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SandWish: Automated Web-Operated Sandwich Maker

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Abstract—**From the time of hunters and gatherers, humanity has been devoting time to food preparation. Now, in the dawn of the autonomous era, machines can handle these mostly repetitive tasks. Moreover, they can incorporate IoT technology to seamlessly handle interactions with humans. SandWish, is the marriage of these technologies for the food production industry. The system is the comprised of 3 main subsystems: the app and communication, sandwich assembly, and intelligent dispensing. The app provides a place for the customer to specify what ingredients they want on their sandwich. It then converts the desired ingredients into a list of instructions for the machine. The machine then assembles, and finally dispenses the sandwich via the Amazon Locker inspired dispenser system.**

I. Introduction

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ANDWICHES are one of the most popular foods among American consumers. McDonalds estimates that worldwide they produce 75 sandwiches a second. Simultaneous custom sandwich orders are potentially difficult to juggle for human servers. With variable sandwich demand comes unutilized human labor. Each customer has to verbally communicate their custom sandwich with the servers to place their order also allowing for unreliability. This process often causes long lines at events as customer number peaks with dining times.

USDA Agricultural Research Service scientists conducted a survey called "What We Eat In America" which sampled around 6,000 participants and the content of their meals the previous day. They found that 49% of participant had eaten at least one sandwich the previous day. Given all of that sandwich eating, this type of meal makes up a significant portion of Americans' daily dietary intake.

Each server can only serve one customer per time, and has to wait for verbal communication from customer before picking the ingredient to complete custom sandwich assembly. This is a sequential ordering process that can be simplified into a parallel process. The web application allows digital queueing eliminating lines and congestion for food. The sandwich machine makes it possible to concentration human labor into loading the ingredient tray, and leaving the laborious task of ingredient intake and sandwich assembly to an automated assembly system.

With the SandWish machine, human time is freed up from mundane tasks such as assembling custom sandwich or waiting in line to place an order. This results in the saving of time and money to allow servers to handle different tasks and customers to more quickly receive their sandwiches.

Table 1 lists the system specifications for different aspects of the SandWish machine. Other than the requirements of the mechanical aspect of the machine, the table also describes the production process requirements concerning details from initial raw material to how the final sandwich will be presented as a product overall. The software components of the SandWish are required to meet specifications that adhere to interfacing with the user.

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Requirement	Specification	Value
production	multiple ingredient availabel	4 choice of ingredient
	hold enough ingredient for multible production	6 sandwitch in one load
	hold completed sandwiches in reserve for pickup	3 pieces
	ingredient don't stickout between breads	<=1" from edge
portable	size	3'x4' foot print
user interface	interface through mobile application	>1 user simultanious
	user have limited access to product	1 samdwithch per order
	producion time per sandwitch	<=5min

Table 1: SandWish Requirements and Specifications

II. Design

A. Overview

For the SandWish we delineated the tasks of the overall goal of building a sandwich to the various subsystems. These three subsystems are shown in the block diagram on the next page.

