

# Trail Mix Dispenser

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## 1 Introduction

### 1.1 Purpose

In the modern world, an increasing number of people are living under high-stress conditions and their time is becoming more and more valuable. A common example of this is the college student who lives a high-stress lifestyle as a result of constant coursework, extracurriculars, and personal endeavors. High-stress lifestyles leave little to no time for thinking about, preparing, and maintaining healthy dietary habits. For example, almost half of all college students in a study done in Gwangju, South Korea ate out at least once a day[1]. In addition, high levels of stress have been linked to increased eating of sweet fatty foods[2]. These two facts, in conjunction, would indicate that high-stress lifestyles lead to unhealthy dietary habits. Diet has a demonstrable impact on people's physical and cognitive function. In the afternoon, a calorie rich snack such as trail mix could provide a much needed boost to a student or young professional[3].

A common problem with home preparation is that it is difficult to accurately measure the amount of calories in a meal without a strong understanding of the ingredients and their masses. Many people that are invested in living healthy lifestyles own food scales now and it has been proven that measuring food before consumption has a positive impact on the outcome of diet plans[4]. Our position is that providing these people with low-effort, healthier, and customisable food options from their home would increase their quality of life. Our conclusion is that a well rounded trail mix with nuts[5] can be healthier and simpler to prepare than the majority of commercially available snacks.

Our goal is to create a trail mix dispenser that will allow the user to remotely create a quick and healthy snack to bring along wherever they go. Rather than taking time out of the user's day to think about and prepare a snack, they will be able to simply indicate the contents of their customisable trail mix from their phone. The trail mix dispenser, using bluetooth, will receive this information and hastily and accurately dispense the desired contents, mix them together, and dispense them into the user's container ready for consumption.

## 1.2 Background

Our research found that there are a few options for automatic snack dispensing[6]. However, these dispensers do not measure the amount of food dispensed. There also exist many different forms of manual dry food dispensers, such as the cereal dispensers commonly seen in cafeterias, however none of these are automatically operated nor do they have an attached food scale. This means that health conscious people and want to count calories have to manually prepare and measure their food.

The importance of having healthy on-the-go options, as stated in the purpose, is growing from a convenience to a necessity in busy modern lives. The goal of our project is to automatically measure, prepare, and dispense the food for the user in their own home using their own ingredients. This allows the user to regain control over their diet without losing more time.

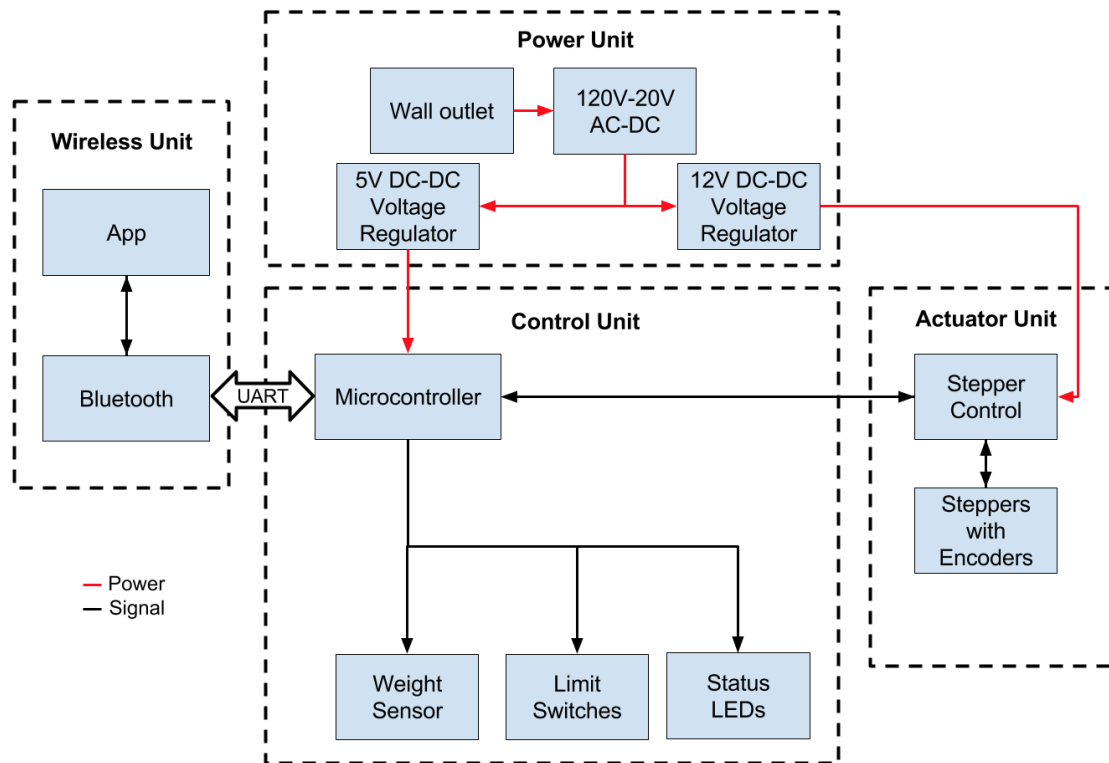
## 1.3 High-Level Requirements List

- The dispenser must be able to dispense trail mix autonomously once request has been issued from the app
- The dispenser must dispense within +/- 20g per ingredient
- The dispenser must be able to dispense within 5 minutes from start to finish

