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July 26, 2018

Steve Whitmore
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Re: ENSC 405W Design Specification for Caneat Inc.

Dear Mr. Whitmore:

The attached document, the **Design Specification**, provides a high-level design requirement for implementing our product, automated kitty litter box. This product, CANEAT, aims to provide a convenient and clean life for pets and hosts.

The design specification document aim to outline the final steps to complete CANEAT. In addition to design specification, this document contains two detailed appendices. The first appendix, the **User Interface Appendix**, concentrates on the interaction between CANEAT with user. Secondly, the **440 Planning Appendix**, focuses on the timeline, detail of task of project that will be complete next semester.

CANEAT consists of 3 brilliant and compassionate senior engineering students: Kailun Liang, Wenjie Li, Zewen Wu. If you have any questions or concerns regarding proposal, please contact kailunl@sfu.ca.

Regards,

Kailun Liang

Enclose: Design Specification for Caneat

CANEAT INC.

CANEAT

Design Specification

Automated Kitty Litter Box

"Make your life convenient and neat"

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Abstract

This document outlines the design specification and implementation of scooping, cat detecting, and waste collecting system. It covers the detailed components that we choose to implement the product for each module which includes technical parts, appearance, and user interface design.

The scooping system is designed to filter out the waste that exists in the cat litter automatically. It will be activated after the detecting system. The detecting system includes a photoelectric sensor to detect whether the cats have used the cat litter or not. If yes, it will initialize the scooping system to do the cleaning job. The waste collecting system will be used to collect waste after each operation of scooping.

The design specifications in this document will provide the basis for the design, and building of a working model. The proof of concept will demonstrate the main functionality of detecting cats, and operation of the mechanism manually. The prototype is aimed to be a more compact and efficient design that can work automatically.

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Glossary

PCB A printed circuit board (PCB) mechanically supports and electrically connects electronic or electrical components.

ESSS Engineering Science Student Society

ESSEF Engineering Science Student Endowment Fund

SFU Simon Fraser University

Microcontroller A small computer on a single integrated circuit.

Gantt Chart A Gantt chart provides a graphical illustration of a schedule that helps to plan, coordinate, and track specific tasks in a project.

Arduino Uno The Arduino UNO is a widely used open-source microcontroller board developed by Arduino.cc.

1. Introduction

Caneat Inc. is denoted to developing the most reliable automatic litter box in the current market. The automatic kitty litter box we are designing can scoop the waste intelligently the certain time, that can be set by the user, after a cat has used the litter box. The waste will be stored in the receptacle with a weight sensor monitoring if it has to be replaced simultaneously. Our product is intended to be promoted among all cat breeders, which is 61% of Canadians, especially for the disabled, the elder and people who need to travel for business or leisure frequently. Meanwhile, people who are interested in automated products and willing to invest on their luxurious lives have higher possibility to be attracted by our design.

The document describes the design specifications that must be realized in order to make the automated litter box reliable and popular. Overall, expected specifications can be classified into the following categories, which are the system design overview, and design requirements. And we will detail the design requirements into base orientation system, dimension, scooping system, cats detecting system, waste collecting system, top level controller system, and power distribution system. In addition to systems requirements, the document will include the test plan appendix, user interface appendix, and 440 planning appendix at the end.

2. System Overview

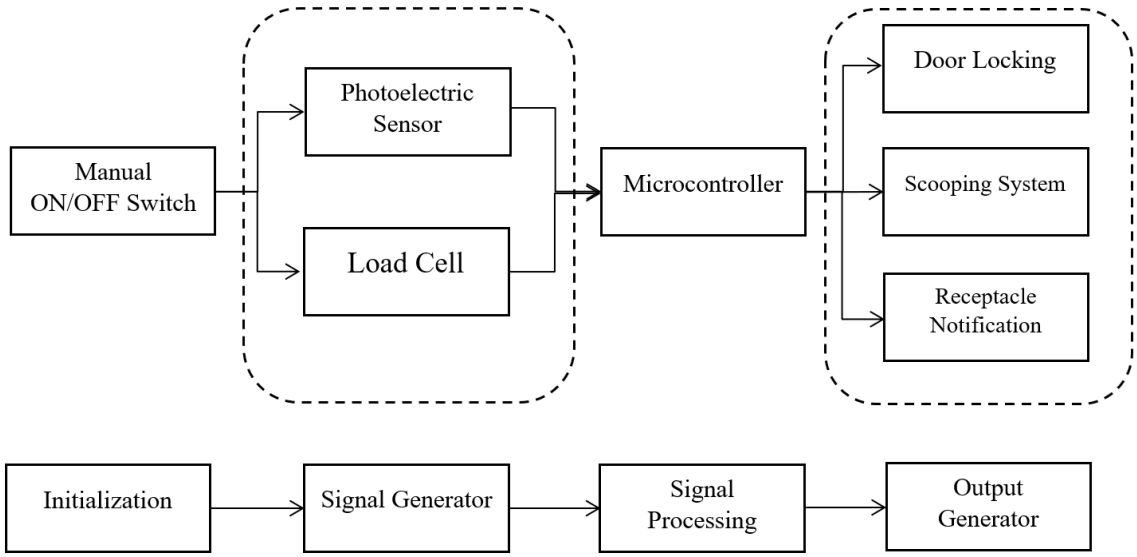

Figure 2.1: High-Level Functional Block Diagram

Overall, the system can be classified into four steps. Once it is initialized, the input signal will be continuously generated, which is going to be processed in real time. Based on the processed signal, the system will compute the output signal controlling the cleaning cycle. To be specific, the manual ON/OFF switch is designed to activate the entire system. Once the system is initialized, both photoelectric sensor, which is used to detect whether the cat is currently in the litter box, and load cell, which is intended to decide if the receptacle is full, are going to generate signals concurrently and simultaneously. Immediately after,

the microcontroller is going to process the signal, make decisions and generate voltage analog signals. Assisted with electric circuit, if necessary, door locking and scoop movement mechanisms will be performed. Meanwhile, if the receptacle is full, the system will be terminated and the audio notice can remind breeders to replace the receptacle. If time permits, we will implement program so that, in this case, a text message will be sent to breeders. Once the receptacle is detected to be replaced, the system will be reactivated.

3. System Requirements

3.1 Base Orientation System

The system consists of:

- one microcontroller,
- one pair of photoelectric emitter and receiver,
- one breadboard for integrating circuits
- LED signal lights

The system is divided in to detection module, operating module, and feedback module which are connected through the microcontroller as shown in the figure below:

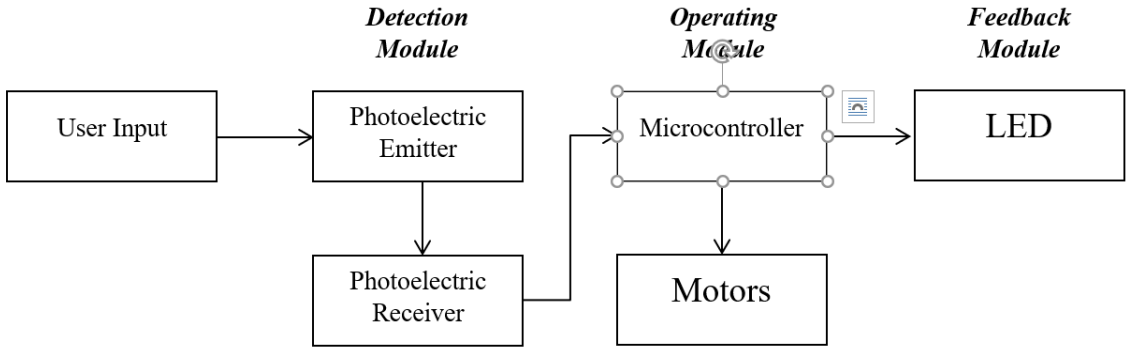

Figure 3.1.1: Block diagram of Modules

After users inputting the commands, the photoelectric sensor will be programmed to do cat detection by using emitter and receiver. As long as the photoelectric pair is activated twice, it will send the signal to microcontroller, and ask for a operating initialization.

The microcontroller will control the operation of mechanism part in order to finish scooping and dumping. Finally, the LEDs will indicate the status of the litter box so that the users can know the current conditions.

3.2 Dimension

The first privilege of the automated kitty litter box is that it is the product designed for cats. Therefore, it should be designed to give the efficient space for cats so that they can comfortably use it. In addition, cats should be used to using it quickly, which means the appearance of litter box is better to be similar to the standard one.

However, due to the product is automated, we have to reserve the space for the mechanical operation. The dimension for Caneat will be 60 cm × 60 cm × 65 cm which can allow most of cats to enter into it, and turn around. So, the size will be enough for a cat to use as a toilet. In addition, the waste collecting system will occupy a size of 60cm× 60 cm ×15 cm space to store the waste at the bottom of the device. The shell of the Caneat is made of wood and Acrylic sheet. The Acrylic sheet, 60 cm × 60 cm × 20 cm, is intended to ensure that the breeder can notice the condition of the litter box no matter when it is in scooping progress or it is in the sleep mode. Other than that, we choose to use wood to create a more privacy space for the cat. Considering the size of the cat, the entrance of the litter box is expected to be 30 cm × 30 cm × 4 cm. The area of the space containing the litter is 1962.5 cm^2. The detail dimension is shown in following three figure, Figure 3.2.1, Figure 3.2.2 and Figure 3.2.3.

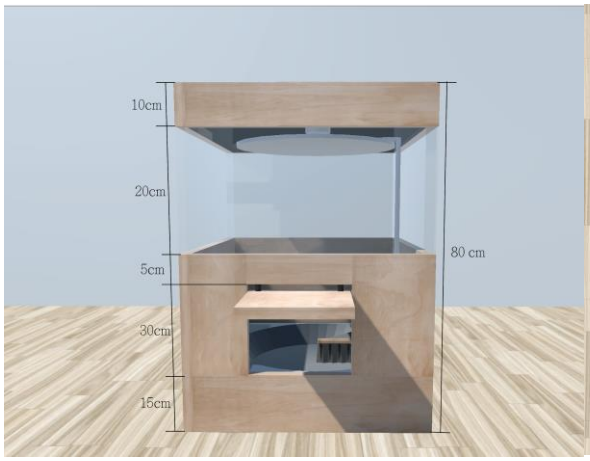

Figure 3.2.1: Front View

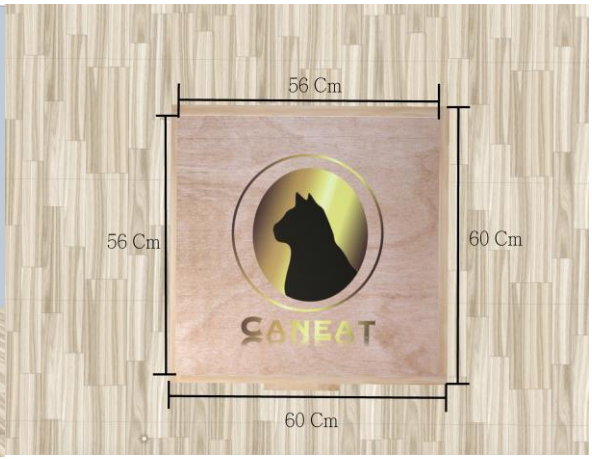

Figure 3.2.2 : Top View

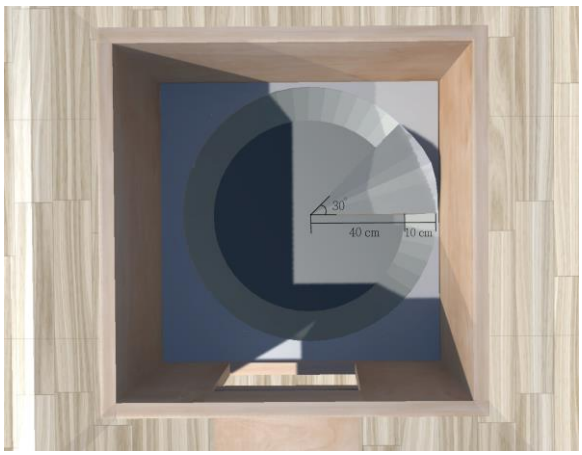

Figure 3.2.3 : Dimension of Litter Box

3.3 **Scooping System**

In accordance with objectives of the automated kitty litter box, the most essential function of the product is that the waste must be scooped and pushed out automatically when the system has been activated, which can be classified as the “Scooping System”.

