I.S.H.O.P.

Midway Design Review Presentation for Team 5

University of Massachusetts Amherst
BE REVOLUTIONARY™

Team Members

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Problem statement

In the past year the Covid-19 pandemic necessitated curbside pickup orders because individuals tried to avoid contact with the others. With the current online ordering system, there is still the need for employees to go and pick up the items in the store and hand them to the customer, which introduces more person to person contact. This also means that employees need to stop helping the customers in the store to grab online orders, which slows the process of moving inventory.

Current Goals

1. Create an autonomous collection system that efficiently traverses through a space, collecting items it is ordered to.

2. Create a digital interface that allows individuals to order desired items to be collected autonomously and prepared for pick up after collection.

3. Address unexpected obstacles in the environment

Specifications & Verification

Spec	***Description***	***Verification type***	***Verification Description***
1	**Collector will be able get all items from space in 2 minutes or less**	**Demonstration Test**	Place an order for all items in the space and time the collector from start to finish.
2	**Collector will be able to hold a max load of 2lbs. in its internal storage**	**Demonstration**	Place a 2lb. load in collector and have it traverse the guiding path.
3	Collector sensors will scan visual indicator on shelf to obtain nearby product information and update current location*	**Demonstrative Test**	Create a test program where the collector goes back and forth on the guiding path, stopping to scan the sensor below each item.
4	Collector can pull items off shelf into internal storage with a custom-made electromechanical arm	**Demonstration**	Show the collector pulling an item off of the shelf into its internal storage.
5	Collector will have 1 cubic foot of internal storage	**Inspection**	Take photos of internal storage with tape measures to show dimensions.

Specifications & Verification

Spec	*Description*	*Verification type*	*Verification Description*
6	Storage environment unit cell will contain 2 shelfs with 4 items on each shelf*	**Inspection**	Take a photo of the storage environment with stocked shelves to show the arrangement.
7	Guiding path for collector will allow collector to traverse back and forth on either side of shelf in addition to providing a connecting path to both sides.	**Demonstrative Test**	Create a test program where the collector goes back and forth on one side of the guiding path, then cross over to other side a then goes back and forth on the other side.
8	There will be a designated start and stop location for collector	**Demonstration**	Place an order for the collector and show it start and stop at the designated location.
9	Individuals will be able communicate with collector wirelessly via a digital interface	**Demonstrative Test**	Show an individual placing an order on the digital interface and then the subsequent fulfilment of that order.
10	Collector will have sensors that allow for emergency stops when path is obstructed.	**Demonstration**	Place a cardboard box on the guiding path and then place an order that requires the obstructed path to be used. Then show the collector stoping before the obstruction.

