Robot Navigation with Computer Vision and EEG Control

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Abstract

This project is the design process towards designing a smart robot that can be controlled using an electroencephalograph (EEG). The robot will be able to autonomously navigate around obstacles using computer vision and an ultrasonic sensor. Using an EEG, we will measure brain activity by interpreting basic alpha and beta waves. By optimizing the EEG design and software, specific thoughts can be more accurately mapped.

The brain imaging software will be integrated with the robot. By reading certain level of brain waves, certain commands can be given to the robot. For navigation purposes, the robot needs more maneuverability to strafe around obstacles than a simple tank drive. Different maneuverable drivetrains, called holonomic drivetrains, were examined. Ultimately, a mecanum drivetrain was decided on; the process of designing this drive is detailed in this project. In addition, the robot requires sensory that will make it suitable for navigation. This project examines the use of both OpenCV for computer vision and an ultrasonic sensor to help the robot with navigation.

Background

The robot was designed to be a simple chassis that would allow us to perform tasks by receiving information from the EEG and camera. Taking into account cost and design feasibility, a mecanum drivetrain was chosen. Mecanum drive consists of mecanum wheels, which contain two parts: a central wheel and outer rollers mounted at 45 degrees [1]. Depending on the wheels direction and speed, a force vector is produced for each wheel.The sum of these vectors determines where the drivetrain will move; the combined force vector can be pointed at any direction, allowing the drive base to move at any angle regardless of orientation.

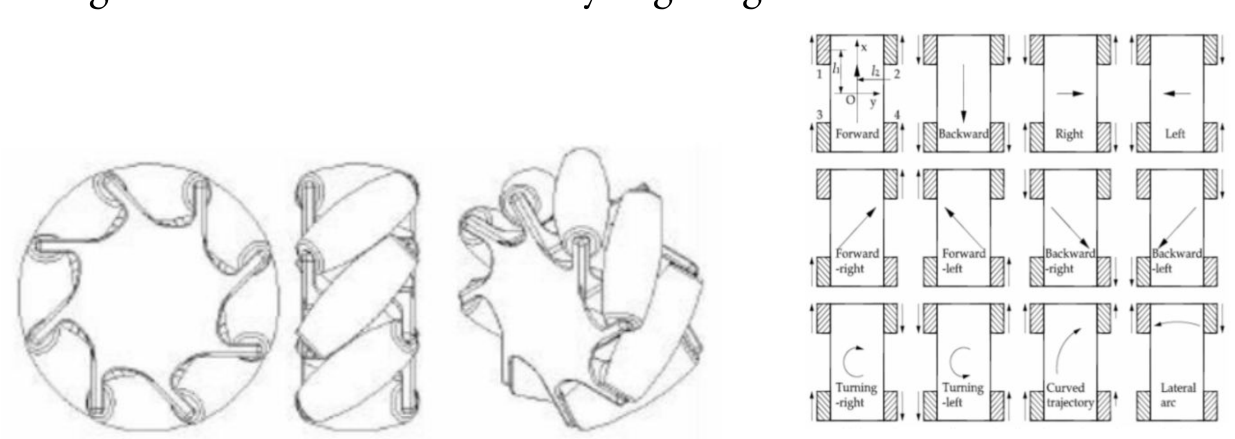


Figure 1: Mecanum Wheel and Options for Motion

A simple circuit that was built based off an EEG schematic. This EEG is tuned to read alpha and beta waves which encompasses all brain waves that have a frequency from 8 to 40 Hz. These waves are the most important as they are the waves associated with conscious thought. Reading these wave values will enable commands to give to the robot based on the level of brain activity.