To be specific, to ensure that the scooping system is satisfied with the function requirements, the entire system can be divided into several components. First of all, the scooping system has to be designed to be reliable and not sophisticated. The basic scooping mechanism is the design of the scoop used to scoop the waste, which is able to efficiently and effectively clean the waste. Moreover, it should be analysed that how forces are expected to be applied to the scoop. With the help of this analysis, the design of the rod connected to the scoop can be finalized (size, shape and material). When the scooping system has been activated, the microcontroller is going to generate the voltage analog output driving the rotation of the rack. Hence, based on the equilibrium of the rigid body, kinematics of planar mechanisms and dynamics of planar mechanisms, the minimum power of the motor can be calculated, which gives a reference for the electric design.

3.3.1 **Scooping Procedure Design**

Overall, the scooping procedure is designed to follow the block diagram below. The algorithm can be divided in time steps. After the system has been activated, the door of the litter box needs to be closed and locked in order to prevent cats to be injured. Then, the scoop is commanded to rotate to clean the waste. Ultimately, the door will be unlocked.

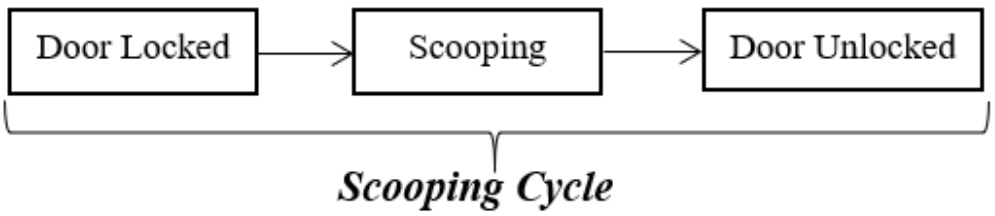

Figure 3.3.1: Block Diagram

The entire scooping action shall be as fast as possible to increase the efficiency. However, due to the characteristic of the product, slower the scoop moves, more effectively the waste can be cleaned. Since the dimension of the base of kitty box has not been determined, in this case, the diameter of the base can be defined as ***r***. Assume the angular velocity is $\boldsymbol{\omega}$, which will be analysed later, Ideally, the synchronous and asynchronous delay between each step shall not be noticeable, compared to the entire scooping progress. Controlled by the implementation of the algorithm in Figure x, the time diagram (Figure 3.3.1) can be generated.

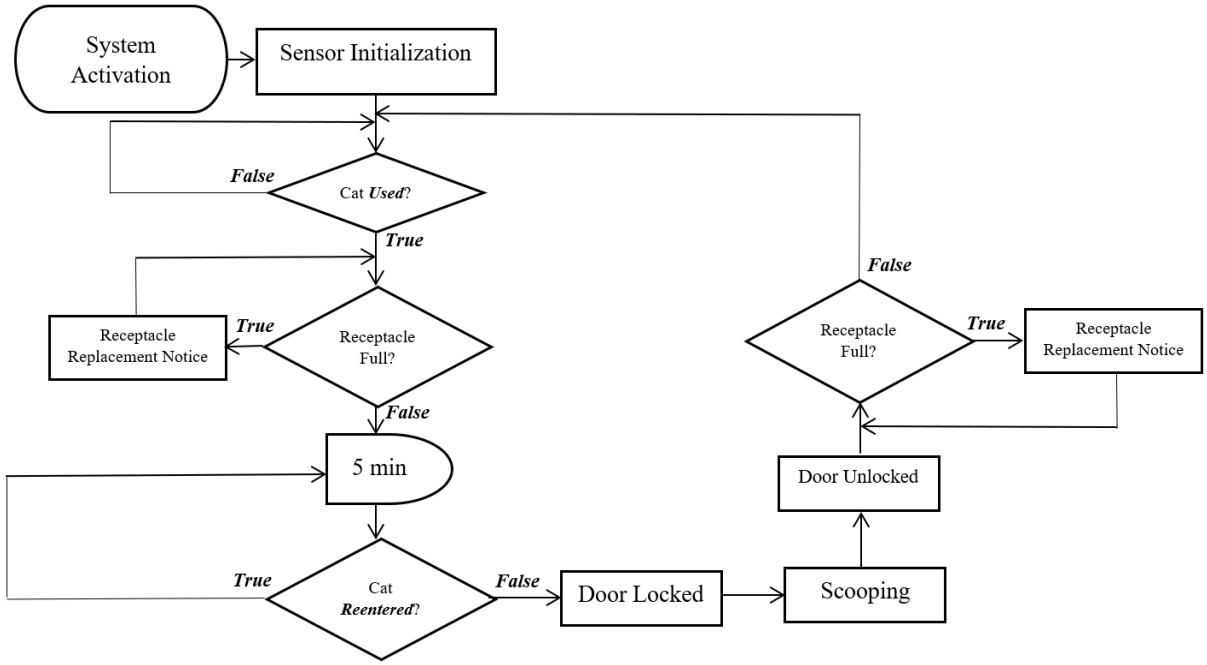

Figure 3.3.2 Flow Chart

The entire scooping system starts from the initialization of the sensor which is intended to detect if the cat is currently using the litter box. The signal generated by sensors will be ignored until the cat is no longer in the litter box. When the cat exits the box, the weight sensor will recall the condition if the receptacle is full to prevent it to be overweight. If not, the sensor is going to start detecting if the cat reenters the box in the next 5 minutes. If the box remains empty for the next 5 minutes, the scooping cycle is going to be in progress following the block diagram (Figure 3.3.2). Ultimately, if the waste receptacle, breeders will be informed that they should replace the receptacle on time. In case that more than one cat share the litter box, ignoring the output of the sensor can reduce the disturbing signal.

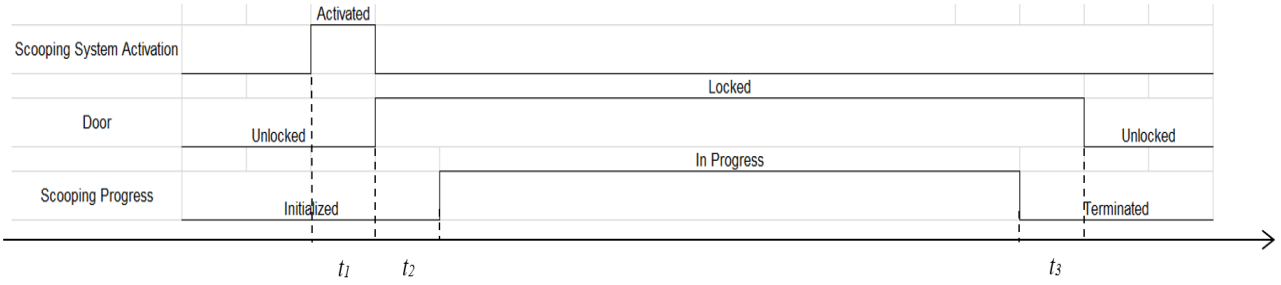

Figure 3.3.3 Time Diagram

Basically, when the system is activated, the door will be locked to stop the cat reentering the litter box. As long as safety issues have been eliminated, the waste is going to be scooped. The system activation signal will remain high for one clock cycle. Referring to the block diagram, considering the possible delay, the time diagram (Figure 3.3.3) reflects how long each step and entire progress is expected to be. t_1 is the time the system takes to lock the door after the system has been activated. t_2 is the delay that the scooping

progress takes to be in progress. Similarly, t_3 (Scooping Completed) and t_4 (Door Unlocked) are the delay when the system is commanded to be terminated.

3.3.2 **Basic Scoop Mechanism**

Basically, the scoop of the automated litter box is similar to the standard scoop.Compared to the standard one, it shall not cause spilled litter, which means it can even work if it is a simple rectangular cube. However, in our case, if the scoop is not sanitary because of the possible sticky waste, our product is not able to reduce odors. Therefore, to make the product more reliable, the scoop must be designed to be able to effectively filter out the waste and remain clean.

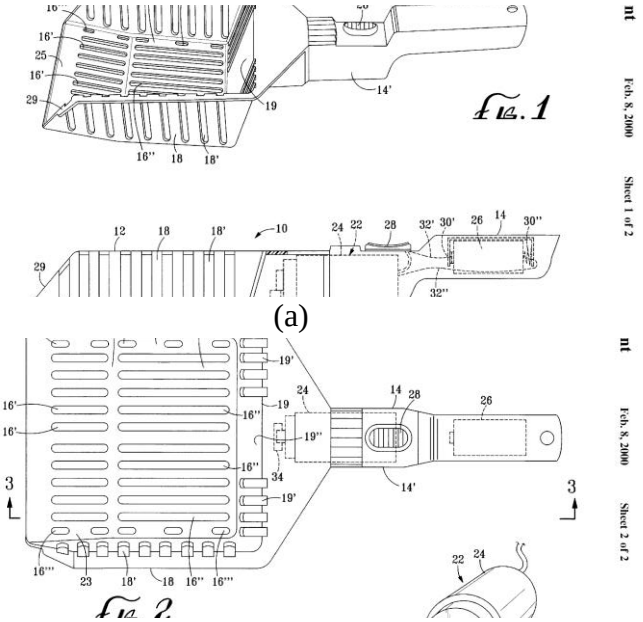

Figure 3.3.4 Vibrating cat litter scoop[1]

US 6022058A is a vibrating cat litter scoop developed by Anthony O'rourke (Figure 3.3.4). Basically, this patent comprises a cat litter scoop with a battery powered vibrating mechanism. Upon activation, the vibrator imparts a high speed oscillation movement to the handle and the scoop portion of the device carried by the handle. [1] The vibration is about the longitudinal axis of the handle, which is intended to accelerate the manual steps associated with the conventional manual scooping motion. The litter scoop device is preferably formed of molded plastic and comprises a forward scoop portion (12) and a handle portion (14). The forward scoop portion is defined by a slotted bottom wall (16) and slotted side walls (18) and a slotted rear wall (19). This combination can efficiently split the waste and the useable cat litter.

