Automated Drink Maker

BY

Brian Smalling (briants2)

Charlie Thiery (cthiery2)

Luke Singletary (lls3)

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TA: Akshatkumar Sanatbhai Sanghvi

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Abstract

In this day and age of quarantining, many restaurants, especially on the smaller scale, face issues from a lack of workforce. This has led to work in the design and development of an automated drink maker to help lessen the load on the work staff. The concept is to allow employees to set drinks to be made while they do other work around the restaurant. This saved time will add up the more it is used and lead to a relief of the stress that has been building up on the waiters and waitresses. Our drink maker has a few key goals that it needs to accomplish in order to serve its purpose of cutting down on labor. It needs to be able to be operated wirelessly, it needs to be able to dispense cups, and it needs to be able to fill those cups with the ordered drink. The paper below details the processes and design considerations that went into accomplishing that.

Contents

1 Introduction

1.1 Problem:

In many industries, staffing has become a huge problem due to covid, and no area has been impacted more so than the restaurant industry. Even before covid, restaurants would have staffing shortages due to the limited number of people in the job pool, poor retention of these employees, and lack of motivation[1]. Now these problems are even worse due to the pandemic, and these businesses are suffering because of it. The wait times are now much longer at these establishments, and once loyal customers are leaving unsatisfied. This leads to bad reviews and less repeat customers, which severely hurts a company's income in these already tough times. For this reason, a lot of restaurants have permanently closed because of bankruptcy. Something has to change to fix this problem.

1.2 Solution:

Our team has come up with the idea to make a remotely operated autonomous drink maker. This will allow the waiter to put drink orders in while at the table and will free up time for them to help other customers in this newfound free time. With this, the problem of extremely long wait times at restaurants will be greatly reduced.

1. Once the process is started, a series of two motors is used to hold up and dispense cups onto the rotating table.
2. The rotating table is controlled by the microcontroller. The table is timed to move to each of our three positions. Once the loading and filling of the cup is complete the rotating table will move the cup to the unloading area.

3. The filling system for the machine is a gravity fed dispenser that will be operated by two solenoid valves. These valves are connected to the microcontroller to make sure they are being operated correctly. The microcontroller has control over the timing for the solenoid valves so that each cup is given the exact same amount of liquid.
4. The microcontroller for this device is in charge of controlling the precise timing that will be needed for each component of our project. It also is responsible for dispensing the correct drink.
5. The Bluetooth device for our project has a receiver to relay the data from the phone to the microcontroller, and a sender that will be transmitting the input from the commands given on the phone.

1.3 Visual Aid:

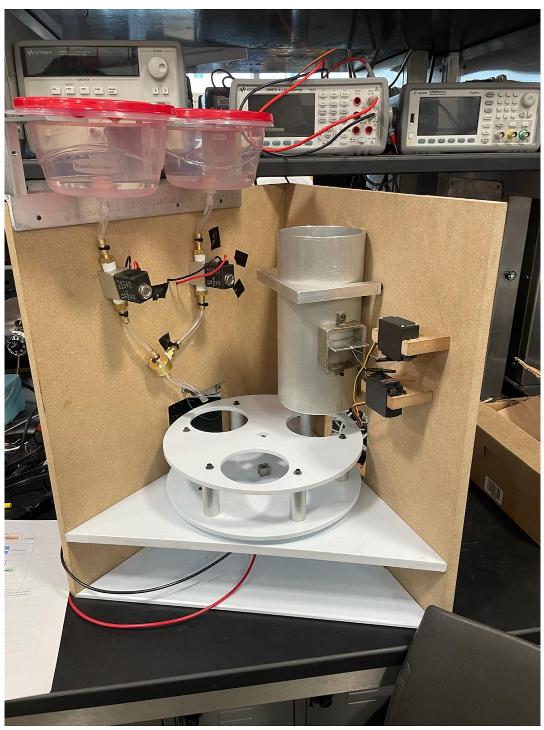

Figure 1

Shown above in Figure 1 is the final build of the Automated Drink Maker.

