Autonomous Guidance Robot

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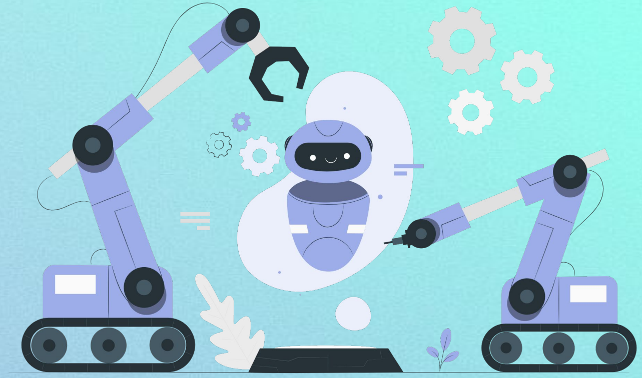


Technology illustrations by Storyset

Identify the Problem

The goal of the project is create an autonomous robot (AuR) that will guide people throughout the Ashraf Islam Engineering Building.

Scope of the Project

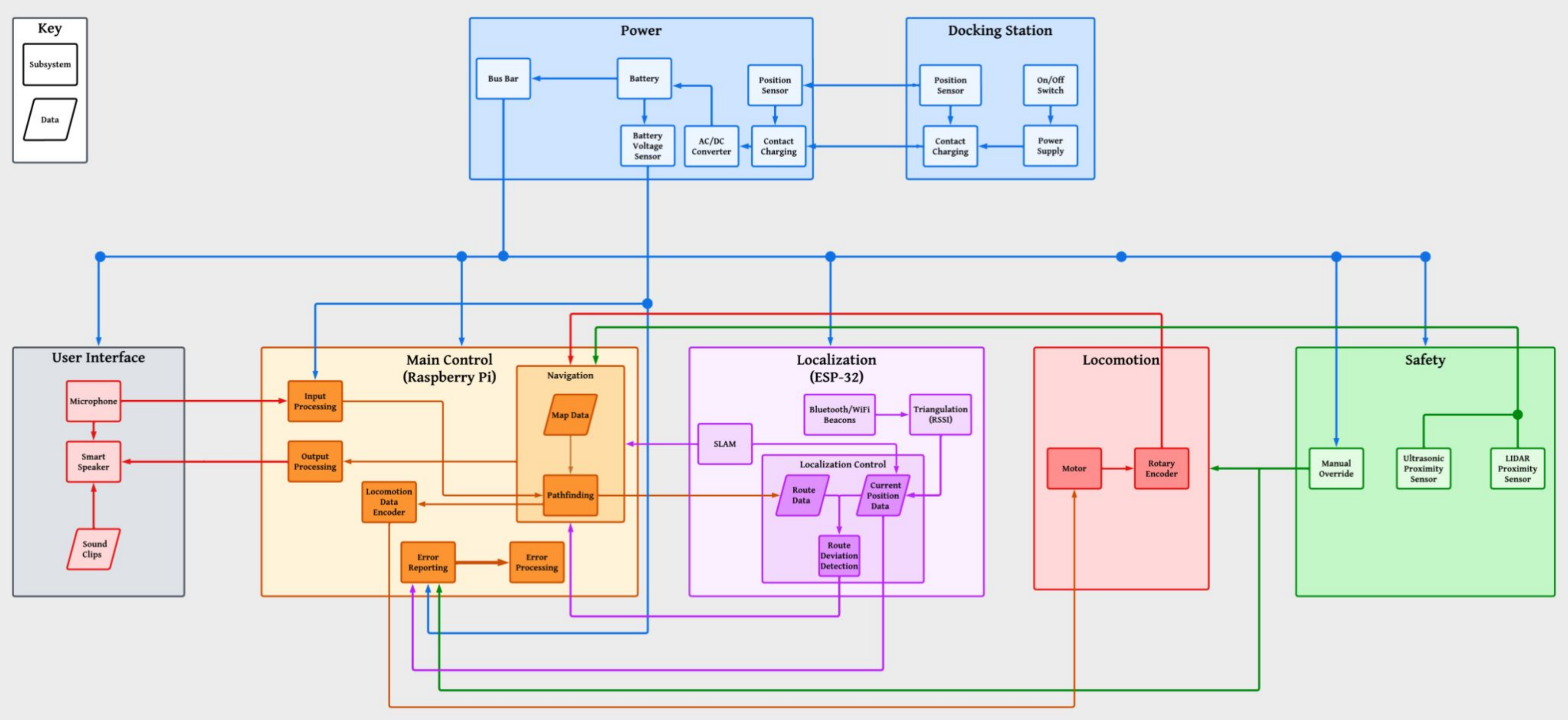
Design the foundations of the AuR which includes the following:

