A.U.T.O.S.H.O.P.

Team 5

University of Massachusetts Amherst BE REVOLUTIONARY™

Team Members

Edon Tuli
EE

Neil Wei
EE

Advisor
Prof. Qiangfei Xia

Rohan Sheridan
EE

Shaun Ghosh
CompE

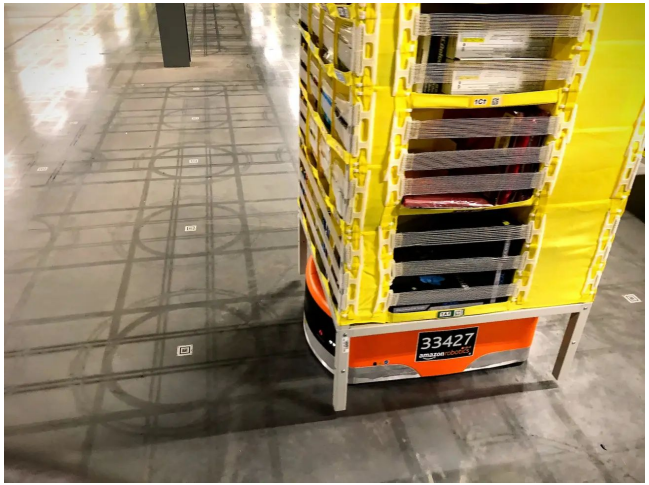
Problem statement

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.

Similar solutions

Amazon Warehouse Robot

- Lifts up shelves and bring them to the employees for pick up
- Follows QR codes on floor for directions
- No humans allowed in the working space
- Uses sensor to avoid collisions
- Does not pick up items



https://www.allaboutlean.com/amazon-fulfillment-1/

Similar solutions

I.G.O.R. - Team 20 - SDP20

- Users give direction to the robot for the location of a package and delivery destination
- Lift the package from the ground and delivers to the designated location
- Works indoor, e.g. offices
- Raspberry Pi, Pi Camera, Odometry, AprilTag, NavStack, Ultrasonic Sensors
- Does not pick up items from shelves
- Does not pick up more than one item at a time

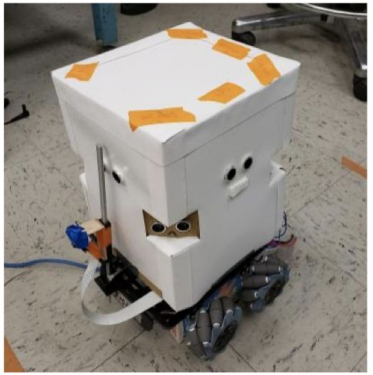


Figure 5. Product Implementation

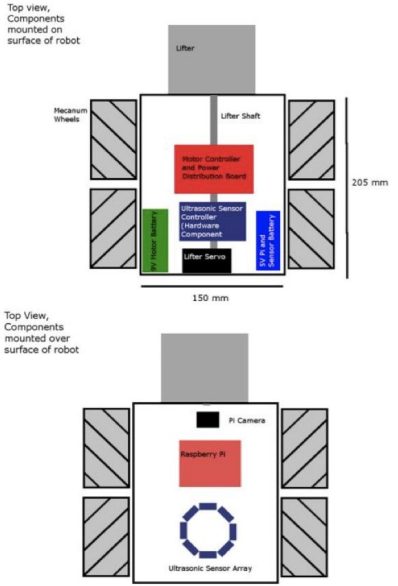


Figure 4. Product Sketch

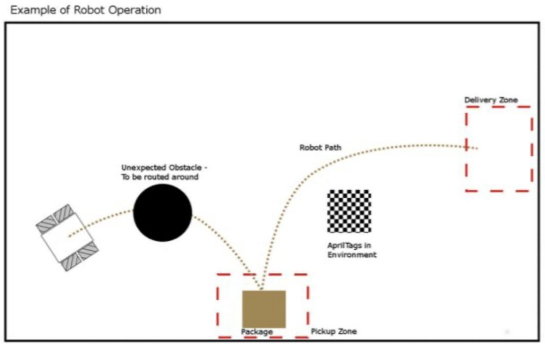


Figure 6. Robot Operation

http://www.ecs.umass.edu/ece/sdp/sdp20/team20/slides.html

Similar solutions

Marty

- Goes around the store to find dirty areas and notify employees
- Has navigation system, high-resolution cameras, sensors and its software system
- Takes ~40 min trip around the store to create a 3D map
- Does not take directions
- Does not pick up items
- Cost ~ $35,000

