CS 362 Project Design
The Automatic Bartender
(T.A.B.)

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Introduction & Acknowledgement

Four students from University of Illinois at Chicago enrolled into “Computer Design,” and one of the requirements of the class is created a project using arduino boards and sensor components. Our group for this project are Andy Cervantes, Paul Nguyen, Dhruv Patel, and Kunal Shah. After several meetings, we decided to create “The Automatic Bartender,” also known as “T.A.B.” When one goes to a bar and order a drink, the bartender listens for which drink is requested, creates the drink, and serves it. One of the reason why we choose this project is because when you go to a bar, it usually takes some time to order and make a drink. So what if there was a faster way of serving drinks. We figure that “T.A.B.” will solve that problem, and would require no human labor/expenses, except for maintenance. As a bartender would ask, “Would you like me to start you a “T.A.B.?”

We would like to give special thanks to Engineering Design Team (EDT) and Association for Computing Machinery (ACM) for allowing us to use their machines and tools. They were very helpful into designing our “T.A.B.”, especially the mechanical aspect of this project. Without any help from them, this project would have not been very successful. Also we would like give thanks to our parents for any extra help they put in, and giving us a budget to work with.

Objective & Purpose

The objective of this project is create a prototype of “T.A.B.” for real-world use. “T.A.B.” can be used in bars, parties, and other social event to bring a unique atmosphere to the environment. The goal is to reduce the time to make a drink, eliminate human labor, and make “T.A.B.” at a low cost. Upon request, “T.A.B.” will serve the user an alcoholic or non-alcoholic beverage of their choosing. The user will input which drink they desire and place a glass on the glass track, and the “T.A.B.” will fill up the glass with the appropriate beverage. Which the user may pick up and enjoy.

The functionality of the “T.A.B.” can be broken down into four essential components. There is going to be a framework created to house the entire bartender, there is going to be an input component which allows the user to choose their beverage, there is going to a track system which moves a glass to the desired beverage output, and finally, there is going to be a dispenser mechanism which dispenses the liquid into the user’s glass. Each of these components will individually use an arduino and come together to create a fully functional bartender, “T.A.B.”

Materials

1x - 2’ x 2’ x ¾” Fiber Board

2x - 2’ x 2’ x ¾” Plywood

4x - 6’ x ¾” Aluminum C - Channel

4x - Steel Angle Plates

1x - 4-Bottle Liquor Dispenser

1x - 3’ x 6” x ¾” Wood

1x - 3D Printed Platform

1x - Grease Tube

1x - 6’ x ⅜” Aluminum Rod

1x - HITEC HS-645MG High Torque Metal Gear Servo

1x - 2’ x ⅛” Wire

1x - Electrical Tape

1x - 3’ x ⅜” - 8 ACME Threaded Rod

1x - ⅜” - 8 ACME Threaded Nut Block

1x - ⅜” Servo Shaft Coupler

1x - HITEC HSR-2645CR Continuous Rotation Digital Servo

1x - 3” x ¼” PVC Pipe

1x - 2 x 16 LCD Display

4x - LED Lights

1x - 9V Battery

1x - 9V - 7V Converter

2x - 4’ Wire Loom

1x - 1” Eye Strap

Framework

Design

To construct “T.A.B.”, the platform has to be sturdy and able to handle the proper weight of the whole mechanism. Considering the mechanism will hold 4 bottles, a rough estimate of 15 pounds, we want the frame to be able to support such weight. So the design we went with was a ⊥ shape base. The base platform needs to be heavier, therefore we have the fiberwood as our base. The width depends on the length of the dispenser, for our case the length will be 2 feet. In the middle we attached a plywood going vertically, which is attached by 4x steel angle plates. We also wanted to consider the backboard to be adjustable for different sizes of glass. By implementing a sliding rail with the aluminum C - Channel. Placing another plywood through the sliding rail will allow “T.A.B.” to have adjustable height. Then we drilled several holes into the the aluminum C - Channel, which we will place screws to keep the second plywood to lock at certain position.