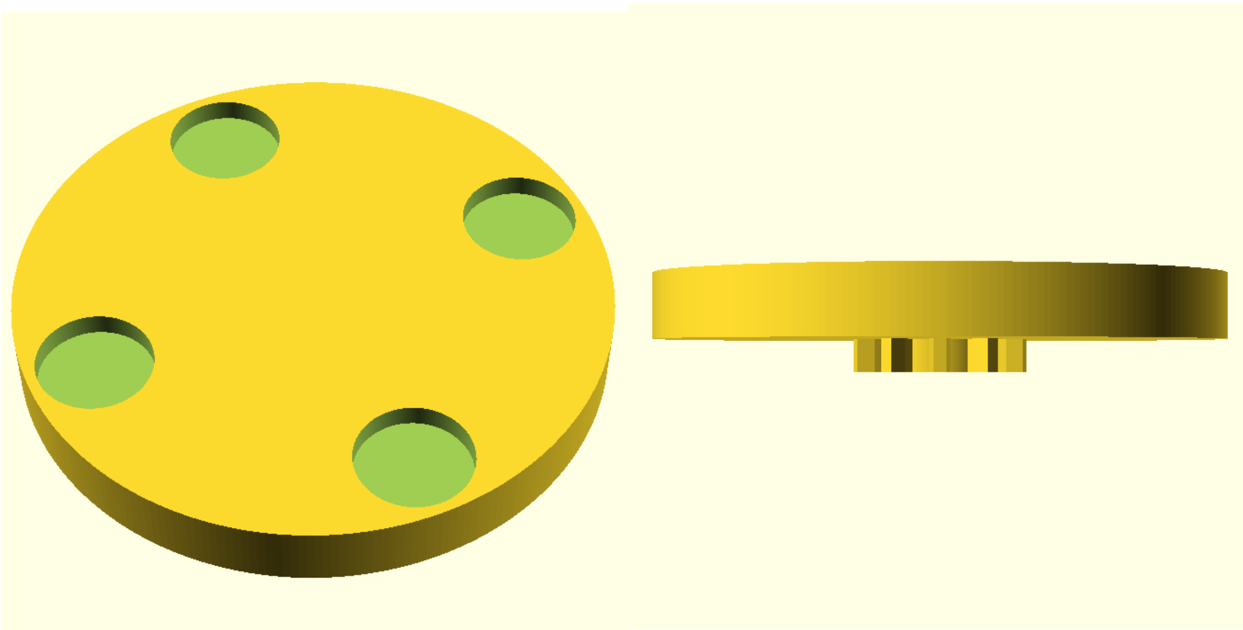

Figure 2

This rotary table above in figure 2 was a preliminary design created in OpenSCAD in order to better visualize what it might look like when built. It's not the final design, but it was used as inspiration for the final product.

1.4 High Level Requirements:

The first thing that our machine has to do is drop cups one at a time on the rotating table. We used two servos to do this, one to hold the cups and the other to push the bottom one-off. Without this, we won't have cups to fill.

The next requirement is that our rotating table has to move the cups properly. First, it has to move an empty cup under the nozzle on the dispenser. Then, once the cup is full, the table must rotate the cup out of the way in order to make room for the next one. This is also where the full cups can be picked up.

The dispenser must give the correct amount of soda at the right time. The cup needs to be 50% +/- 5% full once done, and the soda must correspond to the one selected on the remote. If the machine dispenses at the wrong time, it could spill soda everywhere, so the timing needs to be correct too.

The Bluetooth chip needs to be able to communicate with the microcontroller. This is how we select the drink that we want, so if this doesn't work nothing will. Pressing the button on the remote should dispense the corresponding drink into a cup.

