OUTDOOR SMART DOG FEEDER

ECE 445: Senior Project Design

Team 14

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1. Introduction

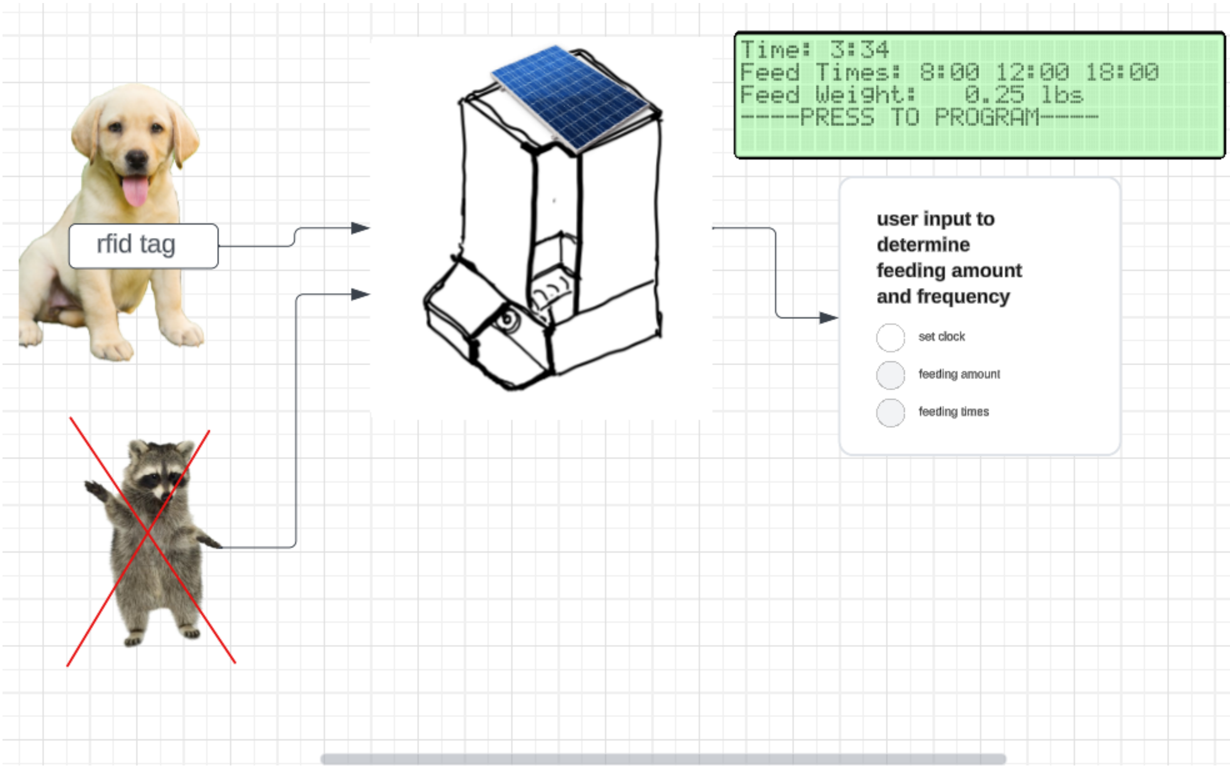
1.1. Problem

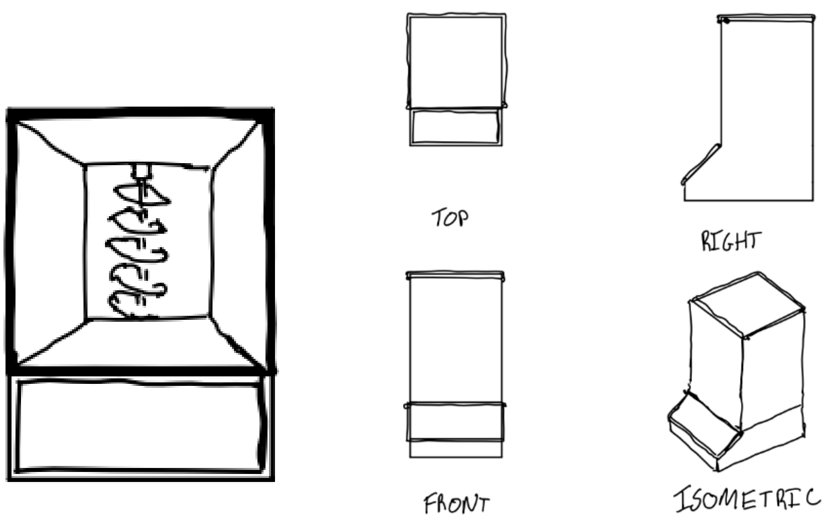
An automatic dog feeder can relieve a dog parent of the habitual task of refilling their pets' bowls. Due to work, travel, and other essential tasks that result in lengthy absences, it can be difficult to keep track of and complete on a regular schedule. Most dogs cannot be self-governed when it comes to how much food they eat and it results in gorging sickness, canine obesity, and sometimes death. An automatic dog feeder prevents these situations and ensures that the dog only gets the amount of nutrition they need throughout the day. The market for indoor automatic dog feeders is saturated with hundreds of brands and models; However, there are limited automatic dog feeders robust and adaptable enough for larger outdoor/part-time outdoor dogs.

1.2. Solution:

