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Design and Fabrication of an Automatic Pet Food Dispenser

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ABSTRACT

This study presents the design and fabrication of an automatic pet food dispenser system, aimed at providing controlled, precise, and timely feeding for pets. The system utilizes a 12V DC motor, a load cell for weight measurement, a 4x4 keypad for user input, an LCD for real-time feedback, and a real-time clock (RTC) for scheduling. The screw feeder mechanism driven by the DC motor ensures controlled dispensing, halting automatically when the load cell confirms the desired weight. An emergency function allows feeding outside regular intervals. Tests with two pet food types (small and large kibbles) showed a ±10% margin of error, demonstrating reliable functionality. This solution offers practical, energy-efficient automation for pet care, with potential for enhancements such as IoT integration and advanced power management.

1. Introduction

Caring for pets is an essential responsibility for owners, particularly when it comes to feeding. However, many pets, especially those in domestic settings, lack self-control over their eating habits, leading them to overeat if food is continuously available. This issue is exacerbated when owners must leave their pets for extended periods, creating a challenge for ensuring their pets are fed in a controlled and regulated manner. The need for automated pet food dispensers that provide scheduled and portion-controlled feeding has become increasingly relevant as pet ownership rises globally, particularly in urbanized areas where owners may be absent for long periods due to work or travel commitments [1].

Traditional gravity feeders are the simplest form of automatic feeders and rely on gravity to release food as the pet consumes it. These systems ensure that food is always available but fail to regulate portion sizes, which can lead to overeating and associated health issues such as obesity in pets [2]. Other types of automated feeders, such as programmable feeders, allow for scheduled dispensing but may still face challenges in accuracy and energy efficiency. Programmable systems can dispense pre-set amounts of food based on the owner's input, but they often lack features such as real-time monitoring and precise weight control, which are necessary for optimal pet health [3].

Smart feeders have emerged as a more advanced solution, incorporating features such as Wi-Fi connectivity, remote monitoring, and mobile app control. These systems offer the advantage of allowing pet owners to adjust feeding schedules and portions remotely, but they often require stable internet connections and can be expensive for some users. Moreover, issues such as food portioning accuracy, especially when dealing with different types of pet food, and power consumption remain key challenges that need to be addressed [4][5].

This study aims to bridge the gaps in existing pet feeder technology by designing and fabricating a fully automatic pet food dispenser that combines precise portion control, energy efficiency, and ease of use. By utilizing a load cell for accurate weight measurement and a screw feeder mechanism driven by a DC motor, the system ensures that pets are fed the correct amount of food at scheduled intervals. A Real-Time Clock (RTC) module tracks feeding schedules, while the 4x4 keypad allows for easy user input, making the system intuitive and adaptable to different pet sizes and feeding requirements. The system's energy-efficient design, powered by a 12V rechargeable battery, optimizes power usage, making it suitable for prolonged operation without the need for frequent recharging.

The rationale for this study lies in the growing demand for reliable, affordable, and energy-efficient solutions for pet care. With pets becoming increasingly integral to families worldwide, ensuring that pets receive the right amount of food at the right time, even in the absence of their owners, is crucial. The proposed solution not only addresses the need for portion control but also focuses on reducing energy consumption, making it suitable for extended periods of use, which is critical for households with busy schedules or frequent travel.

2. Methods

2.1. Design and Working Principle

The automatic pet food dispenser is designed to simplify the feeding process by dispensing a precise amount pet food (Solid and dry pet food such as kibbles) at set intervals, ensuring pets are fed on time even when their owners are unavailable. The system was built around an Arduino Uno microcontroller, integrating several components to achieve efficient and automated operation.

The design considers feeding requirement of dogs with adjustment provision to cover other pets as shown in Table 1. The machine is designed to be used for only solid foods, therefore a screw feeder attached to a DC motor will be used as the mechanism for dispensing the food.

Table 1: Feeding requirement of dogs based on size.

Dog size	Weight range	Daily food intake (Cups)	Approximate Weight (Grams)	Approximate Weight per Meal (Grams)
Small Dogs	5-15 lbs	1/2 to 1.5 cups	125 to 375 grams	42 to 125 grams
Medium Dogs	20-50 lbs	1 to 3 cups	250 to 750 grams	83 to 250 grams
Large Dogs	50-100 lbs	2 to 4 cups	500 to 1000 grams	167 to 333 grams

At the base of the dispenser is a load cell that measures the weight of the dispensed food. The user begins by entering the desired weight of the food (in kilograms) and the time interval (in hours) between feedings using a 4x4 keypad. This information is displayed on a 16x2 Liquid Crystal Display (LCD), which provides real-time feedback to the user.

