Purrfect Cat Care

Initial Project and Group Identification Document
Divide and Conquer

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Group 18

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1 Narrative Description

Waking up every morning with small paws walking across the bed or a cold nose to the hand can be very rewarding if you are a pet lover. According to the 2017–18 National Pet Owners Survey approximately 84.6 million homes own a pet (APPA). The friendly, playful, loving and independent qualities of cats make them a fantastic companion. While independent, cats rely on their owners to satisfy the basic needs of food, water, shelter, and welfare. Taking care of an animal can be a demanding job, but pet owners have a responsibility to keep the animals safe and healthy. Maintaining the health of one's cat can be an especially difficult task. Due to their independence, and subtle behaviors, it is often difficult for pet owners to notice the subtleties of their actions. Differences in eating, or water intake typically go unnoticed, and over time may lead to a trip to the vet. Hence, developing a product to track an animal's feeding, hydration, and liter box habits is the perfect avenue to blend convenience with functionality.

The goal of our project is to provide cat owners a convenient and completely automatic way to track their cat's health, while also filling the role of other automatic cat chore systems. We want to create a reliable, autonomous, and easy to use monitoring system that handles many of the common chores associated with keeping cats. The system must also be able to detect small changes in the cat's behavior. In order to meet these goals, the Purrfect Cat[1] Care system will consist of four main subsystems: the feeding station, water station, waste station, and base station.

The feeding station will handle the food intake of the cat. To be autonomous, it will dispense a user-determined amount of food at regular intervals throughout the day, similar to off-the-shelf cat feeders. However, it will also measure the amount of food the cat eats. Changes in a cat's diet can be indicative of numerous feline diseases, including diabetes, digestive problems, and dental problems. By tracking the weight of food consumed each day by the cat, increases or decreases in appetite can be detected.

The water station serves a similar role. It will automatically pour the cat's water supply to keep the owner from having to provide fresh water each day. It will also track how much water the cat drinks each day to ensure that the cat is adequately hydrated. A lack of hydration can be a symptom of diseases like diabetes or kidney disease.

The waste station will consist of an automatic litter box that automatically cleans itself. We will add on to this litter box an array of sensors to detect how often the cat uses the litter box and what type of waste it is producing. Changes in litter box habits and waste production can indicate digestive issues, urinary tract infections, and other diseases in cats.

All the information collected from each station will be sent to a central base station for recording and processing. The base station will calculate statistics of the cat's behavior, such as mean and standard deviation, and can detect outliers that might indicate health problems (Llera). The base station will also present a simple interface to the user that shows their cat's history and current statistics as well as allow the user to control the feeding system.

[1]"Cover image courtesy of Thingiver user AllCoffeeShop; `https://www.thingiverse.com/thing:2546710`

2 Current Market

The current market of cat care automation favors cost and convenience above all else. For most use cases, these two parameters should be the primary concern. This has led to the overwhelming supply of automatic pet feeders, water bowls, and litter boxes on the order of $30 to $300 to flood the market. Many devices offer week-long food and water storage, and up to 50 automatic litter box cleanings. These capabilities offer a convenient experience to the owner, however, they lack significant innovation across the market. Our implementation aims to take it a step further through our data collection capabilities. Tracking quantities such as food and water intake, as well as litter usage provides a breadth of information for owners and veterinarians. Hopefully our proof of concept may become standard practice in order to save the lives of cats whose ailment may have been caught too late otherwise.

3 Requirements Specifications

The requirement specifications for this project are broken down by system. There will be slight overlap between various systems, but we have included it this way to emphasize that each subsystem is independent from one another.

