Motorized Luggage Carrier

Charles W. Davidson College of Engineering

Department of Mechanical Engineering

ME 106, Fall 2021

Fundamentals of Mechatronics Engineering

San Jose State University

Brandon Chang

Andres Cisneros

Cameron Reyes

December 4, 2021

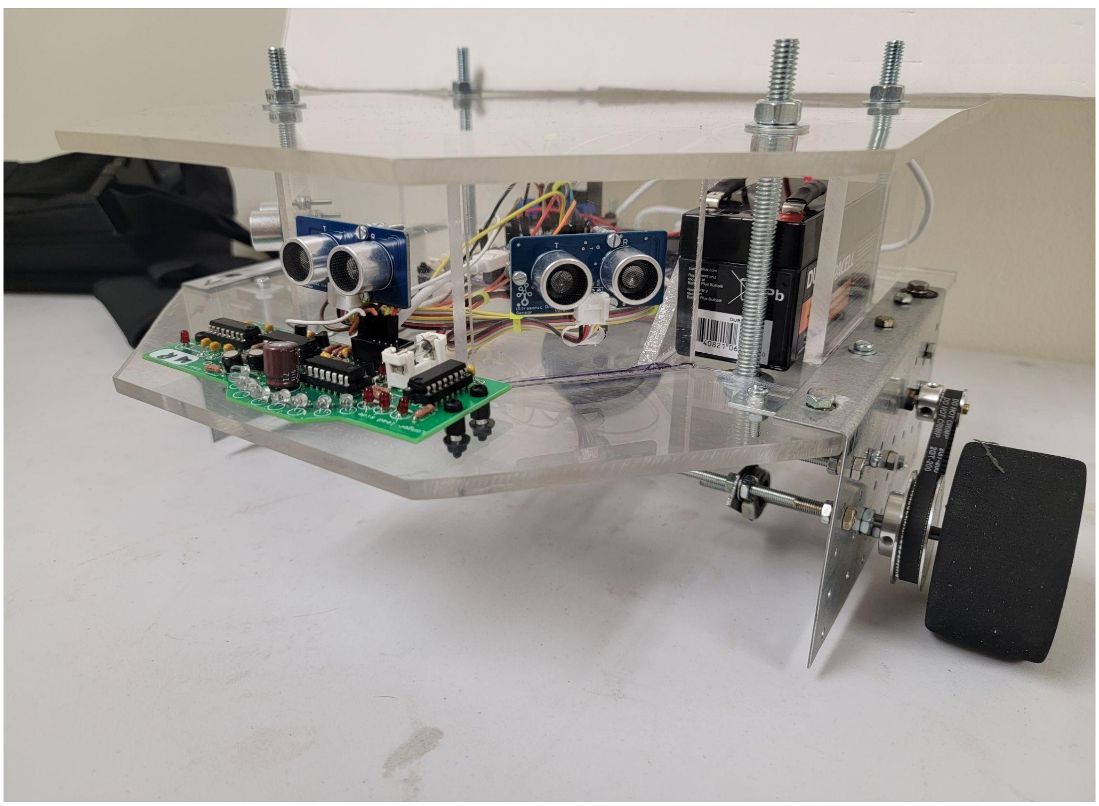


Figure 1: Fully Assembled Prototype

Summary

Our team designed and built a working prototype of a motorized cart capable of changing its path based on infrared and ultrasonic feedback from the immediate surroundings. This motorized cart is proof of concept for our team's initial idea for a remote-controlled luggage dolly in airport terminals. However, the current iteration of our design only incorporates the series of ultrasonic sensors as there was not enough documentation to read analog inputs from the IR sensor board properly.

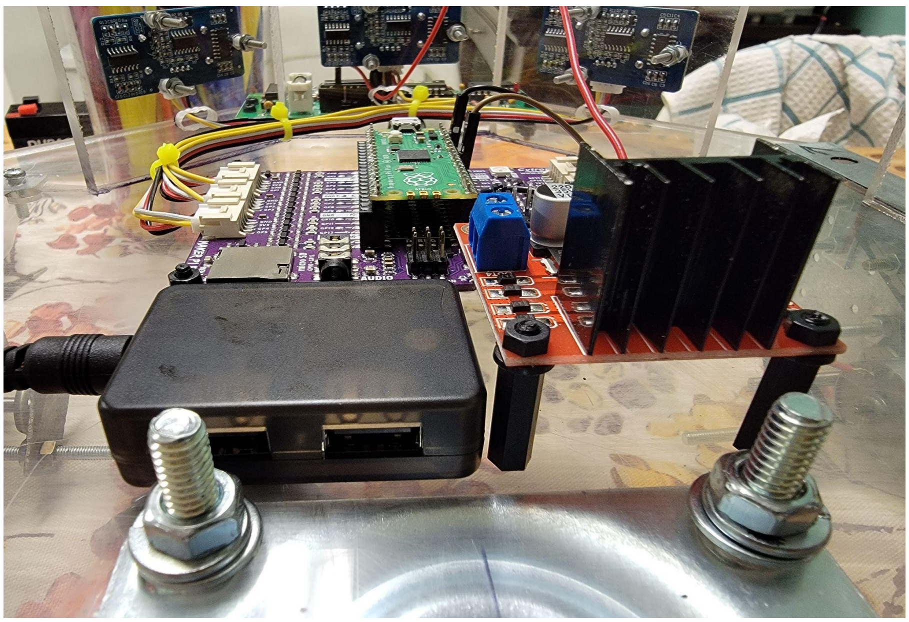


Figure 2: Microcontroller, Motor Driver, and Buck Converter layout.

We built the cart's chassis around a 1 Ft. x 1 Ft. ¼ in. acrylic base, consisting of 2 independent motor mounts with 12V, 60RPM motors, and a single 3 in. caster for balancing. In addition to the components mentioned above, there are seven 3 in. X 3 in. acrylic squares secured to the base with acrylic cement to house the 12v 1.3AH power supply, 12V-36V to 5V buck

converter, L298N Dual H bridge, 3 Grove HC-SR04 Ultrasonic Sensors, E10 IR Board, and a Raspberry Pi Pico in a Maker Pi Base.

In testing the E10 IR Board, we could not read any meaningful sensor data from the IR receivers on the board. Since our team did not have the intended interface meant to communicate with the board, we made assumptions based on the given documentation as to where the analog output would be. Instead of using the E10 IR board to guide the cart, our team used the 3 ultrasonic sensors meant for obstacle avoidance and repurposed them to control the movement and direction of the carriage based on the position of the user and their proximity to the cart.

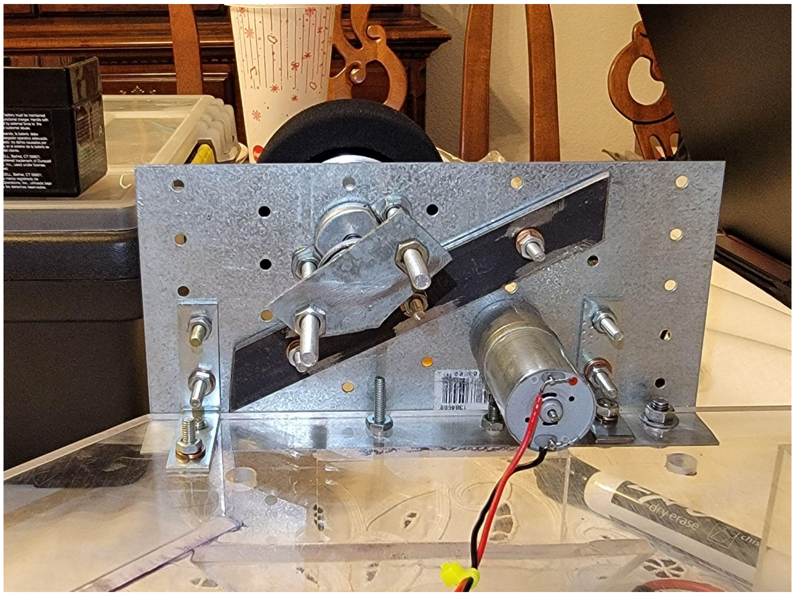


Figure 3: Motor Mount Backside

Naturally, this project was a great learning opportunity that offered experiences in team logistics, mechanical design, fabrication, hardware integration, coding, and troubleshooting system issues. For example, once it became apparent that we would no longer be able to use the E10 IR board as our primary sensor system, we quickly repurposed the obstacle avoidance system to demonstrate the integration of sensors, controls, and the drive system. We also learned that the sensors' limitations significantly constrain the performance of a system.