Referring to the vibrating cat litter scoop, in our case, vibrating the scoop can prevent it being sanitary, although it makes the mechanism more complicated. Moreover, the orientation of the scoop with respect to the base of the litter box is one other factor affecting the scooping efficiency, which is presented in Figure 3.3.5. The advantage of this design is that the waste can be easily filtered out of the cat litter. However, it will

probably block slots, which will result in the consequence that cat litter, after being scooped, is not flat. Ideally, since the bottom one third of the scoop works dominantly, slots which approach the bottom should be longer than that around the top. Therefore, compared to the one developed by Anthony, the pattern should be flipped.

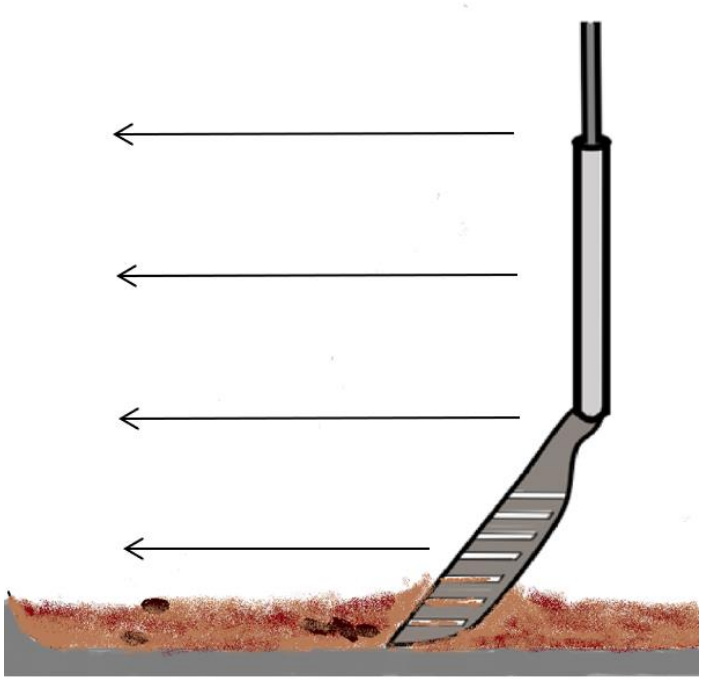

Figure 3.3.5 : Scoop

3.3.3 **Scoop Connector Mechanism**

Our motor controlling the scoop is designed to be installed at the top of the box. Therefore, there should be a rod connected to the scoop so that the scoop can attach to the base. In accordance with our design, the waste is expected to fall down into a receptacle through a gate on the base, which means, under the promise that the scoop always attach to the base, the length of the rod is adjustable. To make the design simpler, the connector will not be controlled by the microcontroller. Instead, it a simple mechanism consisting of two rods.

Physically, along the horizontal direction, the upper rod is always stationary while the lower rod was applied the normal force, gravity of the lower rod, gravity of the litter and the friction between the lower and upper rod, which is visualized in the free body diagram (Figure 3.3.6).

$$\because \sum F = 0$$

$$\therefore \textit{friction between two rods} + \textit{normal force} + \textit{gravity of the rod} + \textit{gravity of the waste} = 0 \quad (1)$$

Therefore, the length of the connector is self-adjustable depending on the height of the base.

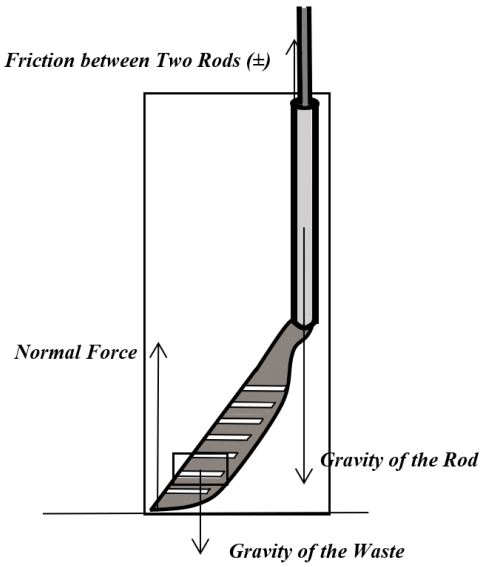

Figure 3.3.6 Free Body Diagram

3.4 Cat Detection System

As it is presented in the flow chart, the system has to detect if the cat is using the litter box. To realize this function, there are some feasible solutions. In order to make the ensure the reliability and cats' safety,

3.4.1 Photoelectric Sensor

we decide to use **photoelectric sensor**, which is commonly used to discover the distance, absence, or presence of an object by using a light transmitter, often infrared, and a photoelectric receiver. In practical, it is widely used in fields of manufacturing, surveillance and delivery. Related to our product, the cat passing between the sensor and reflector will either block or attenuate a perceivable percentage of the emitted light. Theoretically, Figure x shows the case when the electric output signal will be generated.

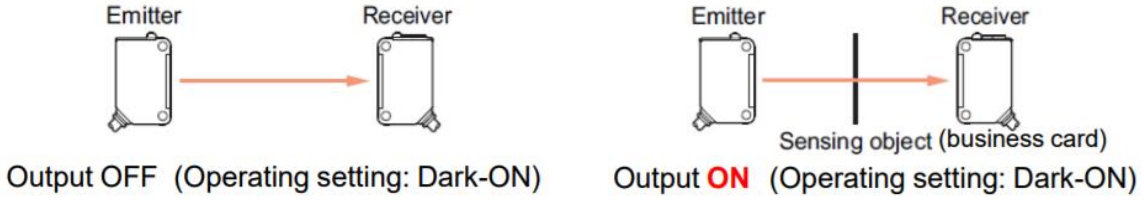

Figure 3.4.1.1: Photoelectric Sensor [2]

By adjusting the sensitivity of the receiver, photoelectric sensor can be succeeded to detect if the cat is coming though in the dark environment (night). The sensor is designed to be installed against the door frame (Figure 3.4.2) so that, once the cat enters the box, the output signal will be generated. Similarly, when the cat goes out, there will be a output signal either.

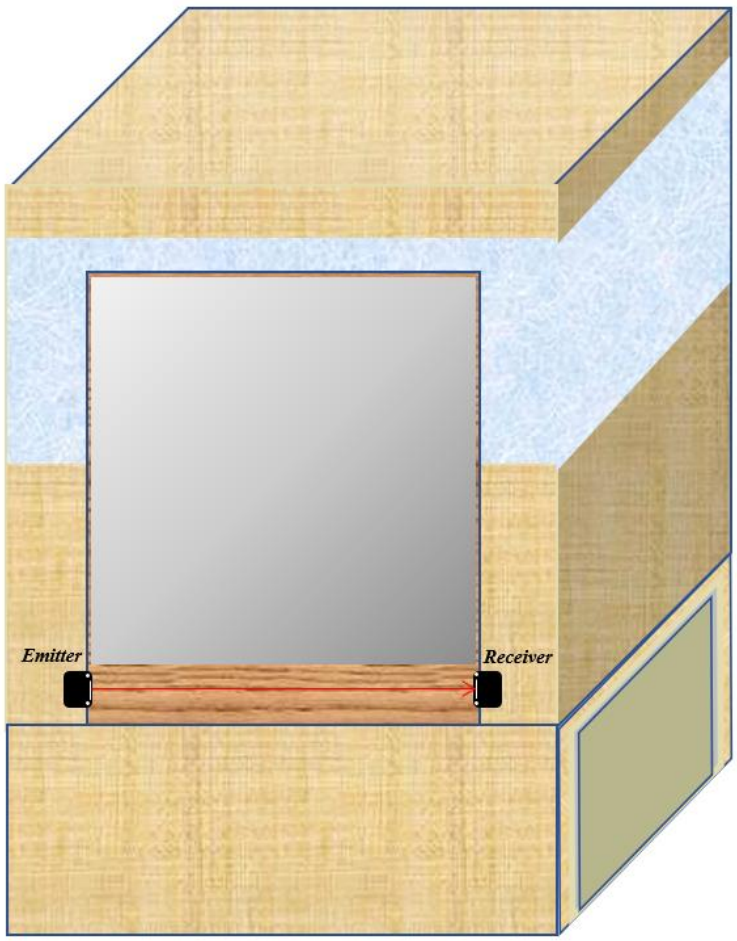

Figure 3.4.1.2 : Orientation of Photoelectric Sensor on the Litter Box

3.4.2 **Sensor Implementation**

As it was mentioned, the photoelectric sensor consists of an emitter and a receiver. Related to that, there is a tutorial posted on Arduino showing how a Arduino Uno is able to interface with an Infrared Emitter and an Infrared Receiver. In the schematic (Figure 3.4.3), the circuit based on a photoresistor uses a resistor divider to allow the high impedance analog input to measure the voltage. These inputs do not draw almost any current, therefore, referring to Ohm's law, regardless of the resistor's value, the voltage measured on the other end of a resistor connected to 5V is always 5V. To get a voltage proportional to the photoresistor value, the circuit uses a photoresistor and a fixed resistor to build a voltage divider. Therefore, the voltage measured

$Vout = Vin \times \frac{R_2}{R_1+R_2}$, where $\boldsymbol{V_{in}}$ is 5 V, $\boldsymbol{R_2}$ is 10 kΩ and $\boldsymbol{R_1}$ is the photoresistor value that ranges from 1 MΩ in darkness to 10 kΩ in daylight (10 lm) and less than 1 kΩ in bright light or sunlight (>100 lm).

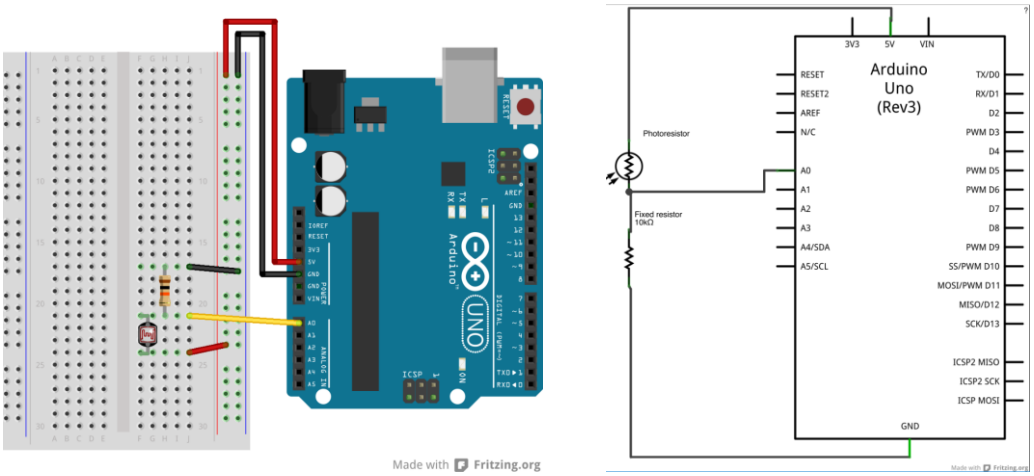

Figure 3.4.2.1 Photoelectric Sensor Interfaced with Microcontroller [3]

