Automatic Pet Feeder
Project Proposal and Design Review

TA: Henry Duwe

Project Contributions:

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1. **Introduction**

We chose this project because pet keeping is a time consuming responsibility and we want to provide convenience to owners by helping them feed their pets easily and smartly.

1.1. **Motivation**

Keeping pets takes many commitments. This includes keeping them company, showing your concerns and of course, feeding them on time and in the correct way. However, not everyone is a pet expert, taking care of your pet’s diet can be hard and time consuming. One of the top health concerns of pets are overeating and obesity. Especially at younger age, they are usually satisfied with however much is given to them. Many adult pets are fed unscientifically that later may cause short lifespan. Another problem of feeding pets is that owners might not always be home regularly. Being occupied by personal plans knowing that they still have a starving little fellow at home to be taken care of is always a concern that bothers owners. The third concern that we want to deal with is the fact that there hasn’t been any product on the market right now that is able to dispense different foods for different kinds of pets. However, pets themselves might not necessarily recognize the potential health problems of eating the wrong food. Therefore, we want to take care of owners’ concern of feeding by building a phone-controlled automatic pet feeder that can dispense the correct amount of food on time, based on the type of animal that’s demanding it.

1.2. **Objectives**

Our project is designed to help all the pet owners to feed their pets remotely and smartly.

**Benefits to customer:**

- Owners will be able to feed the correct amount of food to their pets by setting it on the phone app. The information will be transferred to the PCB via Bluetooth, which will send signals to food dispensing gates.
- Owners will be able to monitor their pet’s health condition via their daily consumption of food recorded by the app. Sensors will be embedded on the food plate, which measures the difference of weights by the end of each day. Information will be processed by PCB and sent to the phone app.
- Owners with two different types of pets will be able to feed them separately with corresponding food. In particular, a household can have dogs of different ages that need different food; or if the owner owns both dog and cat and does not want them to eat the wrong food by accident. Each pet will have a RFID tag. When the RFID receiver identifies the type of animal, the correct angle of food plate will be spinned so that the corresponding food will be exposed.

**Product feature:**

- The phone app could set the correct amount of food to drop at the correct time.
● The phone app could save a pet profile (name, age, birthday, weights, etc) for owners to keep track.
● The app could keep track of how much food the pets have consumed in a long run graphically.
● The machine could be sustained by both power cords.
● RFID will be embedded into pets’ tags to differentiate types of pets for different food needs.

2. Design

2.1. Block Diagram

Figure 1: General block diagram of the hardware design
2.2. Block Descriptions

2.2.1. Microcontroller

We choose to use AVR 8-bit microcontroller because it provides a nice compatibility with any of the other modules on the market. 8-bit is also sufficient for our purposes. The microcontroller is the central control unit of the whole system. It will be collecting many inputs. This includes: measurement from sensors, which will be transferred to phone devices via Bluetooth; RFID activation signal from the reader, which will be processed in the microcontroller; data acquisition signal from the Bluetooth, which asks the daily food consumption data stored inside of the microcontroller. The microcontroller also generates several outputs. First, after receiving triggered signal of RFID, it will look up the angle to spin for the round food plate if current exposed region is not for the particular animal. Second, when the weight sensor on the food plates measures insufficient amount of food, the microcontroller will signal to rotate the gate by the precalculated angle and dispense 100 grams of food for the animals. We chose to dispense 100 grams of food at once to make sure that the dispensing process is in a range that we can control and it also helps minimize collateral damage in case the pet trips the machine over and spills all the food. Once the total amount dispensed has reached the upper limit that the owner has set, no more food will be able to dispense. This feature helps
prevent overeating problem of pets. The microcontroller will be storing the weight of remaining food in the containers only when there is an action of food dispense, while storing the food weight on the food plates at regular time to keep track of animals’ food consumption. In addition, the microcontroller also stores the consumption data which will be transferred to the phone upon Bluetooth request.

2.2.2. RFID Module

Passive RFID module will be used to recognize different pets and dispense food correspondingly. We chose passive RFID for two reasons. First, it minimizes the consumption of electricity and potential danger of the pets by having no on-tag power supply. Secondly, passive RFID grants small read range for the receiver. Having a small read range minimizes the possibility that the receiver misrecognizes a pet for eating when it’s only hanging out around the machine to prevent unnecessary mechanical movements and electrical consumption. When the animal has come to the range of the reader (50 cm), microcontroller will be notified by the receiver. The microcontroller will signal the round food plate to spin at the precalculated angle and expose the correct section of food for the animal to have.