Introduction

The problem our group is attempting to solve with this device is to relieve people who cannot carry around their heavy luggage on their own in an airport. These people may have a disability such as being in a wheelchair, not having the strength to carry a luggage bag due to old age, or even just for general convenience, so people don't have to struggle to carry their heavy bags around the airport. Our goal is to design a scaled-down prototype of a motorized luggage carrier that can allow anyone to carry heavy luggage around an airport all on their own, even with possible disabilities. In addition, this prototype will have the ability to follow the user around autonomously via sensors, locate any potential obstacles in the way, and stop before hitting them.

Our first objective was to design a prototype that could efficiently move around and easily maneuver around tight corners of an airport. The chassis would hold the electronic components and wiring of the motorized luggage carrier and the heavy luggage itself. After many revisions and discussions with Dr. Furman, we made the design decision to utilize a three-wheeled carrier design with two motorized front wheels and a non-motorized rear wheel on a swivel. The chassis of the prototype would be acrylic with a compartment to hold the electronic components and a base on top to hold the luggage. The mechanism we decided on can be seen in Figure 4 down below.

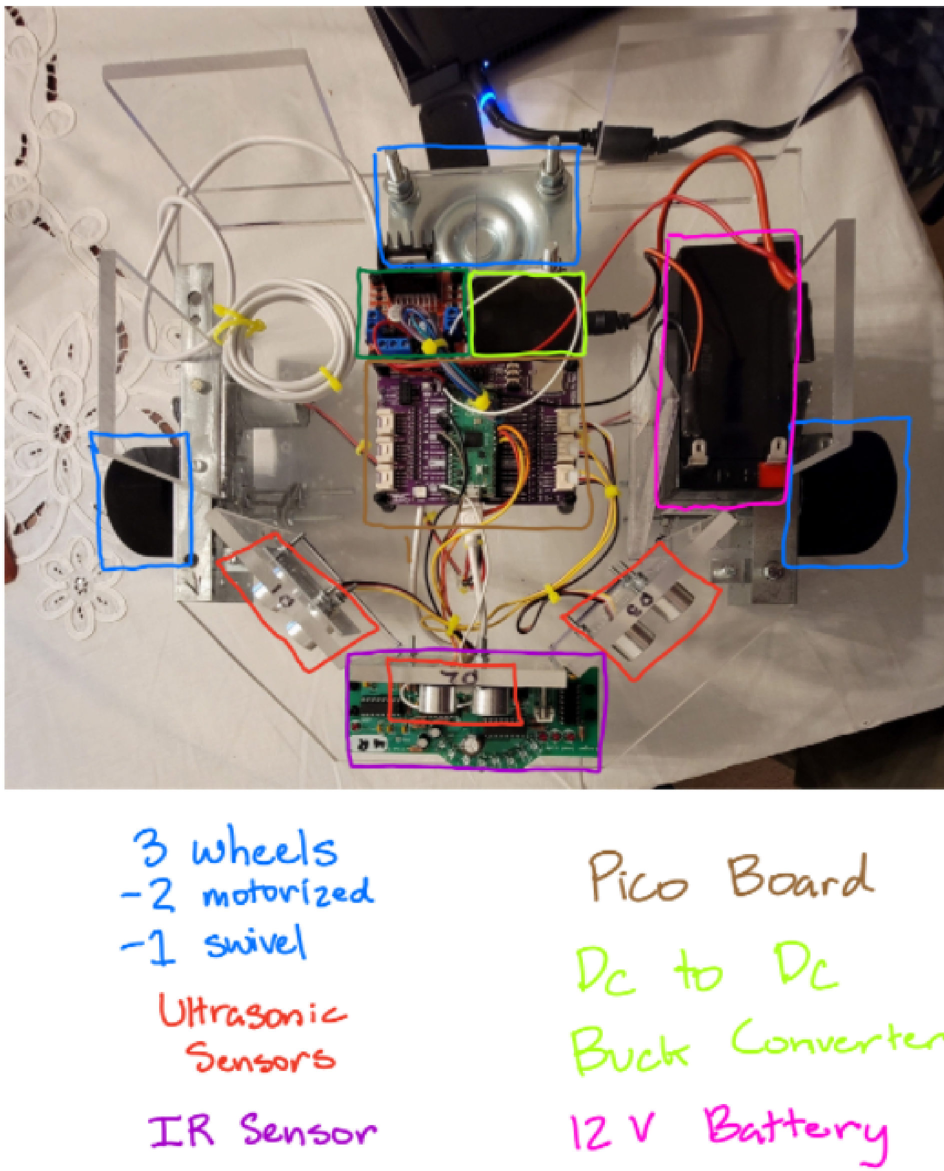


Figure 4: Diagram of the Motorized Luggage Carrier

The next objective was to have an autonomous way to make the luggage carrier follow the user around the airport. The design required a beacon of some sort that the user would have on themselves, and a reader on the luggage carrier that could sense where the beacon was so the luggage carrier could follow the user accordingly. We soon realized an IR sensor along with its beacon would integrate perfectly with our design. A diagram of the IR sensor can be seen in Figure 5 down below.

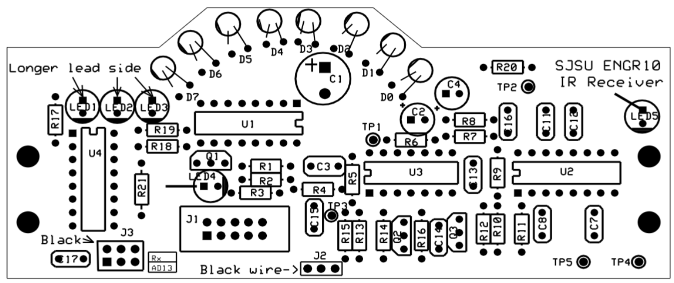


Figure 5: Diagram of E10 IR Board

Design Specifications

The design specifications of the project is to create a smaller scale prototype with the desired maneuverability, sensors and well coded program to allow autonomous movement of the luggage carrier. Our scaled down prototype is one-third of the actual one.

Detailed Design Overview

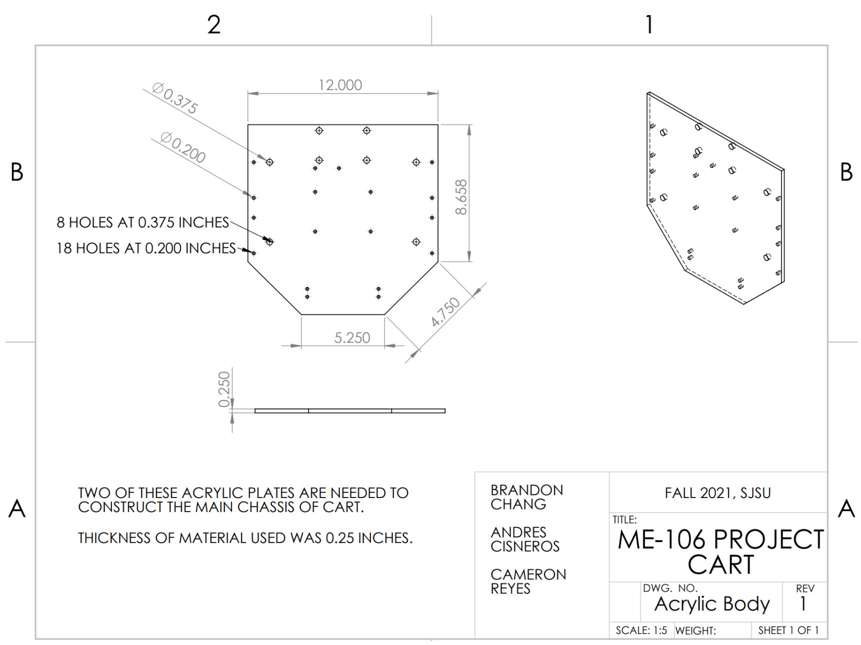


Figure 6: Chassis Drawing and Thru-Hole Layout

This plate was exclusively used as a base to mount all hardware and components used to assemble this project. In figure 6, we see a plate having various holes, where on the sides with a length of 8.658 inches, four holes are necessary for the plates holding our motor and drive system. Larger holes of .375 inches in the middle towards the 12.000-inch side allowed us to mount a rear caster wheel that acted as back support for the cart itself. The smaller .200 inch holes near the middle of the cart allowed for the microcontroller, voltage regulator, and L298 H-bridge placement.