A0, the pin on the Arduino, has a incoming voltage signal $5V \times (10\,k\Omega\,/(R1 + 10\,k\Omega))$. Therefore, at the beginning of this sketch, the variable is set to to analog pin 0. In order to visually check if the photoresistor functions properly, a LED Light, connected to digital pin 13, was integrated into the circuit. sensorValue is a variable storing the values read from the sensor, similar to a voltage metre. The ADC inside the microcontroller converts the value read from A0 to a digital signal by calling the command ***analogRead()***. In this case, a 0 to 5 V analog signal can be converted to a decimal digital signal [0, 1023]. Other than that, ***digitalWrite(Pin#, High)*** is intended to generate a analog voltage output supplying the LED light.

```
int sensorPin = A0;    // select the input pin for the potentiometer
int ledPin = 13;       // select the pin for the LED
int sensorValue = 0;  // variable to store the value coming from the sensor

void setup() {
  // declare the ledPin as an OUTPUT:
  pinMode(ledPin, OUTPUT);
}

void loop() {
  // read the value from the sensor:
  sensorValue = analogRead(sensorPin);
  // turn the ledPin on
  digitalWrite(ledPin, HIGH);
  // stop the program for <sensorValue> milliseconds:
  delay(sensorValue);
  // turn the ledPin off:
  digitalWrite(ledPin, LOW);
  // stop the program for for <sensorValue> milliseconds:
  delay(sensorValue);
}
```

Figure 3.4.2.2 Microcontroller Implementation [3]

The schematic above is a sample how to enable the optical sensor using Arduino. As for our project, the photoresistor can be replaced by a Photodiode which can receive IR laser beam. Besides, a IR emitter will be supplied by a power source. Regardless of the Opamp, which is used to optimize partial of the analog output generated by PhotoDiode. in the schematic, Figure 3.4.4, the IR LED is simply cascaded with a resistor, $R_1 = 100\,\Omega$, sharing the voltage of 5 V. As for the Photodiode, with the various resistance, R_{PD}, the

estimated analog output is $Vo = 5\,V \times \frac{10\,k\Omega}{R_{\square\square} + 10\,k\Omega}$, which is same with the sample above. Similarly V_0 will be connected to the input pin on the microcontroller. However, referring to our algorithm, once the microcontroller has detected the signal, it is going to wait for the second similar signal to confirm that the cat has used the litter box and activate the scooping system.

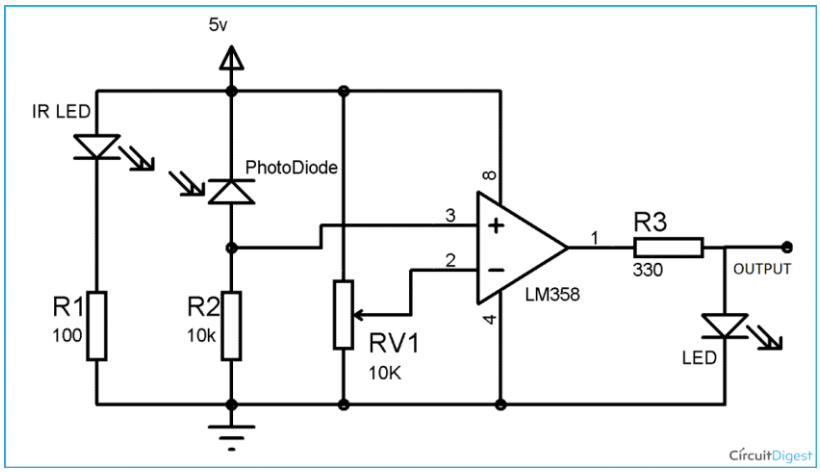

Figure 3.4.2.3 Electric Circuit containing Photoelectric Sensor [4]

3.5 **Waste Collecting System**

For our waste collecting system, it should reduce odors, increase the space efficiency, notify breeders when it is full and communicate with the scooping system.

3.5.1 Carbon Filters

Since our design is intended to reduce the contact between breeders and the waste as much as possible, the receptacle has to be able to contain more waste than other litter box. It is how our product impress customers. Meanwhile, it is a challenge for us to eliminate odors. As for the self-cleaning cat litter box, carbon filter is normally be used to refresh the receptacle. Carbon filter can effectively eliminate odors and it has been widely applied. Activated carbon removes odors by offering the odor-causing compound a more attractive place to reside than circulating in the air. [5]

In order to make our receptacle capable for carbon filters, we have to design the space inside the receptacle to contain carbon filters (Figure 3.5.1(a)). The 12-pack carbon filter produced by LitterMaid is CAD 5.99. The dimension is 3×3×2 inches. It is more efficient if filters can be evenly deployed, visualized in Figure 3.5.1(b).

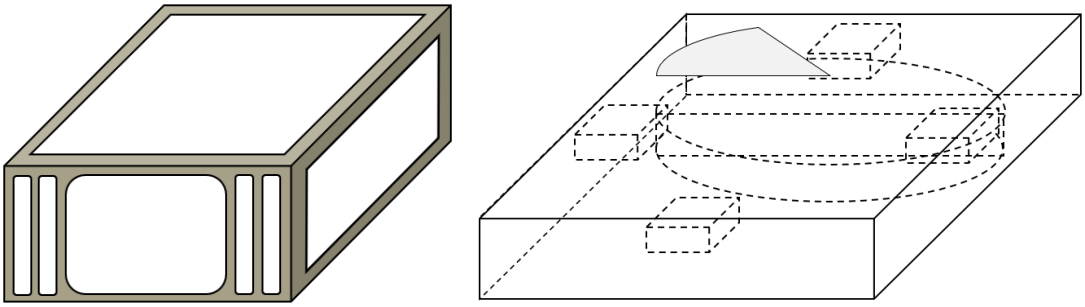

Figure 3.5.1.1 Carbon Filters (a) Container (b) Receptacle

3.5.2 **Swiveling Receptacle**

In order to make our product share more market, compared to other self-cleaning litter boxes, we have to enlarge the dimension of the receptacle. For our design, the waste is expected to be pushed down to the receptacle through a gate on the base. The area of the gate is: $A_{gate} = (25^2 \times \pi) / 8 = 245.313\ cm^2$. Physically, along the horizontal axis, the waste is only be applied gravity. Although, as long as the waste is accumulated high enough, it will slightly slip around, the usable volume is 12.5%.

Therefore, taking advantage of the circular receptacle, the receptacle can be designed to be rotationable. To be specific, the receptacle is designed to rotate by 35°. In this case, a motor interfaced with microcontroller can realize this functionality. However, the friction between and the receptacle has to be alleviated. For our design, we design a holder to catch the receptacle so that it is easy to be rotated and disassembled (Figure 3.5.2).

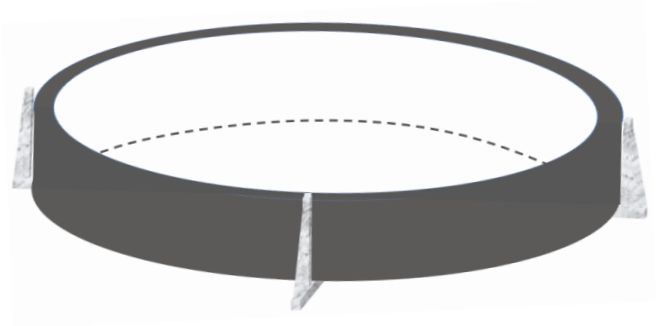

Figure 3.5.2.1 Receptacle Holder

Therefore, the block diagram can be finalized as the one in Figure 3.5.3

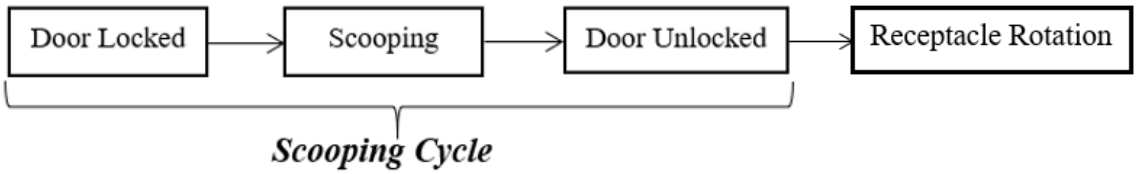

Figure 3.5.2.2 Block Diagram

3.6 **Top Level Controller System**

The automated kitty litter box requires several processes to be synchronized, which are object detection and weight detection. The process is shown in Figure 3.7.1.

These process will be operated in real-time in automated kitty litter box proof of concept iteration.

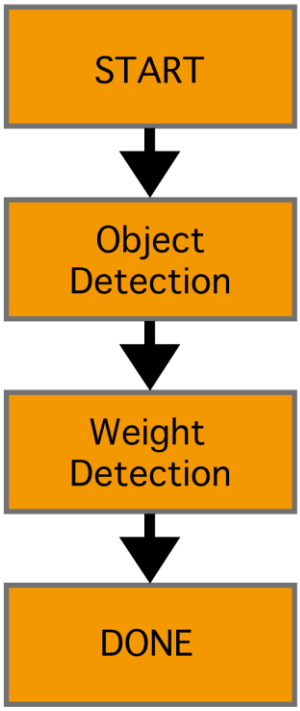

Figure 3.6.1 : Top Level Procedure

The automated kitty litter box begins in the START stage, which the system going into this stage after power is on. This stage plays an important role in Caneat system, because this state contains all the initial setup. The initial setup completes the first time scooping for checking the motor condition, door locker test and the photoelectric sensor test.

In addition, object detection stage contains not only the detection of cat but also the scooping procedure, which will be triggered after finishing the detection procedure. The detail of detection procedure is introduced in section 3.5. In weight detection state, the green and red light on the top of kitty litter box represents the weight of excrement exceed the limit or not. Green light shows excrement weight is in below the weight level. On the other hand, red light represents that user have to remove the excrement garbage bag right away. The final stage, DONE, will turn back to Start stage, so it is a infinity loop after turn on the power of Caneat.

3.7 **Power Distribution System**

3.7.1 **Power Supply**

In power supply section, the power requirements of Caneat's prototype and final product iteration will be evaluated, driving the selection of a rechargeable DC power supply. The parameters, shown in Table 3.8.1.1, allow an estimation of power consumed by the gear motor and servo motor.

Model NO.	Voltage	Current	Torque
KM-25A370-481-1210.5	12 (V)	0.06 (A)	2 (Kg.cm)
SG-90 9g Micro Servo	5(V)	0.2 (A)	1.98 (Kg.cm)

Table 3.7.1.1 Parameter of Motors ***[6][7]***

The actual current that can run in the servo motor with loading is 0.7 A. However, 0.7A larger then 0.2A the maximum current in Arduino Uno **[8]**, so we calculated the power by inputting 0.2A as the current in micro servo motor. The maximum power of draw from 12V DC rail due to 1 gear motor and 5V DC rail due to 1 micro servo motor is shown in equation (1).

$$P_{\square\square\square\square\square} = V_{gear} \times I_{gear} + V_{servo} \times I_{servo} = 12V \times 0.06A + 5V \times 0.2A = 1.72\,W \quad (1)$$

In the figure 8.3.1.1 and 8.3.1.2 shows the dimension of 2 motors that we applied in prototype and final product.