2.2.3. Sensors Measuring Food Containers

Two identical cylindrical containers will be assembled at the top of the machine, with a weight sensor attached to the bottom of each container. The sensors will be taking measurements constantly and sending their data to the microcontroller, while microcontroller stores data only when an action of food dispense has occurred.

2.2.4. Sensors Measuring Food Plates

There will be two separate food plates in the shape of half-circles. Two weight sensors, one for each half of the food plate, will be attached to the bottom of the plates. The sensors will keep track of the amount of food the pets have consumed. The sensors will be taking measurements constantly and sending their data to the microcontroller, while microcontroller stores data on specified time of the day.

2.2.5. Bluetooth Module

Bluetooth module will be implemented by HC-06 Wireless Bluetooth Transceiver Module. HC-06 module is a widely used bluetooth module which supports Bluetooth 4.0 technology and can provide a significant small latency (approximately 3ms). It can be connected directly to the 5V AVR 8-bit Microcontroller. The effective distance of this device is 10m, which would satisfy an easy connection and pairing.
2.2.6. Servomotor Controlling Food Gate

There will be a 120° pie shape opening on the bottom of each food container, which corresponds to the same 120° pie shape on the gate plate. The gate plate is a smaller circular shape plate attached in the middle of the two containers. With the 120° opening on the gate plate, it allows the food to be dispensed when the two pie shapes overlap with each other. Servomotor, controlled by microcontroller, will be spinning the gate plate to desired location.

2.2.7. Servomotor Controlling Food Plates

The food plate will be a half closed structure where only one side of the food plate would be exposed at a time. Once RFID reader signal is triggered, microcontroller will be sending spin information to the motor. The servomotor will spin the plate by the specified angle and direction to expose the corresponding half of the plate for the particular pet.

2.2.8. Phone application

Figure 2 is a state diagram that shows a complete execution logic of the phone application. The edges represent inputs from the user. The ones without any illustration are assumed to be “of all inputs”. The application will send and receive information to/from the feeder via Bluetooth connection. Bluetooth 4.0 will be preferred but 3.0 will also be accepted.

The first page of the interface will be the Home page. Three tabs will be displayed: “Set”, “Profile”, and “Data”. When user clicks on either “Set” or “Profile”, they will be prompted to select either Pet 1 or Pet 2 first. The user will then have the option to enter the food information for the selected animal. If the entered amount is invalid (negative or exceeds our maximum capacity), a warning will be prompted and it will go back to the previous state and ask user to enter the numbers again. After completing the “Set” information, the software will go back to its initial Home state.

If the user chooses to enter the bio-information of the pet by pressing “Profile”, a form which contains questions including the age, weight, and gender will be given to the user. Then the user will again go back to the Home screen. In addition, the third tab “Data” enables the users to collect information of pets’ food consumption. When the tab is pressed, the phone will be sending a data request signal to the microcontroller. When the data is acquired, it will ask the user to choose between “Graph” and “Today”, which will generate either a graph of pets’ weekly consumption or more detailed information of today’s consumption.

2.2.9. Power Supply

Specified below in Section 3.
3. Calculation and Simulation with Power Supply

3.1. Block Diagram

![Block Diagram](image)

Figure 3: Block Diagram

3.2. Block Description

From the circuit diagram above, it could be easily seen that the voltage was changed from 120V RMS to 6V RMS by a transformer with N2/N1 = 1/20. The diode rectifier is a full-wave rectifier shown below.

![Full-wave rectifier schematic](image)

Figure 5: Full-wave rectifier schematic

The capacitive filter reduces the ripple peak-to-peak voltage since it resists changes in voltage. The output becomes much smoother after the filter. The last component is the voltage regulator, which consists of a zener diode in its breakdown region. It acts like a voltage regulator because at breakdown region, the voltage across the zener diode is always 5V.