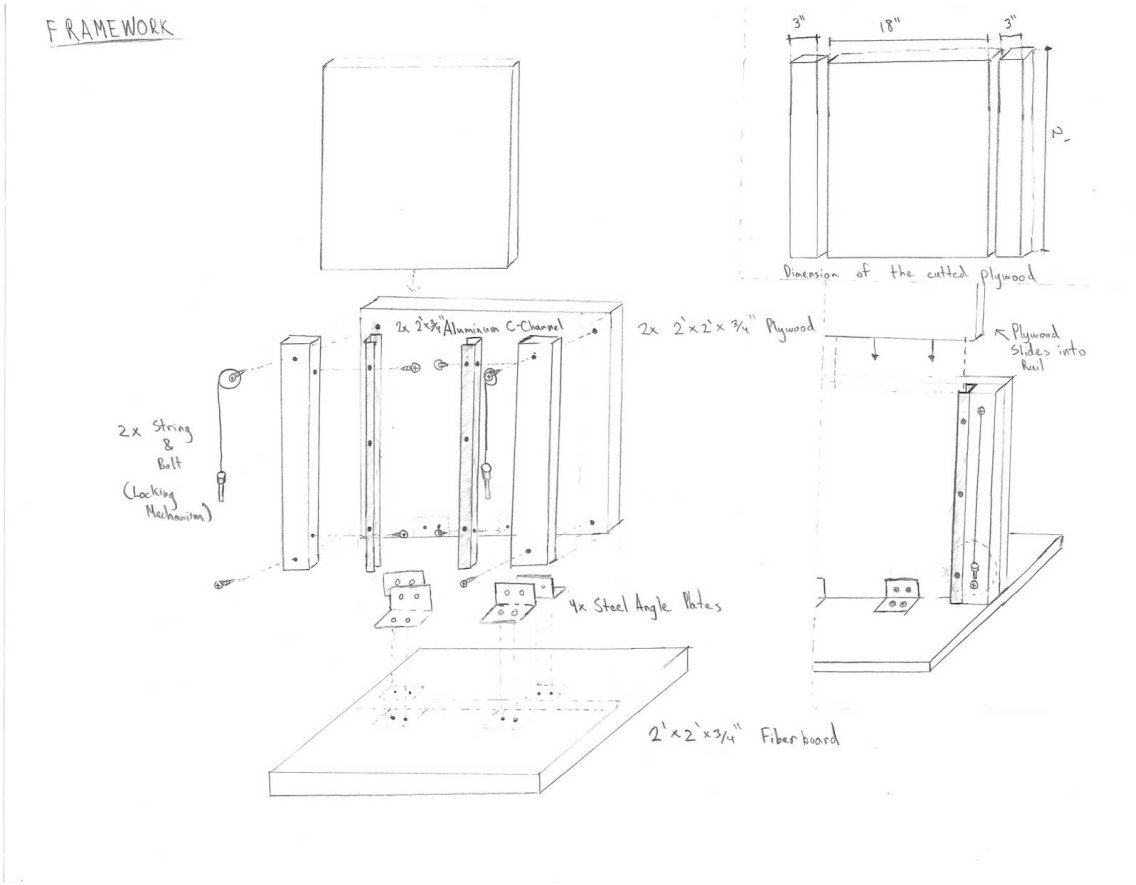

Figure 1: Design for the framework.

Parts

1x - 2’ x 2’ x ¾” Fiber Board

1x - 2’ x 2’ x ¾” Plywood

2x - 2’ x 3” x ¾” Plywood

1x - 2’ x 18” x ¾” Plywood

2x - 2’ x ¾” Aluminum C - Channel

4x - Steel Angle Plates

Mechanism & Usage

The objective of the C-Channel mechanism holding the plywood which holds the 4-Bottle Liquor Dispenser is to enable the height of the dispenser to be modular. Therefore, we can adjust the height as per necessary based upon the height of the glasses which are being placed on the platform. In order to make the height modular, holes were drilled on the channels where a screw could be placed. The screw acts as a stopping mechanism which keeps the plywood from falling further down the channel. Ergo, allowing different heights to be possible based upon which hole the screw is inserted into. In order to keep the user from losing the screws, one side of the screw is tied to the screw and the other side is attached to the Aluminum C-Channel. Overall, the modular height gives “T.A.B.” a height range of 1’ to 4’. Therefore, allowing different glass sizes to be filled.

The perpendicular placement of the plywood is chosen in order to leave about 11.5” space behind the plywood in order to hold our arduinos and maintain proper wire management. Then, we left 11.5” in the front in order to leave ample space for the track design. Ample space was left in the front in order to avoid any future problems of the track not fitting onto the base.

Dispenser

Design

To dispense the drink in the glass, it was required that the mechanism used to dispense the drink be sturdy and accurate. The mechanism used to dispense drink consisted of a base which hold the glass, with two rods ⅜" the rod is holding a 3D printed block 3" x 4.5" with a 1.5" hole in the middle that will allow the drink to fall into the glass. The 3D printed block will be pull up using a servo, which will cause the wine dispensers to be pushed up causing the drink to be poured into the glass.

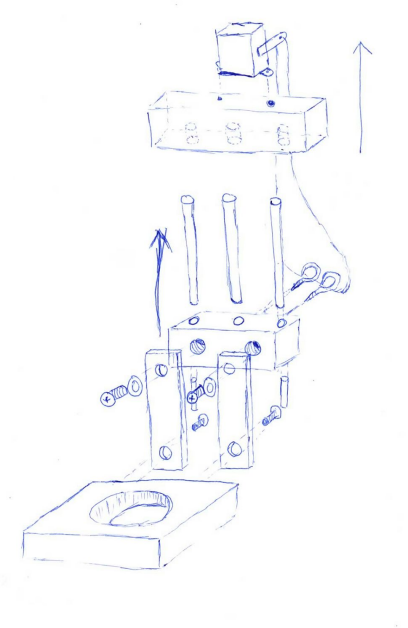

Figure 2:
Original Design for Dispenser Mechanism.