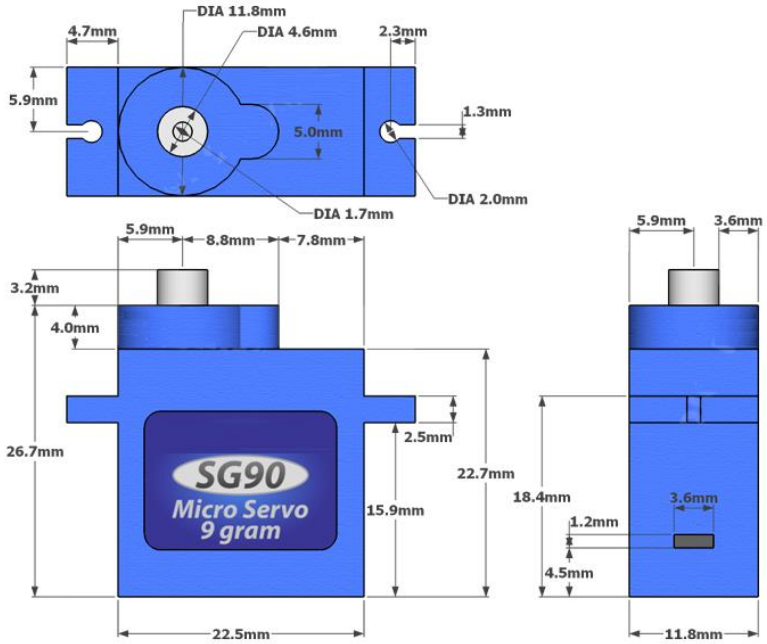

Figure 3.7.1.1 : Specification of SG90 Micro Servo Motor ***[7]***

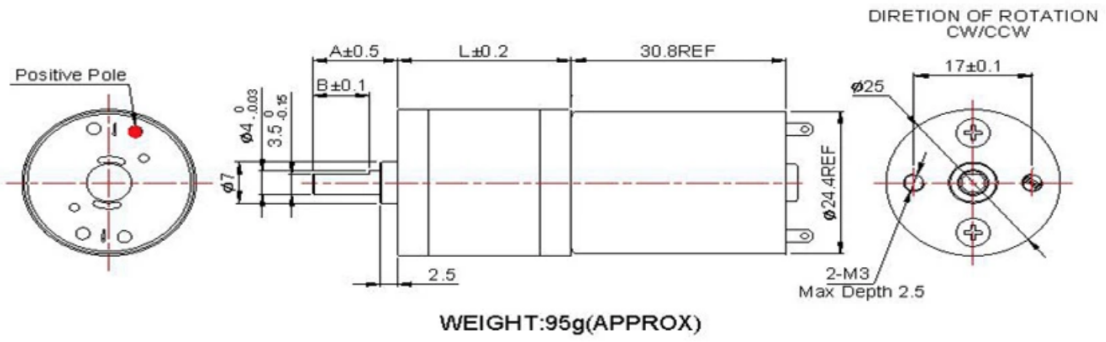

Figure 8.3.1.2 : Specification of Gear Motor ***[6]***

The power consumed by 5V DC USB rail due to the applied Arduino Uno board, needed to be considered. The specification of the Arduino Uno board is shown in Table 8.3.1.2.

Specification	Voltage	Current
Arduino Uno	5 (V)	0.2 (A)

Table 3.7.1.2 : Specification of Arduino Uno

The estimated maximum power for applied Arduino Uno board is shown in equation (2).

$$P_{\square\square\square\square} = (5V) \times (I_{Arduino}) = 1W \qquad (7)$$

Adding the control units and motors power consumption is calculated in equation (3).

$$P_{\square\square\square\square\square} + P_{ctrl} = 1.72W + 1W = 2.72W \qquad (8)$$

3.7.2 **Wiring**

In our design, Caneat Inc. requires the connection of gear motor to the 12 V DC and servo motor to the 5V DC and a ground rail of the power supply. In addition, 5V DC USB rail supplies the power for Arduino Uno board. In Figure 8.3.2.1, the red wire is the power supply of 12V DC and the orange wire represents the power supply of 5V DC USB rail. Finally, the black line connects to ground.

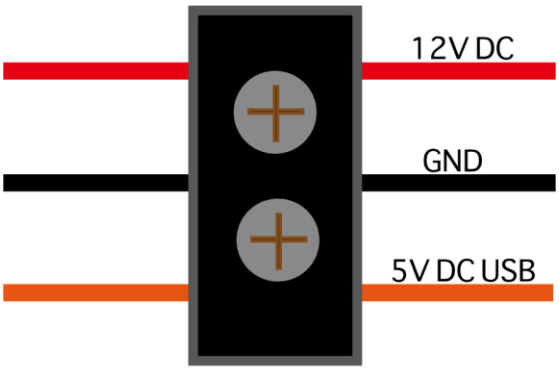

Figure 3.7.2.1: Wiring

4. Conclusion

Caneat is a robust, compact, and powerful system for cleaning the cat litter box. By using photoelectric sensor, the device will detect whether a cat has used the litter box or not. At the same time, the detecting behavior initialize the mechanism operation to clean the litter box. The system design consist of 3 major sections:

- Mechanism: it is aimed to implement an operation that can filter out the cat waste in the cat litter as much as possible.
- Software: it is aimed to develop code on the microcontroller in order to give the mechanism part a necessary command on time.
- Firmware: it is aimed to connect the mechanism part and software part in order to provide a complete operation.

To minimize the shipping delays, faulty or incorrect components, and other unexpected problems, we prefer to collect those components locally, so that we can test through different components efficiently. We will focus on the main functionality of the device, and this document provides a detailed requirement specification for mechanism, software, and hardware which includes detailed electrical circuits, and codes on the microcontroller.

Although there are couple similar products on the market already, we are trying to build a product with a lower cost, more robust, and easier to use to win the competition.

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Appendix A: Test Plan

A.1 Introduction

The general approach to system testing consists of firmware test, separately mechanism test, combined modules test, and the complete unit test. Once the proof-of-concept has been reached, and the device generates an excepted functionality, we will seek some volunteers to experience the product, and ask for some detailed feedback. The trials shall provide some further considerations and suggestions. Testing procedure will be discussed through various aspects, and the primary function will be focused on as a major task. If necessary, more specific aspects and methods for problem solving will be discovered and introduced during the development.

There are many requirements on the physical dimensions of the litter box, and its operation of the mechanism. The dimension will be designed in a reasonable way, and then sketched in an appropriate ratio using software in order to have an more intuitive view for further modification and discussion. After producing the prototype, the requirements will be finalized, or improved if necessary.

First of all, all the components of the mechanism will be assigned calculated data such as angle, length, and moving speed. After designing, and calculating these data, we will simulate this on the mechanism system manually before connecting to the microcontroller so that there are chances for modifying and improving on the structure. When connecting all the bar components, some nodes will apply just in case that the mechanism is adjustable, and it will be easy to modify and record data during the tests.

Secondly, we will make tests on the microcontroller in order to control the mechanism properly. One of the most primary thing is to test the code that related to switches and buttons since the signal lights are going to give information back to us about the status of the operation. Then it is the time to check whether the servo motors can rotate in the correct direction and speed at the exactly period that we wish.

Thirdly, we will have a combined modules test which will be the most necessary part before finalization because of the gravity, friction between each mechanism components, and resistance between the cat litter and the scoop will be introduced. So, we need to find a ratio that can make the ideal measurements to the actual data trial-by-trial. The calculated data will always be a reference only.

Ultimately, as a complete unit, the prototype will be assembled, and test its whole functionality during daily use. This is the opportunity to discover some unforeseen issues which may improve on algorithm and mechanism of our project. The detailed test plan shows in Table 5.1:

Test	Description	Result
Photoelectric Sensor	The sensor is able to detect the cats, and it gives a feedback signal.	
Comments:		
Test	**Description**	**Result**
Entrance Locking System	After detecting successfully, the door will lock by the servo motor.	
Comments:		
Test	**Description**	**Result**
Microcontroller (locking system)	Microcontroller should be able to control the servo motor in locking system	
Comments:		
Test	**Description**	**Result**
Entrance Door	In unlock mode, objects should be able to go across the door.	
Comments:		
Test	**Description**	**Result**
Scoop	The scoop should be able to move within the cat litter and filter out the waste.	
Comments:		

Test	**Description**	**Result**
Filter Out the Waste	The scoop is able to filter out the waste into the garbage bin.	
Comments:		
Test	**Description**	**Result**
Scooping Motor	The motor is able to control the movement of the scoop.	
Comments:		
Test	**Description**	**Result**
Microcontroller (scooping motor)	Microcontroller should control the movement of the motor.	
Comments:		
Test	**Description**	**Result**
Scooping Mechanism	The torque to connect with the scoop should be large enough.	
Comments:		
Test	**Description**	**Result**
Scooping Mechanism	The torque to connect with the scoop should be large enough.	

Comments:		
Test	**Description**	**Result**
Scooping Mechanism	The torque to connect with the scoop should be large enough.	
Comments:		
Test	**Description**	**Result**
Switches/Buttons	All switches or buttons should be able to execute their corresponding functions.	
Comments:		
Test	**Description**	**Result**
Signal Lights	All signal lights should be brighten in corresponding conditions.	
Comments:		

Table 5.1: Test Plan

Appendix B: User Interface

B.1 Introduction

Caneat Inc. is devoted to developing the most intelligent automatic self-cleaning cat litter box. Self-cleaning litter box, Caneat, is applied basic technology of robotics, which is able to realize its designed objectives. Basically, it is being controlled by three systems concurrently, including scooping system, cat detection system and waste collecting system. Corresponding to these systems, User Interface (UI) is essential to ensure that automated litter box is able to work properly and safely when the product is being applied practically.

Caneat's prototype iteration will contain the following main UI elements:

1. **ON/OFF Switch**: To activate the cat litter box, the user will fill Caneat with the litter and press this button (green) to turn it on.
2. **Emergency Stop Button**: In case of an emergency or something unexpected occurs, this button (red) allows the user to turn Caneat off immediately. Once pushed all operations cease instantly to prevent any damage.
3. **Time Selection Button**: This button is designed in case that the customer breeds one multiple cats. Caneat is going to wait for the selected time to initialize the scooping system after the cat is detected to have used the litter box.
4. **Mobile Application**: Mobile Application is developed as a detection of the condition of Caneat and a reminder when the receptacle needs to be replaced.
5. **Onboard LED Light**: The LED light is **GREEN** when the scooping cycle has been activated to be in progress. It is **YELLOW** when the mission has been completed. When there is any error appears, it turns to **RED**.

B.1.1 Purpose

This document aims to assist potential customers in to have a better understand of Caneat's main features and how to utilize them through its simple UI design. To achieve this, diagrams illustrating key UI design related concepts and component placements will be presented. These diagrams will be followed by brief descriptions explaining the reason behinds each UI design choice.

B.1.1 Scope

As Caneat is in its early design stages, this document will focus on its Proof of Concept (PoC) and Prototype iterations. As a result, the following key topics will be discussed.

1. User Analysis (Section 6.2)

Looks into the required user knowledge for safe operation procedures. Additionally, clearly states any restrictions which the user needs to be aware of.