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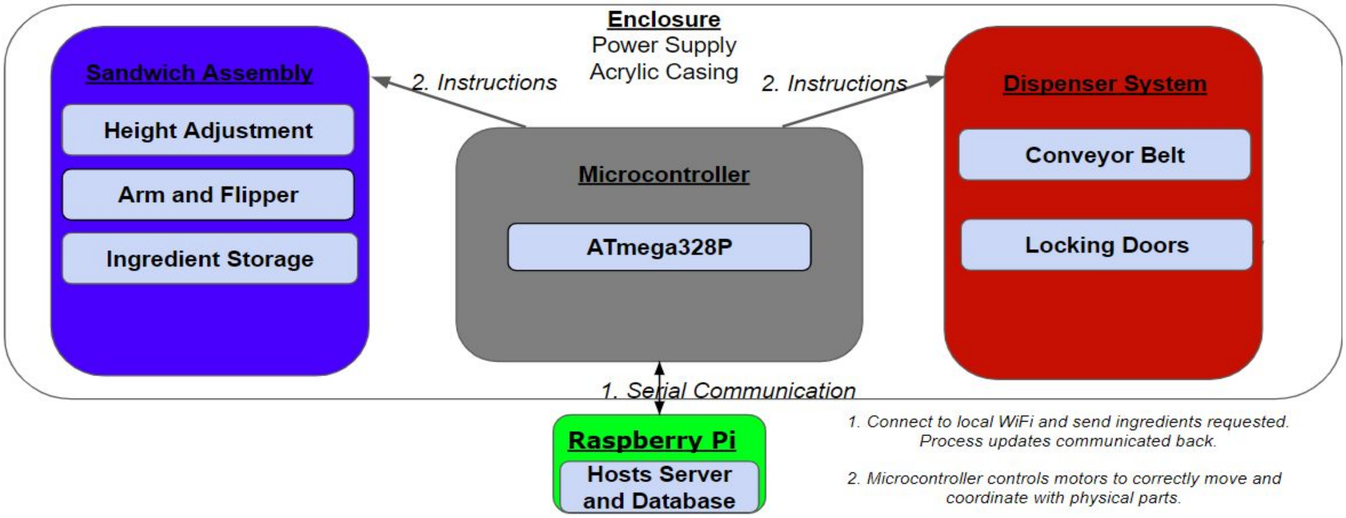


1) Assembly: The storage subsystem holds all of the raw ingredients required to make a sandwich. They will be held on aluminum trays mounted in 3D printed shelves. It will all be mounted on a lazy susan with a stepper motor to turn the base. The arm and flipper are both mounted on a plate that can be raised and lowered by 3, Nema 17 stepper motors attached to lead screws. The plate is raised to the height of the ingredients in the storage so the arm can interact with the proper ingredient. The arm retrieves the ingredients with a Nema 17 and lead screw as well. The flipper then uses two servo motors to flip the bread onto the building area.
2) Dispenser: The dispenser system uses a Nema 17 to index empty lockers so a sandwich can be built on a fresh plate. The lockers can be accessed by the user to retrieve the sandwich they ordered.
3) Microcontroller: All of the ingredient ordering is handled by the SandWish web which takes user inputs and turns them into 6 byte stream containing all information of a order to the microcontroller. the microcontroller have a serial event detection actively waiting for a 6 byte income information. upon receiving the sandwich order, microcontroller first pass a check comparing the remaining ingredients on storage with order requirement to insure enough material is available to complete the sandwich. if this test fails, the microcontroller sends web server a certain character indicating machine require reload.

Figure 2: Close up of Storage System with Ingredients Loaded

B. Sandwich Assembly System(sensor /power supply)

The SandWish assembly system includes a storage mechanism, an arm and flipper, and a platform that indexes the arm/flipper vertically (See fig. 2). The storage mechanism is comprised of four ingredient racks with seven-ingredient capacity each mounted to a rotary platform. each racks has a trigger that activate the sensor when it reaches the targeted rotation position. there is one rack equipped with special bumper that will trigger sensor in a short time interval. the special rack is used to identify the zero position storage rack. the chip and servo motors are powered by 5V power supply. a separate 12V power supply drives all four stepper motors. The storage system rotates to present the correct rack to the arm