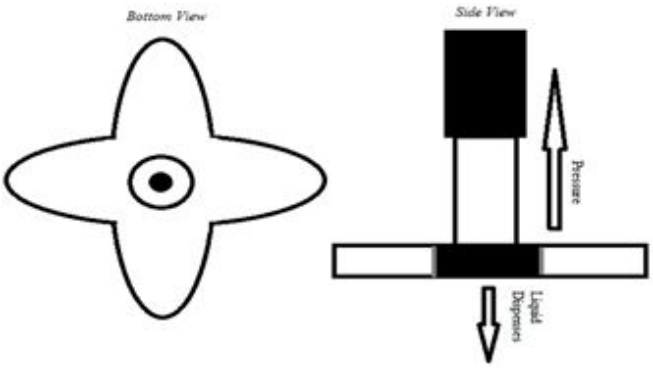

Figure 3:
4-Bottle Liquid Dispenser, Pressure Activated, Dispenser

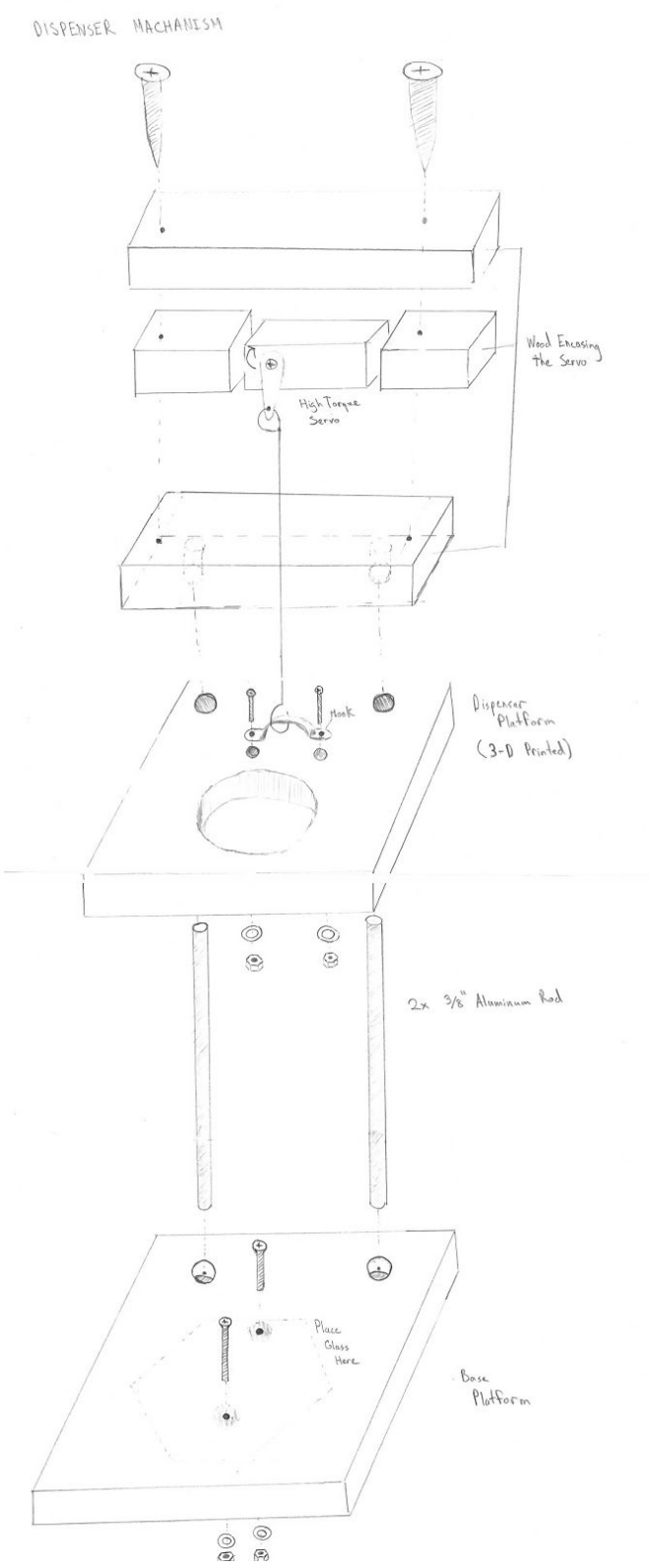

Figure 4:
Implemented Design for Dispensing Mechanism

Figure 5:
The Dispensing Mechanism with the Liquid Dispenser

Parts

1x - 3’ x 6” x ¾” Wood

1x - 3D Printed Platform

1x - 4-Bottle Liquor Dispenser

1x - 6’ x ⅜” Aluminum Rod

1x - HITEC HS-645MG High Torque Metal Gear Servo

1x - Grease Tube

1x - 2’ x ⅛” Wire

Mechanism & Usage

The servo is the most critical component of this mechanism. The HITEC HS-645MG High Torque Metal Gear Servo is a 180° rotational servo, which allows us to move the platform twice the distance based upon the size of the servo’s arm. In our case, the servo’s arm is 1.25” which will be able to pull the platform up by 2.5.” Furthermore, this servo has a very high torque, which can handle anywhere from 6.5 to 8.25 pounds. The reason why more torque was necessary was because the liquid dispenser requires a significant amount of pressure to dispense the liquid. Finally, we encased the servo on top of the dispensing mechanism, by surrounding it with wooden studs.

The dispenser mechanisms’ objective is to pull the 3D printed platform up, and applying enough pressure to push against the liquid dispenser. The liquid should then

flow through the 1.5” diameter of the hole we created on the platform directly into the glass placed on the platform below the hole. After we finish dispensing the proper amount of liquid, the servo arms drops down and the platform should slide down. This mechanism will be mounted onto the track platform.