- Localization
- Main Control
- User Interface
- Safety
- Locomotion
- Power

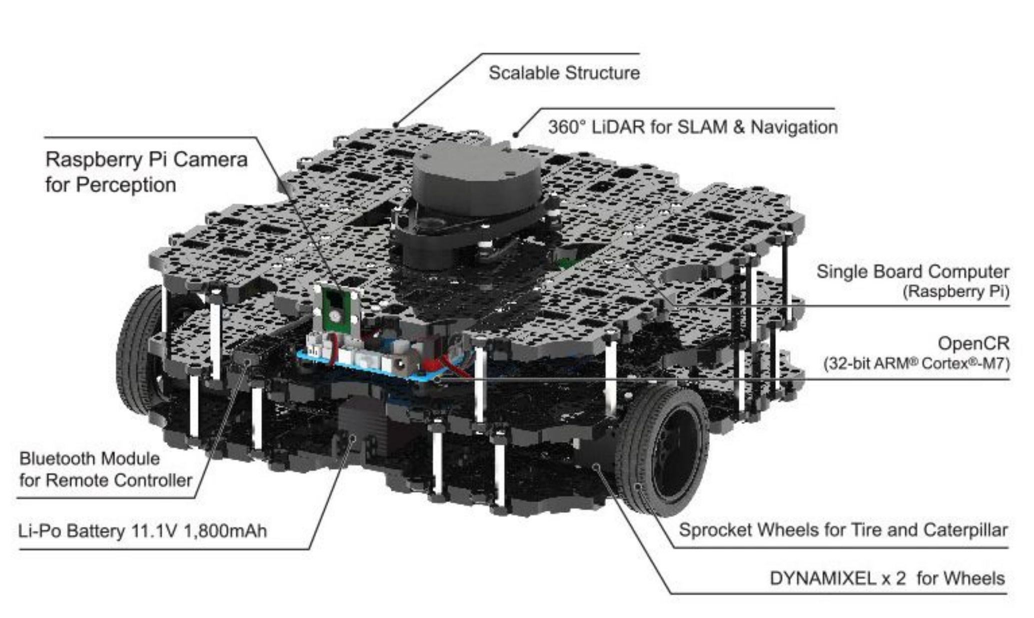
Specifications and Constraints

- Detect the AuR's position to a precision of 15 cm
- Maintain a distance of 0.5 m from obstacles and people
- Guide users to within 1 m of their desired destination
- Use voice interface
- Travel at a speed of 0.7 ± 0.1 m/s

Full Block Diagram of the Entire System



Turtlebot Waffle Pi



User Interface

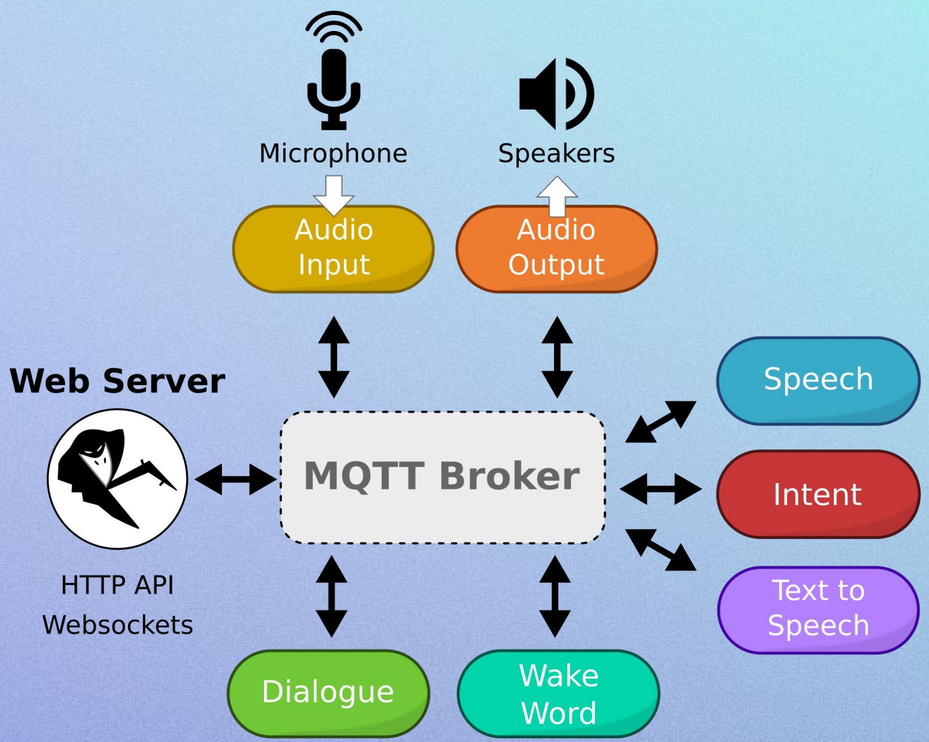
- The user interface must be easily accessible and must not require physical interaction with the AuR