An improved automatic dog feeder will be effective for outdoor pets in which it operates from a battery. To allow for more versatile locations, the unit is powered by solar energy to maintain its functionality throughout long periods of time. Our dog feeder will distribute an accurate amount of food depending on the owner's input of the desired food amount per cycle, the dispensing time, and the current time to keep track. RFID tags will also be implemented to determine when the tray of the feeder opens, which assures that only the specified pet is approaching the feeder and prevents unwanted meal stealers. In all, this solution should eliminate concerns from pet owners as they can continue their responsibilities and travel while taking care of their pets at home.

1.3. Visual Aid:





1.4. High-level requirements list:

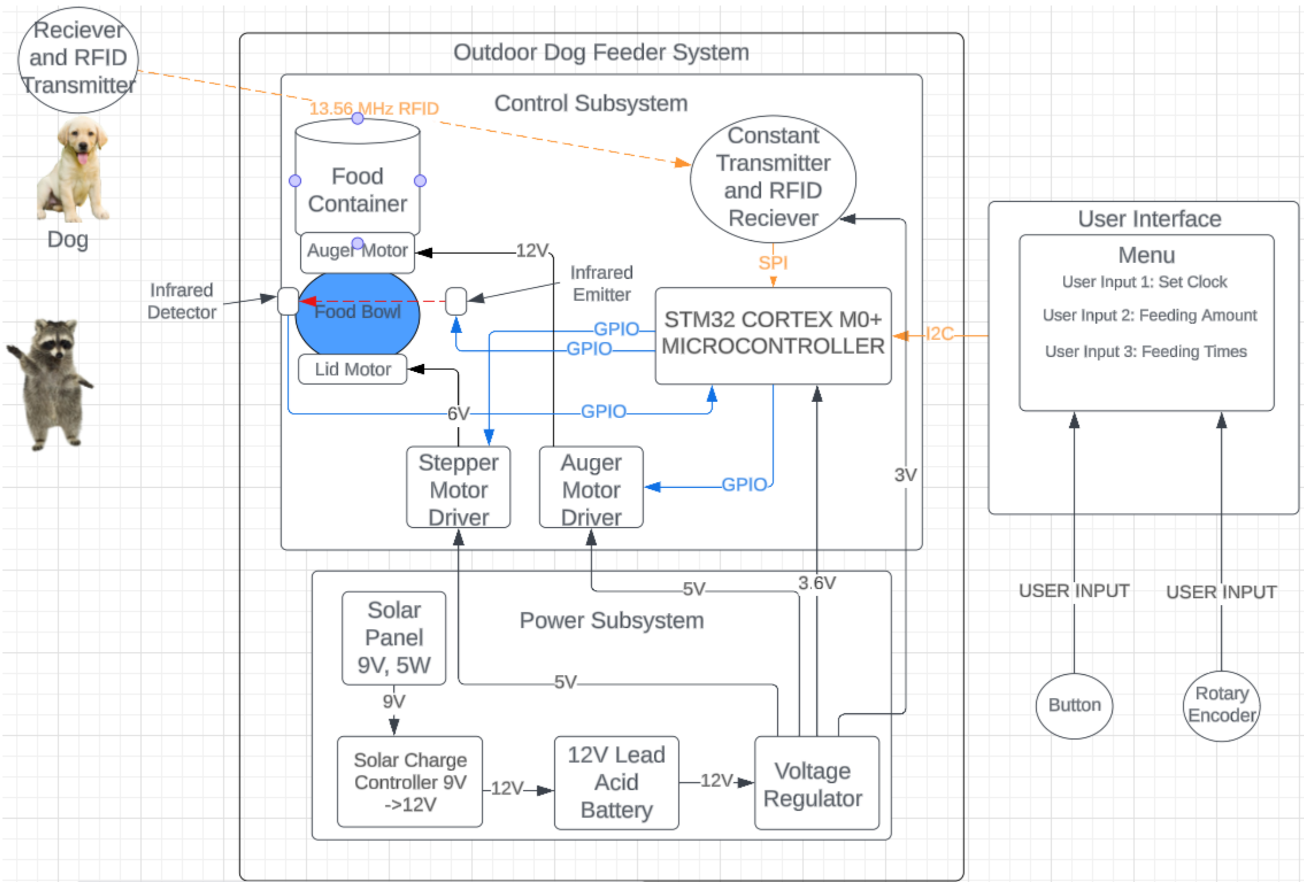
- Active RFID Communication- This requirement will be verified when the unit successfully transmits and receives a signal by the transponder on the collar. The MCU on the feeder will communicate a ‘request’ and receive a unique ID from the MCU on the collar. (Approximately 2 ft of range.)