Track

Design

A track is use to transport the glass through the assembly. The track consists of an ACME threaded rod, which is connected to a ACME Threaded Nut Block holding the dispenser mechanism and the platform. A HITEC HSR-2645CR Continuous Rotation Digital Servo is used to move the rotate the threaded rod such that the rotation causes the ACME Threaded Nut Block to rotate via a one-to-one gear ratio. Which, in turn, causes the entire platform, connected to the ACME Threaded Nut Block. Initially three design were chosen the first one and the most expensive one included a linear actuator. The second option was using a timing belt and the third option was using a ACME Threaded rod and a ACME Threaded Nut Block to move the platform. The first design was voted out because of the length of the actuator causing issues to the track and the cost involved in implementing it. The second design was voted out because it the it was too mechanically inclined making the design much harder to implement. The third design which is described above was chosen because it was easier to implement and was also the most cost efficient.

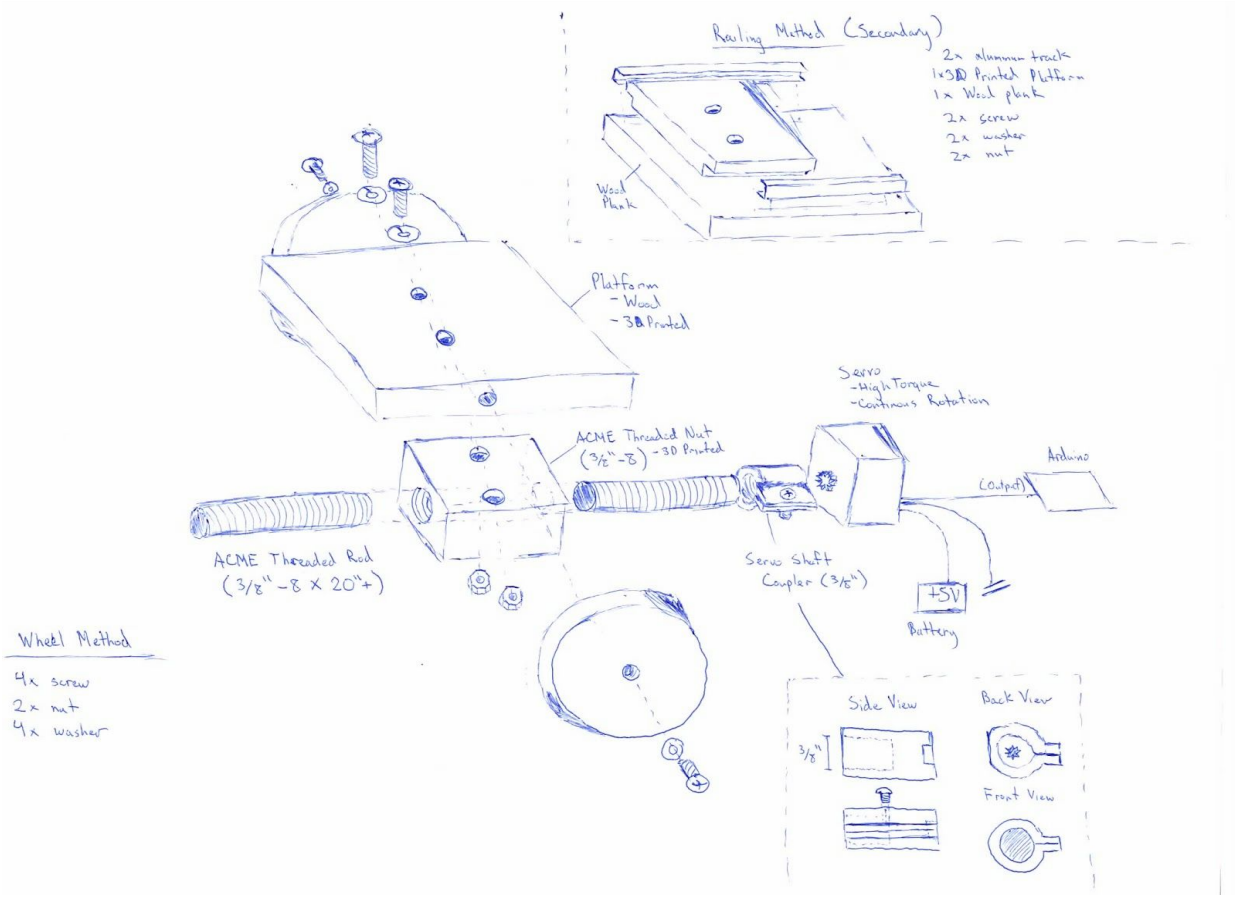

Figure 6: Threaded Rod Track Design (Above) which was implemented in "T.A.B."

