Automatic Food & Water Dispensing System for Pets

Design Document - Fall 2022

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Team 21

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1 Introduction

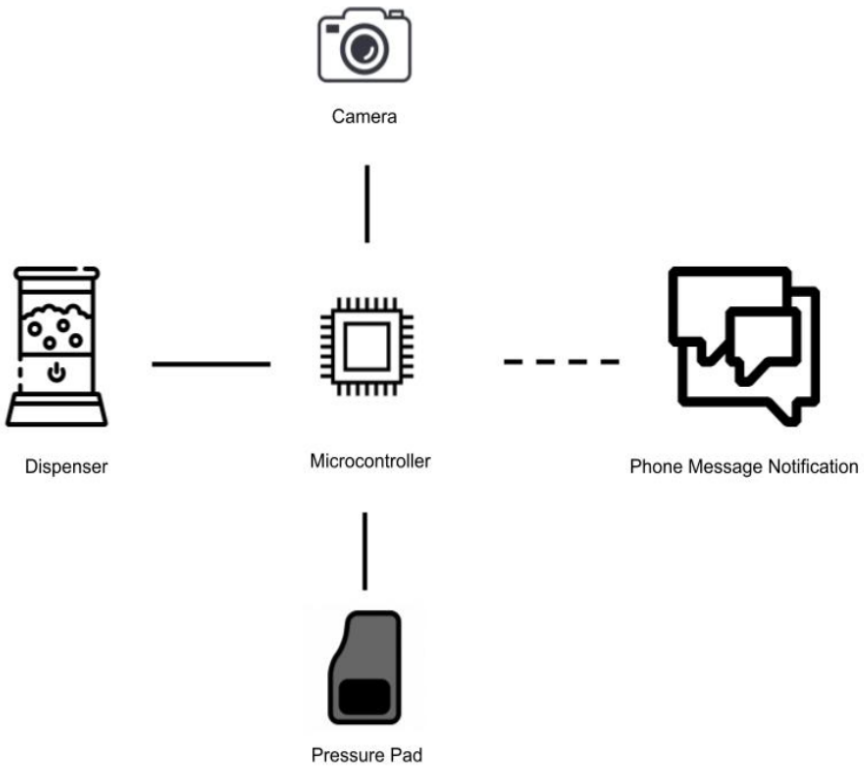
1.1 Problem

Tyler's friend Andrew is a recent college grad who is now working full time. Andrew has a pet cat that he has trouble feeding while he's away at work because he does not want to leave food and water out while he is away from home. Andrew would like a way to automatically feed his cat with the peace of mind of not overfeeding, while also knowing how much food and water his cat is consuming throughout the day. Lastly, Andrew would like to be provided updates on when the food/water bowl needs to be refilled and how much needs to be dispensed.

1.2 Solution

The solution to this problem is to design an automatic dispenser setup that delivers food and water to the user's pet. Our solution will involve a couple of subsystems in order to provide users' pets with the most comfort and care. Each dispenser is purposed for a single pet. The first and main subsystem will revolve around a pressure pad/sensor that will act as the main trigger for the dispensing system. The pressure pad can be customized to a certain weight range for the specific pet and while configure the amount of food and water needed based on those specifications and the breed of the pet itself. The next subsystem involves the dispensing mechanism for food and water.

1.3 Visual Aid



1.4 High-Level Requirements

These three requirements outline what's most important towards building a successful and optimal food/water dispensing system:

1. **Accuracy:** We want there to be easy communication between the user and when a pet interacts with the dispensing system. This will be judged by the accuracy of the dispensing system to provide food to the pet, as well as how accurate the measurements of the pet's weight are.