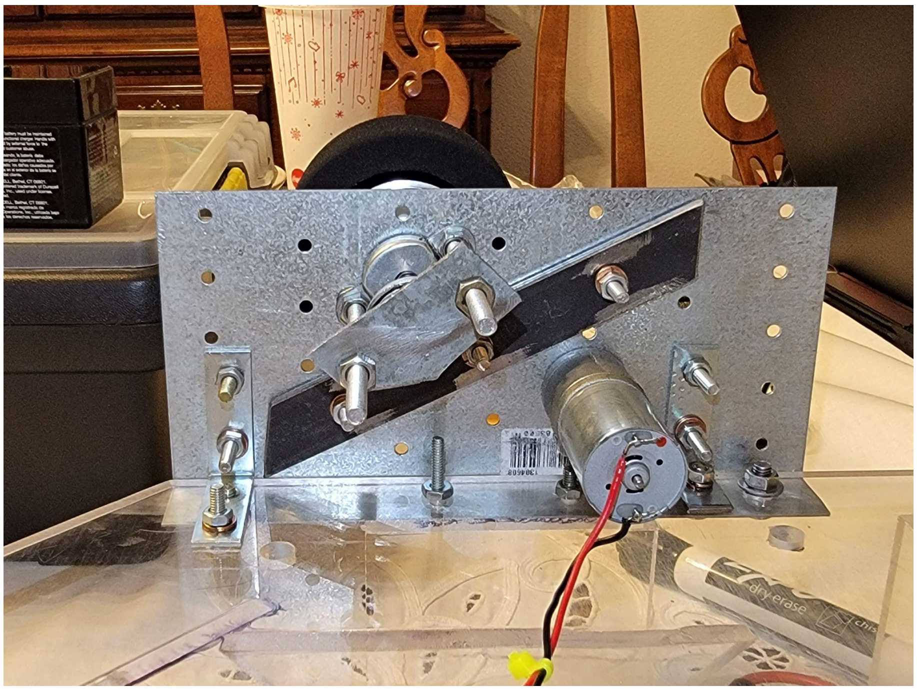


Figure 7: Backside Motor Mount

Here we see the rear set up for the drive system created for the carrier, and used a metal plate to mount the DC motor and wheel system to drive it, which consisted of two pulleys and a belt from the DC motor to the wheel assembly. As you can see in Figure 7, due to sourcing for a proper bearing size that matched up with a drive shaft of 5mm, we have created the hardware that allowed us to surface-mount a bearing initially not designed to be surface mounted. Given the thickness of the mounting plate and forces that acted when the motor actuated, the drive system needed support using screws and extra mounting hardware to allow proper tension on the belt for the drive system to function correctly.

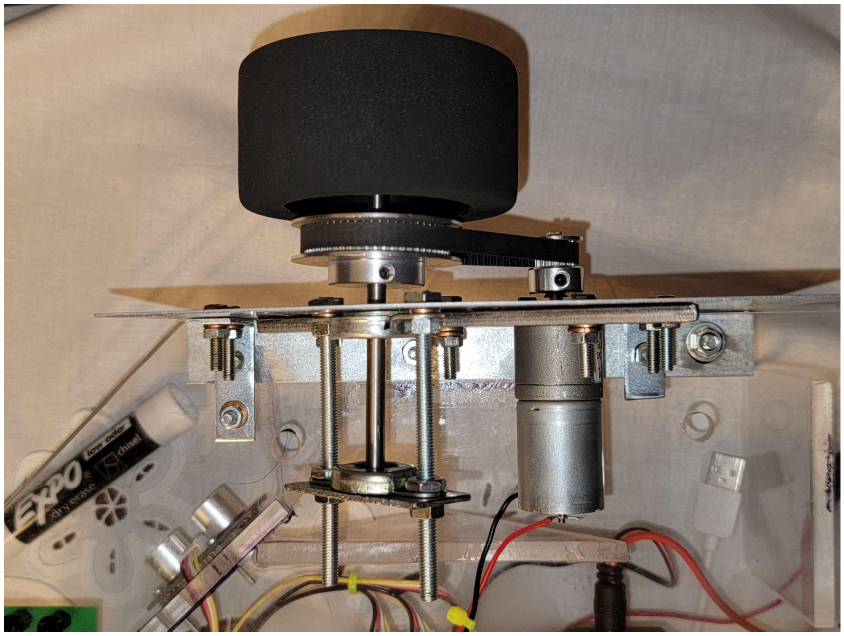


Figure 8: Top-Down Motor Mount

In the Top-Down motor mount view, we can see extra hardware used to support the movement and flexibility of the mounting plate was implemented by having the drive shaft at the back end be held by another bearing that forced the shaft to stay in its desired state.

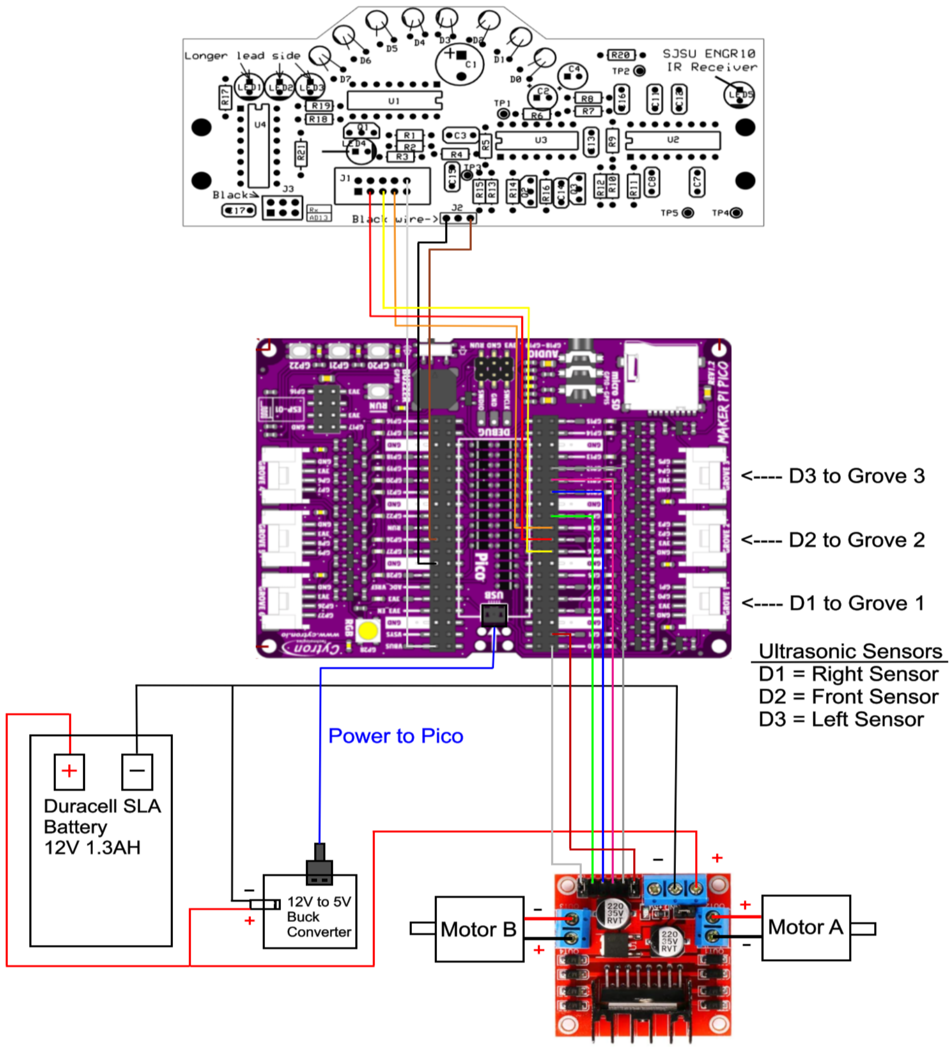


Figure 9: Motorized Cart Circuit Diagram

In figure 9, the IR board receives a 1kHz or 10kHz signal based on the frequency selected. This signal is measured at each of the 8 sensors to determine the direction based on the strength of the signal. The subsequent direction observed by the IR board can then be used by the pico to determine the duty cycle needed by Motor A and Motor B to maintain high signal strength in the middle 2 IR sensors.