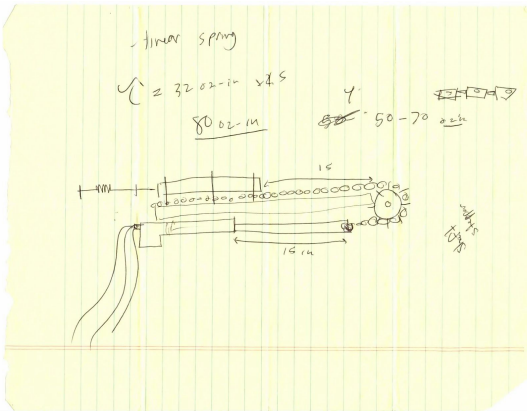

Figure 7: Actuator Track Design

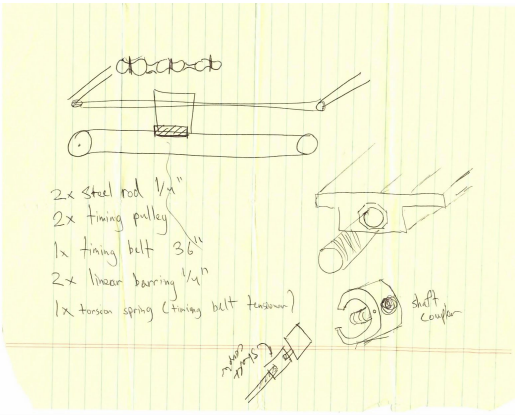

Figure 8: Timing Belt Track Design

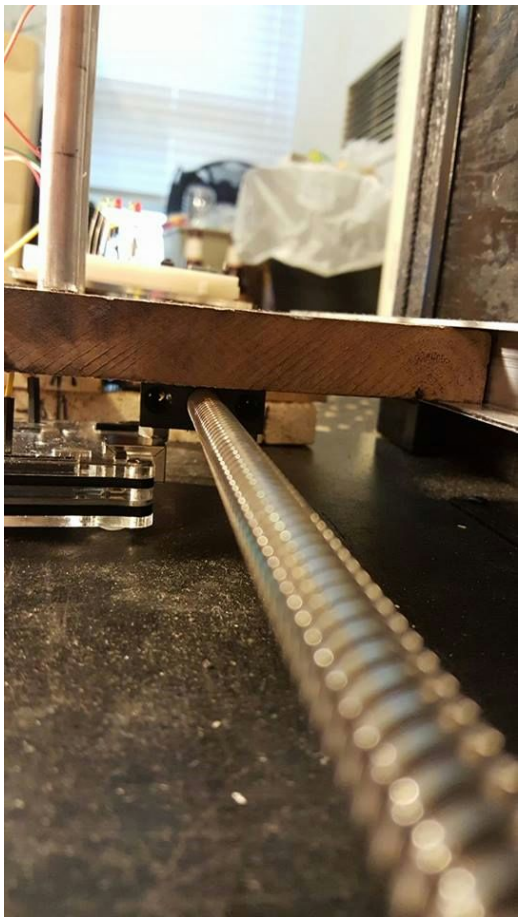

Figure 9:
ACME thread rod connected to the platform.

Figure 10:
The whole track holding the dispensing mechanism

Parts

4x - 6’ x ¾” Aluminum C - Channel

1x - 3’ x ⅜” - 8 ACME Threaded Rod

1x - ⅜” - 8 ACME Threaded Nut Block

1x - ⅜” Servo Shaft Coupler

1x - HITEC HSR-2645CR Continuous Rotation Digital Servo

1x - 3” x ¼” PVC Pipe

Mechanism & Usage

The track component needs to move the dispensing mechanism under the correct bottle for the machine to dispense the liquid. With the servo being the most crucial part of this track, we needed to have something to spin the ACME Threaded Rod. Since the rotation required more than 180°, we acquired the HITEC HSR-2645CR Servo, which allowed us to have continuous rotation for the ACME Threaded Rod. This servo can also handle up to 6.9 to 10.3 pounds of pressure, based upon the battery power supply.

With the proper voltage given to the servo, the servo will spin either counterclockwise or clockwise based upon the given code operation. The servo is attached to the ⅜" - 8 ACME threaded rod by a servo shaft coupler, and along the threaded rod we attach a ⅜" ACME nut block. After those components are attached we installed a railing system for the dispensing mechanism to slide on. Then we attached the nut block to the base of the dispensing mechanism. So when the threaded rod spins, the entire platform of the dispensing mechanism will move to its proper location based on input.

User Interface

Design

Communication between “T.A.B.” and the user is accomplished via an Arduino LCD display and four Arduino Buttons. When “T.A.B.” starts up, it well prompt the user with a welcome statement. Then, it will immediately allow the user scroll ‘Up’ and ‘Down’ using via two buttons. The ‘Up’ button will proceed to the next drink; whilst the ‘Down’ button will recede to the previous drink. Once, the user has selected their drink, they may press the ‘Enter’ button in order to tell “T.A.B” to tend the specified drink. Alternatively, should user choose not to have a drink created, they may press the ‘Exit’ button and will be prompted with a goodbye screen.

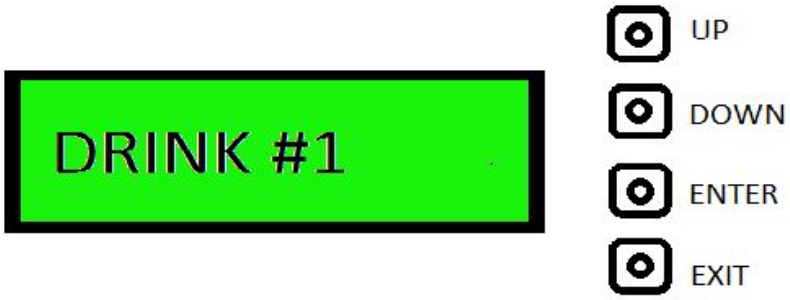

Figure 11: LCD User interface and operation

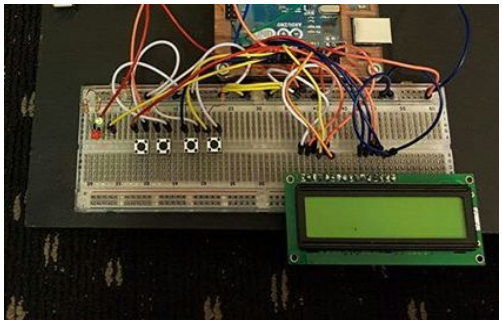

Figure 12: Result of the User Interface

Problems & Reconfigurations

At the beginning of the project during the thinking-phase, we assumed issues would arise and decided to resolve each issue as it presented itself. Once we started the building-phase we realized that a lot of issues would pop up, one after another, as we moved along with building our project.