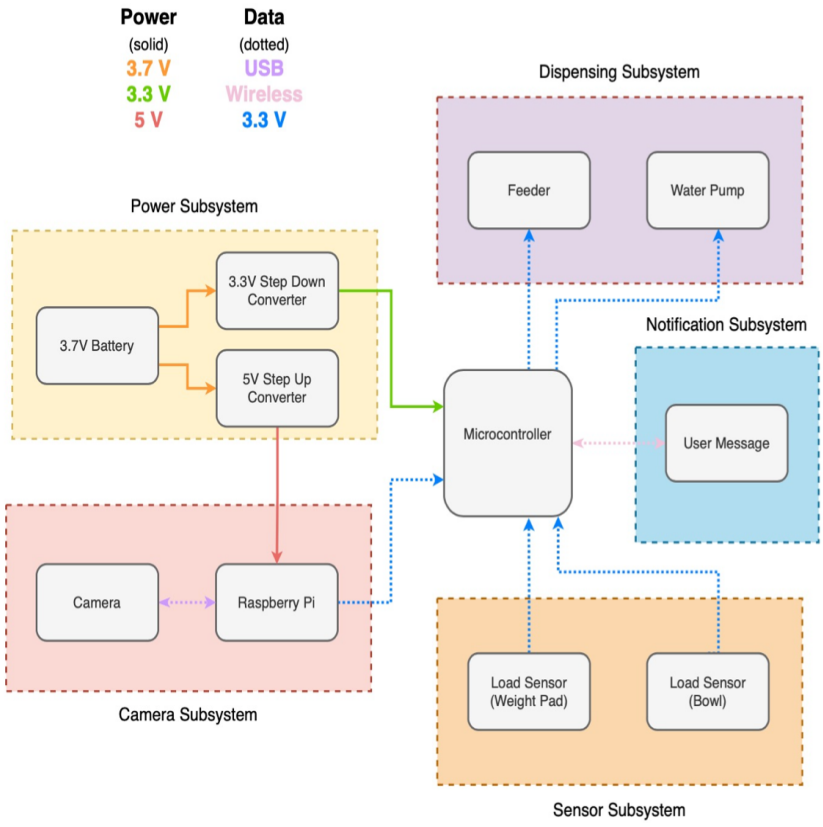
2. **Timeliness:** The user's ability to react when a pet interacts with the dispensing system will depend on how quickly these updates can be sent. The pet's weight, the amount of food/water

to be dispensed, as well as the updates corresponding to these actions need to be fast enough for any situation that may occur.

3. **Adaptability:** The dispensing system must be able to account for a variety of scenarios in order to ensure the safety of the pet and to maintain the user's trust. This includes having the right contingency plan when the pet does not step onto the weighing scale long enough or when a refill is needed or even when the dispensing system malfunctions.

2 Design

2.1 Block Diagram



2.2 Physical Design

For our food dispensing system, we will have a refillable container that will have an opening with tubing and then our Servo Motor that will control the dispensing of the food from the container. This will directly fill food into the food bowl, with tubing ending right by the bowl so there will be low risk of food spilling out of the container.

For our water dispensing system, we will have a refillable water jug that will have an opening that we will attach our water pump to. This will be controlled by our micro controller and will dispense water right to the water bowl. Similarly, the tubing will go right to the water bowl so there will be a low risk of splashing.

For our weight detection, we will put our load sensors under our weight pad. There will be four load sensors, with one each near the corners of the weight pad. This way we can evenly distribute the load sensors about the weight pad to compensate for the pet putting their weight on any part of the weight pad.

We will also put one load sensor under the food bowl and one load sensor under the water bowl. Each sensor will be put under the center of the bowl and will give us data that can allow us to calculate how much food or water the user's pet has consumed.

2.3 Subsystem Overview/Requirements

2.3.1 Dispensing Subsystem

DC Servo Motor

The motor will be connected to the micro controller and will control the sliding doors for the food and water containers. Its power will be supplied by the power subsystem and will require 5V.

1. The motor should be able to push or rotate the door at a precise amount proportional to the opening of the container to control rate of dispensing.
2. The motor must be powerful enough to move the door with 5lbs of food weighting the door

down.

3. The motor must be able to be controlled by the micro controller.

Food/Water Containers

The containers will be used to store dry food and water for dispensing and will have the sliding door attached to its opening.