Furthermore, there are 3 Ultrasonic sensors mounted on the front of the cart that form the obstacle avoidance system. The ultrasonic sensors above are provided 3.3V from the grove 1-3 connectors which receive its power from a DC-DC Buck Converter as seen in Figure 6. The buck converter steps down 12V to 5V USB power for use by the pico. In addition to powering the pico and sensors, the 12V battery also powers the L298N motor driver directly which drives both DC motors.

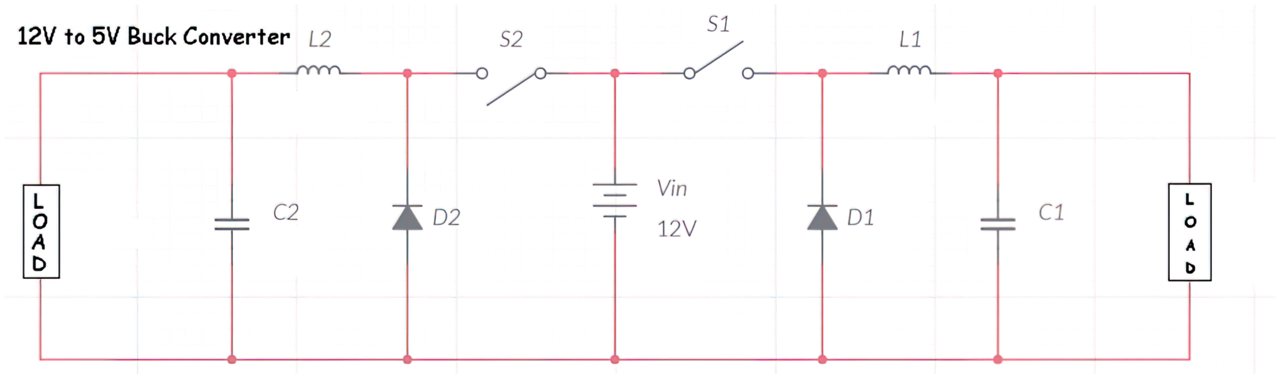


Figure 10: General Purpose Buck Converter Circuit Diagram

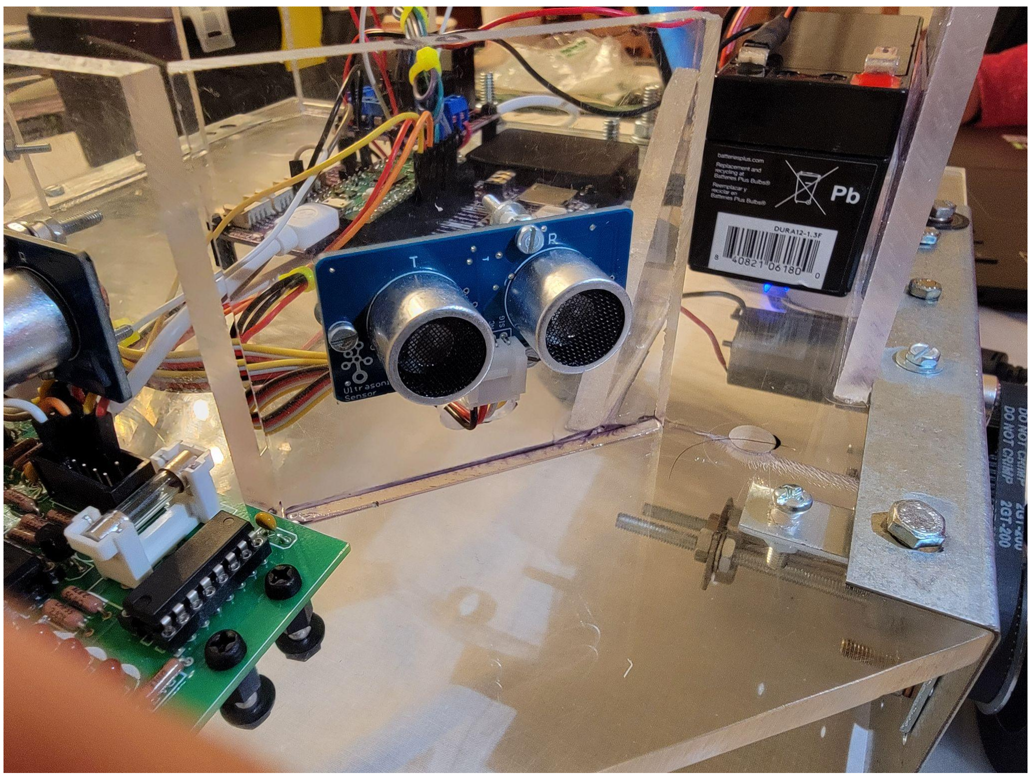


Figure 11: Grove HC-SR04 Ultrasonic Sensor

The ultrasonic sensor seen in Figure 7 has a range of 3.5cm, a 15-degree viewing angle, and a 1cm resolution. It functions by sending an ultrasonic sound wave that propagates until it reaches a solid object and is subsequently bounced back to the sensor. The time spent sending and receiving the return wave gives us the distance between the sensor and the object.

Project Outcome

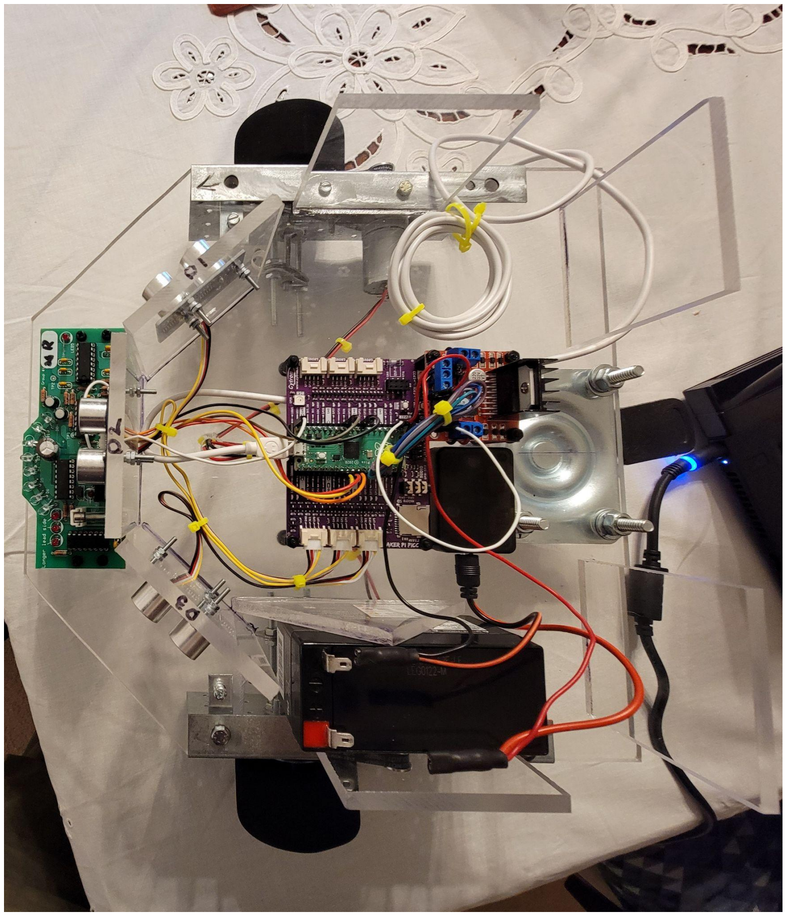
Although we had to adjust from our original design, the outcome of this project was an overall success. At first, we planned on using an IR sensor to control the interface between the user and the motorized luggage carrier. The beacon was attached to the user and the IR sensor to the luggage carrier. The IR sensor would then detect where the beacon was and move the luggage carrier accordingly to follow the user. However, during our testing phase, the values we got from our IR sensor were very inconsistent, which made our IR sensor impossible to use. Therefore, we decided to adjust our design to use the ultrasonic sensors that were supposed to be used to prevent the luggage carrier from running into obstacles as a replacement for the IR sensor. The three ultrasonic sensors would instead detect the user's position and move the luggage carrier accordingly. When the user of the luggage carrier was not within a 400 range of the ultrasonic sensor, the device would move in a straightforward direction. For example, if the user were in front of the leftmost sensor, the luggage carrier would shift left. Likewise, the luggage carrier would turn right if the user was instead in front of the rightmost sensor. Lastly, the motorized luggage carrier would stop if an obstacle were to get too close to the middle ultrasonic sensor. Although we could not complete the design we originally planned, using the ultrasonic sensors allowed us to accomplish our project goals.