https://martyatstopandshop.com

Similar solutions

Tally

- Goes around the store scanning inventory to check for missing items or wrong price tags
- Goes around to create a map of the store
- Sensors to avoid collision and high-resolution cameras to scan shelves
- Does not take directions
- Does not pick up items
- Cost ~ monthly subscription for $2,000 - $4,000

https://www.simberobotics.com/platform/tally/

Preliminary Goals

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

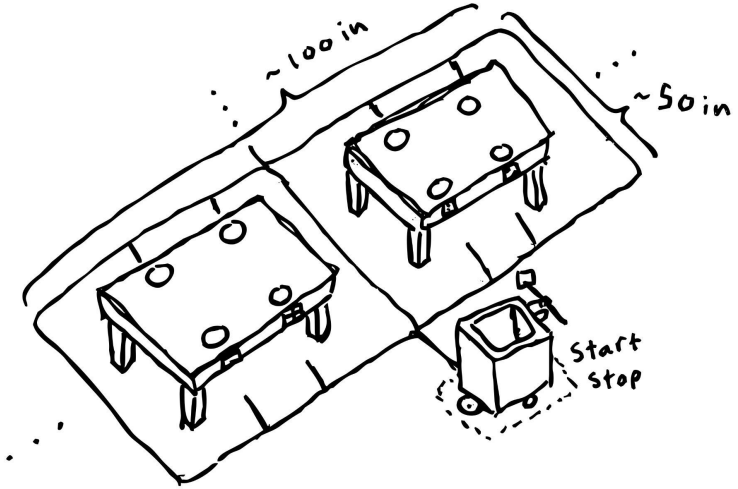
2. Create a digital interface that allows individuals to order desired items to be collected autonomously and prepared for pick up after collection.

3. Address unexpected obstacles in the environment

Solution general overview

- Environment Unit cell
- Guiding Tape Functionality
- Barcode Scanner
- Obstacle detection
- Electromechanical Arm