2 Design

2.1 Block Diagram:

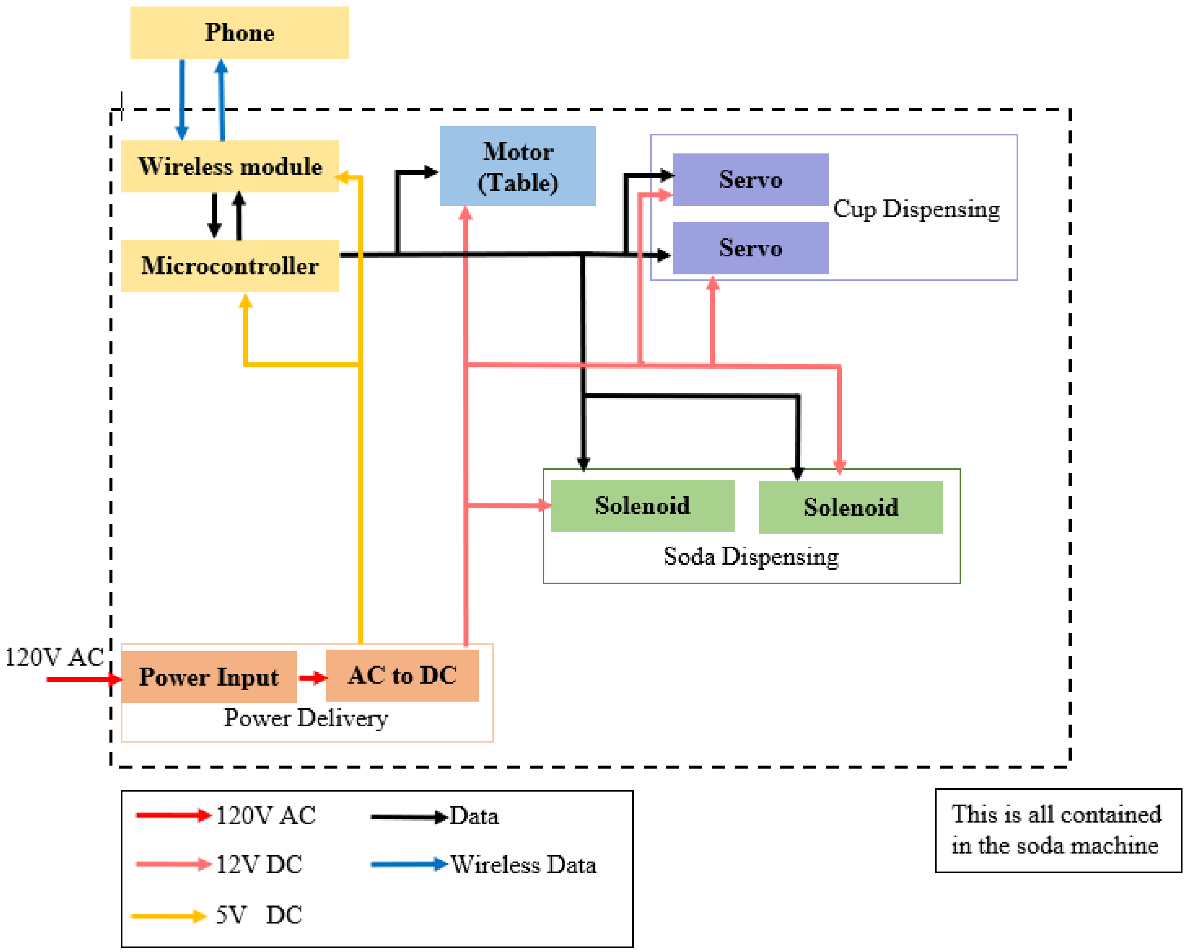

Figure 3

The block diagram in Figure 3 above shows the final block diagram that represents our machine. The microcontroller and bluetooth module are powered by 5V power, while the motors are run on 12V DC power. The microcontroller runs our code and tells each individual motor what to do at what time, after being given a selection from the phone app. The phone pairs over Bluetooth with our wireless module, and controls the whole operation from there.