System	Description	Value	Unit
Food:	Dry Food Storage Capacity	7	Day
	Maximum Dry Food Storage	1	kg
	Maximum Dry Food Distribution	80	g
	Sample Period	1	Hour
	Maximum Dispensing Delay	<2	Minute
	Weight Error	<±2	% of T.S.
	Minimum Feeding Interval	1	Hour
	Maximum Operating Power Draw	<20	Watt
Water:	Water Storage Capacity	7	Days
	Maximum Water Storage	1.5	L
	Maximum Water Distribution	50	ml
	Sample Period	1	Hour
	Maximum Dispensing Delay	<2	Minutes
	Volume Error	<±2	% of T.S.
	Minimum Dispensing Interval	1	Hour
	Maximum Operating Power Draw	<20	Watt
Waste:	Maximum Operating Power Draw	<20	Watt
	Minimum Cleanup Delay	1	Minute
	Maximum Cleanup Delay	10	Minute
Base:	Maximum Operating Power Draw	<5	Watt
	Data History	12	Month
	Communication Delay	< 5	Second
	Website Size	< 2	Page
	Onboard Memory	< 64	GB

Table 1: Requirement Specifications per subsystem.

4 Constraints

As with the requirement specifications, the constraints have also been divided into subsystems. The list below also includes common constraints such as time and cost due to their overwhelming presence and emphasis within Senior Design. There is only one note worthy constraint from a whole-system perspective, the ability to track a single cat's behaviors. The remaining list of additional constraints is provided below:

System	Description
Feeding:	Motor must be used to drive the dispenser's feeding mechanism.
	Weight sensor will be used to measure the weight of food in the bowl.
	System controller will be used to drive the motor, sensor, and collect data.
	Serial data interface will be needed to transmit data to the microcontroller.
Water:	Pump will be used to drive liquid into the bowl.
	Flow sensor will be needed to measure the water's flow.
	Weight sensor will be used to measure the weight of water in the bowl.
	System controller will be used to drive the pump, sensors, and collect data.
	Serial interface will be needed to transmit data to the microcontroller.
Waste:	Temperature and humidity sensor will be used to determine urination or defacation.
	System controller is needed to drive the sensor and collect data.
	Serial interface will be needed to transmit data to the microcontroller
Base:	Wireless communication interface will communicate between subsystems
	Database must be used to efficiently store cat health history.
	Server is required to interface the user interface with the database
	A user interface is needed to allow input of portion size, timing, and health history
All:	Wireless communication module will transmit data back to the base station
	Wall power plug must power each of the four systems.

Table 2: System constraints per subsystem.

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5 House of Quality

The house of quality below has been adapted to focus on what is believed to be the key factors influencing this project.