Once the system is initialized, the motor, which controls a screw feeder mechanism, rotates to dispense food into the pet's bowl. To ensure accuracy, the motor runs for the first 30 seconds before the load cell starts checking the weight. This initial period allows food to settle into the bowl, avoiding false readings. After this, the load cell continuously monitors the weight until it reaches the user-set target weight, at which point the motor stops automatically.

The system also includes an emergency feature: pressing the "D" key on the keypad triggers an immediate food dispensing, without overriding the scheduled feeding intervals. This function is useful for feeding pets outside the normal schedule.

The Real-Time Clock (RTC) module is used to track time intervals between feeding cycles. Once the set time interval has passed, the system initiates a new feeding cycle by checking the current weight on the load cell and dispensing more food if necessary.

The dispenser is powered by a 12V battery, with energy efficiency considered by optimizing motor run time and implementing a delay between checks to avoid unnecessary power consumption. Additionally, the system is designed with a fail-safe mechanism that stops the motor if it runs for more than a specified period (5 minutes), preventing overfeeding or motor burnout.

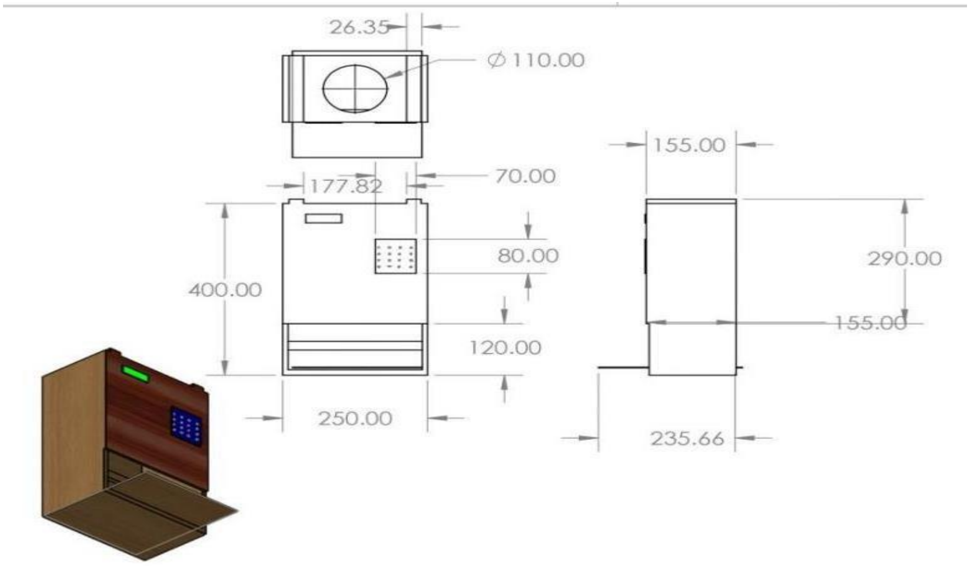

Figure 1: Orthographic projection drawing of the system.

2.2. Components and Specifications

The hardware and software components used in the design are detailed below:

2.2.1. Hardware Components:

- **Arduino Uno Microcontroller:** Handles input processing and controls peripheral devices.
- **DC Motor (12V)**: Drives the screw feeder mechanism for dispensing food.
- **Load Cell (20kg) with HX711 Amplifier**: Ensures precise weight measurement for dispensing accuracy.
- **4x4 Keypad**: Accepts user inputs for weight and feeding intervals.
- **16x2 LCD**: Displays system status and user inputs.
- **RTC Module (DS3231)**: Provides accurate timekeeping for scheduling.
- **L298N Motor Driver module**: Controls the motor and supplies regulated 5V power to the Arduino.
- **12V Battery**: Powers the motor and other components via the L298N.
- **Screw Feeder Mechanism** as shown in Figure 2 ensures controlled, uniform food dispensing.

The dispenser was constructed with all the components assembled as shown in Figure 3.

Figure 2: Dispensing mechanism, screw feeder attached to a DC motor.

Figure 3: Side and front view of feeder.

2.2.2. Software Tools:

- **Arduino IDE:** Used for programming and uploading code to the microcontroller.
- **SolidWorks:** Assisted in designing the dispenser's structure and screw feeder.
- **Cirkit Designer:** Used for circuit diagram development (figure 4).