2.2 Flow Chart:

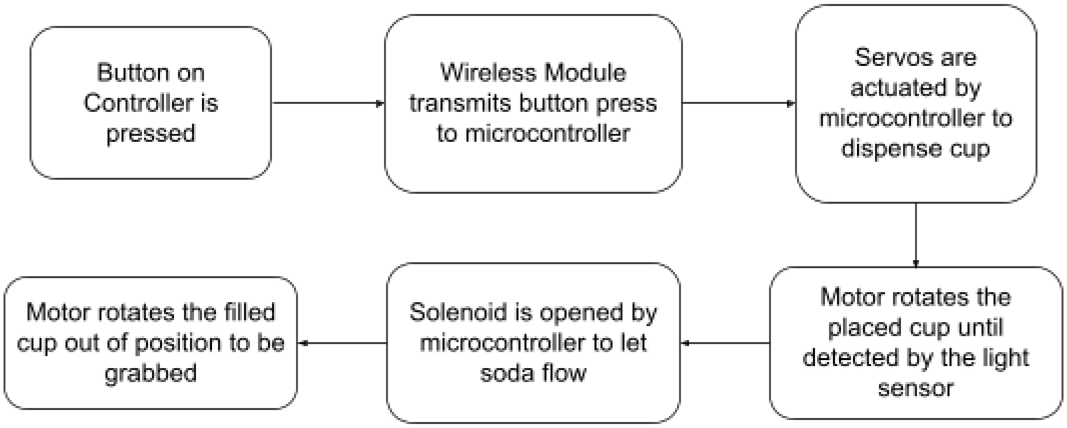

Figure 4

This flowchart in figure 4 above is used to show the process the machine goes through from the press of a button. The machine starts by receiving the button press from the wireless module, which now comes from a phone as opposed to a controller. Then based on what the input was, it will drop a cup and dispense the desired liquid after it has rotated into position. It then ends by rotating the cup into the waiting position of the table. It's a pretty simple code to run, and it does the job well.