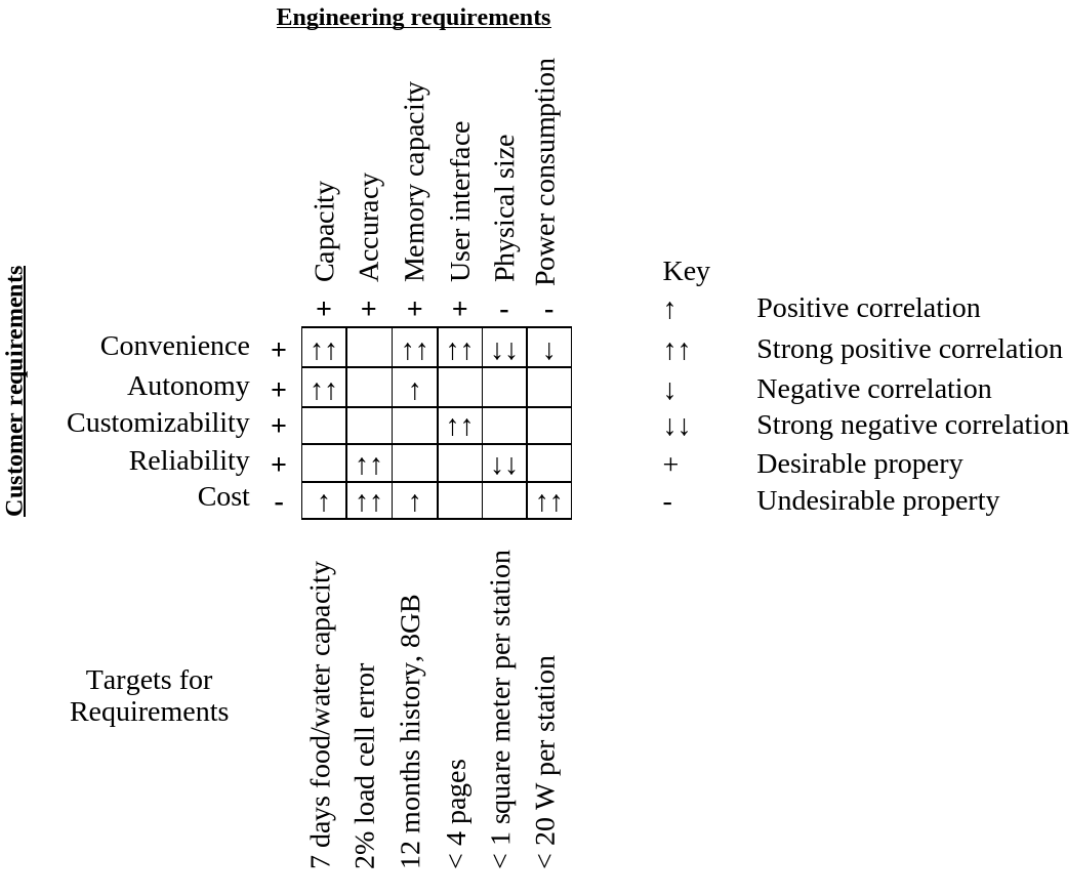

Figure 1: House of quality diagram

6 System Block Diagram

6.1 High Level:

At the top-most system level, four subsystems will operate independently. Each subsystem will communicate with the base station through a wireless communication protocol such as WiFi or Bluetooth. Included in the figure below is a fairly straightforward diagram, however, each system will be discussed in further detail. The legend in the figure below will be used across each subsystem. There will be several common blocks throughout each subsystem, while redundant, they have been included to provide an accurate subsystem diagram.

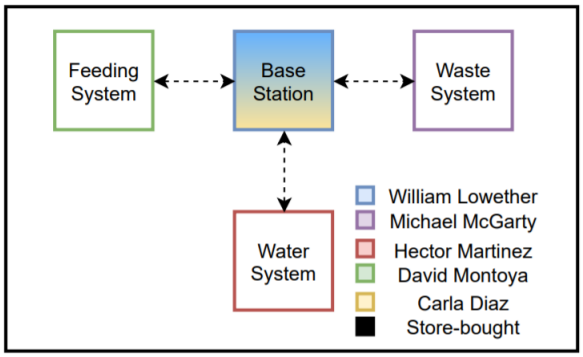

Figure 2: System overview and color key

6.2 Base Station

The base station will be the heart of the entire system. It will host a database to store recent data from the several subsystems, issue commands to each system, and host a web server for the user to access their pet's health information. On the web site will be recent data of the pet and inputs to change the feeding schedules and amounts.

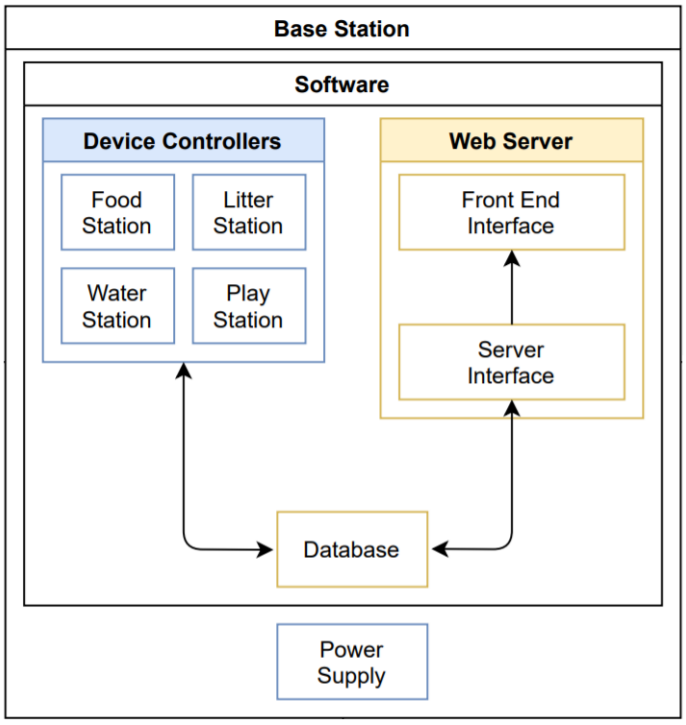

Figure 3: Base station block diagram

6.3 Feeding Station

There is some significant mechanical contribution within this project. A motor will be necessary to drive a certain weight of food into the bowl. It is planned to purchase the motor,

attachment hardware, any proprietary motor drivers, the food dispenser, and a bowl. The emphasis of this system is in controlling and accurately measuring the amount of food delivered to the cat, and how much the cat has ingested over time; not the mechanics.