- Programmable Controller- This requirement will be verified when the microcontroller receives and stores input from the user. Then use that input to activate motor controllers, RFID communications, display a menu, and utilize the IR sensor and emitter for closed-loop control.

- Power Management- The solar panel can provide energy under close-to-ideal conditions (8 hours of direct sunlight) to recharge the battery after a reasonable amount of operation (4 uses in a day). The battery will be able to supply enough power to drive the motors, transmitters and MCU.

2. Design

2.1. Block Diagram:



2.2. Subsystem Overview:

- **Control subsystem**:

  The control system consists of the Cortex®-M3 STM32F2 microcontroller, that needs to have area control over a network of the following devices. A 433MHz RFID transceiver, an infrared emitter, an infrared detector, a stepper motor driver, and a brushed DC motor driver. The RFID transceiver will transmit a 'seeking' signal during the eligible feeding times. Once the transponder tag is within the range of the seeking signal, the tag's STM32 receiver will relay a transmit signal to the micro controller which will then prompt the MCU to transmit a signal back to the feeder. The MCU then proceeds with opening the feeding tray. This is achieved by commanding the stepper motor drive to operate the stepper motor to a certain degree of angle which opens the lid. In addition, the microcontroller receives the current time (clock), dispense times, and the amount of food as user inputs through the LCD, rotary encoder, and pushbutton. From stored user input the microcontroller will send signals to the H-bridge DC motor driver to activate the auger motor to dispense food from the container-. To be specific, the amount of food and times per day is based on the user input. The infrared detector will send a signal to the microcontroller to stop the auger motor once the dispensed food reaches the maximum level (the level at which the food blocks the infrared light from being detected). This ensures the dog feeder does not overflow and discourages overeating.

- **Control subsystem requirements:**
  - The control system receives a signal from RFID (QIACHIP RX480e 433mhz), upon 2 feet, and sends a signal to the MCU which triggers the stepper motor driver to open or close the lid.
  - Based on user settings, the microcontroller will send a signal to the auger motor driver to drive the auger motor which controls dispensing dog food.

♦ **Power/Energy subsystem:**

The power subsystem supplies energy to the control subsystem through a 12V lead acid battery. To ensure consistent operation of the dog feeder, we will implement a 9V 5W solar panel with a 12V solar charge controller module to consistently charge the lead acid battery (EXP12180 12V 18Ah) once its energy decreases overtime. The voltage regulator in the power system ensures that all components receive the appropriate voltage.