2.3 Circuit Schematics

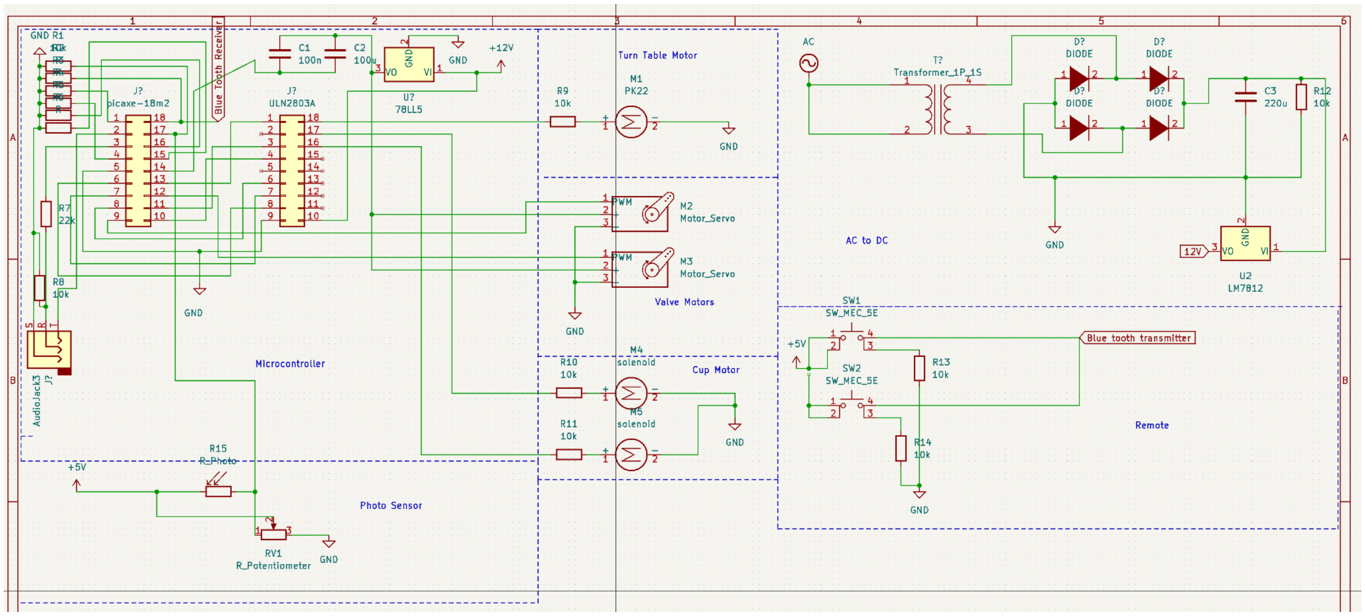

Figure 5

Figure 5 above shows our original circuit schematics that were used throughout the entirety of our project. As seen though there are some aspects of our design in it that we ended up not using in the end. Such as the photosensor, the Picaxe chip, and our own remote. The remote was not able to be complete since we were unable to get a proprietary part to code it so we ended up using an android phone app. The Picaxe chip's driver was not compatible with any of our computers so we made the decision to use an Arduino red board to perform its tasks. Lastly, the photo sensor was not added due to it not being able to detect the clear cups that we were using for our project.

2.4 Subsystem Overview:

1. The power delivery subsystem's purpose is to provide power to the actual soda machine. It consists of a power input to take 120V AC from a wall outlet, which is then

transformed to 24V AC. That is then is paired with a rectifier to change the AC input to DC output for the rest of the components in the machine to run off of.

2. The wireless component is accomplished using Bluetooth connected to a phone. An android phone can pair with our device, and send commands to it wirelessly to dispense multiple drinks[7].
3. The microcontroller gets power from the power delivery subsystem and receives data from bluetooth over serial input. It uses that data to determine when to dispense a cup, when to move the conveyor, and when to dispense the soda. It will be the brain of the machine and have a hand in every aspect of the machine short of the power delivery.
4. The cup dispensing subsystem has power given to it in order to run the two servos to dispense the cups. One motor drops the bottom cup onto the table, and the other holds the rest of the stack up so that we don't drop more than one cup. The servos are timed and controlled by the microcontroller through PWM so that it works every time.
5. The rotating table takes data from the microcontroller in order to know when it should start moving after the cup has been placed on it. Then, it moves the cup underneath the soda fountain waiting for the proper amount of soda to be dispensed. After the soda has stopped, it can then continue moving the cup around, and it can wait there to be taken by the user.
6. The soda dispensing subsystem is the final one. It is turned on when needed by the microcontroller, and uses solenoids in order to dispense soda into the cup placed underneath it by the conveyor belt. There will be a timer in order to know when the solenoids should turn off to stop dispensing the soda. There are two solenoids total, one for each drink to be served by the soda machine.

2.5 Subsystem Requirements:

1. The cup dispenser must be able to dispense one cup at a time without dropping the whole stack. If anything other than one cup came out, we counted it as a failure. There are two servos to do this, one to drop the bottom cup, and another to support the rest of the stack. All the movements are done by servos controlled by the microcontroller.
2. The rotating table must move the cups to the correct positions at the correct time. A cup is placed on it by the cup dispenser, and from there the table has to move the cup under the nozzle to have soda dispensed into it. After it is filled, the cup turns further around the table and is able to be picked up from there.
3. The soda dispenser must be able to dispense the correct soda into the cup. The microcontroller needs to know which soda to dispense, and then open a valve to allow the correct amount of soda into the cup so that it is full but not overflowing.
4. We need to be able to connect to the dispenser with a phone. Without this, nothing will work, as we will have no way to control the machine, rendering it useless. The phone must be able to connect over distance and transmit data back and forth to the dispenser.

2.6 Requirements and Verifications

Wireless Communication	
Requirements	Verification

1. Machine dispenses cup from button press
2. Table waits for cup then moves into proper position
3. Correct soda is dispensed in proper amount based on which button is pressed
	1. Verification for 1
	   a. Verified output voltage of 5V is outputted using multimeter
	2. Verification for 2
	   a. Verified output voltage of 12V is outputted using multimeter
	   b. Verified voltage appears

	shortly after cup has landed in at least 3 seconds 3. Verification for 3 a. Verified output voltage of 12V is outputted using multimeter b. Verified voltage appears for enough time for cup to be 50% +/- 5% filled