- Voice control was the most efficient and effective option

User Interface

- Consists of a microphone in addition to voice processing software running on a Raspberry Pi 3B+
- All processing is done locally on the Raspberry Pi

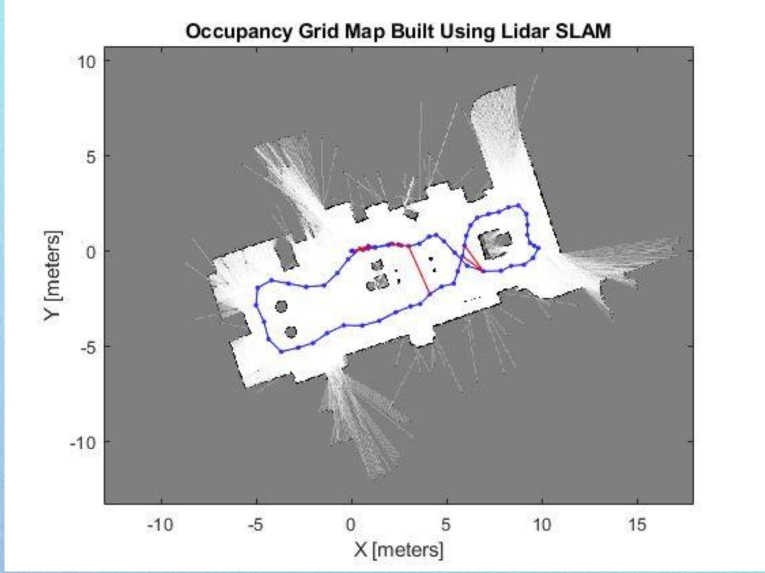
User Interface



- Uses Rhasspy as an intermediary layer
- Rhasspy allows easy configuration and consumption of voice commands

Localization Subsystem Design

- Collects depth data from the Lidar sensor
- Uses Lidar to form a map
- Can be given external reference coordinates
- Compares input data with a stored map to find its location

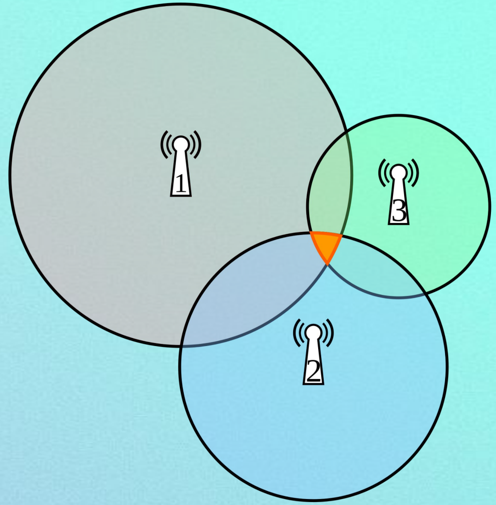


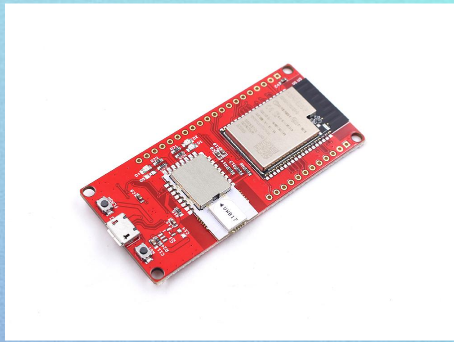
Localization With UWB Beacons

- Measures distance using TDoA

- Calculate location using trilateration

- UWB beacon capabilities
    - Official distance error of <10 cm
    - Simulated beacon localization with matlab to ensure an error of <15 cm