Fig 1. Sketch of the shopping environment



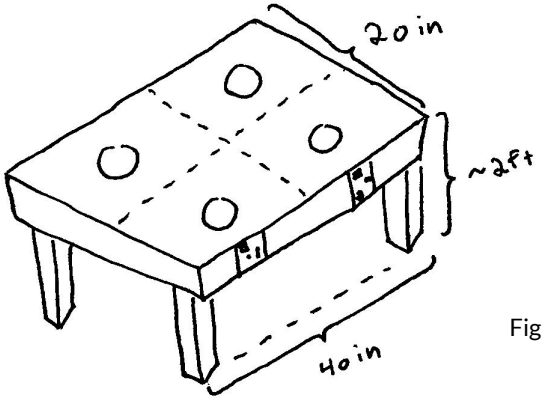


Fig 2. Sketch of the shelf

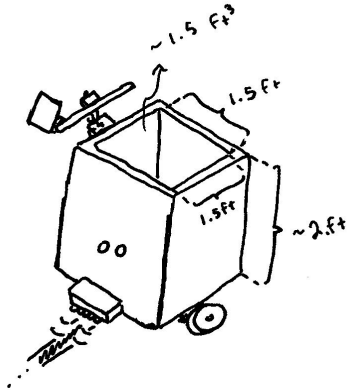


Fig 3. Sketch of the robot and its characteristics

Specifications & Verification

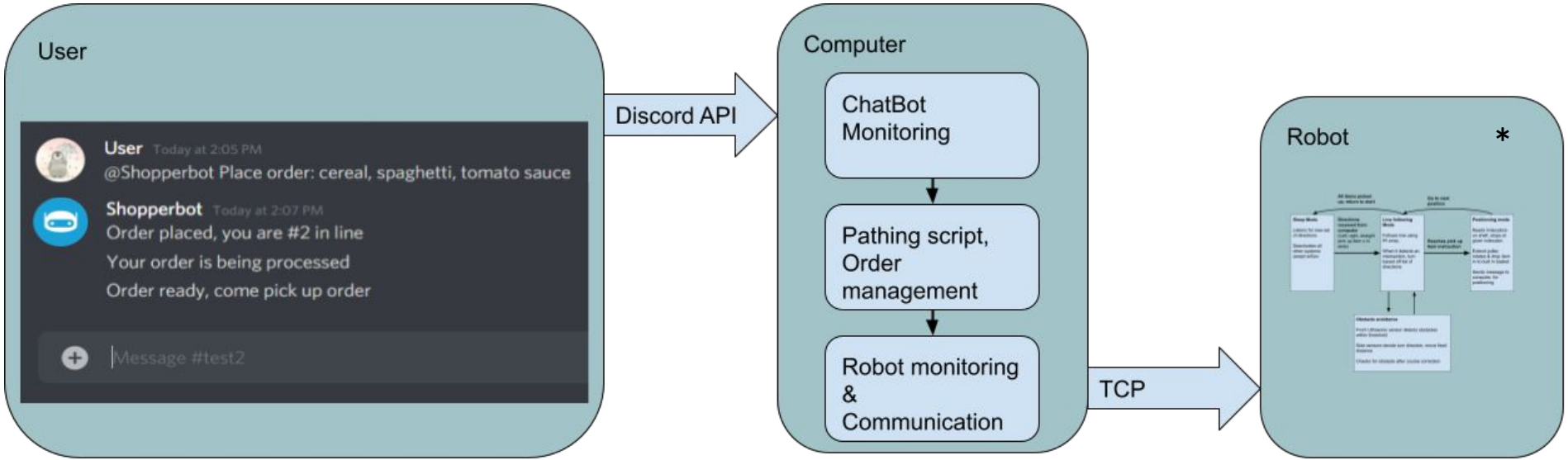
Spec	*Description*	*Verification type*	*Verification Description*
1	Collector will move at a top speed of 50 centimeters per second	**Demonstrative Test**	Place a meter stick next to guiding path then put a 10 lb, 1.5 cubic foot, load in collector. Then run a test program that makes the collector traverse through the storage environment.
2	Collector will be able to hold a max load of 10 lbs. in its internal storage		
3	Storage environment unit cell will contain 2 shelfs with 4 items on each shelf		
4	Guiding path for collector will allow collector to traverse throughout the storage environment.		
5	Collector will have 1.5 cubic foot of internal storage		