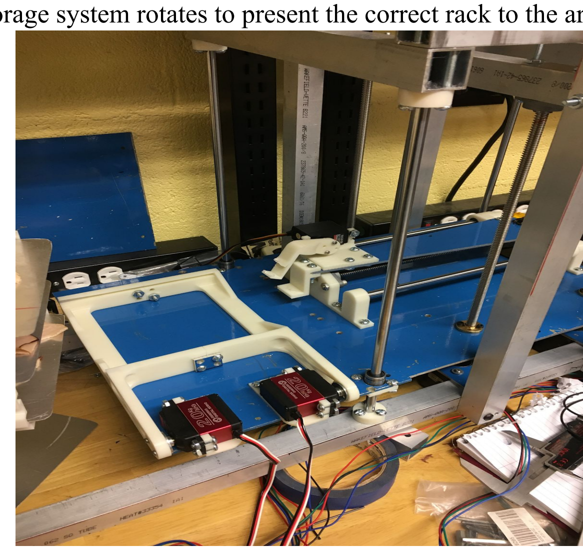
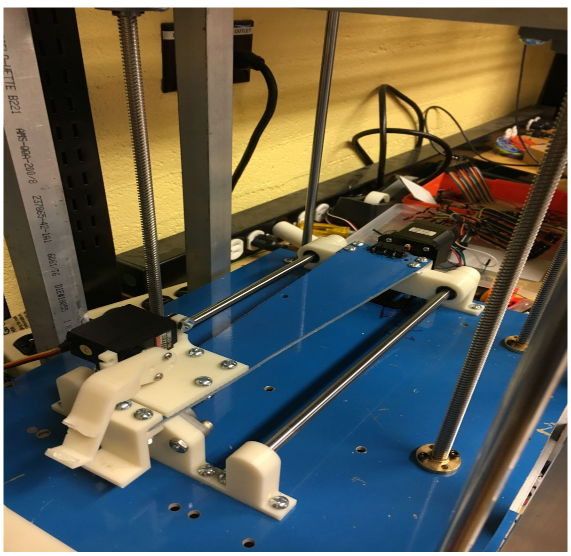


Figure 3: Close up of Flipper

and flipper. The arm is on a platform which is able to index up and down to the 7 heights where ingredients are available in the storage system. When at the correct height, the arm extends towards the rack, grabs an ingredient tray, and retracts, pulling said tray into the flipper.

The flipper, which has a channel to ensure that ingredient trays are secure, then flips 180 degrees to place the ingredient and construct the sandwich. Finally, height adjustment platform will move to its lowest position and the arm will re-extend to push the tray into a bin to be washed. We used aluminum extrusion, waterjet cut aluminum plates, and 3D printed ABS to make the structure of the machine. Movement is facilitated by stepper motors driving lead screws as well as servo motors. Position of the system will initially be determined by limit switches. These switches will allow the machine to stay calibrated even after making many sandwiches.

Figure 4: Close up of Arm and Gripper



C. Sandwich order System(communication)

The SandWish Dispenser is composed of online app and atmel microcontroller chip. the online app takes in user input on a online website. the user place sandwich order specify ingredients they want from 6 available ingredients.after the online order is placed the web will send a 6 byte stream to microcontroller. each byte contains one char integer. the microcontroller will convert char into int value and store it in a int array. the process of sandwich construction starts with microcontroller traversing through the int array and extract corresponding ingredients from storage tray and assemble a complete sandwich at the end.

D. SandWish Web App

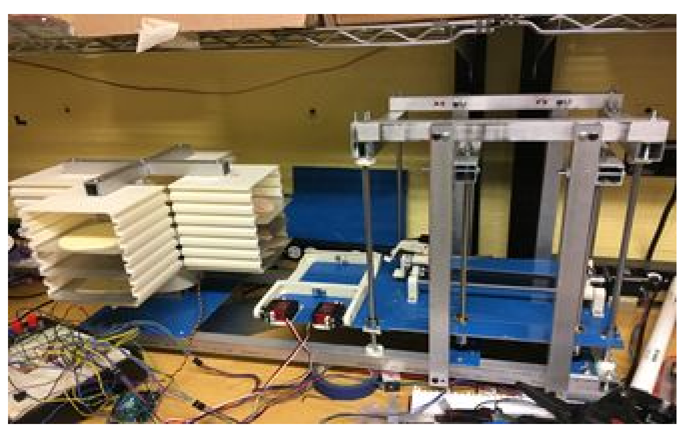
The app and communication system provides a streamlined process for ordering a customized sandwich. It will be web-based, allowing theoretical universal access regardless of device OS. A user will be able to order a custom sandwich of his or her design. The web-based app will be aware of SandWish limitations and prevent the user from ordering a sandwich that isn't possible. The app will also be able to notify the user when his or her sandwich is ready for pickup.