2. Technical Analysis (Section 6.3)

Presents the 7 crucial elements of any UI design/interaction, namely discoverability, feedback, conceptual models, affordances, signifiers, mappings, and constraints.

3. Engineering Standards (Section 6.4)
Lists specific engineering/safety standards that Caneat's UI must adhere to in order to be a marketable product.

4. Usability Testing (6.5 & 6.6) Details both the analytical (designer perspective) and empirical (client perspective) usability testing/scenarios that PaintBot Inc. members need to consider.

B.2 User Analysis

User analysis is intended to outline the user expertise and restrictions with respect to the users' prior experience with automatic self-cleaning cat litter box and with their physical abilities to use Caneat.

B.2.1 Required User Expertise

Firstly, our product is designed for the cat. Therefore, it should be comfortable for them when they use it. Most importantly, the cat has to get used to it. Otherwise, consequently, they will defecate indiscriminately.

For breeders, Similar to other self-cleaning litter box. they have to assemble the litter box, following the User Manual, themselves. It is not a hard and complicated procedure since it is similar to that of a standard litter box. The only difference is that the user has to place the receptacle on the holder and ensure that the receptacle will not slide away when it is rotating. Then, Caneat has to be manually connected to Wi-Fi to enable the function that the breeder will be notified with the condition of Caneat and if the receptacle has to be replaced. It is optional depending on our progress. This step is different from all other automatic litter box at the current market.

Before Caneat is ready to be used, the user will be asked to check the functionality of the photoelectric sensor. This step could eliminate the safety issue in short term.

When there is any error occurs, on the display window, the error message will appear. In this case, the user is better to turn off Caneat and report the error to us.

If the some parts are better to be replaced because of their lifetime, it is better and less time-consuming that the user can replace the certain part following the procedure on the User Manual. For sure, parts that can be replaced by the user are not designed to be sophisticated wired up or hard to be disassembled.

B.2.2 User Restriction

In order to ensure that Caneat is able to work properly and eliminate all safety issues. There is one most important restriction that the user will ever go beyond. Under any circumstance, the user will never ever debug the mechanism error even when the error has been reported on the screen.

B.3 Technical Analysis

This section will analyze technically how we considered the “Seven Elements of UI Interaction” by Don Norman in user interface. The analysis will be based on the point of view of the users, and it will help our team to greatly improve the usability and quality of the products during the time of design.

B.3.1 Discoverability

Discoverability is one of the key components of engineering design, and it indicates that users can easily understand how to operate or find more detailed information about the device by looking at the user interface. When we designing the device, we first determine the primary functions of the product, and they will be focused on to design in a highly discoverable way. Firstly, we will set up a “reset” button on the user control panel. In that case, as long as the device is in an unexceptional condition, users can initialize the device through this button. Secondly, we will set up a “run” button which indicates that if customers press this button, the system will go into the operating status. So, after every time the cats using the device, the functionality of automated cleaning is activated. Thirdly, there will be a “period choose” button. Just in case sometimes the photoelectric sensor is not detected successfully, and the device will still do the self clean peroidly. Finally, there will be a “stop” button so that if any emergency conditions happen, the stop button can stop the operation immediately.

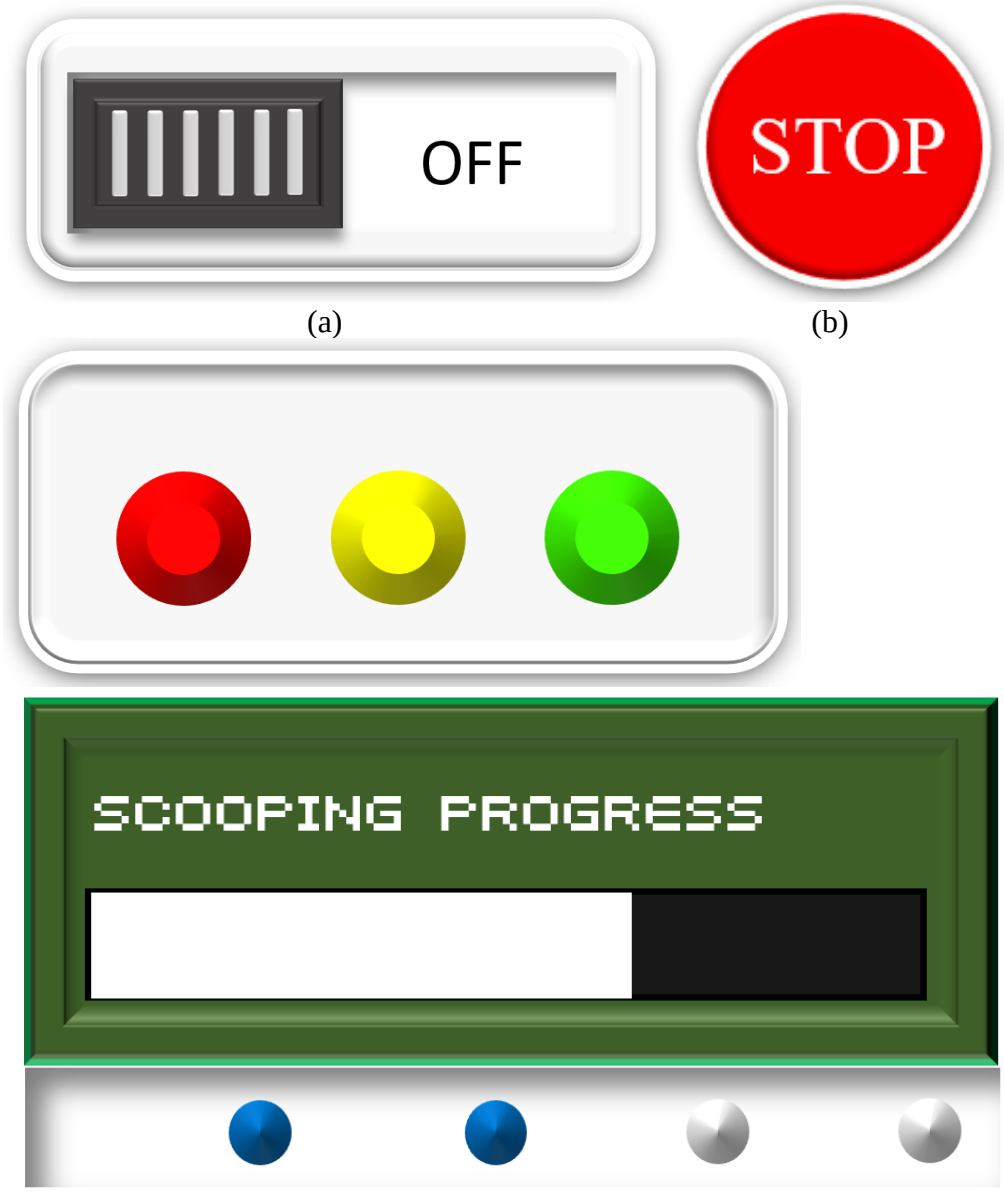
B.3.2 Feedback

Feedback is used to provide users a confirmation of input or some information that is necessary to report. In our design, we will use LED lights as a form of signals. There will be 3 LEDs to represent the current status of the device. If all of them are off, this means that the device is powered off, and need to input the voltage. If the red light is on, it means the device is in a serious condition that need to power off, and go fix it. If the yellow light is on, it means the device may not operate properly or some errors occur, and it is better to restart or reset to make it into a normal operation. If the green light is on, it means everything is in a good mode, and every functionality will be worked properly. In addition, in order to tell the users the cleaning progress, we are using 4 leds to indicate the working load that is every light represents 25% of the total work. Cleaning is finished when four of the loading lights is on.

B.3.3 Conceptual Models

A conceptual model is the mental model that how thing can be done when users are actually using it. For our design, we have a simple mental model which is intuitive for users. We will have a switch which will be either “ON” or “OFF” in order to tell users that is the way to switch on or off the device. There will be a emergency stop button in

red to catch the users' attention, even though they are in an emergency condition so that they can stop the device immediately. Four kinds of periods of cleaning gap can be set by users by pressing on the corresponding button. Also, red, yellow, and green led lights will be easily distinguished by their colors. Finally, there will be 4 led lights to indicate the percentage of the cleaning progress.The figure 6.3.3 shows the details.



(a) (b)

(c)

Figure B.3.3: Switches and buttons. (a) On/Off Switch. (b) Emergency Stop button. (c) LEDs, the top one represent the status, and the bottom ones indicate the loading progress

B.3.4 **Affordances**

Affordances describe the quality of the objects that enables an user to understand how to operate the device properly. By looking at our product, users will understand the main functionality is to scoop away the cat waste since there will be a special scoop within it.

B.3.5 **Signifiers**

As described above, the led lights will play an important role on the user interface since different colors of the lights represent different status of the device. After the colors show up, the users may then decide to do the next operation.

B.3.6 **Mapping**

Mapping describes the position of control buttons. Since the device will finally put on the ground to let the cats to use, all the buttons, switches, and signal lights will be installed on the top of the device which will be easier for users to use and observe. The detailed mapping appearance is shown in figure B.3.6.