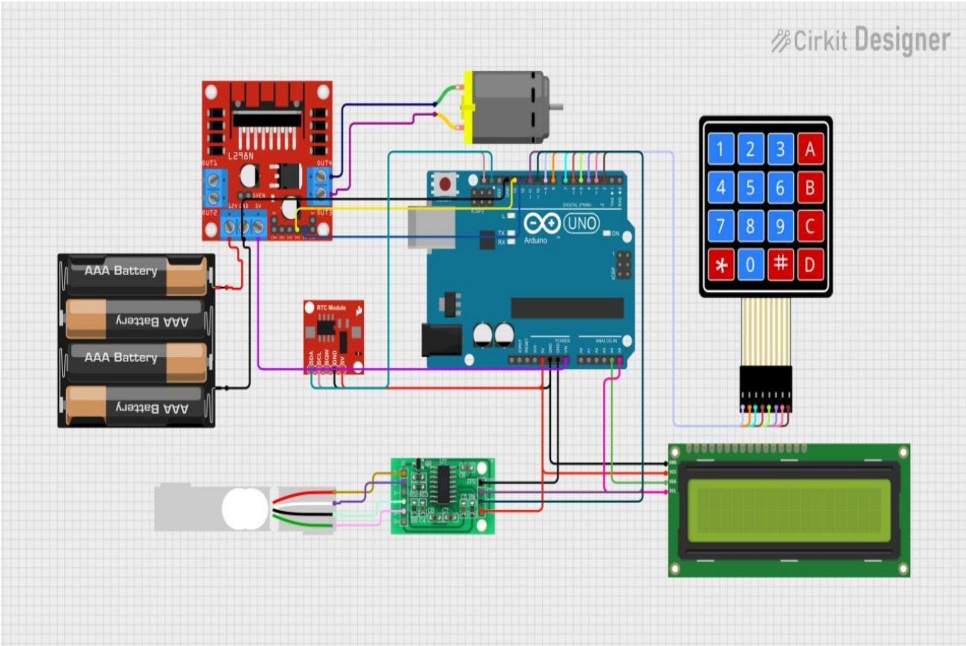

Figure 4: Circuit diagram, showing the wiring of all the components connected to an Arduino Uno.

2.3. Equations, Units and Acronyms

Key calculations were performed to ensure efficient and accurate operation of the system:

2.3.1. Screw Feeder Design

The screw diameter (D), pitch (P), Efficiency factor (0.4 to 0.5) (η) and speed (N) were calculated to achieve a dispensing rate of 0.2 kg/min. Using Equation (1), the screw diameter was determined to be approximately 58 mm.

$$Q = \eta \cdot D^2 \cdot P \cdot N \quad (1)$$

2.3.2. Motor Selection

Torque (T) and power (P) were calculated to select a motor capable of turning the sc rew feeder efficiently (Equation 2):

$$T = F \cdot D, \; P = 2\pi \cdot N \cdot T \quad (2)$$

The motor's rated torque was determined to be 1.2 kg·cm, sufficient for the screw feeder's load.

2.3.3. Load Cell Calibration

Calibration was conducted using a known weight of 0.2 kg. A calibration factor of 129,000 was determined experimentally using Equation (3):

$$\text{Weight} = \text{Raw Value} \times \text{Calibration Factor} \tag{3}$$

2.3.4. Error Percentage

Using the equation 4 below to calculate the percentage error for each test run:

$$error = \left(\frac{Actual\ weight - Target\ weight}{Target\ weight}\right) \tag{4}$$

2.4. System Assembly and Testing

The system was constructed using plywood for the body, with components securely mounted. The wiring was routed through a breadboard and connected to the Arduino. A series of tests were conducted to validate the system's performance, focusing on dispensing accuracy, system reliability and energy efficiency. Two types of dog foods were used to test this system, Food A (small kibbles) and Food B (large Kibbles).

2.5. Testing Procedure

- Power on the system and allow the components to initialize.
- Enter target weights using the keypad (e.g., 0.1kg, 0.3kg, 0.5kg).
- Place an empty container on the load cell.
- Measure the weight dispensed after each cycle and compare it with the input weight.
- Repeat each test multiple times to ensure consistent results.

3. Results and Discussion

3.1. Results

Two types of dog foods were used to test this system, Food A (small kibbles) and Food B (large Kibbles). Table 2 shows the values obtained from conducting the above testing procedure for both Food A (small kibbles) and Food B (large kibbles).