References

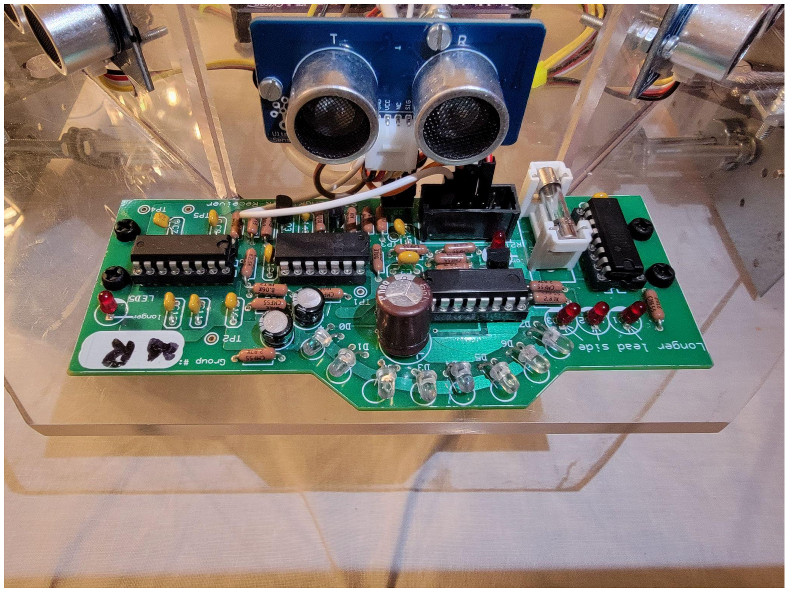
Carryer, J. Edward, R. Matthew Ohline, and Thomas W. Kenny. *Introduction To Mechatronic Design.* Pearson College Div, 2010.

[Motorized Cart Project - YouTube]