# 2 Design

## 2.1 Block Diagram

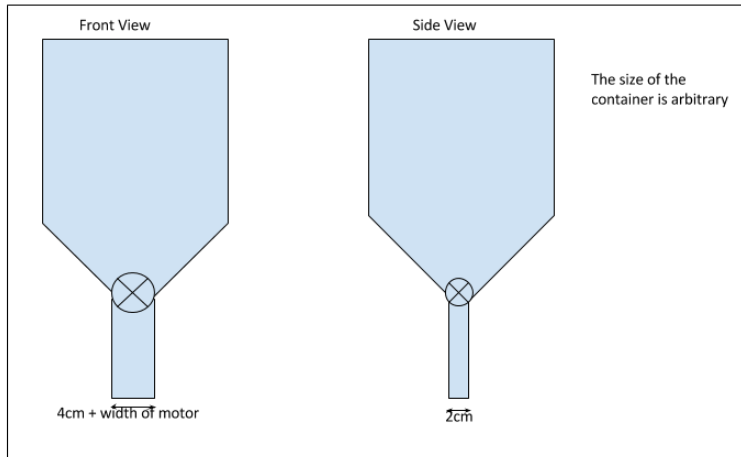
The entire design requires four functional modules that are all interdependent for proper function: the power supply module, the control unit module, the actuation module, and the wireless module. The power supply module's purpose is to take 120VAC 60Hz power from a standard wall outlet and convert it to manageable 12VDC and 5VDC to power the other modules. The wireless module will include an application that will communicate to the system using bluetooth, which is how the user will interface with the design. The control unit module will control stepper motors and LEDs based on the current state and encoder data.



## 2.2 Physical Design

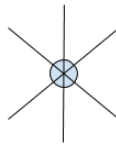
Our physical design consists of three separate processes: dispensing ingredients from the four containers, mixing them in a bowl, and serving them into a container of the user's choice. All three of these processes will be carried out with different motors and pumps. The dispensing will be controlled by stepper motors that are at the bottom of the containers. Once all the ingredients have been dispensed into the bowl, a motor within the bowl will mix the ingredients. The bowl will then be tilted, pouring the trail mix into the user's container.