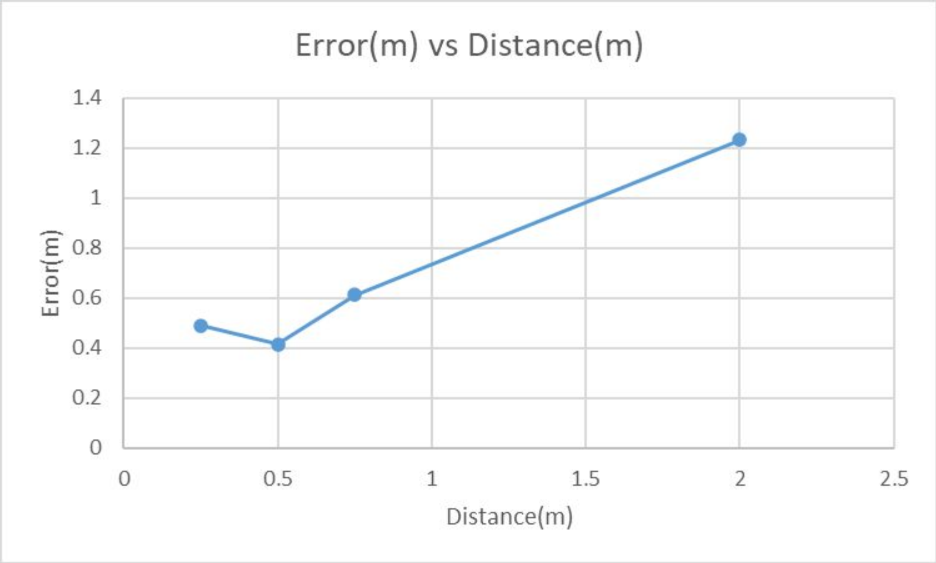


Substitute Beaconing System

- ESP32 Devkits
- BLE beacons
- RSSI Distancing

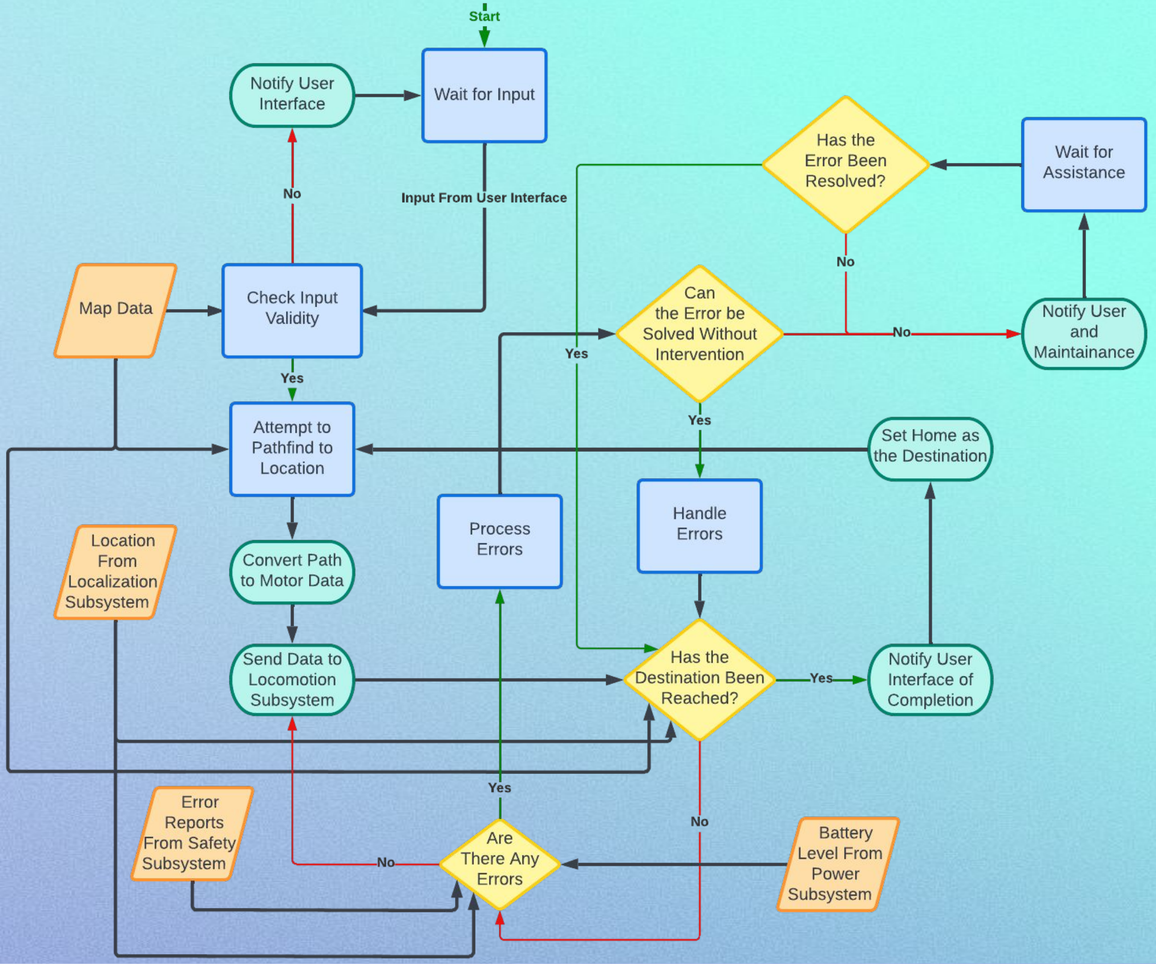
Error Tests for BLE Beacons

- Max error of 1.2m
- High Variance
- NOT VIABLE



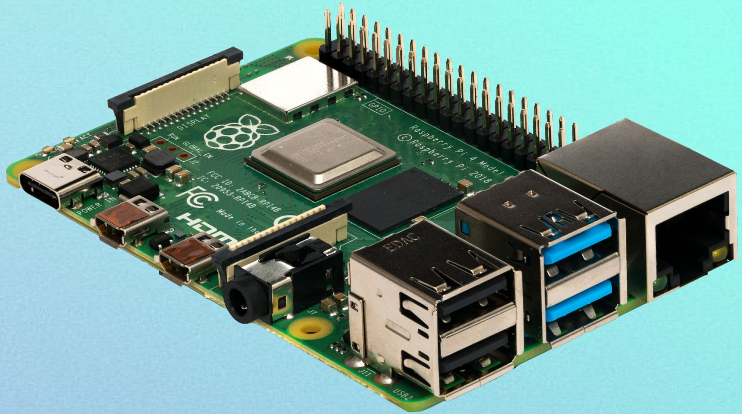
Main Control Flow Chart

- Orange - Data
- Blue - States
- Green - Actions
- Yellow - Decisions

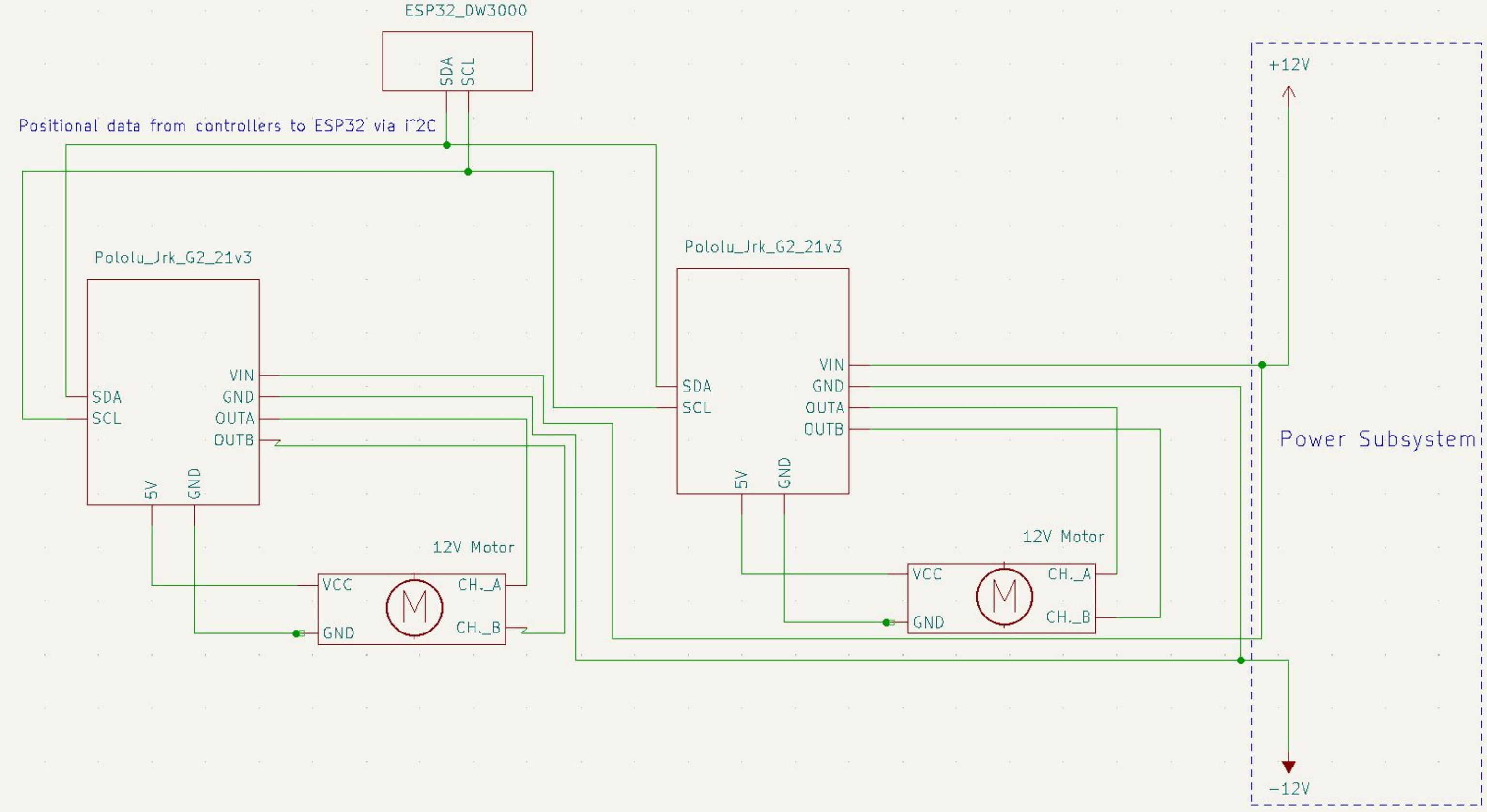


Functions of the Main Control