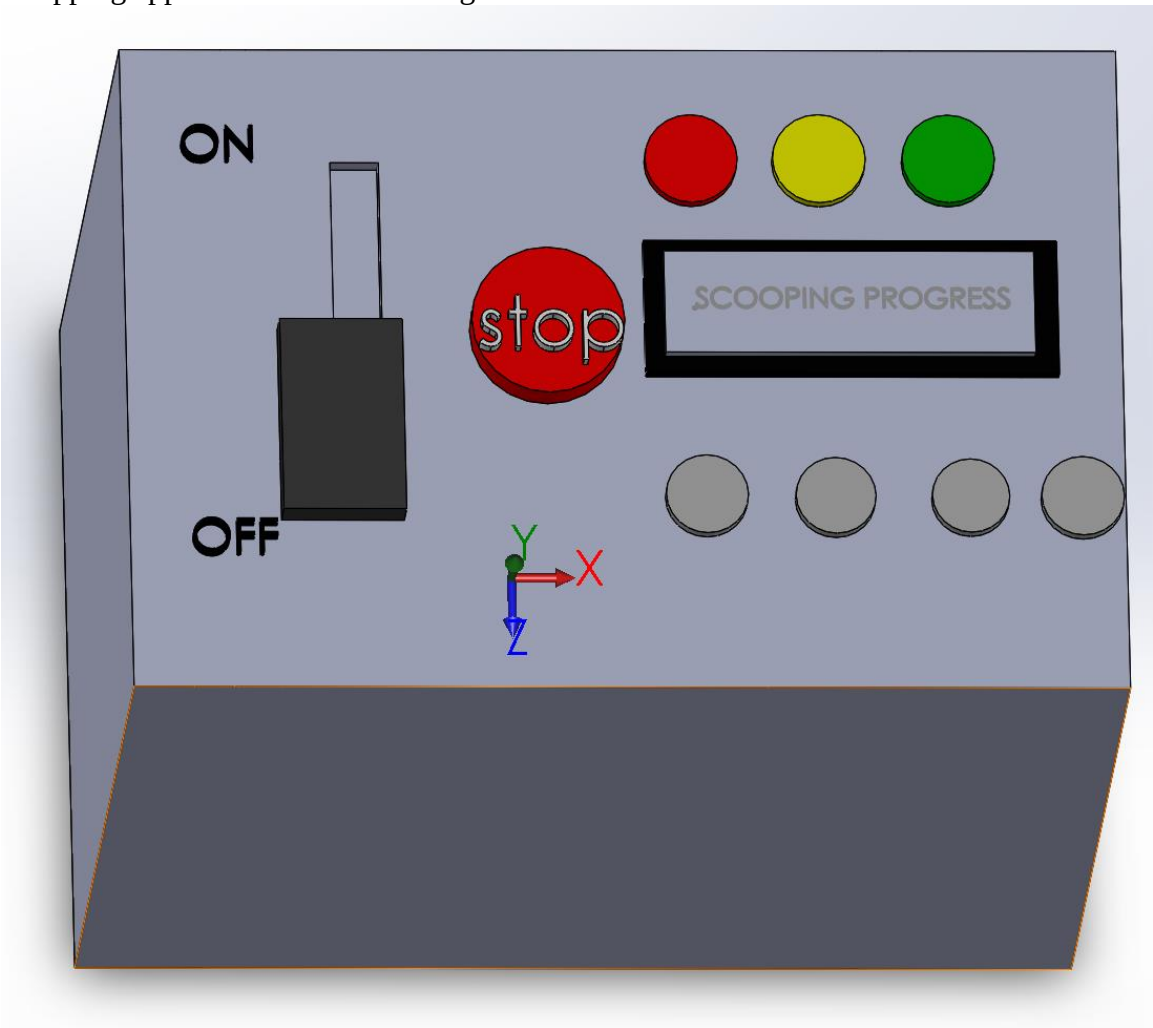


Figure B.3.6: Mapping of the switches and buttons

B.3.7 **Constraints**

Constraints limit the actions that can be performed by the users, the device needs exactly matched ports and properly connected cables to perform a complete operate.

B.4 **Engineering Standards**

The device meets all industry safety standards, and the following table 6.4 shows the detailed information:

Standard	Description
ISO/ DTR 23482-2	Robotics -- Application of ISO 13482 -- Part 2: Application Guide[13]
IEC 61508-2	Requirements for electrical/ electronic/ programmable electronic safety-related systems[14]
ISO 13482:2014	Robots and robotic devices -- safety requirement for personal care robots[15]
CAN/CSA-C22.2	Functional safety of electrical/ electronic/ programmable electronic safety related systems[16]
IEEE C2-2017	2017 National Electrical Safety Code ® (NESC(R))[17]
ISO/ DIC 18646-2	Robotics - Performance criteria and related test methods for service robots[18]
IEEE Std 1872-2015	IEEE Standard Ontologies for Robotics and Automation[19]
ISO 10218-1:2006(E)	3.1 Actuating control - a) Mechanical mechanism within a control device[20]
ISO 10218-1:2006(E)	3.9 End effector - Device specifically designed for attachment to the mechanical interface to enable the robot to perform its task[20]
ISO 10218-1:2006(E)	3.2 Automatic mode - Operating mode in which the robot control system operates in accordance with task program[20]
ISO/IEC 26551:2016	Software and systems engineering - Tools and methods for product line requirements engineering[21]
IEEE 2050-2018	IEEE Approved Draft Standard for Real-time Operating System for Small -scale Embedded System[22]

Table B.4: engineering standards and their descriptions

B.5 **Analytical Usability Testing**

In analytical usability testing stage, it describes the approach the designers will use to perform heuristic evaluation of the usability of our system. Each designer will approach the testing without discussing opinions with the others to ensure there are no biases. The process will be done in parallel to implementation tasks, which will give us a good sense of our product's usability. For our product, which is automated kitty litter box, it contains roughly a week to complete the test, so the test will be made at the early stage of the final product, then that will give us more time to improve our product.

In order to obtain quantitative results from our testing, several test cases are proposed with expected results. The 1-5 rating scale is applied where 5 is strongly agree and 1 is strongly disagree. Our focus during these tests are the following.

1. The device is easily to powered on / off
2. The power button, emergency button and time select button is labeled for increasing visibility
3. The power button, emergency button and time select button is covered by the colorless plastic cover
4. All buttons are not easily to contact by cat
5. The system is turning off immediately while emergency button is pushed
6. The instruction on the interface are easy to understand
7. The user is easily altered in case of error occured
8. The garbage tray can be easily taken out and insert in
9. The door is locked and green LED light on the top of device lights up while scooping system is active
10. The yellow LED light turns on after scooping procedure all done
11. The red LED light turns on while error case occur
12. The four process light turn on in sequence in scooping procedure
13. The message is sent to breeder while the garbage tray is full
14. The recharging port is covered by a rubber retractable case which can be lifted
15. The recharging port is labeled

Once the evaluation of the usability is complete, testers will discuss their opinions of the system together. Actions for improvement will be made and another round testing will be done to evaluate the changes.

B.6 **Empirical Usability Testing**

In empirical usability testing stage, testing of the usability of the Caneat will be of paramount importance as the adoption of Caneat will extremely depend on the user's impression on ease of use. During the proof of concept step, functionality and user

interface testing will be limited, because the interface will be really simple and minimal. However, we still have several user test cases, which might be classmates or friends who has a cat at home. We will provide the operations regarding Caneat ‘sfunctionality to user before the testing. Finally, our team will collect all the document of feedback that the users furish about their experience with Caneat. The following list contains the exercise that we will ask to user to perform during the empirical usability testing.

Test 1

Turn on Caneat and wait 15 seconds

Question

1. Was the scooping system active after power turned on for initial set up?
2. Was the green LED lights up while scooping system is activated?
3. Was the yellow LED light up after the mission is completed?
4. Was the four process light works in the scooping procedure?
5. Was the door been locked before scooping system active?

Test 2

Turn off the system

Question

1. Was the scooping system back get back the initial position?
2. Was the door been lock after the power was turned off?

After collecting enough feedback from testers, then our team will decide which function can be modify or improve to satisfy the user’s need. Eventually, Caneat will be presented to market after all the changes have been made and functions have been enhanced.

B.7 Conclusion

User interfaces plays an important role in the product. A product with good user interface will not only save user’s time but also bring the convenient lift to user. Due to the wide range of markets, we aimed to design the simple and functional interface on Caneat. This variety gives rise to an inherent variation in the needs of the users, and the interfaces that we design must adapt to and make known this reality.

This appendix outlines the technical analysis and usabilities of our product. Currently, the proof of concept phase of Caneat is approximately complete. For the software user interface, the smart phone app will be developed next semester. The data in the app will show the defecation condition of the cat and also the capacity of the garbage tray. Finally, what currently exists is a working proof of concept version of Caneat, with circuitry that connect the motors and sensors with microcontroller.

Appendix C: 440 Planning

C.1 Introduction

The objective of our project is to develop a device that can take care of the cats and keep them tidy when the owners are not at home, or when they are out of town for couple days. Also, it will provide the elderly owners an easier method to do the litter job. The feature function for the device will be cleaning the cat litter box automatically. The device will detect whether the litter box has been used by the cats, and send signals to inform the micro controller. The controller will have to decide automatically whether it is the time to clean up. In order to use the cat litter efficiently, the mechanism of the waste cleaner will be designed to filter it. The clean litter will be kept afterwards, and the device will get rid of the waste. This document is a proposal providing an overview of our projects, outlining the user scope, studying the trending market, sources of funding, and project planning. At the end of the 440 planning appendix, we will show you the detailed budget management, and its alternate method. Gantt chart and the milestones timeline show an ideal schedule, and we will work in this direction as much as possible.

C.2 Project Overview

This section outlines the overall high level system design and overview of our product. We will discuss the scope of the project and the requirements and deliverables that are to be produced. To finish off it will outline the risks that may be presents as well as the benefits that the successful completion of this project will provide.

C.2.1 Scope

The purpose of CANEAT is to provide an easy and convenient device to assist the cat breeders who are disabled, elderly, busy, and lazy to clean up after cats using the litter box. The goal of our project is to design and create a product that is both affordable as well as easy to use to help those kind of breeders to enjoy more convenient lives with their cats. To accomplish this, we establish the main requirements of our device, which includes:

- Detecting whether the cat is inside of the litter box
- Filtering out the waste after separating them from the litter
- Using coloured light to indicate different status
- Reporting to users when the device is in erring process
- Checking the waste is exceed the weight limit

The detailed information for our project will also be posted on a company website with product supports. In addition, the actually cost will be minimized, and much less than the initial cost if we assuming there is a large scale production is planned.

C.2.2 **Risk**

This section discusses the possible risks associated with the product during the period we are designing, prototyping, and final product. It will also point out some potential risks while cats and breeders are using it. The risks include: unable to achieve the goal on time, unpredictable costs, mechanical issues, and uncertain damage from cats.

Unable to Finalize

This should be a common risk for many projects. Especially for a new oriented device, to design and develop each single function costs time for a team to do study and research. In addition, at the stage of integrating, more problems and bugs will need to be solved which is a major reason for postponing finalization. The best method to mitigate the delay is always accomplish every steps ahead of schedule.

Unpredictable Costs

Due to CANEAT will be assembled with 3D-printed components, the material cost is a unpredictable factor. The servo motors' cost which are used to support the prototype are also unpredictable since the motors' price range for different power is huge. Therefore, the table of cost estimation shows the maximize possible cost.

Mechanical Issues

In order to filter the waste from the cat litter properly, the structure of the device must be stable enough to support large amount of litter. The motors need to be powerful enough as well to move around the waste scoop among the litter. Since cat litter is tiny, the mechanical part has to be separated from the litter completely. Otherwise, the mechanism will easily stuck and stop working.

Uncertain Damage From the Cats

If the product is used by a kitten, it will get used to use it, but if the adult cats use Caneat someday instead of using the original litter box, they may do not like it, and even try to damage it since it is something strange. Therefore, it is necessary to attach some protections.

C.2.3 **Benefit**

In this section, we will discuss the benefits of Caneat, which include life efficiency, health and safety and reliability and quality of service. These benefits bring not only convenient but also comfortable life to breeders.

Life Efficiency

Although breeders love their cats, they may be tired of cleaning the waste someday. Now it is the time for Caneat to demonstrate their ability! No matter the breeders are disabled, busy or tired of the day, they can can just leave the litter box alone without the stinky smell, and spend time with their lovely cats. Ultimately, the product creates a more convenient lifestyle.

Health and Safety

To ensure there is no health issue that is harmful to the breeders or cats, the material which assembles the device will be followed the material standards strictly. To ensure it is a safe device, the power source will be under controlled, and all wires will be banded properly.

Reliability and Quality of Service

Our product aims to provide a consistent, high-quality cats waste cleaner. Detailed online instruction is posted on our website, and we welcome any kinds of suggestion and questions.