New Specs

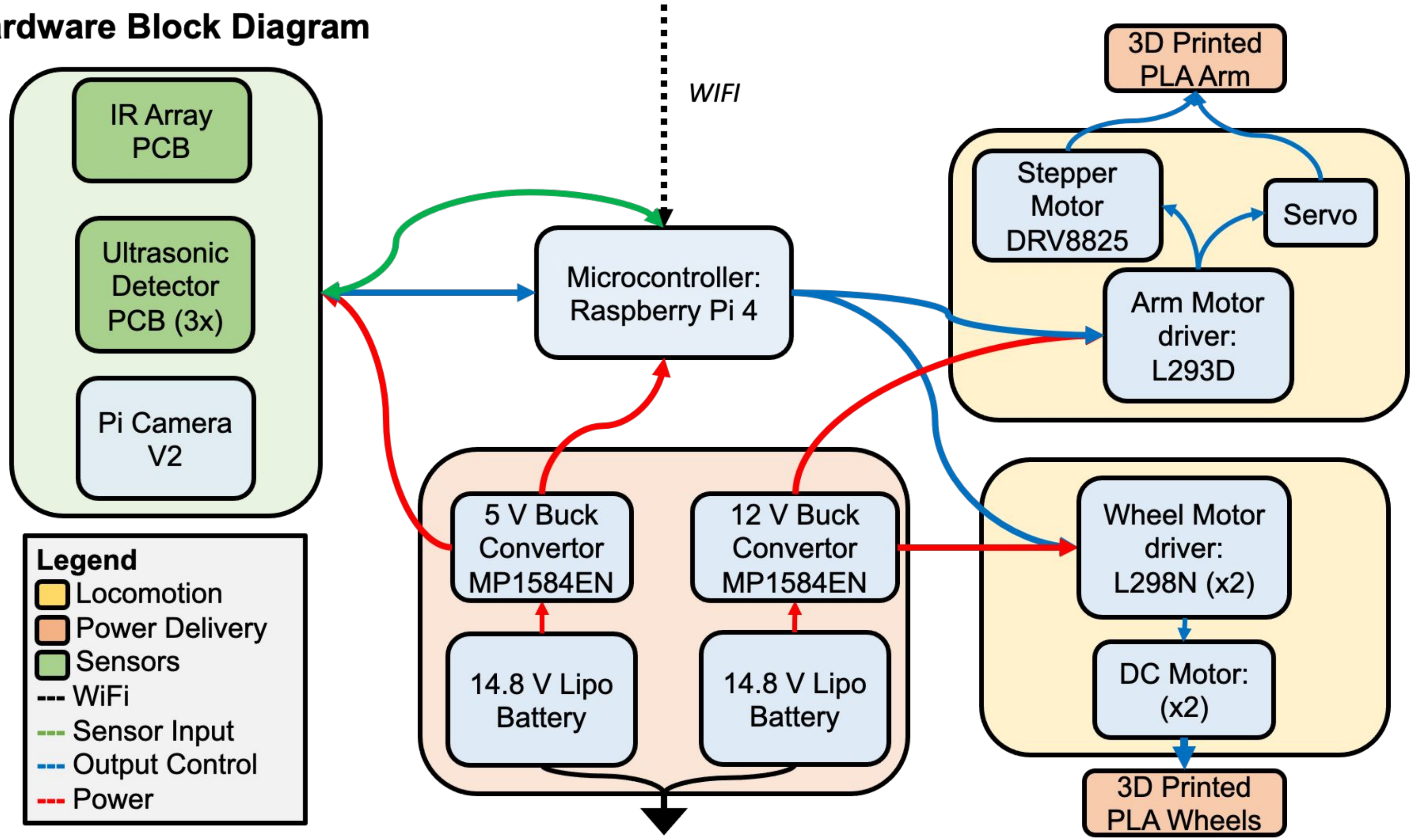
Spec	***Description***	***Verification type***	***Verification Description***
11	Collector will follow a guiding path and automatically make locomotive corrections when deviating from path.	**Demonstration**	Placed the collector so it is deviated from the path and allow it to automatically correct itself
12	Collector will initiate a turn at designated junction and will stop turning when guiding line is centered perpendicular to front of collector	**Demonstration**	When placing an order, the collector will turn at various designated junctions, demonstrating its ability to turn accurately.
13	The collector will stop in front of ordered items to initiate a collection sequence	**Demonstration**	After placing an order, collector will only stop at items it is ordered to...