- Used as a hub to tie all subsystems together
- Consists entirely of the Raspberry Pi
- Takes commands from the user interface



Motor Schematic



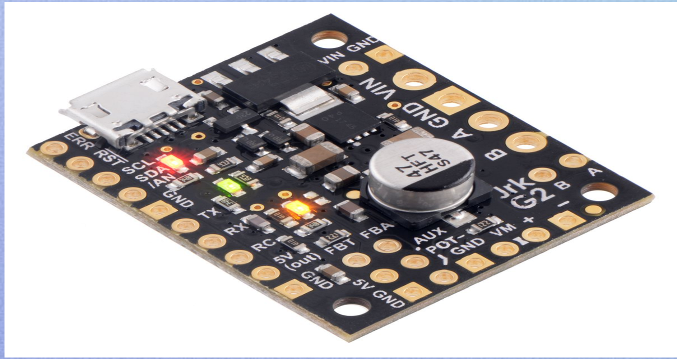
Why redesign an existing system?

- Constraints not met
- Existing components were very specific in compatibility
- System was not modular
- Difficult and expensive to service

What are the most crucial features for our application?

Motor Controller (Jrk G2 21v3):

- Feedback loop input
- Compatibility with arduino interface
- Closed loop velocity control
- Overhead operating voltages and currents



Motor (Pittman GM9236S025):

- Rotary encoder output
- Power efficient
- Able to obtain and maintain velocity within reason

Calculations for verification

- Newton’s second law
- Torque required per motor
- Current draw of the entire system
- Power draw of the entire system