Table 1

Cup Dispensing	
Requirements	Verification
1. Only one cup is dispensed at a time and lands in slot of table	1. Verification for 1 a. Applied voltage pulse of 5V to lower servo to release cup verifying that it lands in slot b. Applied same voltage pulse to close the prior servo c. Applied same voltage pulse to open top servo and lower cups to the bottom servo d. Applied same voltage pulse to close the upper servo e. Ran multiple times to see consistency of dispensing system

Table 2

Soda Dispensing	
Requirements	Verification
1. Able to differentiate which soda is dispensed 2. Soda is dispensed in order to fill cup 50% +/- 5% of the way to the top 3. Soda does not leak	1. Verification for 1 a. Applied voltage of 12V to solenoid to make sure the desired soda is the one let out b. Went back and forth checking for consistency 2. Verification for 2 a. Determined a rough time guess to fill cup volume to 50% b. Tested and refined time value

	using graduated cylinder to get closer to an average of 50% c. Repeated for the other soda 3. Verification for 3 a. Filled containers as much as possible to create max possible strain on solenoid valves b. Found time needed after dispensing for dripping soda to leave the tubing

Table 3

Table	
Requirements	Verification
1. Table can hold the cup and keep it from falling or spilling 2. Table rotates once cup is filled with next slot in position for next cup to be dispensed	1. Verification for 1 a. Dispensed cups using cup dispensing method stated above b. Ran table with unfilled cup viewing how stable it is c. Repeated b with a filled cup 2. Verification for 3 a. Used timing from soda dispensing verification b. After rotation was complete, repeated verification 1 to ensure it has rotated the proper amount

Table 4

Power Delivery	
Requirements	Verification
1. AC to DC converter can provide the 12V +/- 10% necessary to power the separate parts of the machine	1. Verification for 1 a. Measured output voltage with reference to ground using a multimeter to verify 12V +/- 10%

Table 5

2.7 Tolerance Analysis:

There are a lot of aspects to this project that could break the whole thing. If the remote doesn't work, we won't be able to dispense any soda. If the cup dispenser doesn't work, we won't have any cups to fill. If the table doesn't work, the cups won't be in position to be filled by the machine. If the dispenser doesn't work, we may overfill the cup or not fill it enough. We could also dispense the wrong drink, which would also be a failure.

The vast majority of these errors will be solved with proper coding. A lot of it comes down to timing, which electronics can do very well when designed correctly. Making sure this works will be the hardest part of the project, but we are confident that it will be done.

Our product will have a large focus on consistency across uses. We want it to dispense the same amount of soda into a cup every time, at the right time. To test this, we will be looking at the fill level of the cup after the soda is dispensed. We will check to make sure that the level stays near the top of the cup every time, at approximately 95% full. If we need to be more precise, we can always check the exact volume using a graduated cylinder. Other testable components are simple "yes or no" questions, such as if the cup is dispensed properly, does the machine dispense the correct soda, does the soda fill the cup, or pour onto the floor. Making sure the table rotates correctly will also be tested, but again that's really only yes or no.

Unit testing can be done with oscilloscopes and multimeters on individual parts. Motors are driven at 12V, so we can measure the voltage along those lines to make sure they are active at the right times. This can be used to test the solenoids and DC motor for the table. The servos are driven by a PWM signal, so we will use an oscilloscope to measure the signal.

3 Costs

Part	Price ($)	Quantity	Total ($)
Picaxe 18M2	6	2	12.00
DC Table Motor	6.50	2	13.00
HiTec Servos	13.54	2	27.08
Photodiode	0.12	1	0.12
Solenoids	9.45	2	18.90
AC Power Cable	3.69	1	3.69
Perforated Solder Board	1.43	1	1.43
220 µF Capacitor	0.58	1	0.58
100 µF Capacitor	0.50	1	0.50
ULN2803 10 Pack	8.95	1	8.95
Surface Mount Resistor Pack	6.49	1	6.49
120-24V Transformer	16.99	1	16.99
Surface Mount Capacitor Pack	8.99	1	8.99
L7805CV 10 Pack	9.45	1	9.45
18 Pin DIP Socket 10 Pack	9.50	1	9.50
10K Ohm Resistor	2.31	10	23.10
Total			160.77