The user begins on the home page. They cannot yet access the ordering page. This is for the sake of security and not allowing just anyone to order a sandwich. The user goes to the Create Account page and creates a user account. A verification email is sent to the email submitted by the user. Once the email is verified, the user can now go to the ordering page and other pages such as account management. The ordering page contains six different ingredients that can be checked off in order to customize one's sandwich. Once submitted, the order will be created by the machine

The website is hosted on a LAMP server on a raspberry pi 3. It is hosted on the raspberry pi in order to more easily access directly the pins of the raspberry pi to send data serially to the ATmega328.

E. Microcontroller Subsystem

The microcontroller subsystem will consist of an Atmega328 microcontroller for processing information. A 16MHz clock crystal will be chosen for timing. The microcontroller subsystem is constructed on a piece of PCB board coordinate motor movement.different sandwiches are constructed correspond to the sandwich order information sent through serial communication from raspberry pi to the microcontroller. microstep signals are sent to stepper motors for smooth and precision control synchronized control of the three stepper motors which raise and lower the arm platform. with integration of the limit switch, it reach all 7 ingredient height. precise positional control of the lazy susan motor. This includes integration of the limit switch and the zero finding capability of the positioning geometry. It interface with ALL 4 storage racks. this motor is a continuous rotation servo and is not controlled the same as the other servos, it only has position feedback, and does not hold its position when sent stop signal. precise control of the arm and grabber mechanism pull in new trays and eject old ones from the flipper every time a ingredient is assembled onto a sandwich.



III. Project Management

MDR Goal	Status
Complete Storage Subsystem	Rotation motor calibration incomplete
Complete Arm and Flipper	Accomplished
Complete Rotation, Grab, and Flip Process	Accomplished
No ingredients will hang more than 1” outside of complete sandwich	Did not reach 1” mark; currently at 2”

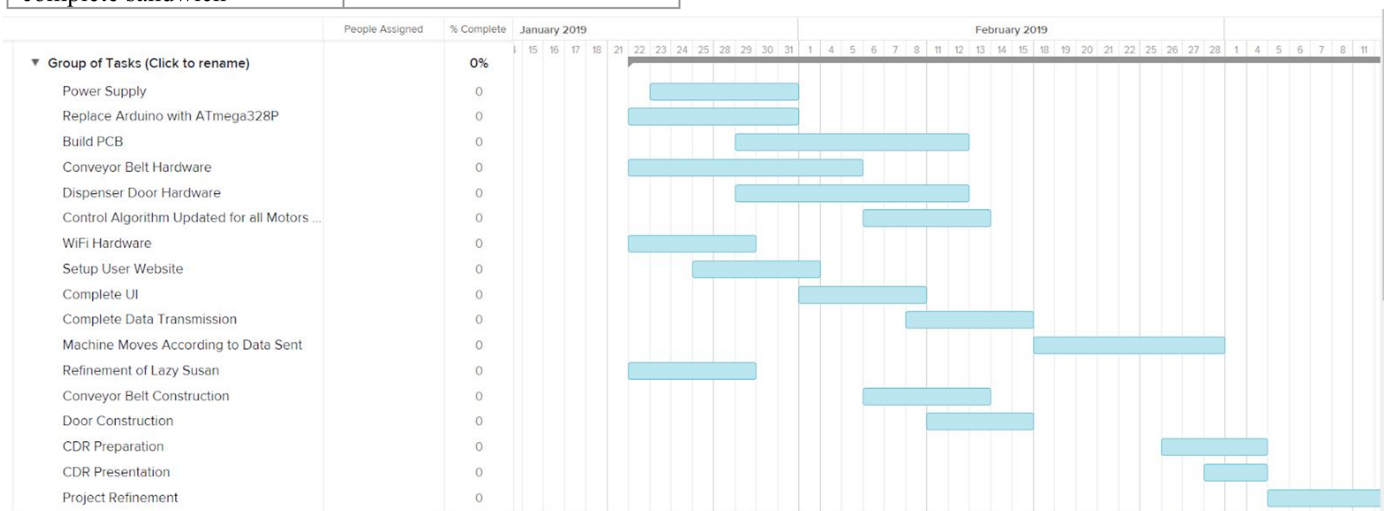


Figure 6: Gantt Chart

Table 2 lists technical goals that were set to be accomplished by MDR. The main goal of setting these requirements was to demonstrate the critical functionality of SandWish machine. The critical functionality achieved through the specifications was the ability to successfully build a sandwich.