$$2.1434N = 3.062kg * 0.7\frac{m}{s^2}$$

$$0.3537Nm = \frac{(2.1434N * .033m)}{2}$$

$$3.09A = \frac{0.03537Nm}{0.0229\frac{Nm}{A}}$$

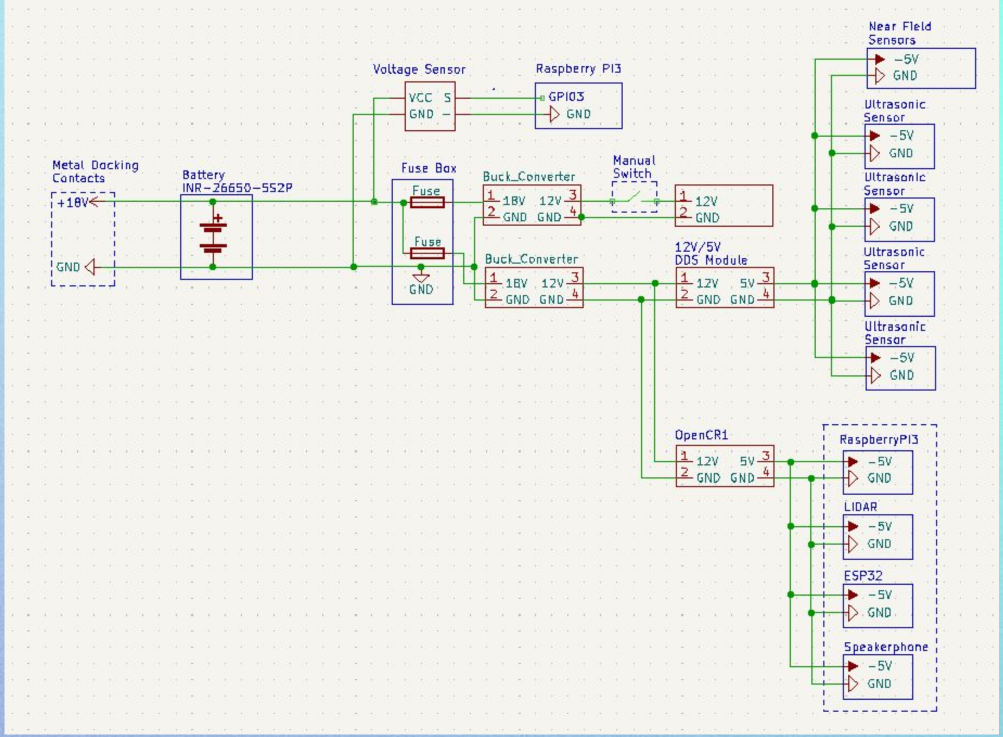
$$37.08W = 12V * 3.09A$$

Power + Docking Station Subsystem

- Increase the power to meet the specifications of added components

- Provide electrical protection to the system

- Implement new charging method



Plugless Charging

- Increase autonomy

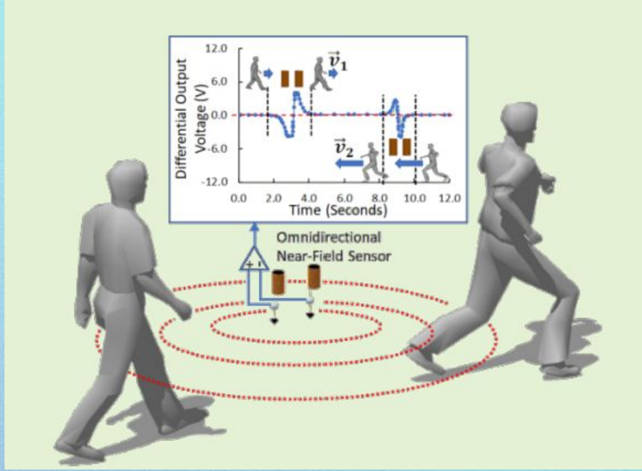
- Surface Mount Contacts
    - Affordable
    - Simple

Safety Subsystem: Near Field Sensors

These sensors will be using a 360° obstacle avoidance technique which will determine the location of the obstacle.

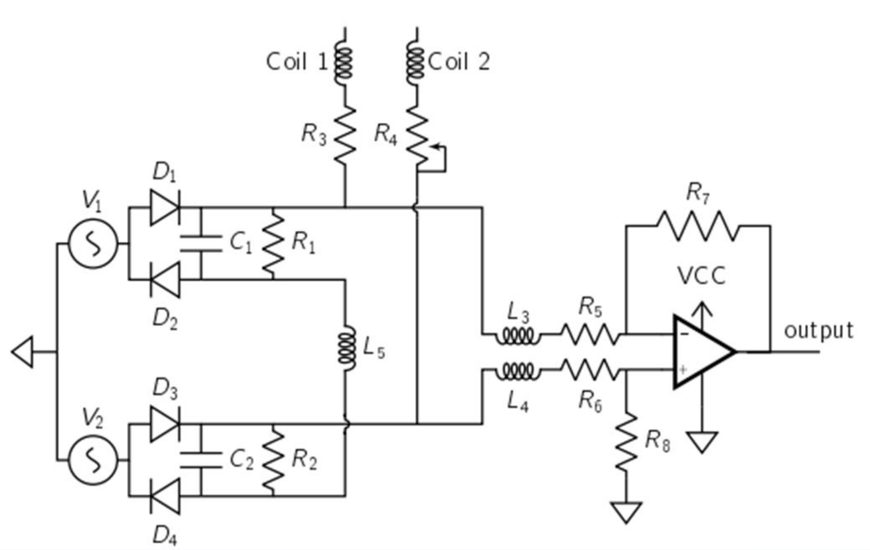
As the sensors come into contact with an object, the voltage will decrease or increase depending on which coil is being triggered.

The coils that I used are in cross-sectional formation. This was to achieve detection at all corners of the robot.