Specifications & Verification

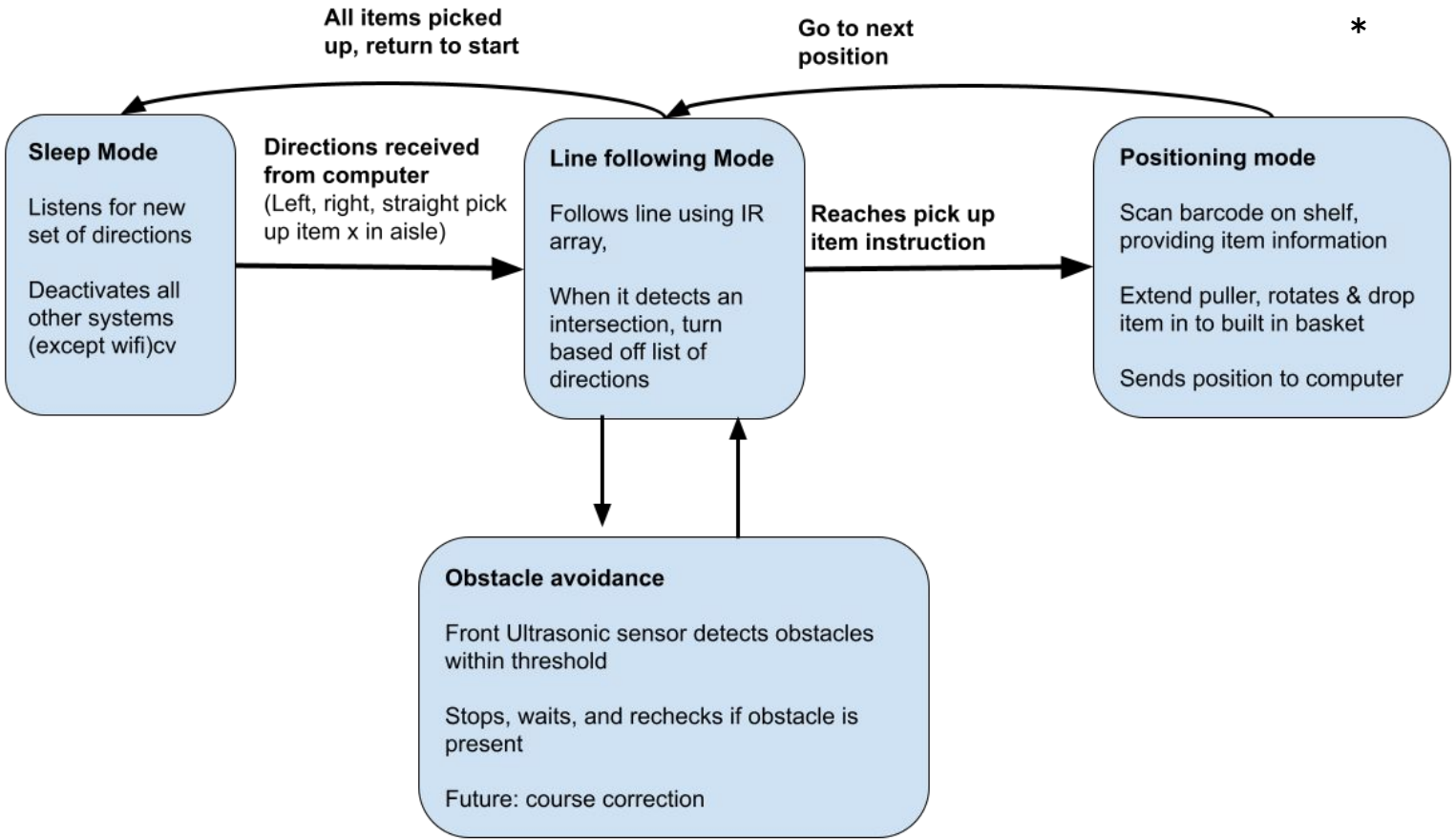
Spec	*Description*	*Verification type*	*Verification Description*
6	Collector sensors will scan visual indicator on shelf to obtain nearby product information and update current location	**Demonstrative Test**	Create a test program to simulate a customer order. -Test program will show location updates and pathing calculations - A cardboard box will be placed in front of the collectors path, triggering its emergency stop. - Cardboard box will then be removed and the collector will finish its order.
7	Collector can pull items off shelf into internal storage with a custom-made electromechanical arm		
8	There will be a designated start and stop location for collector		
9	Individuals will be able communicate with collector wirelessly via a digital interface		
10	Collector will have sensors that allow for emergency stops when path is obstructed.		

Preliminary design: Software

- Individuals send orders over Discord (communication app)
- Orders fed into pathfinding script (on server computer)
- Directions sent to collector over wifi

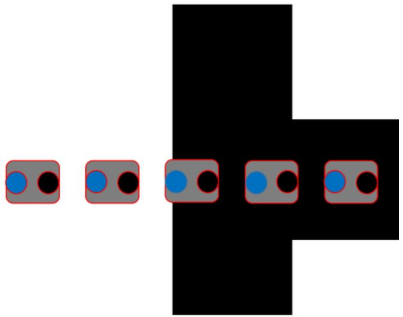


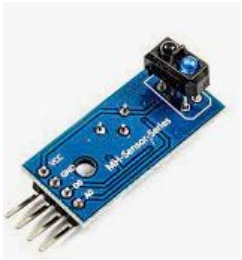
Software cont.

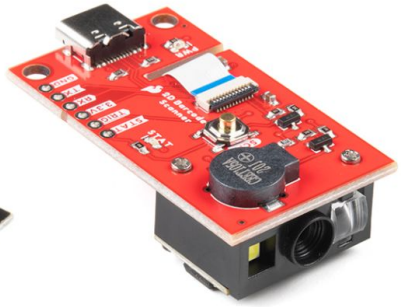


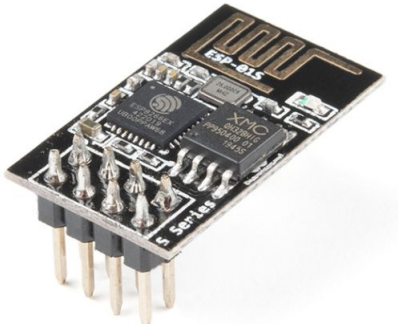
Sensor Design

- Line Following
  - Array of 5 TCRT IR sensors
- Obstacle detection
  - 3 HC-SR04 Ultrasonic sensors
- Scanning
  - 2D barcode scanner breakout
- Communication
  - ESP8266 Wifi chip
- Controller
  - Arduino Uno R3 control board