Battery Life

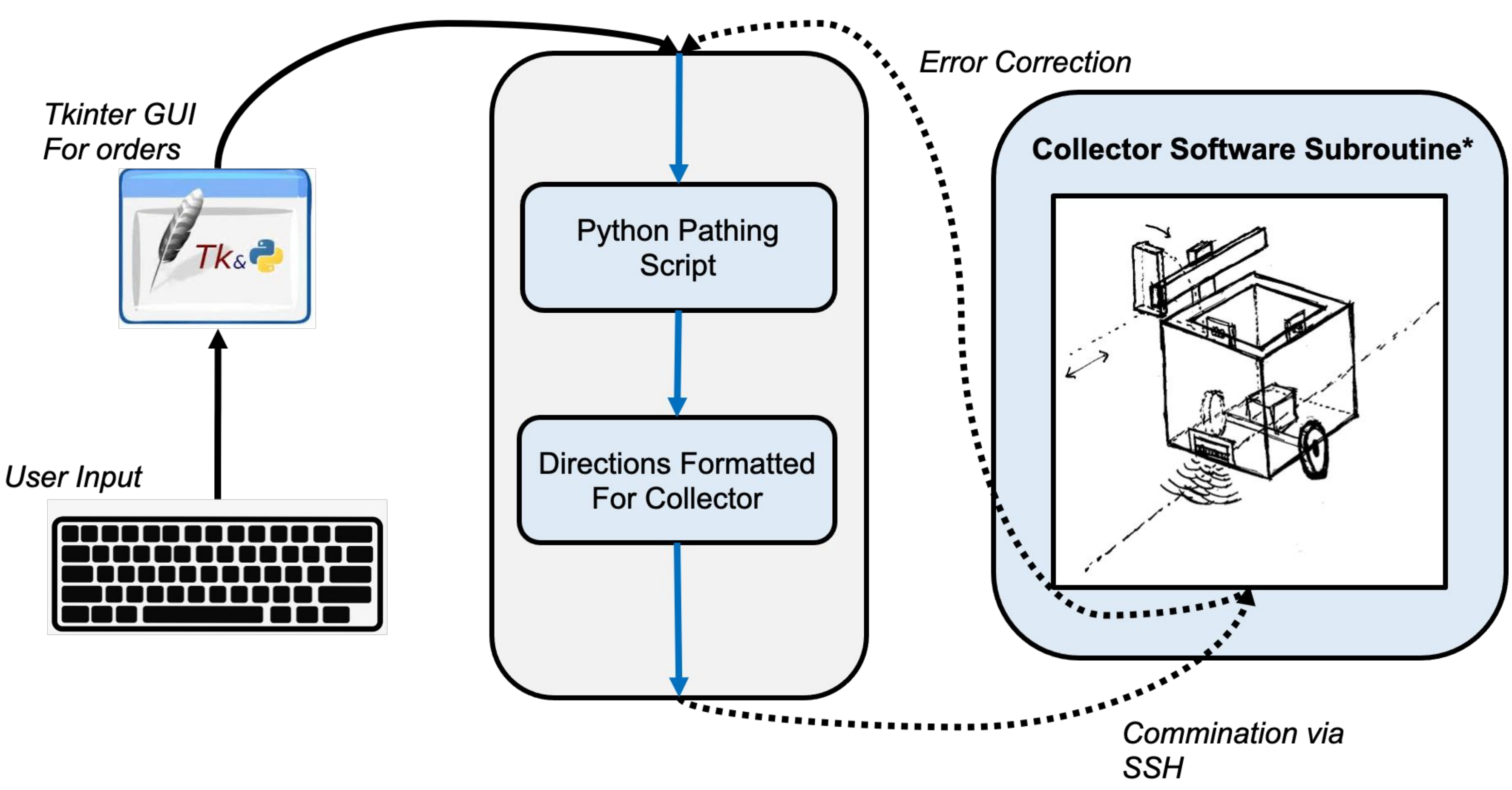
4s Lipo Battery	3300	mAh		
Equipment	Usage (mA)	Notes		
Raspberry Pi	1010			
IR sensors	100			
Ultrasonic	15			
Servo	9	Used intermittently, 5% of a run		
Total Usage	1134	Running time:	2.91	Hours

Equipment	Usage (mA)	Notes		
DC motors	1600	2 motors under load, operating at 50% speed		
Stepper motor	35	used intermittently, 10% of a run		
drivers/converters	5	negligible to DC motors		
Total Usage	1640	Running time:	2.01	Hours