Near Field Sensor Schematic
Circuit Schematic

- Wheatstone bridges are used to measure very small changes in the environment
- The op amp will amplify the resulting signal
- The capacitors and the resistors will set the response time
- The inductors are chokes and by implementing these are filtering out the high frequencies

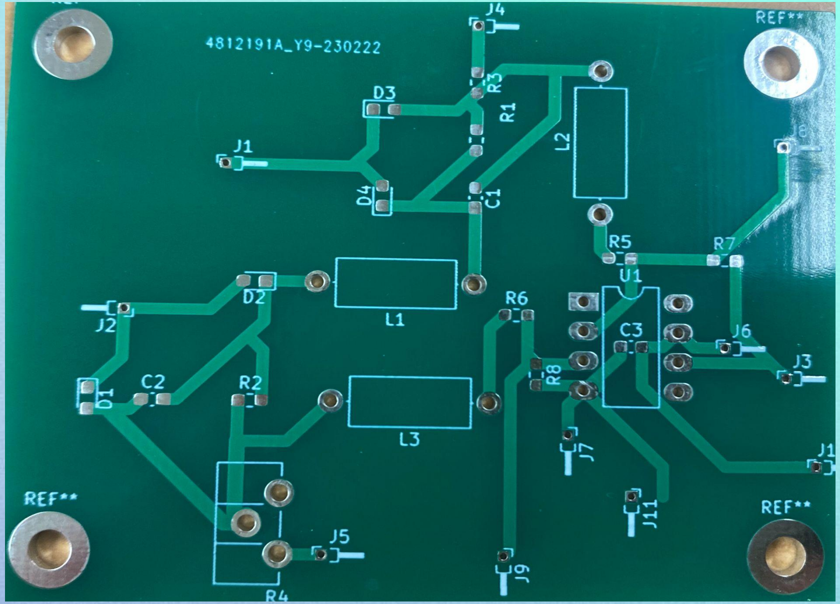


Component	Value	Unit
$D_1 - D_4$	1N4001	-
C_1, C_2	4.7	µF
R_1, R_2	1	kΩ
L_3, L_4	300	µH
L_5	300	µH
R_5, R_6	2	kΩ
R_7, R_8	20	kΩ

PCB Design

Image of the how the circuit was design and Implemented on a PCB breadboard

Simulated circuits before printing the PCB boards



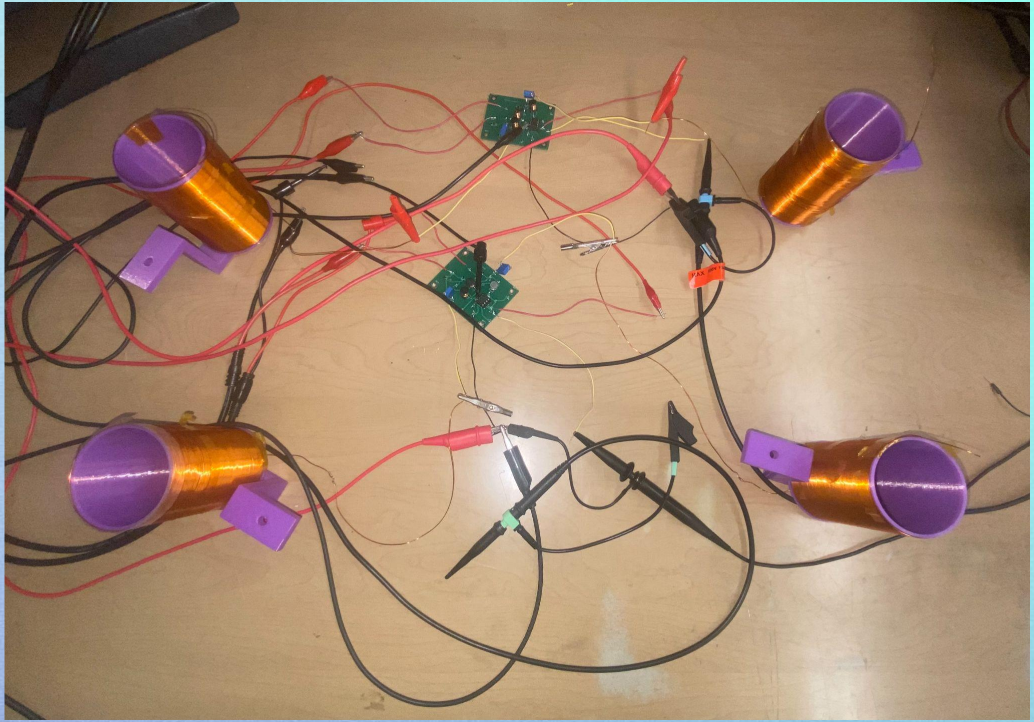
Cross Sectional Formation of Coils and Testing Process

Experimental Process included two PCB boards

Two coils connect to each circuit

Coils were within the range of 3.35-3.45 of Resonance frequency

Used variable resistors to balance the Wheatstone Bridge circuit



Videos of the Coils Functioning and Detecting

Videos of the Coils Functioning and Detecting

Video demonstrating the AuR’s navigation and user interface

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