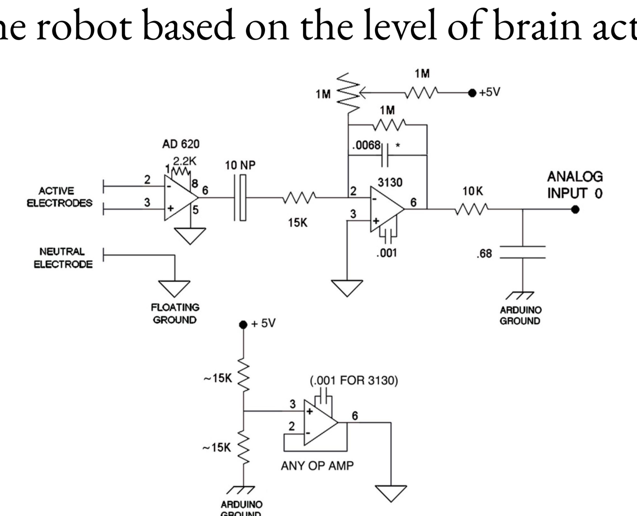
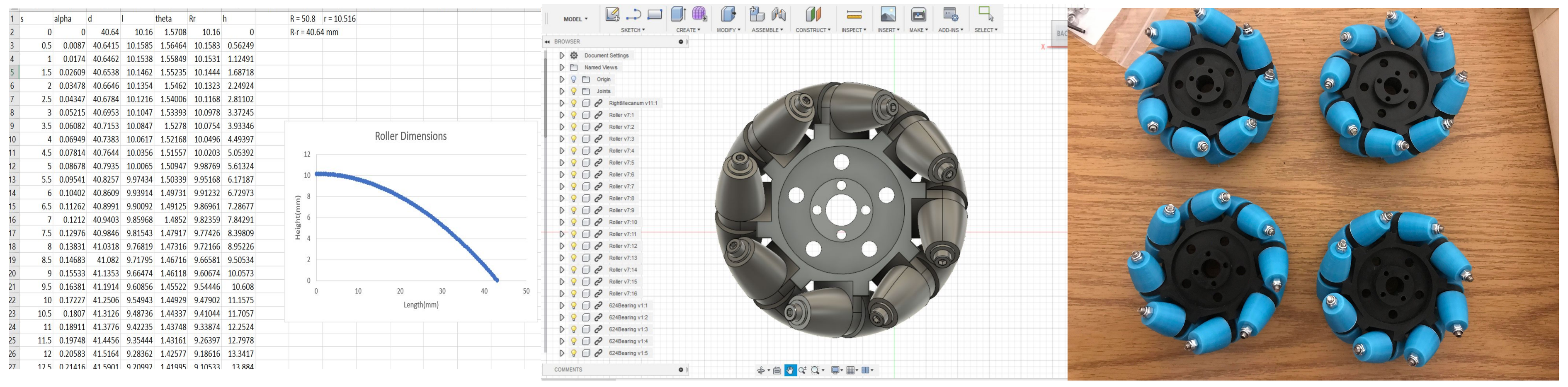


Figure 2: EEG Schematic [2]

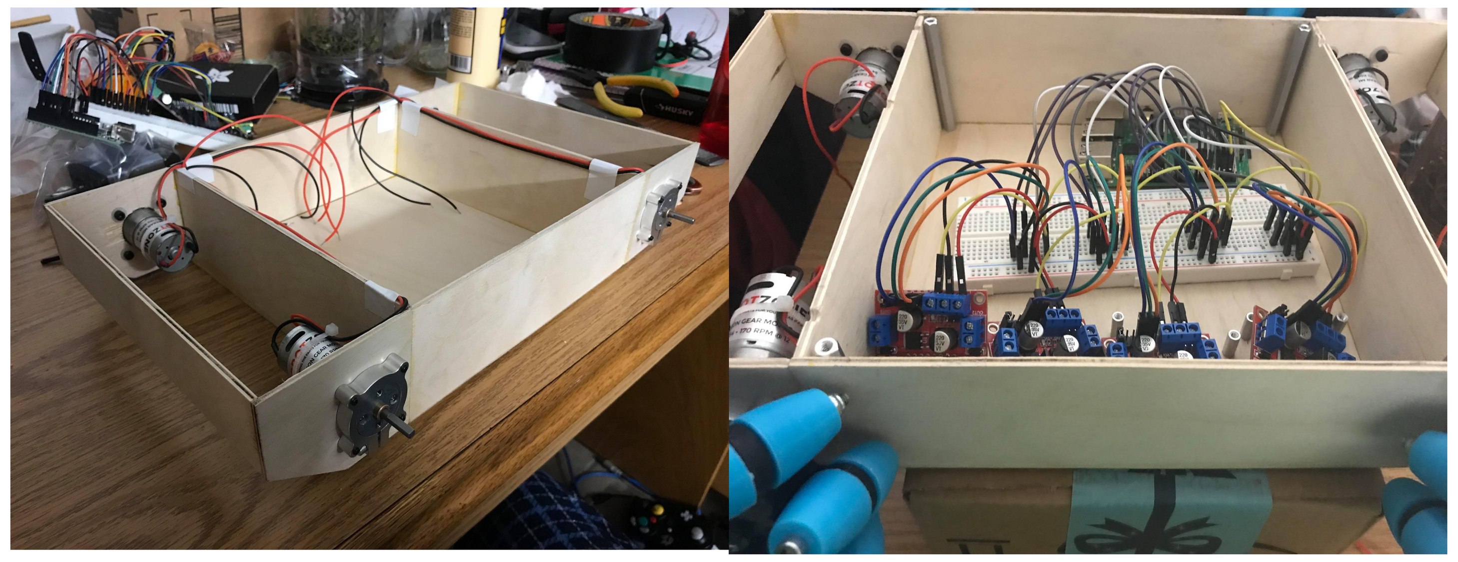
Methods

In order to strafe properly, the mecanum wheel has to be as close to circular as possible to avoid vertical deflection while strafing. The curvature of each mecanum roller was modeled and optimized through calculus curve optimization [3]. The values for the curvature were tabulated in Excel. These values were then imported as a spline curve into Autodesk Fusion 360, which was used to create a 3D model of the roller.