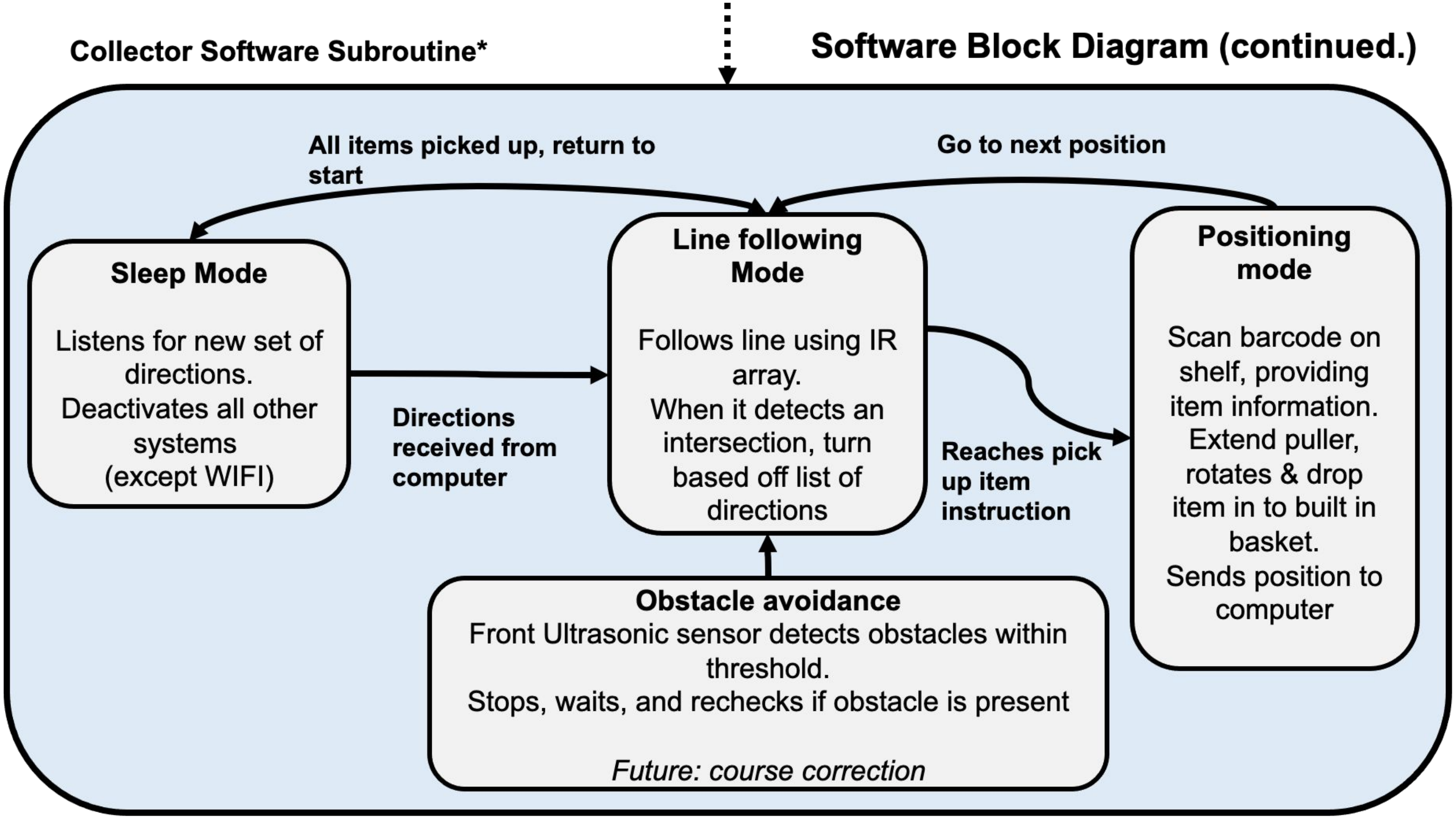
Hardware Block Diagram



Software Block Diagram



Software Block Diagram (continued.)



Hardware used

Ultrasonic range finder

- **HC-SR04**
- Atmega328P

IR array

- **5x TCRT5000 IR Sensors**

Locomotion

- 2x L298N Motor Drivers
- **2x BRINGSMART DC Worm Gear Motor**
- PLA Printed wheel

MCU

- **Raspberry Pi 4B**

Collector arm

- DRV8825 Stepper Motor Driver
- Servo Motor
- Stepper Motor
- PTG Printed arm

Power Delivery

- 2x 14.8 LIPO Batteries
- 4x MP1584EN buck convertors
  - 12 V step down (2x)
  - 5 V step down (2x)