C.3 Market

C.3.1 Market Analysis

According to GfK (Growth from Knowledge) survey, 61% of Canadians own at least a pet. 35% of Canadians have cats (compared to 23% internationally), which is slightly greater than the dog ownership percentage [4]. In total, around 8.8 million of cats are breeded in Canadian families. [5] Therefore, it can be derived that, currently, more and more families have more than one cat at home. Spending on pets and pet food in Canadian households rang in at CAD 4.1 billion in 2015, according to Statistics Canada. [6] By counting the number of reviews to the most popular automatic litter box, PAL17-10786 produced by PetSafe, on Amazon, over the last 12 years (2006 ~ 2018), the volume of sales can be summarized as the figure below. It is obvious that the demand of the product is increasing. In 2007, there is only 12 reviews. 11 years later (2018), in May, 46 feedbacks have been left in a single month, which is 3.83 times of that in the entire year (2007). From 2017, the market share of the automatic litter box tends to be stabilized. In March, April and May, 2018, 50, 45 and 46 feedbacks have been left respectively. Overall, the automatic litter box has potential to equally share the market in the future.

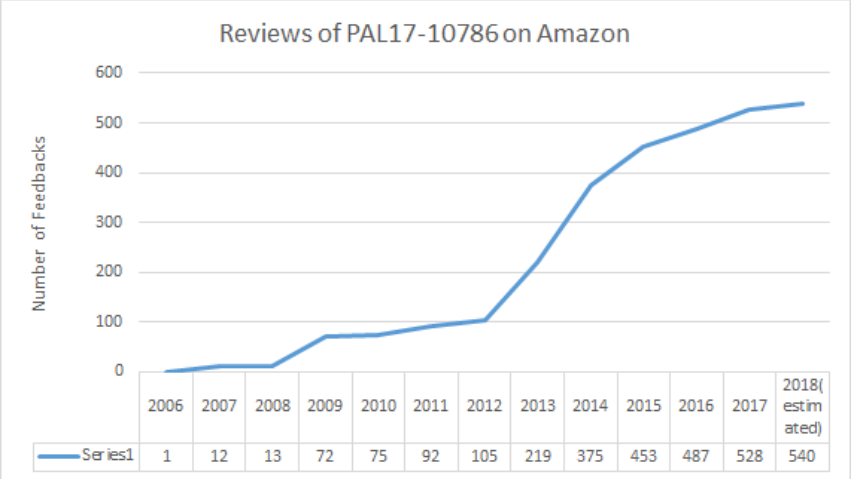


Figure C.3.1 : Reviews of PAL17-10786 on Amazon

There are several reasons resulting in an increasing demand of the automated litter box. First of all, no matter how much you love your pets, taking care of their litter can hardly consider as a pleasant job, especially for the elder. It takes time, needs a bit strength and has to be patient. Moreover, when you have a close touch with their urine and excrement, even if they have already been purified by the cat litter, the litter gives off a pungent smell. Additionally, in the case which breeders leave home several days for business or vacation and their cats have to stay at home alone, probably, as a result, the litter box can not be cleaned up on time. Consequently, cats will not be willing to use the litter box and they are going to pee or poop wherever they prefer. Therefore, in order to resolve these troubles, using automated litter box is always a better choice, compared to manual work.

However, some others factors may have impacts on the promotion of it. The first concern is, as for breeders, that whether the product is reliable and meets the expectation, which can be classified into several points. The automated litter box should be proved that it can effectively filtered out the excrement. Also, the cat litter refilling function should be activated after the cleaning progress has been terminated, which should be tested to check its validity. Once the garbage bin has been detected as full, the litter box should be turned to sleep mode and breeders should be notified. Last but not least, the product will not arouse any safety risks for cats. Addition to the reliabilities, currently, the price of product is much higher than the standard type. Regarding this, not all breeders are willing to pay extra money for it. It is the most direct factor affecting the market.

Overall, even though the automated litter box is not the most indispensible product for breeders, it shall be a valuable investment since the we are confident that our designed product is much more reliable and the price is affordable for most of intended customers.

C.3.2 **Competitions Design**

Currently, several companies have developed their own automatic litter box and many of products are available on Amazon. They are designed to be operated by different software controlling system, although some of them perform similarly. In order to efficiently scoop the waste in the litter box, the cleaning cycle is realized by different mechanisms. The price for automated little box ranges from CAD 104.97 to CAD 598.67 plus tax and delivery fee. These are some litter boxes that has similar function as Caneat, LitterMaid, PetSafe and Litter Robot.

LitterMaid is the cheapest automated litter box available on Amazon. It can automatically scoops waste after the cat uses the little box controlled by an adjustable program. After each cleaning cycle, the sleeping time of the automated progress is subjected to be adjusted. However, the low price can reflect that cost of product development might be lower than similar products in the market, which means the litter box may not perform ideally. Related to its controlling algorithm, even if the receptacle is full, its work is not going to be terminated, which means the waste are not going to be scooped out properly. Referring to my experience, the litter box is better to have a lid, which creates a more private room for cats and can effectively eliminate odors.

Figure C.3.2 : LitterMaid LM680C

The most popular automatic litter box online is PAL17-10786 produced by PetSafe. This litter box has a sensorless controlling system. The litter box is cleaned once an hour no matter if it is occupied. In terms of the scooping mechanism, instead of using a linear transformed rack, the base of it is rotational transformed around the centre of the box. However, this product is not flawless. Since the waste bin is not closed, even if the waste can be removed from the litter box, odors can not be reduced as long as the waste bin is not replaced.

Figure C.3.3 : PAL17-10786

The top rated automatic litter box is Litter-Robot III Open Air Automatic Self-Cleaning Litter Box, which is the most expensive one. In terms of its appearance, it is extremely fashion. The controlling algorithm is similar to that applied to LitterMaid. However, the cleaning cycle will be activated 7 minutes after the cat used the litter box. Compared to two litter boxes introduced above, the cleaning mechanism of Litter-Robot III is totally different and less time-consuming. Specifically, as the globe slowly rotates, the patented sifting system separates the clean litter from the clumps, and drops the waste into a carbon-filtered drawer in the base. The globe returns to the home position, leaving a clean, level bed of litter for the next use.

Figure C.3.4 : Litter-Robot III

C.4 Project Management

C.4.1 Time Management

In Figure 7.4.1 shows the Gantt chart of our project. This project is combined with two, four-month phase. The first phase will be designed the requirements and concept of product in software and the documentation. The second four months are assembled and created the prototype. In Figure 4.7.1 represents the second phase and there are several subtitles, which are physical design, prototype and final product and demonstration.

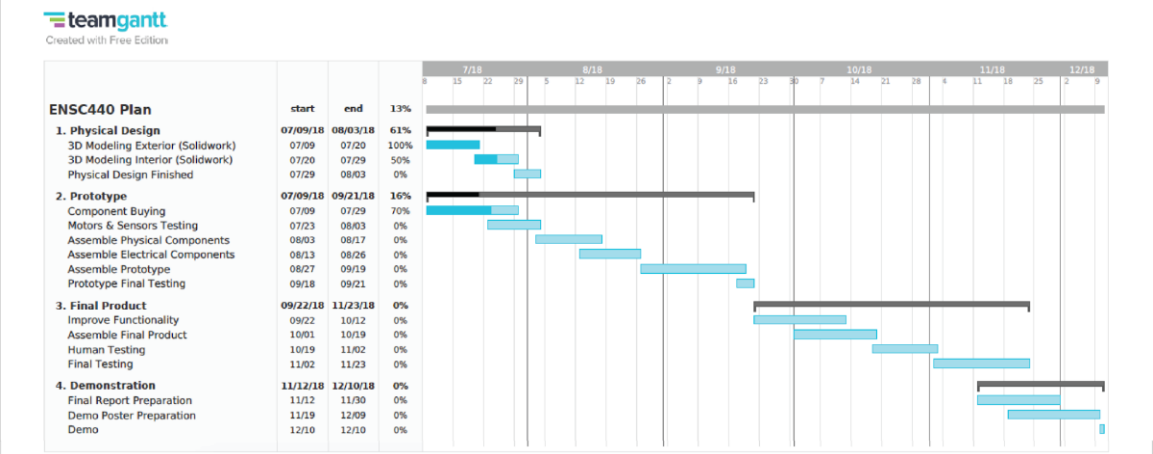


Figure C.4.1.1 : Gantt Chart of 440 [7]

C.4.2 Personnel Management

In Caneat Inc., there are three brilliant and compassionate senior engineering student, Kai-Lun Liang, Zewen Wu and Wenjie Li. In 440, Kailun will be focused on

software development of project app. Zewen will concentrates on mechanical system analysis and development, such as force analysis of scooping system. Finally Wenjie will aims to build the electrical system of Caneat, which includes connection of microcontroller with circuitry.

The priority of application that Caneat Inc team develops will be ios version first then Android version. The programming language that build the application swift code on Xcode 9/10. To analysis the mechanical system of our product, we have made the model in solidwork in progress, which can test the our system and design. For electrical system, we will, firstly, build the circuit of our system on breadboard with Arduino and testing the current and voltage with multimeter that those are not exceed the limit on the microcontroller.

C.5 **Budget Management**

There are two table in this section, which are Table 7.5.1 and Table 7.5.2. In Table 7.5.1 shows the cost consideration of prototype. On the other hand, Table 7.5.2 describes the budget management of final product. The cost of prototype and final product is around $300 in Canadian Dollar, which is $200 lower than previous proposal cost, because we changed some of our product design. After doing the market analysis, we removed the camera feature and replaced the infrared sensor by photoelectric sensor. In addition, the exterior material that applied on CANEAT changed to wood and acrylic sheet instead of high cost of 3D printing.

Device	Description	Cost (CAD)
Litter box & Litter	Litter box, Litter	$38
Arduino Uno	Arduino Uno	$40
Weight Sensor	Detect excrement over limit or not	$10
Photoelectric Sensor	Detect Cat	$20
9V, 1A Adapter Charger	Power source	$4.07
Electrical & Mechanical Components	Motor/ Resistor/ Capacitor/ Opamps/ MOSFETs/ Breadboard/ Adapter,etc	$30
Structural Components	Wood / Acrylic Sheet	$150
Tax	12 %	$35.05
Total		**$327.12**

Table 7.5.1 : Budget of Prototype

Device	Description	Cost (CAD)
Litter box & Litter	Litter box, Litter	$38

Weight Sensor	Detect the excrement & cat	$10
Photoelectric Sensor	Detect Cat	$20
9V, 1A Adapter Charger	Power source	$4.07
PCB	PCB Manufacturing by CM	$50
Electrical & Mechanical Components	Motor/ Resistor/ Capacitor/ Opamps/ MOSFETs/ Breadboard/ Adapter,etc	$30
Structural Components	Wood / Acrylic Sheet	$150
Tax	12 %	$36.25
Total		**$338.32**

Table 7.5.2 : Budget of Final Product

C.6 **Conclusion**

As cat breeders, they will be tired of cleaning the waste sometime, or too busy to clean it on time. Now the automated cat litter box brings you a more convenient method to deal with your pets instead of doing it manually. In addition, there is no more need to worry that the waste will continue to stink the room after a busy day after school or work since CANEAT will handle this for you.

To accomplish this this task, CANEAT will utilize a micro-controller as a core to control our unique mechanical design. The mechanism will include several servo motors and gear motor to separate the waste from the litter then filter it out. In order to detect occupancy of the litter box, some sensor such as weight sensor and photoelectric sensor will be attached in order to achieve more precise results.