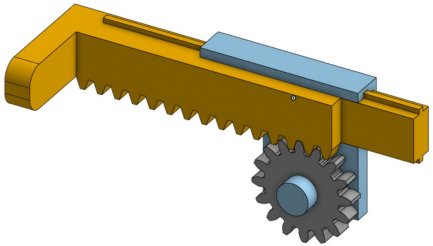




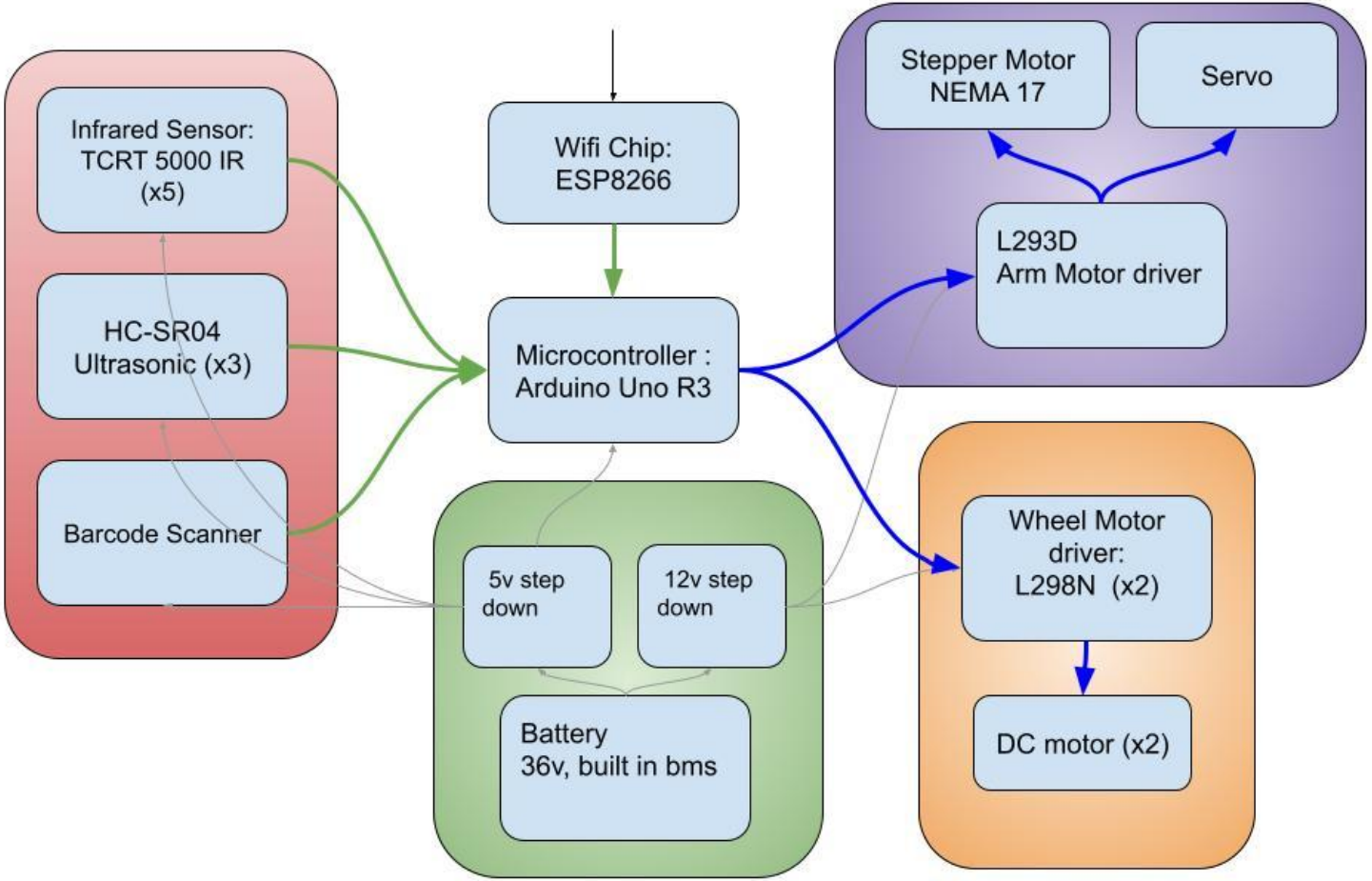


Control design

- Movement
  - “Roomba” control
  - 6 in wheel —> 63 cm/s
  - 12V DC Motor
    - 15kg.cm, 80 rpm, 1.6A
  - 2 L298N H-Bridge driver
    - 25W, 2A
- Arm
  - Rack & Pinion
  - Nema 17 Stepper Motor
  - 20kg Servo
  - L293D motor Driver
    - Drive both motor & servo
    - 600mA/channel