(a) (b) (c)

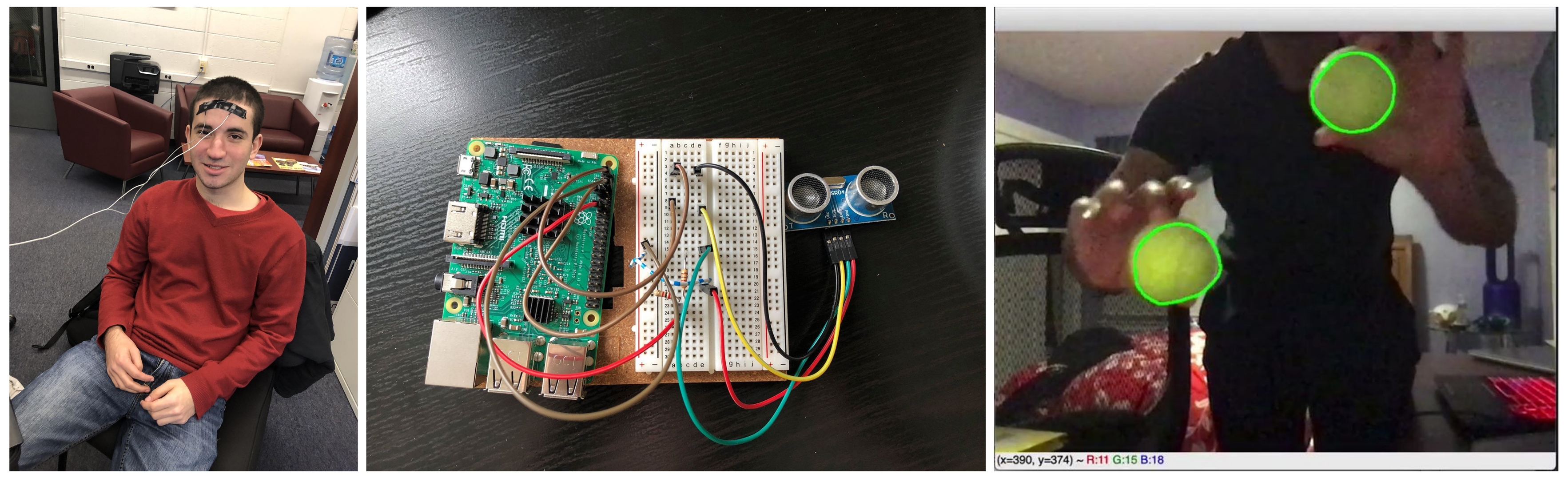
Figure 3: (a) Calculated roller values tabulated in Excel and created roller curvature graph. (b) Created CAD model in Autodesk Fusion 360, confirming designed wheel is circular. (c) 3D printed models assembled into completed mecanum wheels.



(a) (b)

Figure 4: (a) Assembled chassis frame with motors, giving center space for electronics. (b) Wired robot utilizing a Raspberry Pi, battery, power bank, breadboard, and L298N motor controllers.

The EEG circuit interfaces with the Raspberry Pi via Arduino. This particular EEG has three electrodes that transmits data on one analog input in the Arduino. The data is read through the serial port and is processed by a Python script, This script is then integrated with the robot's control program.



(a) (b) (c)

Figure 5: (a) EEG circuit connected to users head through three electrodes: two on the forehead and one on the back of the head. (b) Assembled HC-SR04 ultrasonic sensor used by robot to have a better understanding of its environment. (c) OpenCV library recognizing two tennis balls and drawing bounding circles. This technique is used by the robot for object recognition.

Results

The EEG output collected by our python scripts plotted the waveform below and saved the data as hexadecimal values in a csv format. A preliminary filter creates a bandpass that cuts out alternating high and low values; our output waveform is not ideal and contains noise in the waveform. This can be improved with better application of the electrodes and with better filtering techniques in the software.

