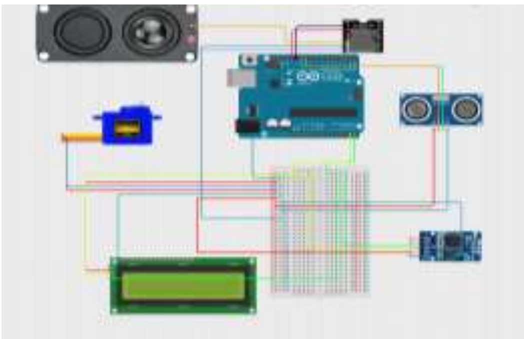

Figure 4. Circuit Design

Phase II. Testing of Indicators

Figure 5 shows the schematic design of the Arduino-based automated dog feeder system that will be tested using dry dog food in a container that acts as the food reservoir; the feeding mechanism will be tested to simplify the debugging process. Once the feeder mechanism is fully functional and performs as expected, the next component, such as the portion control sensor, will undergo testing. The subsequent steps will focus on testing the scheduling system, real-time notifications, and ensuring the system's overall reliability in automated feeding.

- Input and Output Connection
- Detection of the Dog's Presence
- Error Detection of the System
- Testing of the Feeding Schedule Set on the System

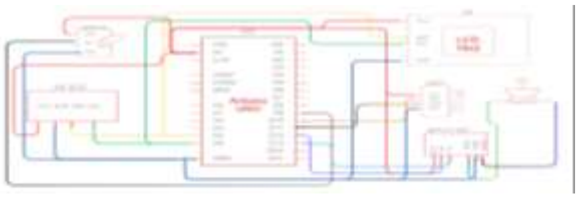

Figure 5. Schematic Diagram

Waste Disposal

All the segregated waste—non-biodegradable was gathered, sealed, and put in a black trash bag. After that, it was then delivered to Barangay 28-C's Material Recovery Facility for appropriate disposal.

Phase III. Data Gather and Analysis

Data Collection

In answering the underlying questions posted in this study, the researcher gathered the data by following these procedures:

- The success of the automated dog feeder in terms of object detection using ultrasonic sensors was examined as the automated dog feeder could detect any object that approached the prototype.
- The success of the automated dog feeder in terms of the real-time clock was examined as the automated dog feeder could continue the time even when the prototype was unplugged.
- The success of the automated dog feeder in terms of recorded recall reinforcement activation was investigated as the automated dog feeder could activate the recorded voice simultaneously during feeding time.
- The researcher made 5 trials for procedures 1 and 2. Table 1 presents the collected data from the functionality test of the features of Automated Dog Feeder.

Table 1. Collected Data from the Functionality Test of the Features of the Prototype

Parameter	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Object Detection	/	/	/	/	/
Real-Time Clock	/	X	/	X	/
Recorded Recall Reinforcement Activation	/	/	/	/	/

- The success of the servo motor was investigated as the servo motor rotated about 90 degrees, 180 degrees, and back to its original.
- The researcher made 5 trials for procedure 4. Table 2 presents the collected data from the functionality test of the servo motor.

Table 2. Collected Data from the Functionality Test of the Servo Motor

Parameter	Trial 1	Trial 2	Trial 3	Trial 4	Tria l 5
90^o Rotation	/	/	/	/	/
180^o Rotation	/	/	/	/	/
Back to Its Original Position	/	/	/	/	/

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- The actual mass of dog food dispensed by the device was weighed using a digital weighing scale. The automated dog feeder could only dispense a maximum of 250 g of dog food for each feeding time.
- The researcher made 10 trials for procedure 7. Table 3 shows the collected data of the weighted actual dog food dispensed by the Automated Dog Feeder.

Table 3. Actual Mass in grams of Dog Food Dispensed from Automated Dog Feeder

Parameter	T 1	T 2	T 3	T 4	T 5	T 6	T 7	T 8	T 9	T 10
Mass of Actual Dog Food Dispensed	245	255	240	260	255	250	250	250	255	245

Data Analysis
The collected data of success trials of automated dog feeders in terms of object detection, real-time clock, and recorded recall reinforcement activation were in the form of a checklist, that is, the goal of the functional testing. The researcher counted the success of each feature and divided it by the number of trials, that is, the number of trials is 5.

Descriptive statistics were used on the actual masses of dog food and the mass of dog food set from the circular plate. Table 4 presents the mean and standard deviation of each data set.

Table 4. Descriptive Statistics

Descriptive Statistics

	N	Mean	Std. Deviation
Actual Mass of Dog Feed Dispensed from the Automated Dog Feeder	10	250.5000	5.98609
Mass of Dog Set from the Circular Plate	10	250.0000	.00000
Valid N (listwise)	10		

The collected data of the actual masses of dog food dispensed from automated dog feeders were measured data or continuous data. Each set of data underwent a normality test using the Shapiro-Wilk test to evaluate whether each data was normally distributed.

Table 5. Shapiro-Wilk Test

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Actual Mass of Dog Feed Dispensed from the Automated Dog Feeder	.174	10	.200*	.952	10	.691

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Table 5 presents the Shapiro-Wilk test result. The Shapiro-Wilk test on the data from actual masses of dog food dispensed from the automated dog feeder yielded a result of a p-value equal to 0.174. If the Shapiro-Wilk is greater than 0.05 the data may be normal. Hence, the researcher utilized a parametric test, specifically an independent t-test to further analyze the data.