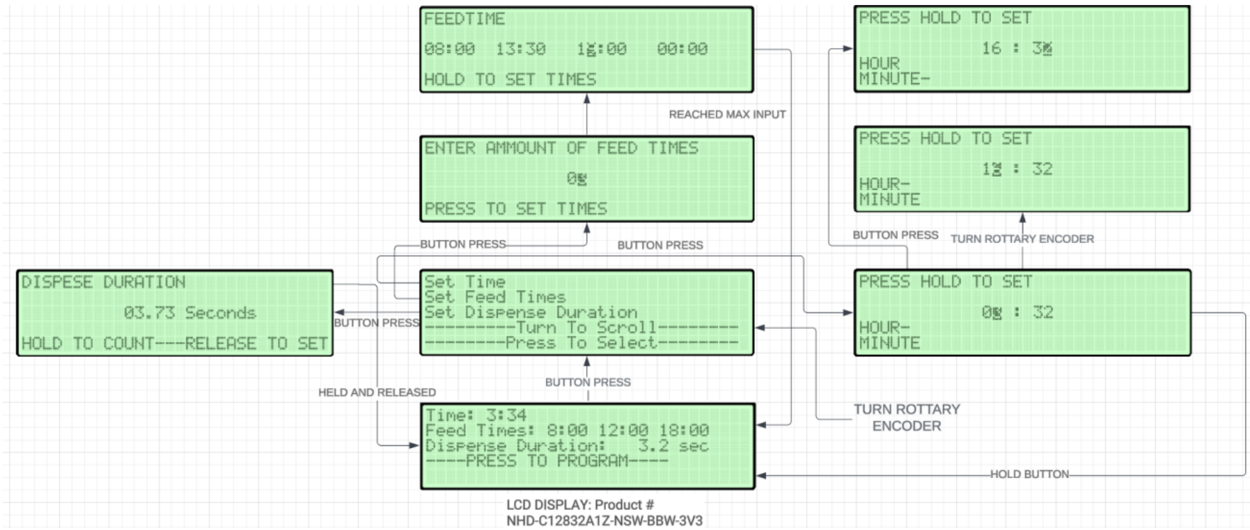
- **Power subsystem requirements:**
  - The solar panel should be transferring energy to the lead acid battery through a solar charge controller. Since the battery is at 12V, the solar panel should be 12V as well. To ensure the battery is sufficiently powered, the solar panel should have about 5W power.

- **Programmable subsystem:**

The programmable subsystem is the user interface that will ergonomically walk the user through the set parameters for how the dog feeder will operate. These parameters include time, feeding times, and dispense duration. The subsystem will accurately keep time increments of its clock cycle allowing the user to control the times the food will be delivered to the food bowl. The LCD screen will be the visual feedback of these settings. The inputs will be a rotary encoder for browsing and a push button for selecting. Users set the feeding quantity for each meal by holding the button to dispense and releasing the button to stop, and the food bowl is visible so the user can visualize and decide how much food they want to feed their dog for each meal. The system will record the time duration the auger runs for (dispense time) and store it as a global variable, then the microcontroller will automatically let the motor run for this long to dispense the similar amount of food at subsequent feeding times. Only when the user decides to set the dispense duration again, will the variable be updated.

- **Programmable subsystem requirements**
  - The MCU can receive signals from the rotary encoder and button. The rotary encoder lets the user browse through the menu and time options, and the button lets the user select. Holding the button for 3 seconds will return to the main menu.
  - Properly display a menu on the LCD screen from MCU configuration. Menu should include set time, set feed times, set dispense duration.

- **Visual Representation**



2.3. Tolerance Analysis:

An aspect of our design that may pose a risk towards the project's completion is the implementation of RFID communication between the dog feeder and collar. Our goal is for the dog feeder to allow access to the food bowl when the dog with the correct active RFID tag approaches the feeder within 2 feet. The challenges are designing and programming a collar to receive the signal from the dog feeder once in range and emit a signal in response. Our current idea is for the feeder to transmit a signal during eligible feeding times and then the dog’s collar receives the signal, passively listening till then. Once the dog has approached the dog feeder within 2 feet, the collar receives the feeder’s signal and then transmits its RFID signal for the feeder to receive and then triggers the motors to open the reciprocal.