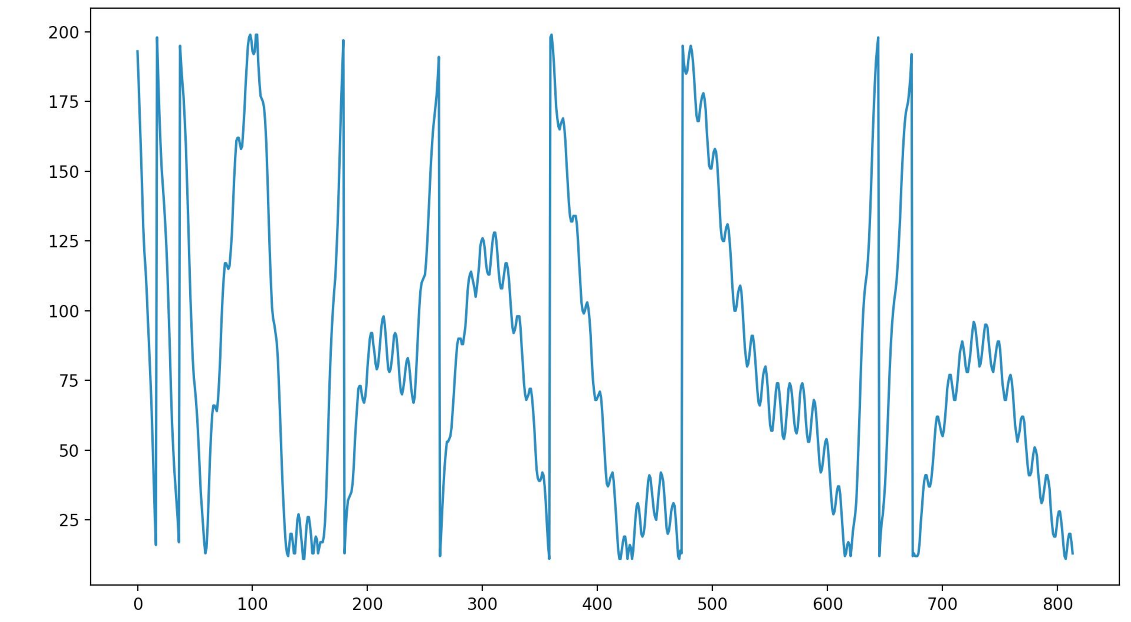
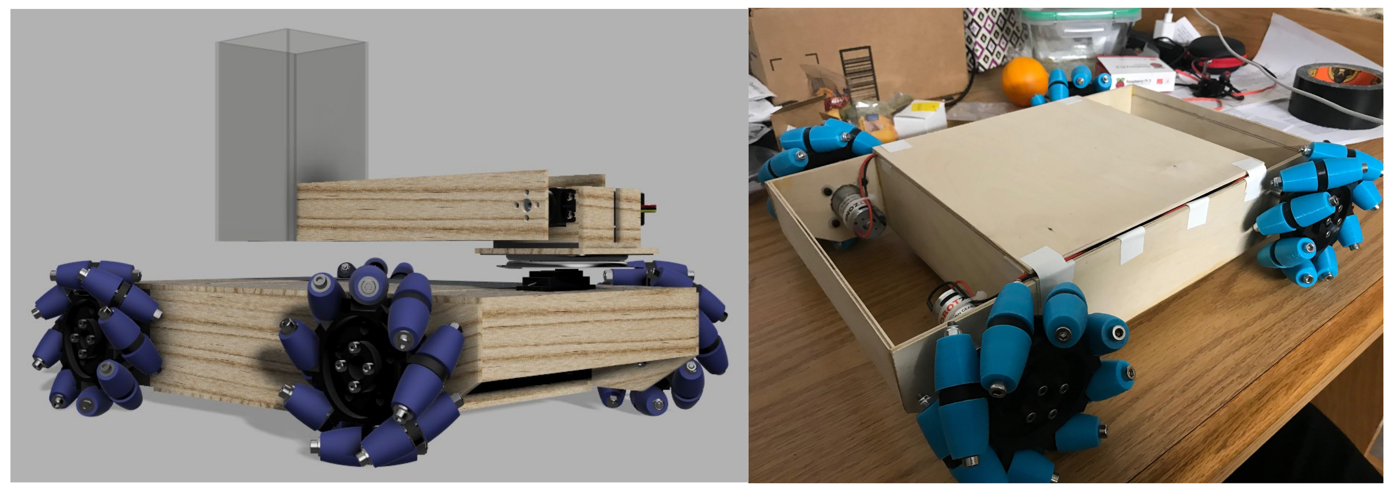


Figure 6: Noisy EEG output after basic filtering

The robot's finalized model was designed in CAD and assembled. Through Raspberry Pi, the robot is successfully able to strafe in all directions autonomously or through manual control using a PS3 controller.



(a) (b)

Figure 7: (a) Finialized robot model in CAD. (b) Fully assembled chassis.

Future Work

1. Further EEG investigation in order to get cleaner readings to be able to assign more complicated commands.
2. Seeing eye dog capabilities; being able to recognize incoming objects, GPS navigation, obeying traffic signals, and having a handle to be able to guide someone that is visually impaired. These interactions will be displayed on a webapp.
3. Suspension system for robot drivetrain to make it more suitable for outdoor travel and various terrains.

References

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