Phase IV. Aesthetics
Presented in Figure 6 is the aerial view of the automated dog feeder. The researchers included two sensors which are the HC-SR04 ultrasonic sensor, and LCD I2C screen in Figure 6 to represent the detection system, allowing the prototype to accurately dispense kibble upon detection of the dog's presence, tracked and scheduled feeding times, enabling automation.

Additionally, the researchers included a transparent food and a white-painted PVC tube. The transparent food container not only provides a clear view of the food level but also contributes to the sleek, modern design. The white-painted PVC tube, which serves as the dispensing mechanism, offers a minimalist yet functional touch, protecting the system components while maintaining a clean look.

The feeder's base is finished in neutral tones, adding contrast and depth for a polished appearance. It also features a customized paw decals made with neon signage, offering visual cues for aging dogs and adding a playful yet practical element. This detail creates a striking contrast with the lighter components.

The inclusion of a customizable plastic container ensures easy access for refilling and cleaning, making the prototype highly functional while maintaining its aesthetic appeal. The thoughtful design not only ensures practical use for daily feeding but also enhances the overall look of any space it occupies. With carefully selected materials, the prototype strikes a perfect balance between functionality and aesthetics.

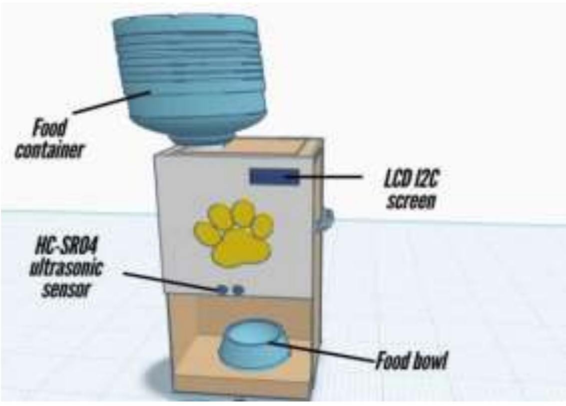

Figure 6. Aerial View of the Automated Dog Feeder.

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IV. RESULTS AND DISCUSSION

This section presents the results of the study and provides a comprehensive discussion based on the data collected throughout the research process. The analysis focuses on the effectiveness and reliability of the Arduino-based Automated Dog Feeder System, highlighting the system's capabilities in automated feeding, portion control, and real-time notifications to ensure proper feeding schedules for dogs.

Table 6 presents the percentage from the functionality test of the features of the Automated Dog Feeder.

Table 6. Percentage of Successful Trials of the Features of the Prototype

Parameter	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Percentage of Successful Trials
Object Detection	/	/	/	/	/	100%
Real-Time Clock	/	X	/	/	/	80%
Recorded Recall Reinforcement Activation	/	/	/	/	/	100%

Based on Table 6, the result shows that the percentage of successful trials of objective detection is 100%, the percentage of successful trials of the real-time clock is 80%, and the recorded recall reinforcement activation is 100%. This means that the automated dog feeder has successfully passed the test in terms of its functionality.

Table 7 presents the collected data from the functionality test of servo motors.

Table 7. Percentage of Successful Trials from the Functionality Test of the Servo Motor

Parameter	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Percentage of Successful Trials
90^{o} Rotation	/	/	/	/	/	100%
180^{o} Rotation	/	/	/	/	/	100%
Back to Its Original Position	/	/	/	/	/	100%

As shown in Table 7, the results show that the percentages of successful trials of servo motors rotating about 90o, 180o, and back to their original position are all 100%. This means that the Automated Dog Feeder has successfully passed the test in terms of its functionality.

Table 8 presents the meaning of the data set. The mean of the actual masses of dog food dispensed from the automated dog feeder is 250.50 g.

Table 8. Mean of Actual Masses of Dog Food

Descriptive Statistics

	N	Mean
Actual Mass of Dog Feed Dispensed from the Automated Dog Feeder	10	250.5000
Valid N (listwise)	10	

Table 9 shows the independent t-test result. As shown in Table 9, the p-value for is 0.795 ($p=0.795$). With this, the null hypothesis should not be rejected. Hence, the actual mass of dog food dispensed from the automated dog feeder has no significant difference (250.50 g ± 5.99 g) compared to the mass of dog food set from the circular plate (250 g ± 0.00 g), $t(18)=0.264, p=0.795$.

Table 9. Independent t-test Result

V. CONCLUSION

Based on the results, the following conclusions are drawn by the researcher:

- The percentage of successful trials of objective detection is 100%, the percentage of successful trials of the real-time clock is 80%, and the recorded recall reinforcement activation is 100%. In general, the automated dog feeder has successfully passed the test in terms of its functionality. The automated dog feeder has the potential to ensure that dogs are fed at the same time every day if the owner is not home.
- The percentages of successful trials of servo motors rotating about 90o, 180o, and back to the original position are all 100%. This means that the automated dog feeder has successfully passed the test in terms of its functionality.
- The mean of the actual masses of dog food dispensed from the automated dog feeder is 250.50 g.

- The actual mass of dog food dispensed from the automated dog feeder has no significant difference (250.50 g ± 5.99 g) compared to the mass of dog food set from the circular plate (250 g ± 0.00 g), t (18)=0.264,p=0.795.

Recommendations

For Further Research:

- Create a mobile application using IOT (Internet of Things) that can be used to adjust the scheduled feeding time and dispense food anytime even when the owner is not present
- Design a combined system that provides dogs with both food and fresh water in a single device.
- Create an auto-refill mechanism for the dog feeder's food storage. When the food is low, the system will refill the food storage.
- Create a portion-controlled system for the dog feeder, using a weight sensor (load cell) to accurately manage the food portion size.

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