A force, or pressure, transducer will be necessary to determine the weight of food currently in the bowl. Preliminary research has led us to strain gauge load cells as a reliable choice, hence its inclusion into the block diagram. However, research is still being done into alternative devices. WiFi is currently the working decision of wireless protocol, but some wireless module will be needed to transmit recorded data back to the base station. An on-board system controller will facilitate the data collection, data transmission, and driving of all mechanical components.

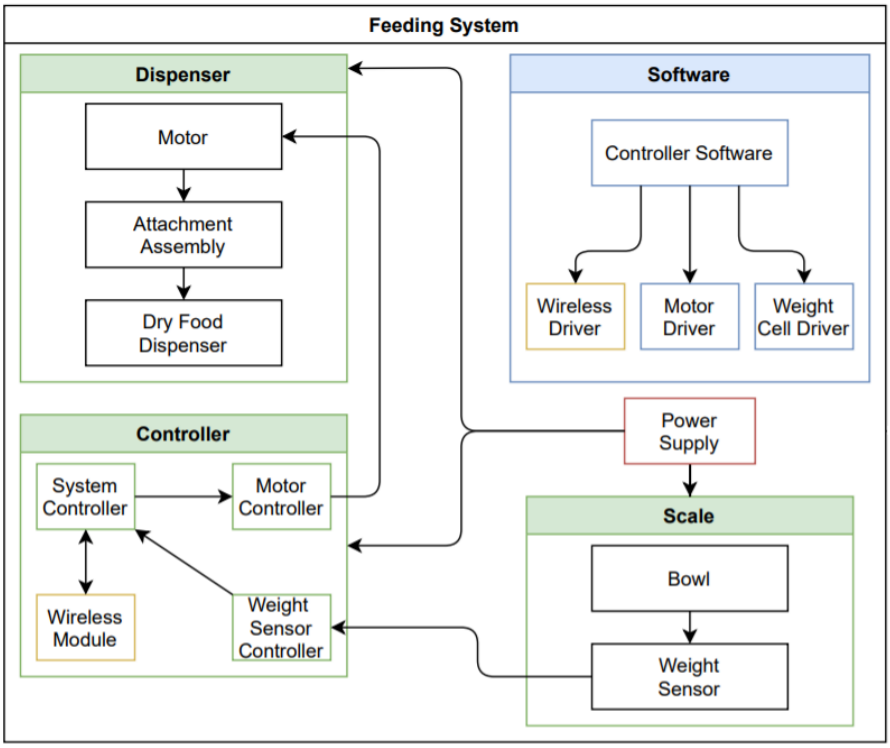

Figure 4: Food station block diagram

6.4 Water Station

The water system functions very similar to the feeding station. The system currently relies on two measurements to determine water intake, weight and volume. A water flow sensor, and load cell will be used in tandem to measure both the weight and flow rate while dispensing the water. This redundancy is needed to ensure the proper quantity of water is dispensed. Using purely the load cell would introduce a delay, resulting in more water being dispensed. Integrating the flow sensor with pump will minimize this delay, increasing the accuracy of the system to dispense water over a specific duration.

The load cell may seem redundant, however, it will be necessary to track long-term water changes. The flow sensor provides short-term accuracy on how much water was dispensed, but

is unable to track how much the cat has ingested. These two data points will allow continuous replenishment of the water in the bowl to ensure that a cat is never without water. A surprising benefit of this design is encouraging the cat to drink more water. Studies have shown that cats prefer to see the bottom of their water dish, and will be sometimes hesitant toward drinking from deep bowls.