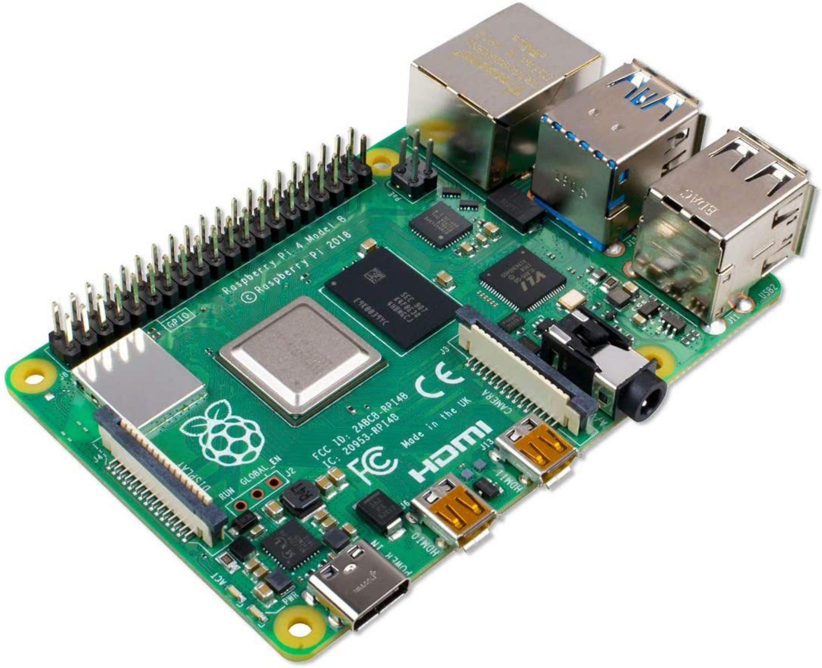
QR code Scanner

- Pi Camera V2

Key Hardware - MCU

Raspberry PI

- Powerful
- Integrated wifi
- GPIO
- User friendly OS



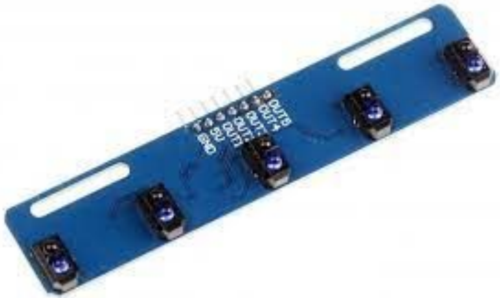
Key Hardware - Sensors

Ultrasonic Sensor

- Experience with module
- Cheap and accessible
- Accuracy
- Form factor

IR Array

- Simplifies pathing problem for collector



Key Hardware - Locomotion

Motors

- High torque
- Worm gear
- High power
- Compact
- Easy mounting

Key Hardware: Arm

Stepper Motor

- Nema 17 Spec.
- Accurate positioning
- 200 steps/rev
- Sleep Mode

www.pololu.com

Servo

- HS-311 Spec
- 4.8-6V operation
- 3.5kg/cm torque
- Holds positioning

Software used

Programming IDE

- Microchip studio
- Thony
- Google Collab

Operating system

- Raspbian

Programming Languages

- Python
  - **PI GPIO**
- C
  - **AVR Library**

Communication

- **Talescale**
- **VNC**

Key Software - Languages