3.3. Current range of the zener diode rectifier

Zener Diode 1N4733A was used in the circuit. Imin = 17.5 mA. The maximum value of diode current was decided by two factors - the output current and the maximum allowed power dissipation of the zener diode. When there is no load connected to the regulator, Imax = Imin + 20 mA. However, there must be a limit that the zener diode can handle. The maximum current
cannot grow unlimitedly as the minimum current increases. It turns that the maximum current allowed is regulated by the maximum power of the zener diode, which is 500mW. Since the real power should not exceed the 75% of the maximum allowed power, \( P_{\text{max}} = 375 \, \text{mW} \), which makes the \( I_{\text{max}} = 37.5 \, \text{mA} \).

3.4. **Determine \( R_s \) and Filter Capacitance**

After determining the maximum and minimum current of the zener diode rectifier, the value of \( R_s \) was found. The diagram below is used to show the circuit for determining ripple voltage across the capacitor.

![Figure 4: Circuit Schematic](image)

Since the ripple voltage is required to be less than 2%, it should be less than 0.2. After applying KVL to circuit, following equations were obtained:

\[
R_{s, \text{full}} = \frac{6\sqrt{2} - V_D - 5}{I_{\text{max}}} = \frac{6\sqrt{2} - 1.4 - 5}{0.0375} = 55.6\Omega
\]

Capacitance for full-wave rectifier were obtained separately as shown below:
3.5. Simulation

Simulation was conducted on the circuit design through the PSPICE. Output DC voltage was measured and plotted as shown in the graph below. It is clear that the power supply has a fast rising time which is almost instantly and a quick stabilizing time which is around 0.3s.

\[ f = 120Hz \]
\[ R_{s,full} = 55.6\Omega \]
\[ I_s = 0.0375A \]
\[ V_{ripple,full} = 0.2 \frac{(R_s + R_z)}{R_z} = 0.854V \]
\[ C_{half} = \frac{I_s}{V_{ripple,full} \cdot f} = 73.17\mu F \]

Figure 7: The average output DC voltage of 120sqrt(2) VSIN without load
## 4. Requirement and Verification

<table>
<thead>
<tr>
<th>Module</th>
<th>Requirement</th>
<th>Verification</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>RFID Module</td>
<td>a. Be able to recognize the pets correctly in the range of 50 cm +/- 15 cm</td>
<td>a) 1. Connect the receiver to a computer through an Arduino &lt;br&gt; 2. Test the RFID tag from 40 cm to 80 cm away from the receiver &lt;br&gt; 3. Check the data sent to the computer and monitor the range when the receiver stops recognizing the tag</td>
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<tr>
<td>Sensors Measuring Food Plates</td>
<td>a. Be able to measure the correct data at 15 grams tolerance &lt;br&gt; b. Be able to respond to the changes of weights in food containers accurately</td>
<td>a) 1. Connect the sensor to a computer through an Arduino &lt;br&gt; 2. Fill the food container with a known amount of pet food (i.e., 200g) &lt;br&gt; 3. Check the data generated by the weight sensor and see if it’s within the tolerance &lt;br&gt; b) 1. Gradually pour food into the container &lt;br&gt; 2. Observe the data change via computer to see if there is any discontinuity or unusual</td>
<td>20</td>
</tr>
<tr>
<td>Bluetooth Module</td>
<td>a. Be able to connect with the phone app &lt;br&gt; b. Has at most 5 ms latency for signal transferring</td>
<td>a) 1. Connect the phone with the Bluetooth Module &lt;br&gt; 2. Check the connectivity status on the phone &lt;br&gt; b) 1. Write a code to check the speed of response signal on Arduino &lt;br&gt; 2. Connect the Bluetooth module to computer through the Arduino &lt;br&gt; 3. Send a signal from the Bluetooth module &lt;br&gt; 4. Check the result responding time</td>
<td>20</td>
</tr>
<tr>
<td>Servomotor Controlling the</td>
<td>a. Be able to rotate the food gate for specified degree in a given direction &lt;br&gt; b. Steady performance</td>
<td>a) 1. Connect the motor to the computer through an Arduino &lt;br&gt; 2. Send specified degrees and direction to the motor &lt;br&gt; 3. Check motor’s performance &lt;br&gt; b) 1. Perform test a) 10 times &lt;br&gt; 2. Check motor’s accuracy</td>
<td>20</td>
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<tr>
<td>Food Gate and Food Plates</td>
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<tr>
<td>Microcontroller</td>
<td>a. Be able to receive inputs and generate right output signals &lt;br&gt; b. Be able to store data</td>
<td>a) 1. Power the microcontroller with 5V &lt;br&gt; 2. Connect a LED to the microcontroller &lt;br&gt; 3. Program the microcontroller to light the LED up when a digital signal of high is received &lt;br&gt; 4. Input the signal through a constant DC voltage as a logic high via function generator</td>
<td>20</td>
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</tbody>
</table>
5. Check if the circuit behaves normally
   b) 1. Power the microcontroller with 5V
   2. Connect the microcontroller to several LED’s
   3. Program the microcontroller to store the data upon receiving it, and display it on LED when the button is pushed
   4. Push the button and check if the circuit behaves normally