Table 6

- Labor [3]:
  - Computer Engineer (1 person)
    - $47/hour * 80 hours to complete * 1 person: $3760
  - Electrical Engineer (2 people)
    - $38/hour * 80 hours to complete * 2 people: $6080
  - Total Labor: $9840
- Totals:
  - $9840 + $160.77 = $10,000.77

4 Conclusion

4.1 Summary of Accomplishments

Overall, the project was a success and worked as intended. You can connect a phone, and operate the machine consistently from there remotely. The cup dispenser works consistently, the table spins to the correct position, and the solenoids always dispense the correct drink. While the back end of the project may have been imperfect, the front end is working as initially designed and serves its purpose well.

4.2 Issues and Future Solutions

There are a few questions that still remain though, even after the success of our project. Because we couldn't build our remote as intended, an android phone is needed to operate the machine, leaving all iPhone users without a way to run the machine. This is easily solved by building the remote initially designed. Another potential issue is in the play that the table motor has. It could potentially stop in a small range instead of using a brake, which can introduce uncertainty into the machine. Again, this is easily solved by using a better option like a stepper motor.

4.3 Impact

We foresee this project having a positive impact on the restaurant business. The machine functions as intended, and can remotely dispense drinks, freeing up time for waitstaff to serve more tables, and cutting down on trips to the kitchen. This automates the drink making process, and could conceivably be expanded to do more than just the two drinks we currently have dispensing now. By doing this, efficiency can be increased even more, and our machine could conceivably even replace one or two waitstaff per restaurant.

4.4 Ethics and Safety

There are a few safety concerns with making a machine like ours. First of all, it will need to be cleaned periodically, so that bacteria doesn't grow inside. We can do this by running warm, soapy water through the machine to flush out any leftover drink, and clean the tubing too. The dispenser also has moving parts that can create a pinch point. This can be partially combated by shrouding moving parts like servos, but the exterior will still move. However, since it is an autonomous machine, people shouldn't need to be around while it is moving. Warning labels will be applied in case though, so that people are aware of the pinching dangers. We will also have electronics around liquids, so those will be waterproofed and elevated as well to prevent short circuits and shock hazards.

We have followed the IEEE code of ethics in all ways possible. We designed our machine to be safe and not cheap, and to protect the users from harm when operating the device. We got outside opinions when necessary, and credit all help which we receive. We held each other accountable to this code of conduct, and made sure that all tenants were and still are being followed. The full code of ethics can be found here.

4.5 Acknowledgements

We would like to thank our TA, Akshat, and the machine shop for their help with this project. Without the machine shop's help building the physical device, we would not have come anywhere close to finishing this project. Our TA was super helpful, guiding us through the project and answering any questions we had.

5 References

[1] *10 restaurant staffing issues and how to address them*. GloriaFood Blog. (2021, November 9). Retrieved February 11, 2022, from https://www.gloriafood.com/restaurant-staffing-issues

[2] "IEEE Code of Ethics." *IEEE*, https://www.ieee.org/about/corporate/governance/p7-8.html.

[3] University of Illinois Urbana Champaign. "Salary Averages | Electrical & Computer Engineering | UIUC." *ECE Illinois*, https://ece.illinois.edu/admissions/why-ece/salary-averages. Accessed 23 February 2022.

[4] Picaxe Microcontroller Datasheet: https://picaxe.com/docs/picaxe_manual1.pdf. Accessed 23 February, 2022.

[5] AC to DC power supply: https://www.circuitlab.com/circuit/wrfeu3/120vac-to-12vdc-power-supply/. Accessed 23 February, 2022.

[6] Transistor Array Datasheet: https://www.ti.com/lit/ds/symlink/uln2803a.pdf?ts=1645742600950&ref_url=https%253A%252F%252Fwww.google.com%252F. Accessed 23 February, 2022.

[7] Bluetooth Module Wiki

https://wiki.dfrobot.com/DF-BluetoothV3_Bluetooth_module__SKU_TEL0026_ . Accessed April 11, 2022