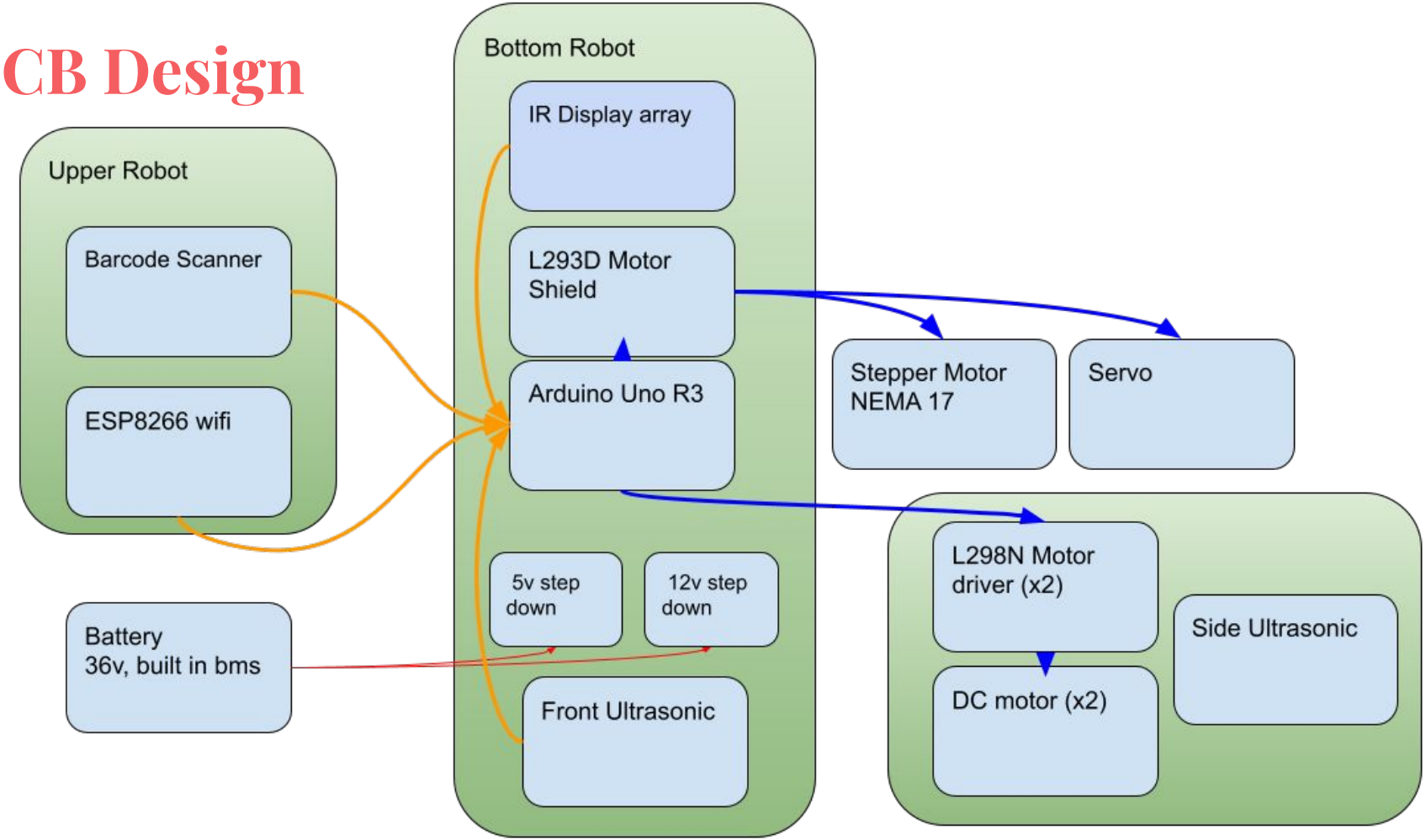


Block Diagram



- Sensor Input
- Output Control
- Power

PCB Design


Bottom Robot
IR Display array
L293D Motor Shield
Arduino Uno R3
5v step down
12v step down
Front Ultrasonic
Upper Robot
Barcode Scanner
ESP8266 wifi
Battery
36v, built in bms
Stepper Motor NEMA 17
Servo
L298N Motor driver (x2)
DC motor (x2)
Side Ultrasonic

Cost analysis

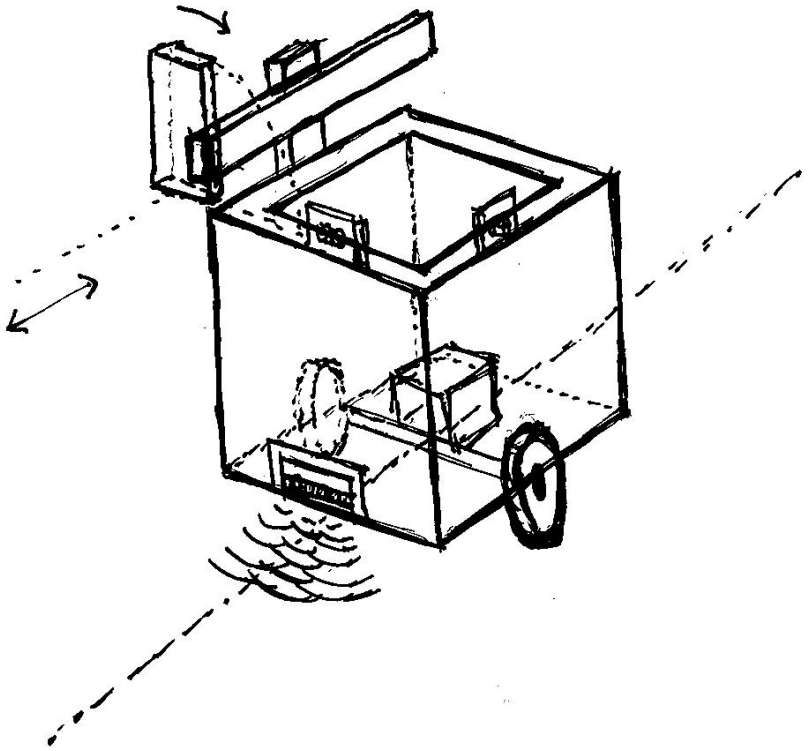
Category	*Item*	*Name*	*Cost*
Line Following system	Ir sensors	TCRT5000	$10
	Item scanner	2D Barcode Scanner	$50
Obstacle Avoidance	Ultrasonic	HC-SR04 (x3)	$12
Networking/controller	MCU	Arduino Uno R3	$23
	Wifi Chip	ESP8266	$7
Robotics	Stepper Motor	Stepperonline NEMA17	$15
	Motor driver	L293D Motor shield	$7
	Battery	36v	$100
	Wheel motor	12v 80rpm 15kg/cm dc	$26
	Servo motor	ANNIMOS 20KG Digital Servo	$17
	12v voltage reg	DC Voltage Converter Buck Converter 36V Step Down to 12V 10A 120W	$20
	5v voltage reg	DC Voltage Converter	$22
PCB	Design	-	$45
	Shipping		$30
Physical	shelves, frame, products, etc		$20
		Total Cost:	$404

Gantt Chart

Task	*Team members*	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13
Hardware								
Shelves	R & E							
Chassis	R & S							
Power delivery	N							
Arm puller	N							
Drivetrain	N							
Ultrasonic	S							
line tracker	R,E & S							
item scanner	R & E							
Cumulative test	R,S,E & N							
PCB	R,E,S & N							
Software								
Discord Bot	N							
Order Management & Pathfinding	S,E & N							
ESP8266 Wifi Comm	S							
Arduino Actuation	R,E,S & N							
Arduino Line Following	R,E & N							
Arduino Obstacle Avoidance	R							

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



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!