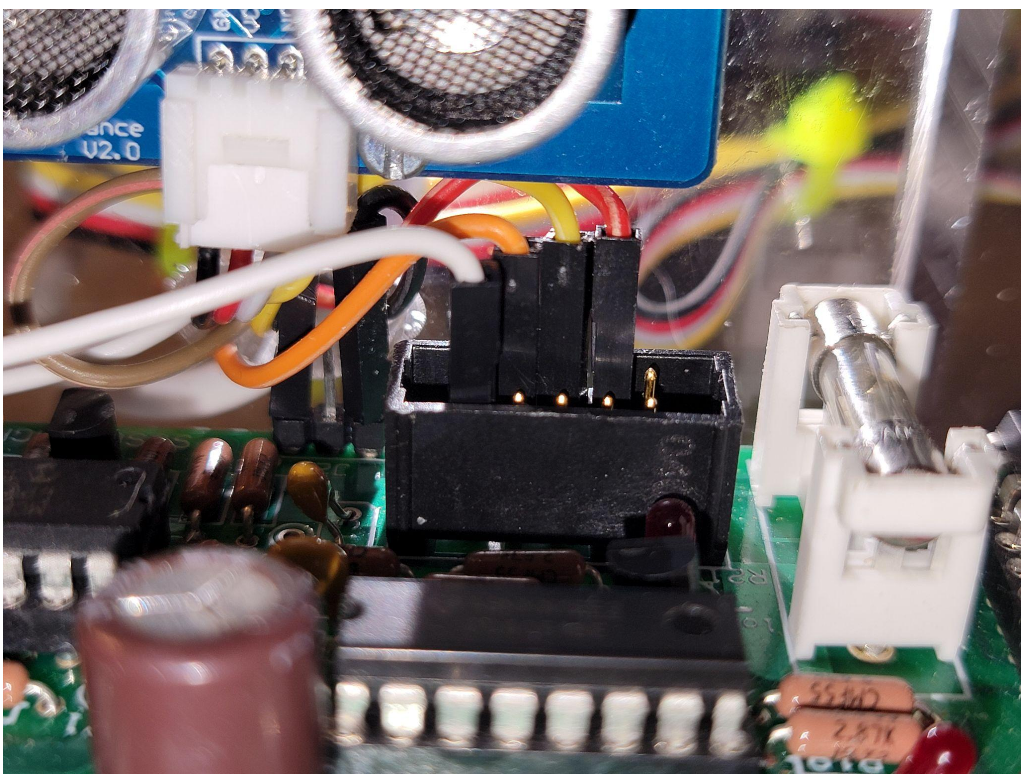
Appendix A



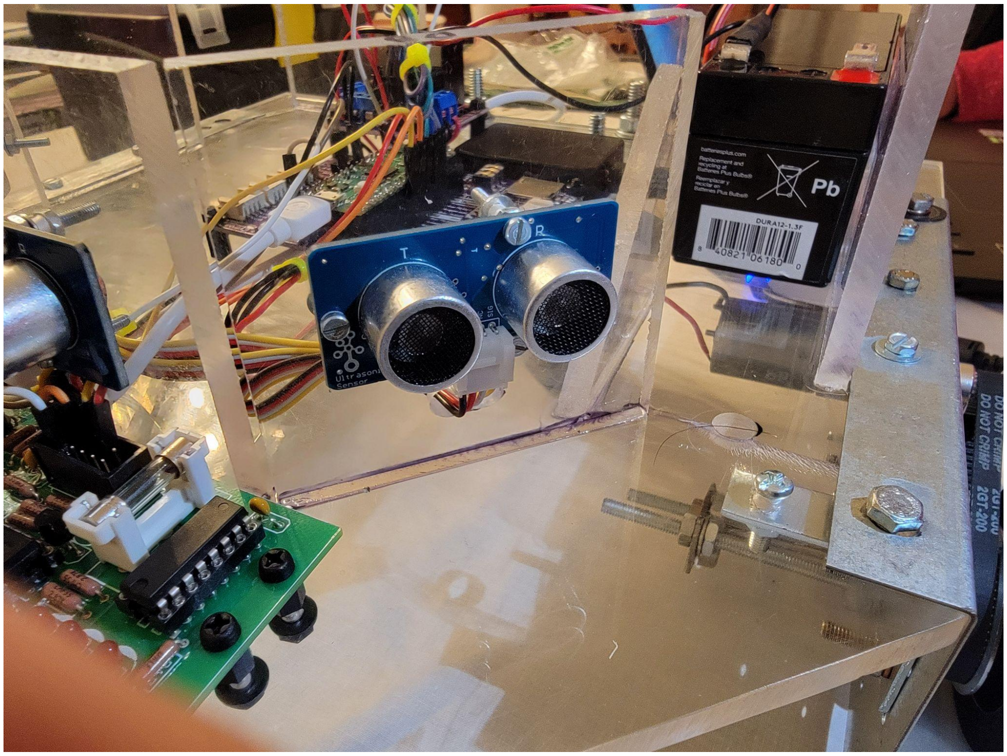
Cart Top-Down View



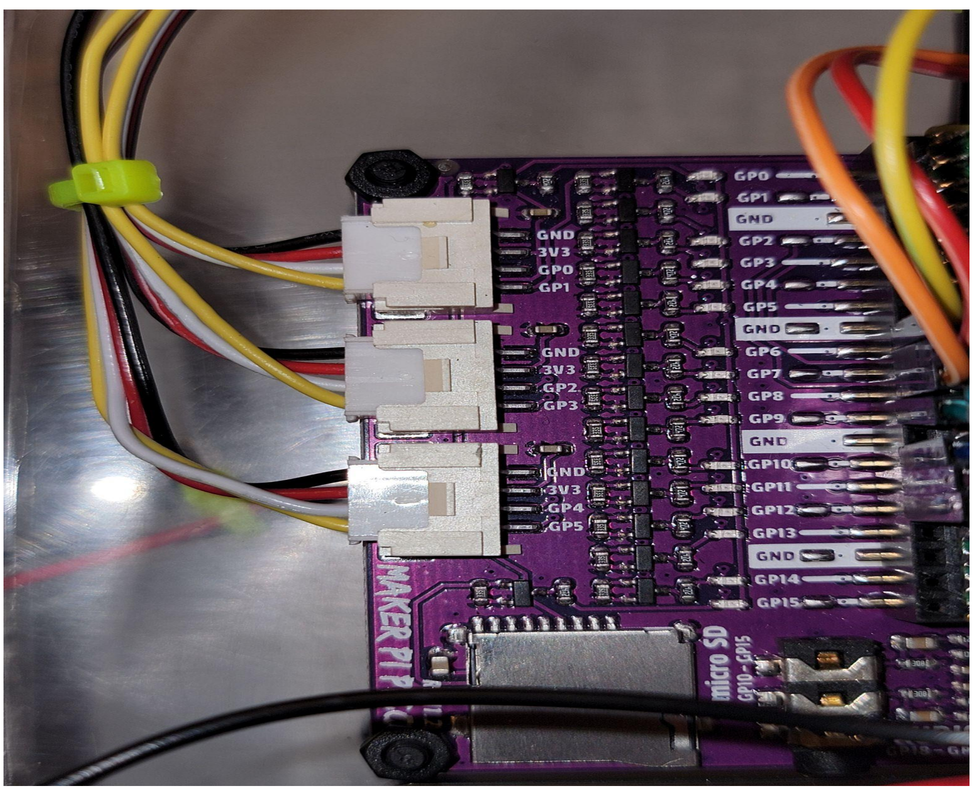
E10 IR Sensors Board



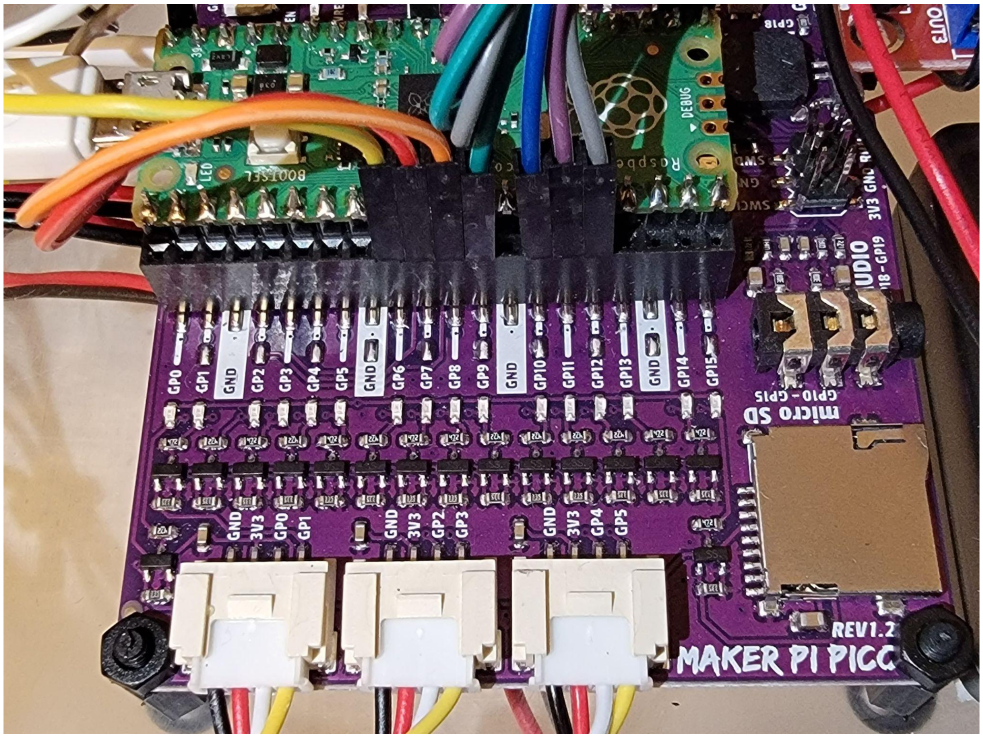
J2 (left) and J1(right) connector pin layout