| Power Cord | a. Supply 5V +/-0.25V at a minimum of 1A +/- 0.25A | a) 1. Place Digital Multimeter in parallel with the power source. Measure the voltage difference across the power source. The voltage should read 5V +/- 0.25V
2. Place Digital Multimeter in series with the power source and heating elements. Measure the current difference from the power source. The current should read 1A +/- 0.25A | 5 points |

5. **Tolerance Analysis**

In terms of our project, the high level goal is to make two pets to be fed by the right food in the correct amount. More specifically, for every time the food is dispensed, 100g of food should be released. The maximum tolerance allowed is +/- 15 g so we are able to keep track of pets’ food consumption in a more accurate way. Among all components, bluetooth latency will not have significant effect because it should not happen at the time of dispensing. The accuracy of the servomotor at the gate of the dispense does not have a huge impact on our high level goal. This is because the amount of food dispensed is controlled by the weight sensors so that it will still be able to dispense the right amount, although the off of angle might cause the dispensing process to be not as smooth.

On the other hand, the weight sensors we will be using, which consist of load cells and AD modules, are the most essential part of our project, because we want to make sure that the correct amount of food is dispensed so that we can obtain the accurate information of each pet. The load cells we are going to use will have a range from 0-5 kg. To test the tolerance of the sensor, we will be loading different amount of food onto the plate and check its accuracy compared to the actual one. Though normally the food container will not be big enough to hold 5 kg, it is still important to test its extremes cases. To perform the test, we will put food of exactly or slightly over than 5 kg on the load cell and see if it’s measuring correctly. The results will be recorded in the notebook.
6. Cost and Schedule

6.1. Cost

Labor:
Zhuokai Zhao: $40/hour * 2.5 * 50 hours = $5,000
Ziyun He: $40/hour * 2.5 * 50 hours = $5,000
Fan Ling: $40/hour * 2.5 * 50 hours = $5,000
Total: $15,000

Parts List:
1. Four HX711 Load Cell Weighing Sensor AD Module ($9 each)
2. Four Load Cell Sensor 0-5 kg ($6 each)
3. Two Arduino T010051 Motor ($14.36 each)
4. Two RFID Module ($8.99 each)
5. Two Buckets for Food Container and Outside Cone Shape ($4+$8)
6. HC - 06 Wireless Bluetooth Transceiver Module($5.99)