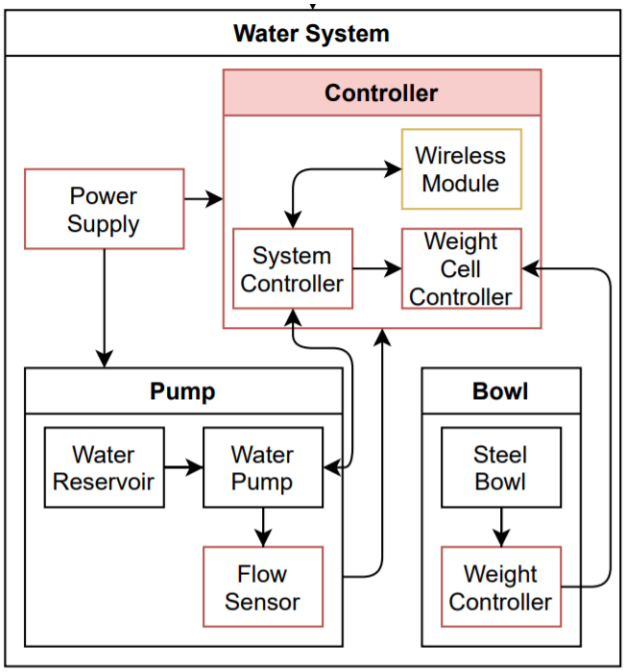

Figure 5: Water station block diagram

6.5 Waste System

While arguably another mechanics-heavy system, the waste station may arguably be the simplest component of the project. A group member currently owns an automatic pet feeder which will be used as a base. Implementing the mechanism from scratch would place this project beyond the scope of a senior design project. Hence, we have opted to use the prebuilt liter station and append data collection capabilities to it. The designed system will not interface directly to the litter box. While a simpler implementation, it is very likely that the driver PCB will be broken in the process. With most automatic feeders on the order of $100-200$, having to purchase another litter box due to accidental shorting, or other electrical mishaps is not an option.

The additions to the waste system will be some sensor to detect if the cat has entered the litter box. Upon detection, a counter is updated within the system controller and a humidity sensor is activated. The humidity sensor will detect an increase in humidity if the cat is urinating. Therefore, the sensor allows the system to determine if the cat is urinating or defecating. The system will not need to drive the motor due to the litter box's built-in detection. As for the firmware, implementation will be simple. An internal counter keeping track of the number of uses, a way of encoding usage type will be needed, and the information will be sent to the wireless module.