## Container



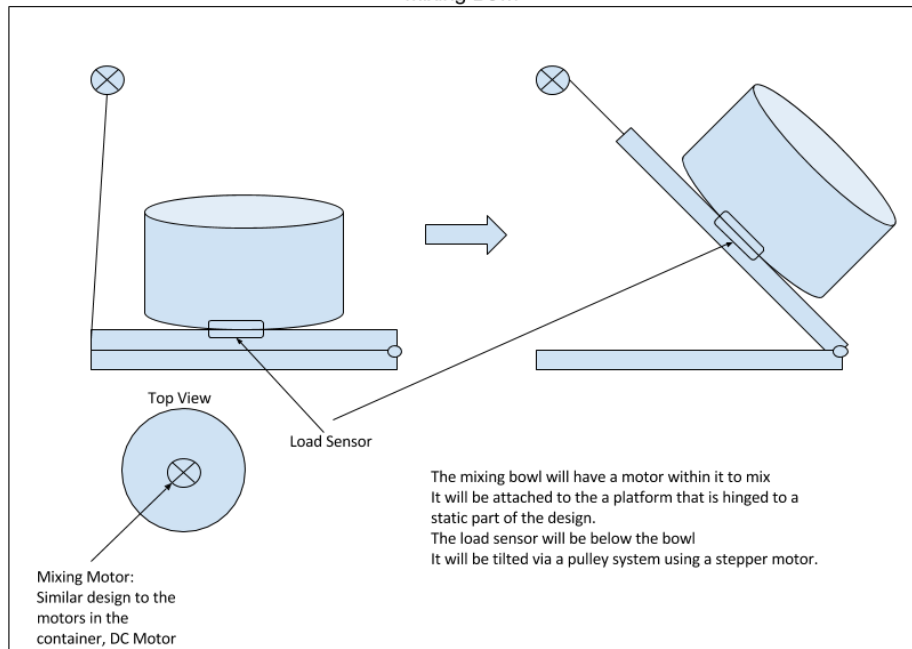
## Motor Fins

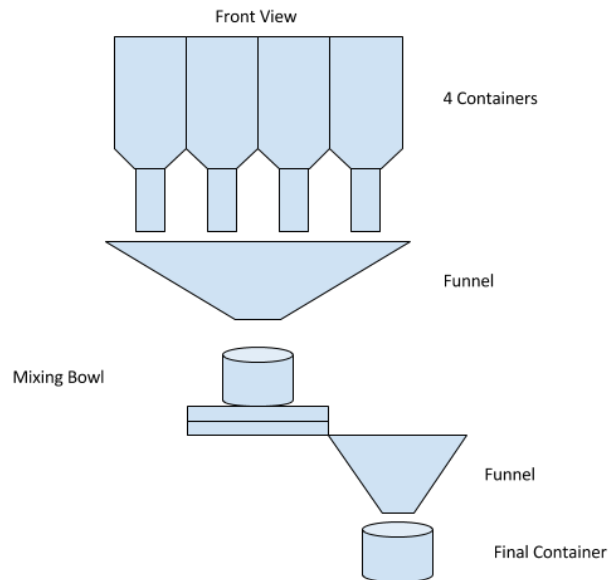
In the limit where the width of the motor is very small  
 $V = \pi r^2 h / n$ , where  $n$  is the number of compartments  
 $V = \pi * 4^2 / 6 = 8.3cc$   
 We believe this is small enough to finely control the amount of ingredients dispensed



Fins will stick 2cm out from the motor  
 Each fin will be separated by 60° for a total of 6 fins  
 The fins will be rectangular 2cm x 2cm

## Mixing Bowl





## 2.3 Functional Overview and Requirements

### 2.3.1 Power Supply

A power supply is required to power all the electromechanical and electrical components of the system such as the microcontroller and stepper motors.

#### 2.3.1.1 AC/DC Adapter

The AC/DC Adapter will convert the wall outlet 120VAC power to a manageable 12VDC that will be used to power the stepper motors and also be further stepped down for use on the MCU.

*Requirement: Must be able to convert 120VAC wall outlet power to 12VDC +/-10% under 7A load.*

#### 2.3.1.2 5V DC/DC Linear Voltage Regulator

The 5VDC linear voltage regulator will be used to continuously provide power to the microcontroller and will be provided power from the AC/DC Adapter attached to the wall.

*Requirement: Must be able to convert and regulate 12VDC to 5VDC +/-5% under 1A load.*

### 2.3.2 Control Unit

The control unit will take input from the Bluetooth module sent by UART (Universal Asynchronous Receiver/Transmitter) and will operate a closed-loop feedback control system that includes the weight sensors and a series of stepper motors through a microcontroller and stepper controller.

#### 2.3.2.1 Microcontroller

The microcontroller we chose to use is ATmega2560 and will take 5VDC as a power supply. It will be used to handle the input from the bluetooth module via UART, weight sensor, and limit switches. It will then output to the stepper control and status LEDs.

*Requirement 1: Program must be retained if the microcontroller is shut off.*

*Requirement 2: Must have at least 12 GPIO pins to communicate with the rest of the control unit and actuators.*

*Requirement 3: Must be UART compatible for interfacing with the bluetooth module.*

#### 2.3.2.2 Weight Sensor (Load Cell) and Amplifier

The weight sensor we chose to use is a load cell (Digikey Part #: 1597-1575-ND) and the output will be amplified by the HX711 since the resistivity changes in the load cell are minute. These will interface with the MCU and are vital in measuring the weight of the already dispensed ingredients.

*Requirement 1: Must have less than +/-1g combined error.*

*Requirement 2: Must be able to measure up to 1kg.*

#### 2.3.2.3 Status LEDs

There will be two contrasting colored LEDs. One of the LEDs will be used to indicate the power status of the system. The other LED will indicate that the system is in operation. These will be controlled directly from the microcontroller.

*Requirement: The status LED must be visible from across a room, approximately 3m away, while being driven by a 20mA current.*

#### 2.3.2.4 Stepper Controller

The stepper control will be designed by us and interface with the microcontroller as well as the five stepper motors. We plan on using the A3967 chip along with combinational logic to implement this.

*Requirement 1: Can independently control and step up to eight stepper motors (not simultaneously).*

*Requirement 2: Keeps motors still while other motors are being operated.*

#### 2.3.2.5 Stepper Motors

Each of our four container modules will contain a stepper motor to dispense the ingredients. After the ingredients are dispensed and mixed, another stepper motor will be used to dispense the ingredients into the user's container. The overall process is described in the Physical Design portion of our proposal. All the stepper motors will be controlled by the stepper controller. They will be connected to encoders that will allow us to precisely track the position of the motors.