Another critical component to ensure the success of the project is the power system. More specifically, we need to make sure the average total power intake is greater than the average total power consumption in one day, one week, or a month considering the weather impact. So, we perform an approximation for both power consumption and power absorption according to the components that we are using:

Energy Consumption (one day)			
	Power (W)	Operation time (h)	Consumption (Wh)
Microcontroller (active)	3.3V*50mA = 0.165W	1h	0.165Wh
Microcontroller (sleep)	3.3V*10uA = 0.000033W	23h	0.00076Wh
LCD	3.3V*20mA = 0.066W	0.08h	0.00528Wh
Stepper motor driver	5V*0.2A = 1W	0.0056h (5s*4=20s)	0.0056Wh
Auger motor driver	5V*0.2A = 1W	0.0056h (5s*4=20s)	0.0056Wh
RFID module	3V*10 mA = 0.03W	0.0056h (5s*4=20s)	0.000168Wh
Infrared emitter	0.075W	0.0056h (5s*4=20s)	0.00042Wh
Infrared detector	0.075W	0.0056h (5s*4=20s)	0.00042Wh
Total	N/A	N/A	0.183248Wh

Solar Power Supply and Battery Capacity			
Battery Capacity	12V*18Ah =216Wh		
	Maximum Power	Average peak sunlight hours (one day)	Energy generated (one day)
Solar Power Supply	1.2W	4h	4.8Wh

As we can see, the approximated energy consumption in one day is 0.183248Wh and the energy generated by the solar panel on average is 4.8Wh. It’s obvious that the energy generated is way more than the energy consumed. Even during the worst weather days where there’s no sunlight exposure, the battery will not deplete fast due to its relatively big capacity. So, it’s safe to say the power system should guarantee the success of the project.

Last but not least, to ensure the success of our project, the appropriate food dispensing process cannot be ignored: since we are utilizing infrared emitter and detector to prevent food overflow (when the food dispensed reaches the level at which the IR receiver is blocked, it sends a signal to the controller to stop dispensing), we have an estimated maximum amount of food allowed to dispense, which is around 60mL (about a quarter cup). Since we manually set the maximum dispensing level that is appropriate for even the biggest dogs with great appetite, the discrepancy will not significantly impact on the overall functionality e.g. the dog would not be overeating by just dispensing 5mL more. Therefore, we set the tolerance to be +/- 5mL.

3. Ethics and Safety

- Non-Discrimination (ACM Code): The feeder should be equally effective for different breeds and sizes of dogs, ensuring it does not favor certain pets over others. This means that we are going to design a feeder to be adaptable for a wide range of dog sizes, which includes several factors:
    - Approximate size of unit: 3 foot tall, 2 foot wide, 2 foot long
    - Weight of unit plus feed: ~80 lbs
- Safety and Welfare (IEEE Code): The wellbeing of dogs must be a primary concern. We aim to ensure that the feeder operates safely under various conditions through rigorous testing and quality control.
- Sustainability (IEEE Code): Using solar energy is a sustainable choice, but we also want to consider eco-friendly materials and design the product for longevity and recyclability.
- Food Safety Standards: The material in contact with dog food is galvanized steel, which meets FDA standards for food safety.

- Electronic Safety Standards: In our design, we estimate that the potential electrical hazards are relatively low since we are using a power subsystem isolated and separated from the main system and outdoor environment. One thing to note is that the lead-acid battery may cause explosions if it is sealed since it releases gases like hydrogen and oxygen which could potentially cause explosions. To prevent that, we will implement a vent next to the battery to make sure gases don't accumulate.
- Animal Welfare Regulations: We want to consult with legal experts to ensure compliance with all relevant animal welfare laws, which may include state and federal regulations regarding pet care products.
- Potential Safety Concerns:
    - Software or hardware malfunction that leads to overfeeding or underfeeding
    - Weather resistance
    - Emergency backup (system failure, power outage, etc.)
    - Regular maintenance (food tray cleanup, power system checkup, etc.)

4. References

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