1. The containers need to be able to store 5lbs of food or water.

2. The containers must have a spout that is able to be closed by the door.

Water Pump

The water pump will get 5V of power from the power subsystem and dispense water out of the water container into the bowl. The water pump will be in the spout of the container.

1. The water pump must be able to be turned on or off by the micro controller.

2.3.2 Camera Subsystem

Raspberry Pi 4 Model B

The Raspberry Pi connects to the camera and captures photos when the load sensor of the weight pad is activated. The Pi should be able to power the camera and control it to take pictures of the pet when it is on the pad to eat or drink. The Pi then sends the photos to the user through the notification subsystem.

1. The Raspberry Pi must be able to power and connect to the camera.

2. The Raspberry Pi must capture photos through the camera in response to the pad load. sensors.

Camera

The camera will be powered by the Raspberry Pi and positioned to have the pressure pad and pet in frame when capturing photos.

1. The camera should be able to take colored photos with a minimum of 720p resolution. sensors.

2.3.3 Power Subsystem

3.7V Lithium Battery

The 3.7 V Lithium Battery will supply power to our components. No components are directly connected to the battery, instead converters adjust the voltage to 3.3V or 5V in order to supply the correct voltage to our components.

1. The 3.7V Battery should be able to supply at least 3.7V +/ 0.1V. sensors.

5v Step Up Converter

A 5V step up converter will take the 3.7 Lithium battery as input, and supply the Raspberry Pi with 5V of power

1. The 5V step up converter should be able to supply at least 5V +/ 0.1V.

3.3V Step Down Converter

A 3.3V step down converter will take the 3.7 Lithium battery as input, and supply the micro controller with 3.3V of power

1. The 3.3V step down converter should be able to supply at least 3.3V +/ 0.1V.

2.3.4 Sensor Subsystem

Load Sensor (Weight Pad):

The Load Sensors in the weight pad will be used to determine whether the owner's pet is on the weight pad. The data from the sensor will be sent to the micro controller to determine whether the sensor reading should trigger the dispensing subsystem to dispense food and water to the bowls.

1. This load sensor should be able to accurately determine the weight of the pet +/- 0.1kg up to 50 kg.

Load Sensor (Bowl)

The Load Sensors in the bowl will be used to determine the amount of the food or water has been consumed by the pet. The data from the sensor will be sent to the micro controller to calculate how much food or water was consumed based on data from the dispensing system versus the amount of food or water in the bowl.

1. This load sensor should be able to accurately determine the weight of food or water in the bowl +/- 0.1kg up to 50 kg.

2.3.5 Notification Subsystem

Notify API

The Notify API which is platformed through Twilio, will be used to send the user notifications through SMS about how much food and water has been dispensed to the pet and if a refill is required. Additionally it will send a picture of the pet interacting with the dispensing system. The user can then contact the appropriate individual to go in and refill the food. If after a certain time, the micro controller finds that the dispensing system has not been refilled it will alert the user again.

1. The API should be able to send notifications instantly after the dispensing actions have been completed.
2. The API should interact with the micro controller such that it extracts the correct statistics about how much food and water has been dispensed and then sends this to the user.

2.4 Tolerance Analysis

Servo Motor Torque

The main specification that needs to be addressed is the sliding door that will release the pet food into the bowl. This sliding door will be moved by a servo motor. We will use a digital servo motor from HiWonder.

The torque on this servo motor is 20kg*cm. The amount of food in the container will be weighing down the sliding door and the servo motor must have enough torque to rotate the door even with the weight of the food. We can use:

$$N = \tau / r$$

First, we get the radius by considering the size of the spout of the food container. We will use a 2 inch by 2 inch door to cover the spout of the food container. Therefore, the radius will be 2 inches.

$$r = 2in * (2.54cm/1in) = 5.08cm$$

We find the total weight the motor will be able tolerate is:

$$N = \tau/r \ = (20kg * cm)/5.08cm = 3.93kg$$

The food container we will use will hold a maximum of 2.5 liters of food, which will never exceed 3.93 kg of dry foods.