Our team did not accomplish every deliverable, however the critical functionality was conveyed. The machine was able to index the platform to the right tray in the storage, grab the tray, put the tray in the flipper, and flip the ingredient onto the plate. This is repeated four times to construct a full sandwich. The motor for the storage subsystem is not fully calibrated to do 90 degree turns in order to have minimal error for the tray grab. Also, the ingredients were not placed consistently enough that each ingredient was within 1” of hanging outside of the sandwich. We believe that once we increase the power and speed of the flipper, the placement will be much more consistent. The next step is to incorporate limit switches to all moving parts of the machine in order to ensure consistency over many orders.

We have worked hard to integrate the electrical and mechanical components of this project. The mechanical and electrical aspects of the project are often done separately so the periods of time spent as a whole team are critical.

Each member of the SandWish team has contributed to the machine’s success mostly split into two categories; the mechanical and the electrical. Zach has designed and built the storage and tray subsystem and has helped with the construction of other parts as well. Anson has designed and built the arm and flipper system and has helped with reducing in mechanical vibration. For the electrical aspects, Jack’s expertise has lied in the calibration of each motor moving each part correctly. Wei has also played a role in calibration but has also held the main role in the power for the system.

Although we all had our main roles, we each would come together and help each other problem solve no matter the bug. We would schedule times to be in our respective labs and always message each other when we would need help or would want to go to check on progress. It was always helpful to have more of an outsider’s perspective on each issue. This method of continuous simultaneous working and meetings leading up to full scale integration as a project and as a team execution led to success for most of our MDR deliverables.

IV. Conclusion

The current state of the project is a completed demonstration of the physical system. The storage system has conveyed holding all the ingredients and allowing all of them to be removed easily. The flipper system was also designed and built to index to the right ingredient on the storage, grab the tray, bring the tray into the flipper, and flip the ingredient. The team has integrated both the storage system and flipper system to an PCB board.the controller system can operate multiple mechanical parts to construct a complete sandwich according to income order information. the storage system and flipper system behaved appropriately and completed assembly of the sandwich. Demonstrating the essential functionality of SandWish machine is completed.

the SandWish machine is still missing the online system that will place byte stream of sandwich order to microcontroller. The WIFI communication functionality and online application also needs to be incorporated into the rest of the system to give SandWish the ability to communicate with the customer and become internet controlled.

Acknowledgment

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References

[1] U.S. Department of Agriculture, Agricultural Research Service, Beltsville Human Nutrition Research Center, Food Surveys Research Group (Beltsville, MD) and U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics (Hyattsville, MD). What We Eat in America, NHANES.

[2] "ESP8266 Send / Receive Binary Data Using UDP." *The Arduino and Me*, 1 July 2015, thearduinoandme.wordpress.com/tutorials/esp8266-send-receive-binary-data

[3] "How Many Hamburgers Does McDonald's Sell Each Year?" *Reference*. IAC Publishing, n.d. Web. 06 Feb. 2019.

[4] Espressif Systems. ESP8266EX Datasheet. 2018, www.espressif.com/sites/default/files/documentation/0a-esp8266ex_datasheet_en.pdf.

Cost

Part	Development	Production
PCB	1.6	0.67
Voltage Regulator	0.95	0.756
Motor Drivers	8	4
RaspberryPi	35	35
Capacitors	1.2	0.46
Resistors	0.4	0.095
Aluminium Extrusion	Free	30.82
Stepper Motors	70.36	52
Servo Motors	43.16	22.99
Nuts and Bolts	29.67	20.25
Printed Parts	Free	42
Machining Costs	Free	675
Rods and Bearings	81.98	54.65
Lead Screws	57.16	38.11
Sheet Metal	Free	22.17
Total	329.48	998.971