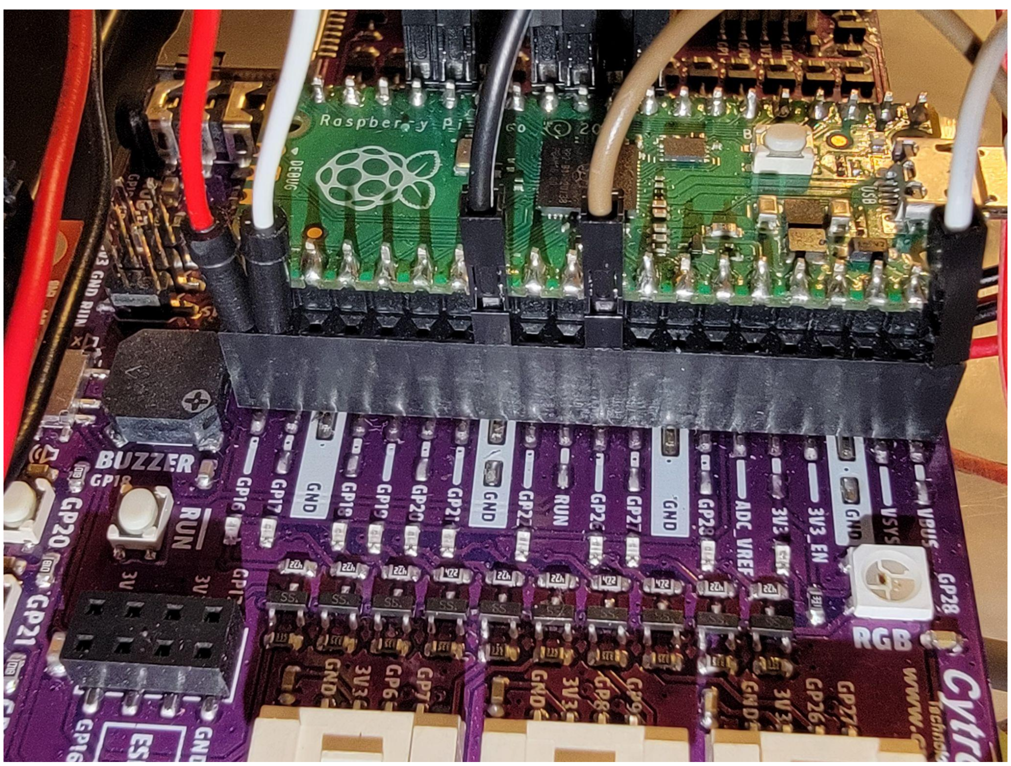
Grove HC-SR04 Ultrasonic Sensor



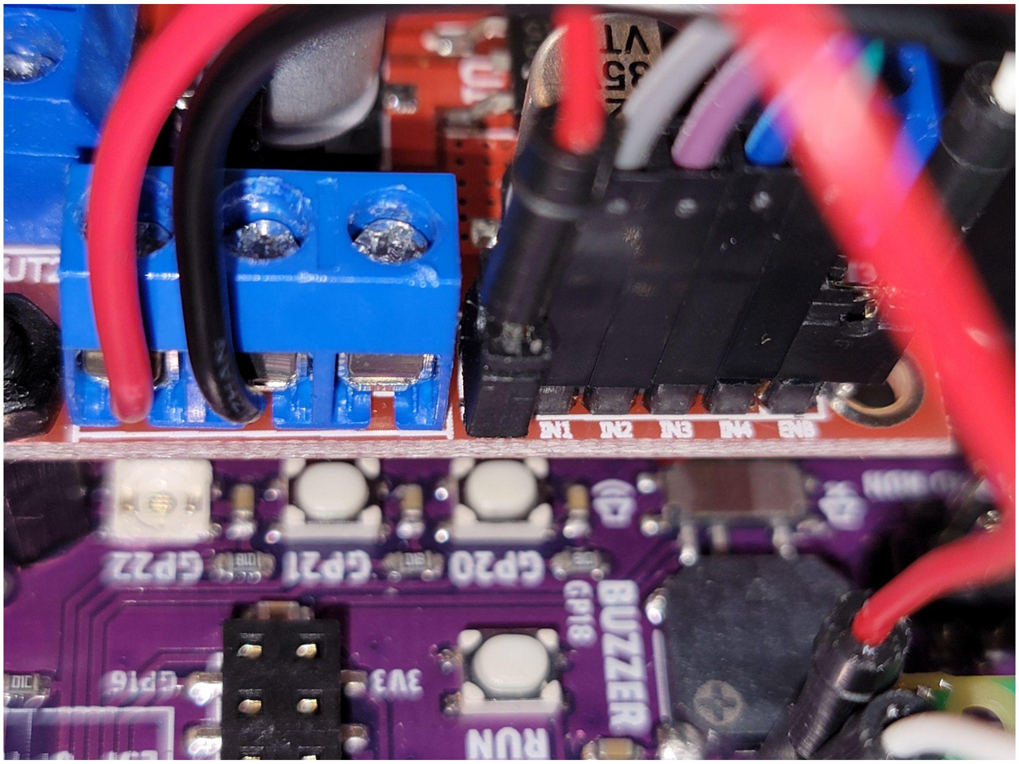
Grove Ports



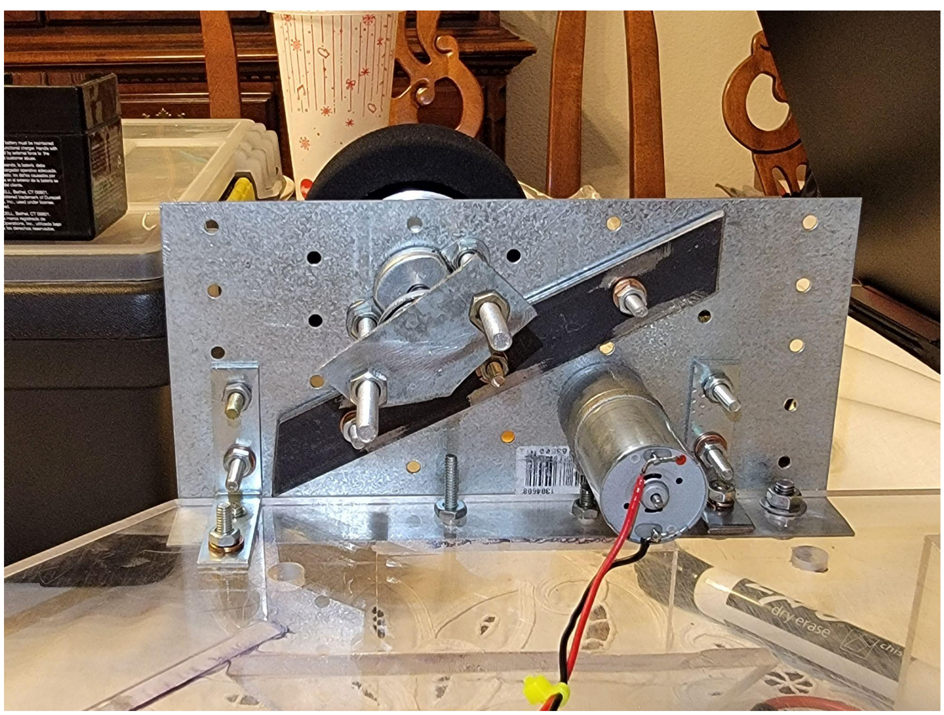
Left Side Cart Pico



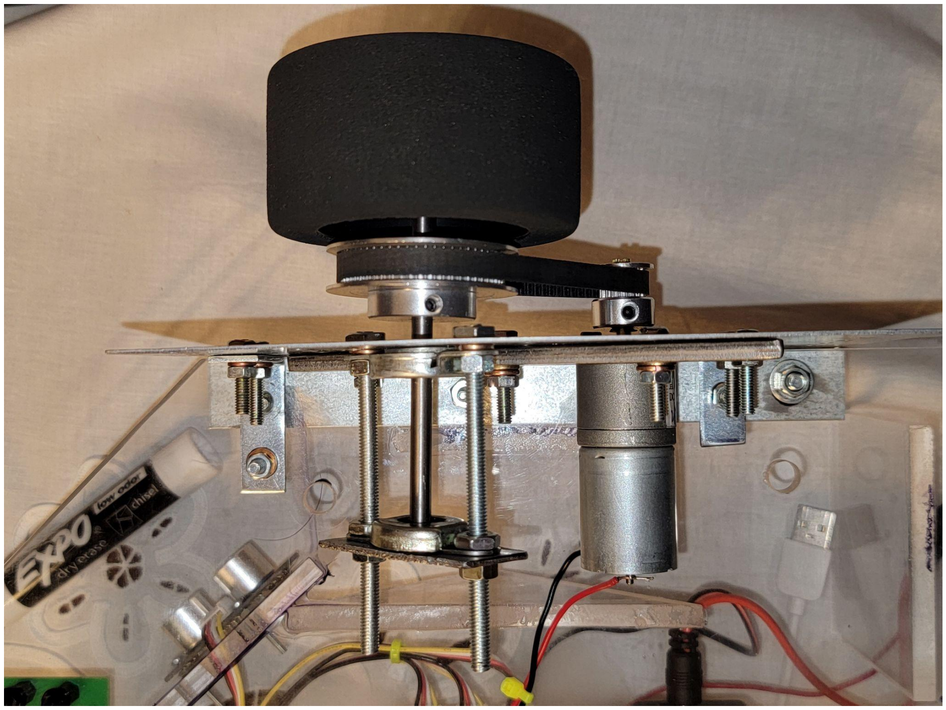
Pico Right Side



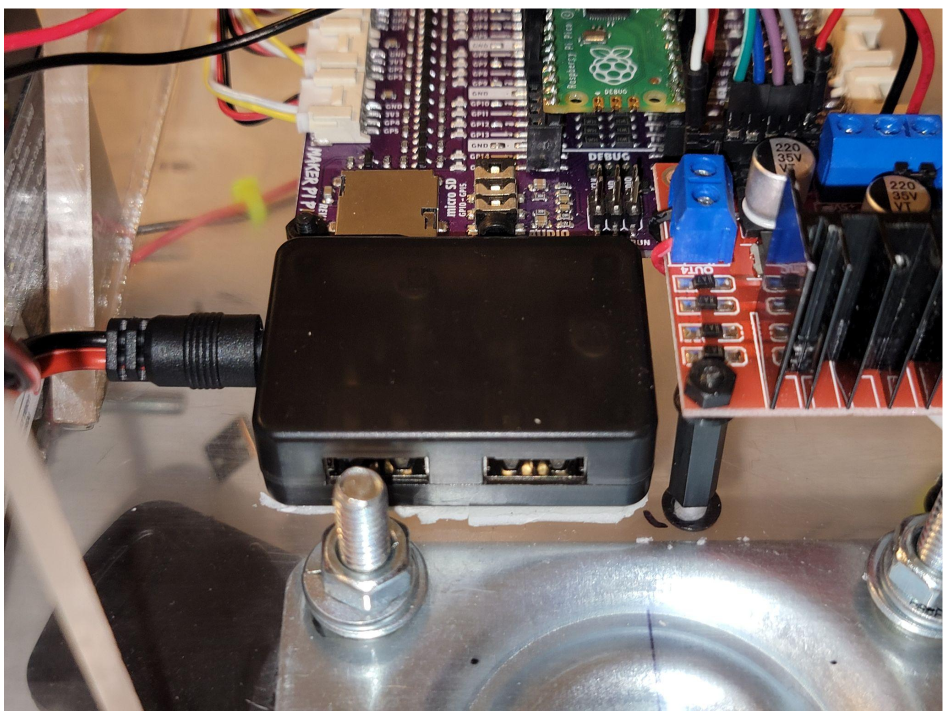
L298N Pins



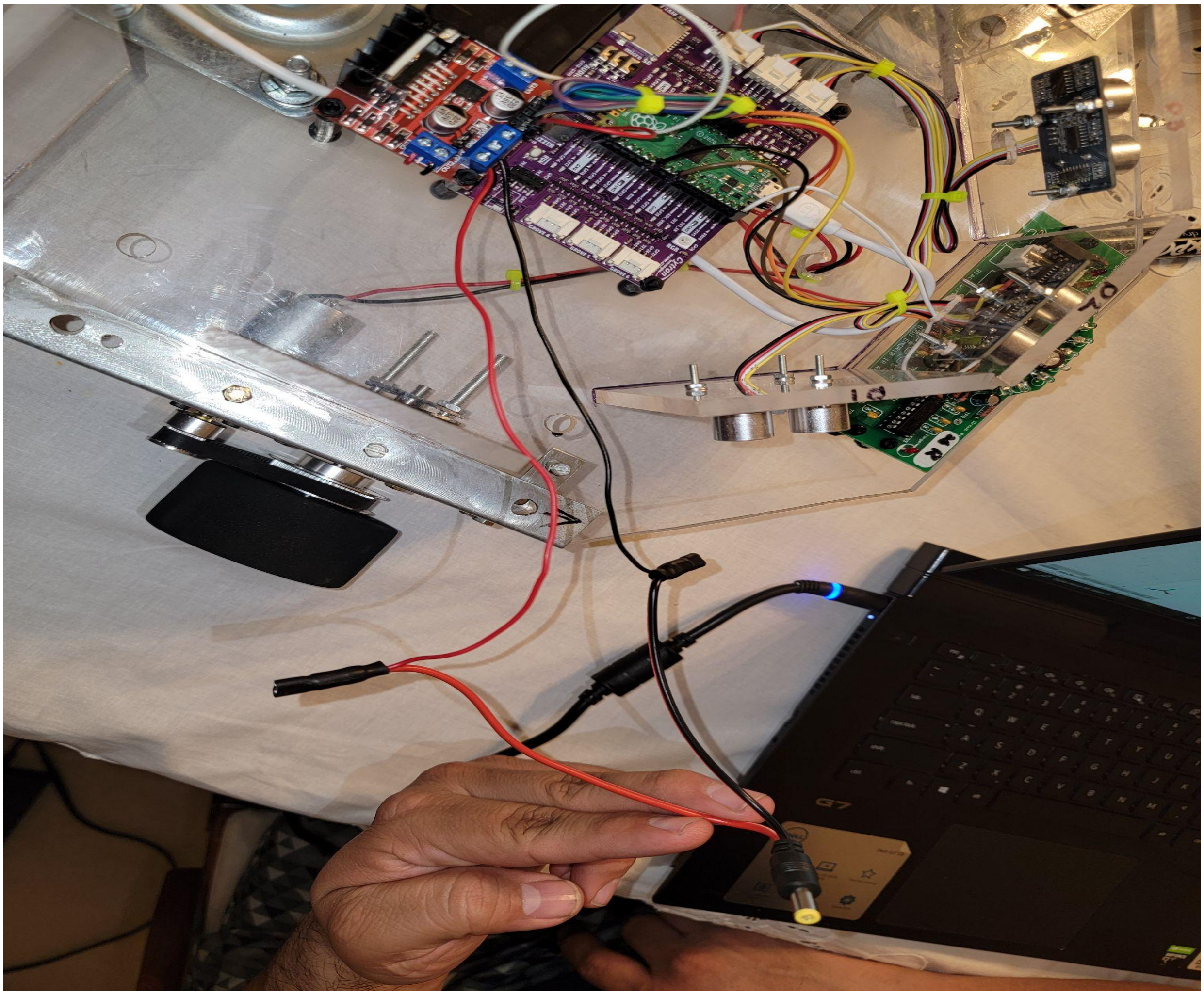
Backside Motor Mount



Top-Down Motor Mount



DC-DC Buck Converter



Wire Harness connecting SLA Battery to Motor Controller and USB Buck Converter

Figure

12V 1.3AH SLA Battery

Appendix A: Main Code

```
#Larai2.py Initializes IR and Ultrasonic Sensors to control speed and direction of 2 DC Motors.
#
#The motors are interfaced with the pico through an L298 Dual H-Bridge Motor Controller
#
#Color Coded Wire: IN1 = grey, IN2 = purple, IN3 = blue, and IN4 = green.
#
#Ultrasonic Sensor Grove #s: Right Sensor = Grove 1, Middle Sensor = Grove 2, Left Sensor =
Grove 3
#
#IR Board Color Code: Power = white, Reset = red, Exposure = yellow, Frequency Select = orange
#
#Written by Brandon Chang (brandon.z.chang@sjsu.edu)
```

```
import machine
from machine import Pin, PWM
import time
import hc_sr04_edushields #Ultrasonic library

#Pin Numbers
EXPOSURE_PIN = 6
RESET_PIN = 7
FREQUENCY_PIN = 8
IN1_PIN = 12
IN2_PIN = 11
IN3_PIN = 10
IN4_PIN = 9
RPWM_PIN = 16
LPWM_PIN = 17
G1_Trigger = 1
G1_Echo = 1
G2_Trigger = 3
G2_Echo = 3
G3_Trigger = 5
G3_Echo = 5

#Initializing Pins
G1 = hc_sr04_edushields.HCSR04(G1_Trigger, G1_Echo) # Right Ultrasonic Sensor.
G2 = hc_sr04_edushields.HCSR04(G2_Trigger, G2_Echo) # Middle Ultrasonic Sensor.
G3 = hc_sr04_edushields.HCSR04(G3_Trigger, G3_Echo) # Left Ultrasonic Sensor.
exposure = Pin(EXPOSURE_PIN, Pin.OUT) # Controls and cycles active IR sensor.
reset = Pin(RESET_PIN, Pin.OUT) # Resets active sensor counter to 0.
frequency = Pin(FREQUENCY_PIN, Pin.OUT) # Tuning; Low pin = 1kHz, High pin = 10kHz.
IN1 = Pin(IN1_PIN, Pin.OUT) # Sets the right motor to CW direction.
IN2 = Pin(IN2_PIN, Pin.OUT) # Sets the right motor to CCW direction.