Sum planned parts cost: $118.71
Grand Total: $15,118.71

6.2. Schedule

<table>
<thead>
<tr>
<th>Week</th>
<th>Task</th>
<th>Responsibility</th>
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<tbody>
<tr>
<td>February 8</td>
<td>-Finish Project Proposal</td>
<td>Ziyun He</td>
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<tr>
<td></td>
<td>-Prepare for Mock Design Interview</td>
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<tr>
<td></td>
<td>-Finish Project Proposal</td>
<td>Fan Ling</td>
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<td></td>
<td>-Prepare for Mock Design Interview</td>
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<tr>
<td></td>
<td>-Finish Project Proposal</td>
<td>Zhuokai Zhao</td>
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<td></td>
<td>-Prepare for Mock Design Interview</td>
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<td>February 15</td>
<td>-Complete the Eagle Assignment</td>
<td>Ziyun He</td>
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<td></td>
<td>-Consult Experts</td>
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<td></td>
<td>-Complete the Eagle Assignment</td>
<td>Fan Ling</td>
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<td></td>
<td>-Consult Experts</td>
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<td></td>
<td>-Complete the Eagle Assignment</td>
<td>Zhuokai Zhao</td>
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<td></td>
<td>-Select and Acquire Equipment, such as Servo, Weight Sensors, RFID,</td>
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<td></td>
<td>and Bluetooth Module</td>
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<td>February 22</td>
<td>-Complete Soldering Assignment</td>
<td>Ziyun He</td>
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<td>-Build “Profile” Tab for Phone App</td>
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<td>-Complete Soldering Assignment</td>
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<tr>
<td></td>
<td>-Build and Test the Power Module</td>
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<tr>
<td>Date</td>
<td>Task Description</td>
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| February 29| - Prepare for Design Review  
- Design and Acquire PCB                | Zhuokai Zhao|
|            | - Build “Setting” Tab for Phone App  
- Design and Acquire PCB                | Ziyun He    |
|            | - Build and Test the Power Module  
- Test and Find the Right Spin Speed for Both Servomotors | Fan Ling    |
|            | - Design and Acquire PCB  
- Build and Test RFID Module            | Zhuokai Zhao|
| March 7    | - Build “Setting” Tab for Phone App  
- Design and Acquire PCB                | Ziyun He    |
|            | - Test and Find the Right Spin Speed for Both Servomotors  
- Test the Weight Sensors and Obtain Their Limits | Fan Ling    |
|            | - Design and Acquire PCB  
- Build and Test RFID Module            | Zhuokai Zhao|
| March 14   | - Build “Data” Tab for Phone App  
- Build the Outside Supporting Structure, Gates, Food Plates, Dividers and Containers | Ziyun He    |
|            | - Test the Weight Sensors and Obtain Their Limits  
- Build the Outside Supporting Structure, Gates, Food Plates, Dividers and Containers | Fan Ling    |
|            | - Build and Test RFID Module  
- Finalize Design for PCB               | Zhuokai Zhao|
| March 21   | - Build “Data” Tab for Phone App  
- Build the Outside Supporting Structure, Gates, Food Plates, Dividers and Containers | Ziyun He    |
|            | - Build and Test Bluetooth Module  
- Test Sensor and Servo with PCB       | Fan Ling    |
|            | - Complete R&V Table  
- Build and Test Bluetooth Module       | Zhuokai Zhao|
| March 28   | - Test App Functionalities with PCB                                                | Ziyun He    |
|            | - Test Sensor and Servo with PCB                                                    | Fan Ling    |
|            | - Test Bluetooth and RFID Modules with PCB                                          | Zhuokai Zhao|
| April 4    | - Finalize R&V Table  
- Prepare for Mock Demo/Debug                                                         | Ziyun He    |
|            | - Prepare for Mock Demo  
- Finalize PCB                                                                                | Fan Ling    |
<p>|            | - Finalize R&amp;V Table                                                                    | Zhuokai Zhao|</p>
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<td>- Prepare for Mock Demo</td>
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<td>- Testing and Debugging App Functionality with PCB</td>
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<td>- Testing and Debugging Sensor and Servomotors</td>
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<td>- Testing and Debugging RFID and Bluetooth Module</td>
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<td>April 18</td>
<td>- Corner cases and Optimization with App</td>
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<td>- Corner cases and Optimization with Sensors and Servomotors</td>
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<td>April 25</td>
<td>- Complete Final Paper</td>
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<td>May 2</td>
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<td>Zhuokai Zhao</td>
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7. **Safety Statement**

7.1. **Electrical Concerns:**
The our product is powered by standard power outlet of 120V through a power cord and protected by plastic wrapping around the metal wire. If the power line is exposed to air, users should not contact the power cord directly. Instead they should turn the power off immediately and rewrap and protect the wires before any harm coming to them or their pets.

Do not place the machine in extreme heat conditions. Temperature over 70°C is extremely dangerous for microcontrollers and power system.
7.2. **Mechanical concerns:**

Two servomotors are used in our product. If the exterior of the product is compromised in any way, please replace the product immediately to prevent any injury that may come to you and your pets. In particular, when the food plate is spinning to the right section of the pet food, although we have polished the structure to prevent people/pet from accidentally getting stuck in between the spinning process, please still pay attention to the machine when it spins.
References