Framework

Along the list of issues, the first one we encountered was related to the base that which would be holding up our liquor dispenser. We decided to go with an adjustable solution which involved a slide-down backsplash board that would be attached to the backboard of the base. We had rails attached to the backboard with button screws. For the backsplash to work, we would need it to slide vertically along the rails. The issue here was the type of screws we used. The channels in the rails were the same width as the backsplash; when we inserted the backsplash into the rails, the backsplash would hit the screws, thus preventing it from sliding further into the rails. To resolve this issue we had to shave off about 1 centimeter from the edges of the backsplash, this would ensure that it would slide into the rails smoothly. This took quite a lot of effort because we had to chisel and powertool the pathway into the backsplash.

Eventually we redesigned the frame, by adding two 2’ x 3” x ¾” on both sides of the backboard. Then we screwed the C - Channel along the new studs we

implemented, and bought a new plywood to slide through the track. So now the plywood fits perfectly through the track without having to chisel the edge of the wood down.

Dispenser

The next issue on our list was the liquor dispenser; the build quality of the dispenser wasn't what we were expecting. The dispenser uses a push-up tripod handle which is attached loosely to the pushrod used to dispense liquor. When we need to dispense liquor there will need to be an equal amount of force on all three "rods" of the tripod handle, otherwise the handle might break or not enough liquor will be dispensed. So we created a 3D print that will have a circular shape hole, enough for the liquid to dispense into the glass and the rest of the platform will apply pressure to all three "rods" of the tripod handle. There is not much we can do about this except hope for the best.

Our initial design for the liquor dispenser was to have a servo below the dispenser that was able to move along with the platform holding the glass. This servo would apply force to the tripod handle on the dispenser by rotating a threaded rod and moving the platform in vertical motion. At the top end of the threaded rod would be the platform attached to it. In order for this setup to work we would need to cut the base to allow sufficient spacing for the threaded rod to move in horizontal motion with the track platform as well as horizontal motion with the dispenser mechanism. With that in mind, the setup of the track platform itself does not allow for vertical

motion of the dispenser platform, to fix this we will need to have a vertical rail system on top of the track platform that will allow us to move an activator in vertical motion in order to have liquor dispensed.

After trial and error, we slightly changed the dispenser mechanism. We installed the servo on top of a vertical rail system used to move the dispenser platform. The vertical rail system consisted of two rails installed between two blocks of wood with holes drilled on each block to support the rails. The vertical rail is attached to the moving platform on the track allowing the dispenser to move along with the track. The servo attached to the vertical rail allows a 180 degree rotation which pulled a cable attached to the dispenser platform, allowing upward pressure to be applied on the tripod handle on the dispenser.

The dispenser platform used for the dispenser mechanism caused another area of problems. The first design of the platform was made out of wood. The issue here was the amount of friction caused by the vertical movement of the platform on the rails, which would prevent the platform to slide back down after it's been raised. We modified the wooden platform and made the holes bigger to allow us to install linear bearings so the rails would slide with less friction. This did not go well; the holes drilled were not the exact fit to hold the linear bearings in place. We even added greases to see if it would remove our issue, but unfortunately it did not work. We scrapped the first design and used a 3D printed design of the platform. This solved

two issues we previously had. The first issue it resolved was the weight issue with the platform. The servo needed to lift the weight of the platform along with the amount of pressure needed to dispense the liquor. The second issue it resolved was the friction caused by the wooden platform. The 3D printed platform reduced the amount of friction caused by the vertical movement on the vertical rail system. We had to go through several 3D prints because some of them did not have the proper dimension to fit the rods through and some were to loose. Eventually we got the perfect print that works for the dispensing mechanism.

After making these adjustments, we ran into another issue with the liquor dispensers. There are a total of four dispensers and each one of them required different amounts of pressure for them to dispense. One of them in particular required too much pressure that the servo was not able to apply enough pressure to dispense. We figure our problem would solved by applying force on the dispenser until it goes smoothly and lessens the pressure required for activation.

Track

Due to the initial design of the track, we ran into several issues as we progressed that we did not think about. We did not thoroughly think about how the servo would be held down to the base. The coupler that connects the threaded rod to the servo created a clearance problem with the track. The coupler spins along with the rod and thus would hit the base at every revolution, as the servo was attached to

it. We changed the design of the track; instead of having the track being held closely to the base, we elevated the track and shifted over the threaded rod and servo over to create clearance for the coupler to rotate freely.

Another issue we ran into was the servo was spinning very slow. After some research we learned the amps outputted from an arduino pin is about 0.1 amps. So we had access to a battery supply, which was able to produce 0.5 amps. We also increase the voltage supply to the servo by 7.4 voltage. By doing so, we were able to make the servo spin at a constant rate without slowing down, considering the amount of force required to move the dispensing mechanism along the track.

The friction of the wood sliding along the rail system we implemented, caused the servo to overheat. Therefore, the servo no longer spins the ACME Threaded Rod. Therefore, rendering the track functionless. The servo no longer outputs enough torque to successfully spin the rod. Therefore, our entire “T.A.B.” is rendered broken.