IN3 = Pin(IN3_PIN, Pin.OUT) # Sets the left motor to CW direction.
IN4 = Pin(IN4_PIN, Pin.OUT) # Sets the left motor to CCW direction.

l_pwm = Pin(LPWM_PIN, Pin.OUT) # Initializes pin for the left motor.
r_pwm = Pin(RPWM_PIN, Pin.OUT) # Initializes pin for right motor.
l_pwm.off() # Sets initial state of PWM for left motor.
r_pwm.off() # Sets initial state of PWM for right motor.
IN1.on() # Sets CW direction for the right motor.
IN3.on() # Sets CCW direction for the left mtor.
```

```
Lpwm = PWM(l_pwm) # Initializes PWM pin for left motor.
Rpwm = PWM(r_pwm) # Initializes PWM pin for right motor.

PWM_MAX = const((2**16)-1)
DUTY_MAX = 100

def Lmotor(duty):
    global LEFT
    Lpwm.duty_u16(int((duty/DUTY_MAX)*PWM_MAX))

def Rmotor(Duty):
    global RIGHT
    Rpwm.duty_u16(int((Duty/DUTY_MAX)*PWM_MAX))

check = time.ticks_ms()

LEFT = 95
RIGHT = 95

while True:
    Lmotor(LEFT)
    Rmotor(RIGHT)

    D1 = (G1.range_mm())
    D2 = (G2.range_mm())
    D3 = (G3.range_mm())

    if time.ticks_diff(time.ticks_ms(), check) > 500:

        if D1 == None:
            int(0 if D1 is None else D1)
        elif D2 == None:
            int(0 if D2 is None else D2)
        elif D3 == None:
            int(0 if D3 is None else D3)

        elif D2 > 400 or D2 == None:
            LEFT = 95
            RIGHT = 95
```

```
elif D1 < 400 or D1 == None:
    LEFT = 95
    RIGHT = 0

elif D3 < 400 or D3 == None:
    LEFT = 0
    RIGHT = 95
else:
    if D2 < 400:
        LEFT = 0
        RIGHT = 0
print("___________________")
print("D1 is: ", D1)
print("D2 is: ", D2)
print("D3 is: ", D3)
check = time.ticks_ms()
```

Appendix B: Bill of Materials

Component	Total Cost ($)	Quantity
Hardware*	50.00	1
Acrylic and Acrylic Cement	30.00	1
Foam Wheels	29.98	2
Duracell 12V 1.3AH SLA Battery	24.99	1
Grove HC-SR04 Ultrasonic Sensor	21.50	5
Wires and Connectors	20.00	1
DC-DC Buck Converter Module	17.98	2
Alum. Pulley Set with Belt	14.99	1
3W IR Led (740nm)	13.30	10
5mm x 100mm Steel Shaft	12.29	5
M3 Nylon Standoff Kit	11.88	1
L298N Motor Driver	10.00	4

*PENDING RECEIPTS