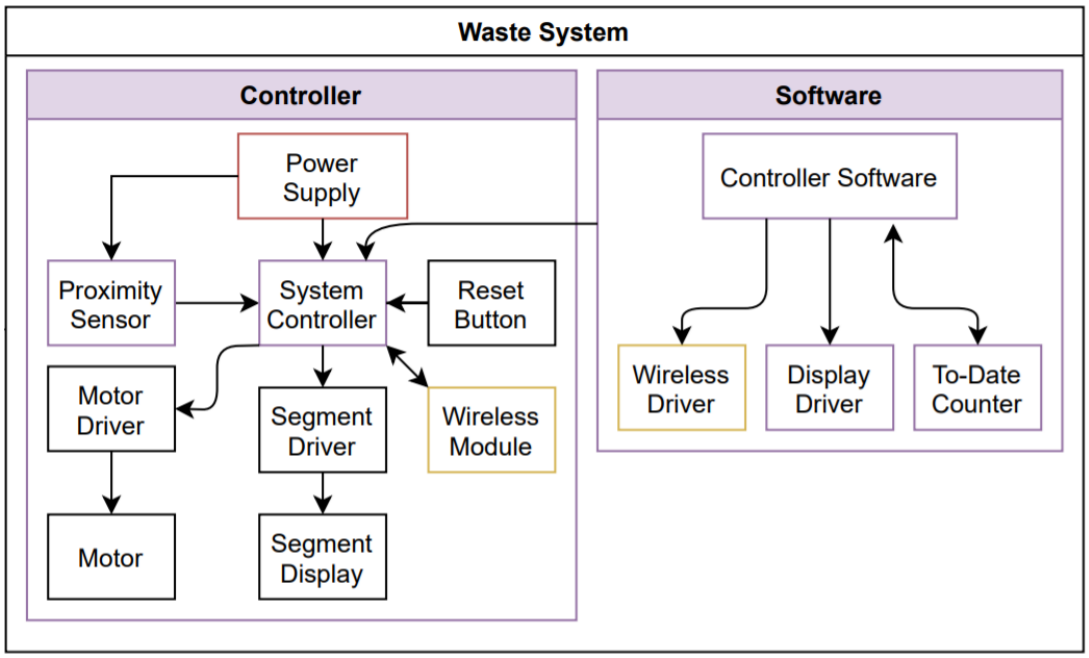

Figure 6: Waste station block diagram

6.6 Power System

Within each of the subsystem diagrams, the power supply has been left as an abstract block. Each system will utilize home wall outlets to provide power. Depending on the power rails necessary for various ICs and mechanical components, this section of the project will be designed last. For a rough idea, a DC wall jack and buck regulators will provide efficient DC/DC conversion for the various power rails.

7 Current Progress

All blocks are currently still being researched except the Waste Station which has been partially acquired. Current focus is directed toward various sensor choice; how the device operates, limitations, accuracy concerns, etc. Once sensor choice is finalized, the head of each subsystem will lead the progress of their respective system. The goal is to have each subsystem working in parallel to reduce the design time, as well as increase overall team productivity.

8 Budget

A large focus of this project is cost. Each automatic system can cost in the ranges of $30-$300. It is not the goal of this project to make a better, or more competitive priced automatic system. The goal is more in elevating the current feeder to provide data a pet owner, veterinarian, or animal shelter owner would want. This additional information cannot be free, sadly. The current budget is $500. The price breakdown is provided below. Note that a significant percentage of the budget is reserved to mechanical components. As more technological discovery is done, it is hoped that more cost-effective components may be found.

Part	Quantity	Price
Load sensor	2	$50
ADC	2	$20
Humidity sensor	1	$5
Water pump	1	$25
Flow sensor	1	$25
Food dispenser	1	$20
Steel bowl	2	$10
Motor	1	$40
Wi-Fi module	3	$45
Power supply	3	$15
Microcontroller	3	$5
SBC	1	$50
PCB	3	$100
Miscellaneous		$50
Total		$460

Table 3: Budget breakdown.

9 Milestones

Provided in the table below is the current milestone schedule. Note the parallel nature of the schedule. Updates to the milestone will be made alongside challenges and progress.

Milestone	Task	Start	End	Status	Responsible
1	Brainstorming	6/22/2021	7/12/2021	Complete	Group 18
2	Project selection	7/21/2021	7/28/2021	Complete	Group 18
3	Block diagram development	8/23/2021	8/30/2021	Complete	Group 18
4	Role assignment	9/6/2021	9/6/2021	Complete	Group 18
5	Initial divide and conquer	9/10/2021	9/17/2021	In Progress	Group 18
6	Component research	8/23/2021	9/17/2021	In Progress	Group 18
7	Schematic development	10/1/2021	10/22/2021	Pending	Michael
8	PCB design	10/1/2021	10/22/2021	Pending	David
9	Base station development	10/1/2021	11/1/2021	Pending	Will
10	Firmware development	10/1/2021	11/1/2021	Pending	Carla
11	Power supply development	10/1/2021	11/1/2021	Pending	Hector
12	Food station development	11/1/2021	12/1/2021	Pending	David
13	Water station development	11/1/2021	12/1/2021	Pending	Hector
14	Waste station development	11/1/2021	12/1/2021	Pending	Michael
15	System integration and testing	11/14/2021	12/3/2022	Pending	Group 18
16	Prototype testing	1/10/2022	2/28/2022	Pending	Group 18
17	Finalize product	3/1/2022	3/31/2022	Pending	Group 18
18	Peer presentation	3/15/2022	4/1/2022	Pending	Group 18
19	Final report	4/1/2022	4/8/2022	Pending	Group 18
20	Final presentation	4/8/2022	4/22/2022	Pending	Group 18

Table 4: Senior Design milestone schedule.

References

[APPA] APPA, C. The 2017-2018 appa national pet owners survey debut. APPA. Slide 9. https://www.mceldrewyoung.com/wp-content/uploads/2018/08/2017-2018-Pet-Survey.pdf.

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