3 Cost and Schedule

3.1 Cost Analysis

The total cost for all parts required for this project before shipping is $168.2. With shipping costs adding another 5% and sales tax being 6.25%, these extra costs tack on $18.92. We can expect a salary of $50.48/hr x 3 hours x 45 = $6,814.80 per team member. Since our team has 3 people, this means we have $6,814.80 x 3 = $20,444. With the cost for the parts being $187.12, this comes out to a total project cost of $20,631.12.

Costs			
Description	Manufacturer	Quantity	Extended Price
20KG Digital Servo Full Metal Gear High Torque	Lewansoul	1	$15.98
Pet Food Storage Container	Pission	1	$11.99
Pet Water Fountain Pump Replacement	Chewy	1	$5.95
Suteck Plastic Access Panel	Suteck	2	$9.94
Raspberry Pi 4 Model B/2 GB	PiShop.us	1	$45
OB5647 Camera Sensor Raspberry Pi Platform Evaluation Expansion Board	Digi-Key Electronics	2	$45.98
702528 3.7 V Lithium-Ion Battery Rechargeable (Secondary) 500mAh	Digi-Key Electronics	1	$6.49
Pololu 5V Step-Up Voltage Regulator U3V12F5	Polulu	1	$45
ETA9740 Battery Charger Power Management Evaluation Board	Digi-Key	1	$4.90
Half-bridge strain gauge Load Cell Body Scale Weighing Sensor Amplifier	Onilab	2	$15.98

3.2 Schedule

Project Schedule		
Week	Task	Person
September 26th - October 2nd	Finish Design Document	Everyone
October 3rd - October 9th	Order Parts for Prototype	Joseph
October 3rd - October 9th	Start PCB design Start Power System Design	Tyler
October 3rd - October 9th	Start 3D print designs	Abhi
October 10th - October 16th	Check Parts and Compatibility	Joseph
October 10th - October 16th	Finalize Power System Start Load Sensor	Tyler
October 10th - October 16th	Print First 3D print versions Start camera attachment	Abhi
October 17th - October 23rd	Finish PCB designs	Joseph
October 17th - October 23rd	Finish Load Sensor Pad/Bowl Implementation	Tyler
October 17th - October 23rd	Camera/Sensor Communication Print First 3D print versions	Abhi
October 24th - October 30th	Order PCB	Joseph
October 24th - October 30th	Revisions	Tyler
October 24th - October 30th	Mobile Device Communication	Abhi
October 31st - November 6th	PCB Revisions	Joseph and Tyler
October 31st - November 6th	Device notification system	Abhi
November 7th - November 13th	Finalize Notification system	Everyone
November 14th - November 20th	Mock Demo and Final Testing	Everyone
November 28th - December 4th	Final Demo	Everyone
December 5th - December 8th	Final Presentation	Everyone

4 Discussion of Ethics and Safety

The IEEE Code of Ethics states the need to uphold safety, health, and welfare of the public. The goal of our project is to automatically dispense sustenance for the pet and give the user a better understanding of the well-being of their pet when they are away. While the project should greatly help users with taking care of their pet, it is not a complete substitute for the care of the pet. The owner is responsible for the overall understanding and care of the well-being and health of their pet. To uphold the Code Ethics, we will explicitly warn users of this.

IEEE Code of Ethics states in Section 1.5 that members must be committed to seek and accept honest criticism of their work and correct their errors. To uphold this code, we will communicate with TA's and the professor during the whole process of creating our project. We will carefully listen to criticism and be thoughtful and quick to fix errors that arise during development.

As team members, we will strive to uphold Section II and III of the IEEE Code of Ethics by making sure members of the group and the TA is being treated fairly and with respect and that there is no harassment or discrimination.

With the system taking pictures and sending them to a mobile device, as a group, we will make sure that the pictures are being securely sent to the user and privacy of the user is kept.

References

@miscweb:lang:stats, author = IEEE, title = IEEE Code of Ethics, year = 2022, note = Last accessed 28 September 2022, url = https://www.ieee.org/about/corporate/governance/p7-8.html