Python

- Object Oriented
- Team experience
- Easy Prototyping
- Compatible with Pi

C

- Fast
- Embedded systems programming

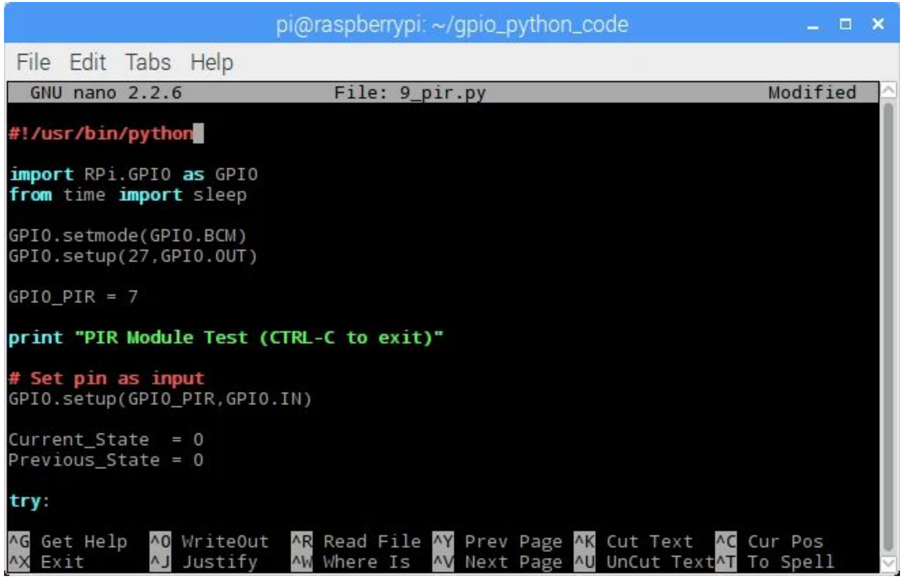
Key Software - Packages

Pi GPIO

- Easy to use abstraction for programming Pi's GPIO
- Well documented

AVR Library

- Easy to use abstraction for programming Pi's GPIO
- Well documented



Key Software - Communication

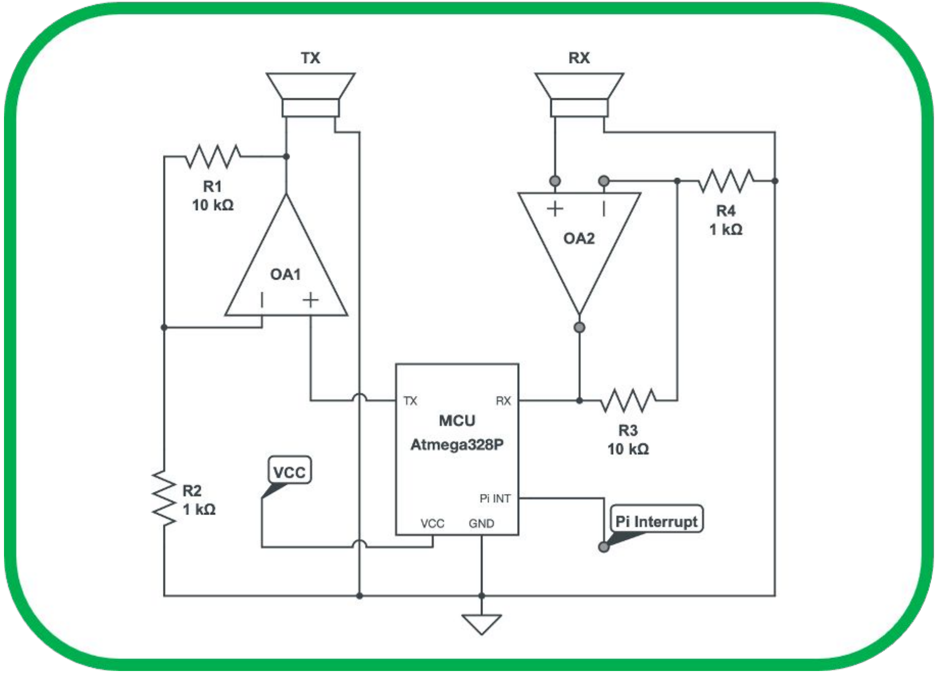
VNC

- Remote Virtual desktop
- Allows for collector mobility
- Collaborative capabilities

TailScale

- Makes SSH with Pi on Eduroam possible
    - Provides new VPN IP for Pi

Ultrasonic PCB



3x

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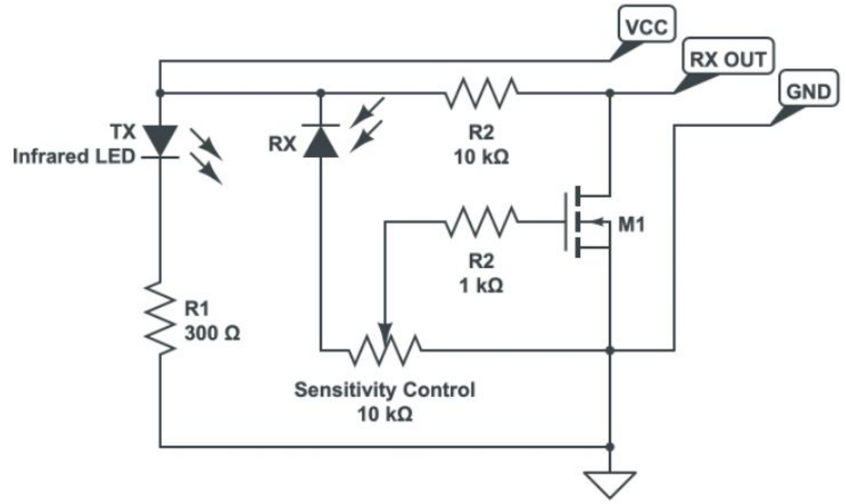
- Two non-inverting Op Amps (~20 dB Gain)
- Amplified Pulse sent to TX transducer
- Atmega listens for return pulse on RX
- TOF calculated on Atmega
  - If obstruction <20cm away, send interrupt