We wanted to created a 3D platform for the base of the track, since it solved our other problem with the dispensing mechanism. We figured weight was our issue and greasing the slides of a 3D platform would probably solved our issue.

Input

There were not any major problems for the input method we chose to implement for “T.A.B.”. It would have been nice to have a nicer looking input mechanism for “T.A.B.”; however, it was the most that we could do with what we had without spending more money. We did not have a proper place to keep the input on the side of the the framework. This was due to a lack of planning on our part when we created the framework. Regardless, the user interface mechanism is going to have to sit on the base of the frame on a breadboard.

Code

"T.A.B." consists of four arduinos ensuring that the machine runs smoothly and successfully tends a drink to the user.

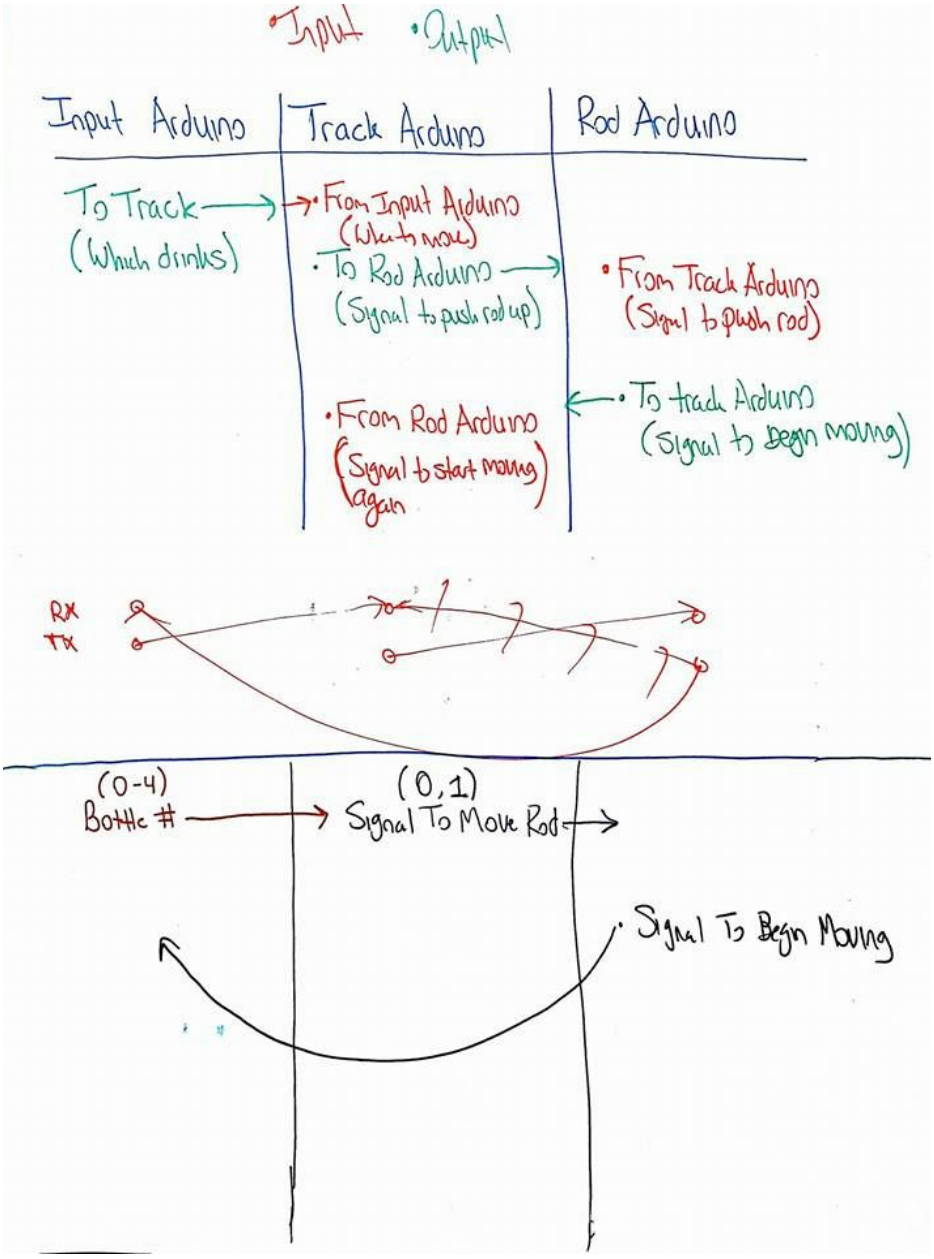

Figure 13: Outline of the connection between the arduinos

- Arduino #1 handles obtaining user input and displaying the drink choices on the 2x16 LCD.
- Arduino #2 handles getting the platform under the bottles, specified from #1, via spinning a continuous servo in order to move the platform to the correct location under the specified bottle dispenser.
- Arduino #3 handles deploying the pressure activation mechanism in order to activate the pressure points on the 4-Bottle Liquor Dispenser.
- Arduino #4 makes “T.A.B” look pretty with some LED’s. Have them flash when “T.A.B.” finishes tending drink.