Table 2: Weight dispensing accuracy test data.

Test Run	Target Weight (kg)	Food A Actual Weight (kg)	Error (%) for Food A	Food B Actual Weight (kg)	Error (%) for Food B
1	0.10	0.11	10.00	0.09	-10.00
2	0.10	0.10	0.00	0.11	10.00
3	0.10	0.09	-10.00	0.10	0.00
4	0.20	0.21	5.00	0.19	-5.00
5	0.20	0.19	-5.00	0.21	5.00
6	0.30	0.32	6.67	0.29	-3.33
7	0.30	0.29	-3.33	0.30	0.00
8	0.40	0.38	-5.00	0.42	5.00
9	0.40	0.42	5.00	0.39	-2.50
10	0.50	0.48	-4.00	0.51	2.00

3.2. Discussion

The system is designed to dispense specific quantities of pet food based on user input. The testing focused on measuring how accurately the system dispenses food in the weight range of 0.1 kg to 0.5 kg, comparing actual dispensed quantities with the target weight as presented in table 2 and figure showing the values obtained from the testing procedure.

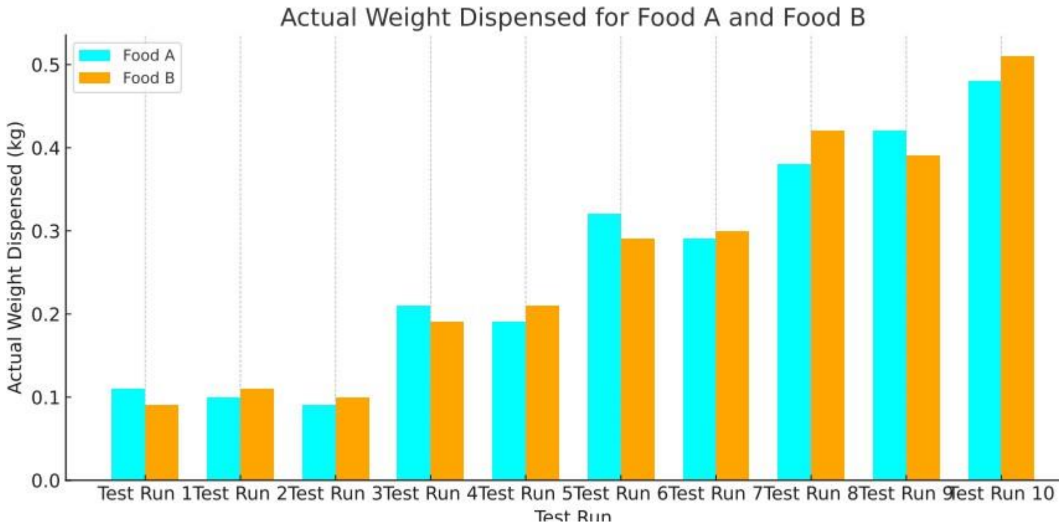

Figure 5: Bar chart comparing the actual weight of dispensed for food A and food B.

3.2.1. Small Target Weights (0.10 kg):

- Errors for both Food A (small kibbles) and Food B (large kibbles) reached ±10%, indicating sensitivities at lower weights.
- Over-dispensing was common at this range, likely due to calibration limitations for finer quantities.

3.2.2. Mid-Range Weights (0.20–0.40 kg):

- Accuracy improved significantly, with errors between -5.00% and 6.67%.
- Performance was stable, ensuring consistent feeding portions suitable for practical use.

3.2.3. Higher Weights (0.50 kg):

- Errors remained minimal, within -4.00% to 2.00%, reflecting reliable accuracy for larger portions.
- A slight under-dispensing trend was observed but remained within acceptable limits.

3.2.4. Comparison of Food Types:

- Performance was consistent across Food A and B, showing the system's ability to handle varying food shapes and sizes effectively.

The automatic pet food dispenser system demonstrated consistent performance across different food types and weight targets, with most errors falling within the acceptable ±10% range.

4. Conclusion

The system was successfully designed, built and tested an automatic pet food dispenser with features like a motorized screw feeder, load cell for precise dispensing, RTC for scheduling, and power optimization for efficiency. Developed using an Arduino and cost-effective, locally sourced materials, the system reliably dispenses food, responds to user input, and operates efficiently, meeting all research objectives. Future improvements include adding wireless connectivity, battery and food level monitoring, real- time alerts, and using easy-to-clean materials. These enhancements will increase functionality, convenience, and user control.

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