IR array PCB



5X

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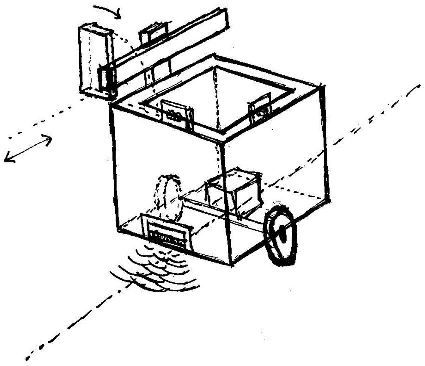
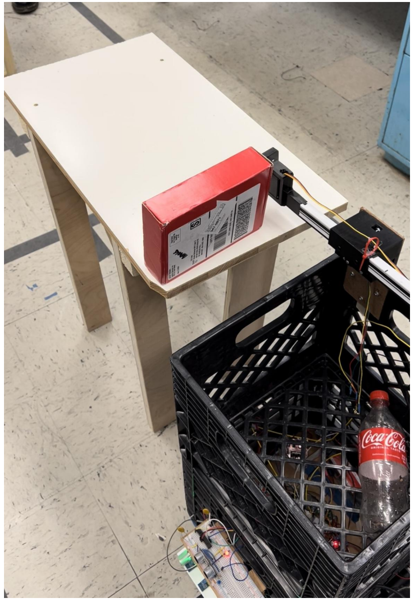
Three main parts

- Transceiver Infrared LED
- Receiver Infrared LED
- RX controlled MOSFET

MDR Deliverables

1. Navigation Subsystem
    a. ✅Infrared Sensing of the line path
    b. ✅Junction based direction change
2. Obstacle Avoidance Mechanism
    a. ✅Ultrasonic sensing subsystem
    b. ✅Stop when obstacle detected
3. Client-Server Server-Robot Communication
    a. ✅Client sends order to the server
    b. ✅❌Server sends pre calculated path to robot
    c. ✅Robot receives the path via wifi chip
4. Robot Physical Structure
    a. ✅Collector Chassis
    b. ✅Arm and hand subsystem
    c. ✅Mobility drivers
5. System Software
    a. ✅Server Side path Computation
    b. ✅Microcontroller Operations





Cost analysis Current expenditures

Category	Item	Name	Price	Cost
Line Following system	Ir sensors	TCRT5000	$8	$8
	Item scanner	Pi Camera	$30	Free
Obstacle Avoidance	Ultrasonic	HC-SR04	$12	Free
Networking/controller	MCU	Raspberry Pi 4 Model B+	$55	Free
	Wifi Chip	ESP8266	$7	$7
	Motor driver	L298N 3PCS	$8	$8
	Battery	14.8V 2PCS	$59	$59
	Wheel motor	12V DC Gear Motor - 2PCS	$60	$60
	Servo	ALMOCN 6PCS Stepper Motor Driver Module	$12	$12
	Voltage reg	DC Voltage Converter Buck Converter	$15	$15
	Battery charger	Tenergy	$33	$33
	Plastic Material	PETG, 3D printer plastic	$28	$28
Physical	shelves, frame, products, etc		$20	Free
		Total Cost:	$347	$230
		Budget Remaining:		$270

Cost analysis Future expenditures

Category	***Item***	***Name***	***Price***	***Cost***
PCB	Design	-	$80	$80
	Shipping		$30	$30
		Total Cost:	$110	$110

Gantt Chart

Task	Team members	Winter Break	01/24/2022	01/31/2022	02/07/2022	02/14/2022	02/21/2022	02/28/2022
Hardware								
Learn Altium	R,S,E & N							
Design and order PCBs	R,S,E & N							
Shelves	R & E							
Pi Camera	R,E & N							
Power Delivery Redesign	E,N & S							
Cumulative test	R,S,E & N							
Software								
Ultrasonic	R							
Pathfinding	S,E & N							
Order GUI	R							
Pi Camera	R,E & N							
Line Following	R,E & N							
Obstacle Avoidance	R & S							

Team Member Responsibilities

Edon Tuli

- Budget Management Lead
- Supporting Fabricator
- Pathing

Neil Wei

- PCB Design
- Locomotion Design
- 3D Printing/Fabricator

Rohan Sheridan

- Team Coordinator:
- On-Board Programming Lead
- Carpenter/Fabricator

Shaun Ghosh

- Software Lead
- Communication Systems
- Actuation Systems

Questions ?

Thank You!