Three of the four arduinos require communication between them in order to make “T.A.B.” functional. This three way communication was handled via Serial Communication between the arduinos. (All inputs received by the arduinos are delimited by ‘-999’)

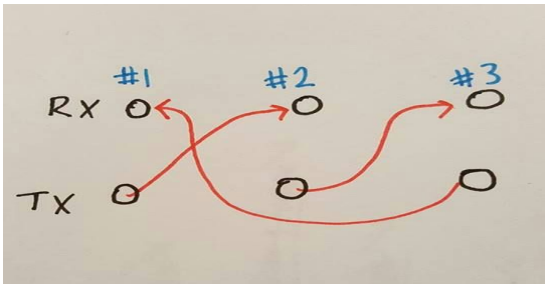

Figure 14: Outline of Serial Communication between Three Arduinos. Arduino #3 signal had to be sent to Arduino #1 because the RX of Arduino #2 is used by Arduino #1.

- Arduino #1:
    - Sends output of which bottles are going to be used (Bottle 1- Bottle 4) to Arduino #2.
    - Receives input signal (1) from Arduino #3 when the pressure activation mechanism has finished.
    - Sends output signal (-1) to Arduino #2 to signal that the track may begin moving after the bottle has finished pouring the drink.

- Arduino #2
    - Sends output signal (1) to Arduino #3 when the track has moved the platform to the correct liquor bottle dispenser.
    - Receives input signal (-1) from Arduino #2 which tells the Arduino that it can begin moving the track to the next liquor bottle dispenser.
    - Receives a series of bottle numbers as input from Arduino #1 specifying which liquor bottle dispensers the platform must travel to.
- Arduino #3
    - Sends output signal (1) to Arduino #1 which tells the Arduino that it can signal Arduino #2 to begin moving the track again since the pressure mechanism has finished pouring the drink.
    - Receives input signal (1) from Arduino #2 signaling the Arduino that it could activate the pressure mechanism since the platform is directly under a liquor bottle dispenser.

Progression & Improvement

Ultimately, “T.A.B”, has been rendered incomplete. Although we were able to grind through the various problems and mechanical issues we were challenged with throughout the span of this project (as stated in Problems & Reconfigurations), we were not able to complete the bartender. This is largely due to the mechanics required to complete the several mechanisms such as the track and the pressure activation mechanism.

First of all, tragedy unexpectedly hit our track system. While testing the threaded rod rotation for the Arduino code, the HITEC HSR-2645CR Continuous Rotation Digital Servo stopped spinning the ACME Threaded Rod. At first we thought that the servo broke all together. The servo does still spin, however it no longer has the torque required to rotate the threaded rod. This is tragic because if our track does not move, it renders the pressure activation mechanism useless because the track will never move to the correct location. The track is the essential component to our Arduino code as well as the mechanical workings of “T.A.B.” in general. After all, the track is in charge of moving the platform to the correct location so that the pressure activation mechanism could work. Now, it is impossible for any drinks to be dispensed. In retrospect, we might have been able to use a DC motor to spin our rod with greater power and torque. We could have also went with a faster method of moving the track by implementing the timing belt track design. It would have been significantly less stressful on our servo; therefore, our servo might have still been working. By the time

the servo stopped working, it was too late and expensive to order a new one and possibly re-implement the track. Alas, we could not do anything to fix this issue.

Secondly, another currently unsolvable issue is our pressure activation mechanism which currently does not have enough torque to activate the liquor dispensor with the highest activation pressure. Remember that for our 4-Bottle Liquor Dispenser, some have higher pressure activation points than others. Therefore, our HITEC HS-645MG High Torque Metal Gear Servo does not give the 3D printed activation platform enough power and upward force to activate some of the dispensers. Therefore, drinks cannot be dispensed from some of the dispensers. We 3D printed a multitude of different activation platforms for the servo to lift up; however, none of which gave enough upward force and mass to activate the toughest dispenser. It should also be noted that our HITEC HSR-2645CR Continuous Rotation Digital Servo generates more torque than our HITEC HS-645MG *High Torque* Metal Gear Servo. Therefore, the pressure activation mechanism does not create sufficient upward pressure to dispense the liquor from certain dispensers. Altogether, we attempted different implementations of the activation mechanism in order to create enough upward force; however, our efforts were in vain and we did not have enough time to create a better solution.

Incidentally, we were not able to complete "T.A.B." as much justice as the idea deserves. It was difficult managing the project along with other classes and happenings throughout the semester. Ultimately, we were restricted by time.

Therefore, moving forward, we would like to continue working on “T.A.B.” over the summer in order to successfully complete this project. One of the things we want to improve is the portability of “T.A.B.” We want to redesign the frame to only hold the mechanism required, and removing any unnecessary space that we do not used. Since one of the main objective was to decrease the time it takes to make a drink, the method we choose for the track is not very efficient. The servo spins very slow, and it takes a while to move from one position to another. We wanted to follow through with one of our other designs with the timing belt, that would pull the platform that slides along two rods. This would put less stress on the servo that we currently have and should move the track more smoothly. Since we wanted this to be for real world use, we figure that we would want to hide all the mechanism away from the user.

What we currently have is a prototype of a prototype, and we would like to move along this path to make a better “T.A.B.” Not just for this class, but for ourselves to get better experience working as a group and interacting with other fields. This project has taught us how to communicate well with each other, writing documents for explanation from one to another of how things work, and the mechanical sides of the project. We ran into many issues while design, which was done through trial and error. As a group we collaborated solutions to our problem, and we kept documentation of every design we came up with. “T.A.B.” could be used any many social events and we would like to continue forward on this project. We plan to meet up in the summer to redesign this machine and improve on it.