*Requirement 1: Must consume less than 1A when not moving.*

*Requirement 2: Must be able to rotate at least 5 rpm when supplied 12 volts and 1A current.*

*Requirement 3: Should be able to supply at least 15oz-in of torque with 12 volts and 1A current.*

#### 2.3.2.6 Encoders

The encoders will allow us to precisely track the position of the various stepper motors and communicate it back through the stepper control to the microcontroller. Encoders are particularly useful in detecting when stepper motors slip or stall.

*Requirements: Must be able to track a stepper motor's location precisely after 20 rotations within +/- 5%*

### 2.3.2.7 Limit Switch

The limit switch will be used to determine when the tilting stepper motor has reached the end of its range

*Requirements: limit switches (and relevant circuitry) provide debounced 0/1 signals when open and closed respectively*

### 2.3.3 Bluetooth

We will be using a Bluetooth IC with an antenna. This will interface between the user's phone application and the control unit.

*Requirement 1: Must be able to connect within 3m.*

*Requirement 2: Must be able to interface with the MCU via UART.*

### 2.3.4 Phone Application

The phone application will be the user interface with the product. They will be able to specify the specific weights of each ingredient they would like to dispense, which will then be communicated to the control unit using Bluetooth.

*Requirement 1: Allow the user to connect via Bluetooth to the design.*

*Requirement 2: Allow the user to indicate total mass between 100g to 450g of trail mix between the four ingredients.*

## 2.5 Risk Analysis

The actuation block poses the greatest risk to our design. Dispensing precise mass and mixing all require a significant amount of mechanical precision and coordination. For example, the dispensing phase requires fast and accurate communication between the various stepper motors in the containers as well as the weight sensor.

We would need to develop a good set of heuristics of weight measurements the microcontroller receives to send the signals to the dispenser at the right time to slow down/stop dispensing. The path between these elements should be fairly short and this will help, but variably sized ingredients and non homogeneity of the mix will pose a fair number of challenges in dispensing the exact right amount of weight that the user requests. The stepper motors will also have to be calibrated and tested to see how much weight we dispense on average for a certain number of steps. We can also toggle the size of the fins at the mouth of the dispenser to adjust the flow of the ingredients and thus we feel that we have a good number of tools in our arsenal to tackle this challenging problem. Since this is a nutrition focused project, we want to ensure that the user gets the most accurate volume of food possible to fit their daily caloric and macronutrient requirements.

## Ethics and Safety

One of the most important safety concerns in our project is that we will be working with 120VAC wall outlet power and stepping it down to a lower DC voltage that we will then regulate. This 120VAC line will be very dangerous when live and as such we will abide by the lab safety standards. This means that first and foremost we will routinely check for both damaged or frayed equipment. We will also be sure not to bring food or drink into a lab setting to avoid damaging any equipment. Also, we will

be sure to practice caution around the system when it is live, such as practicing the one-hand method. Also, given that none of us have significant experience with working with high voltage converters and regulators we will follow Section 6 of the IEEE Code of Ethics[7] and use off-the-shelf components.

As a result of our project being used for measured food preparation, it is important to disclose any inaccuracies in our design. In accordance to Section 1 and Section 3 of the IEEE Code of Ethics we will inform the user of any errors in the measurement of food. We will not mislead or misinform the user as to the accuracy of our design so that they can make informed dietary decisions.

In conclusion, we are responsible for all the design decisions, which means it is also our responsibility to disclose any issues that may endanger the user as stated in Section 1 of the IEEE Code of Ethics[7]. We believe that if designed properly we will be able to minimize and most likely completely mitigate these issues in our design.

## References

- [1] [http://www.koreascience.or.kr/article/ArticleFullRecord.jsp?cn=SSMHB4\\_1999\\_v14n3\\_241](http://www.koreascience.or.kr/article/ArticleFullRecord.jsp?cn=SSMHB4_1999_v14n3_241)
- [2] [https://journals.lww.com/psychosomaticmedicine/Abstract/2000/11000/Stress\\_and\\_Food\\_Choice\\_A\\_Laboratory\\_Study.16.aspx](https://journals.lww.com/psychosomaticmedicine/Abstract/2000/11000/Stress_and_Food_Choice_A_Laboratory_Study.16.aspx)
- [3] <https://www.sciencedirect.com/science/article/pii/S0195666390900519>
- [4] <https://www.ncbi.nlm.nih.gov/pubmed/27298083>
- [5] <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3257681/>
- [6] <https://smile.amazon.com/SnackMan-Motion-Activated-Treat-Candy-Dispenser/dp/B008Z8VXPK?sa-no-redirect=1>
- [7] <https://www.ieee.org/about/corporate/governance/p7-8.html>