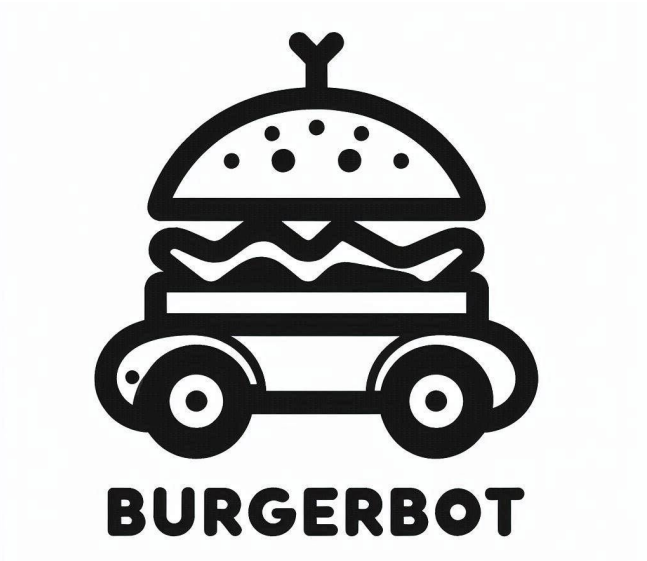


UCLA ME Senior Project

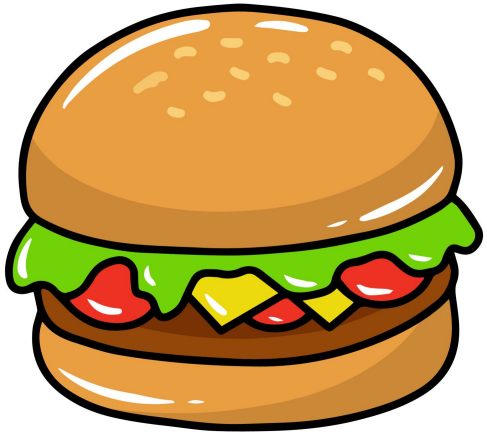
Karla Bonilla
Colston Leonard
Milad Mesbahi
Aiden Taylor
Umer Badar

The *Burger**Bot***™ Team

Aiden Taylor | Milad Mesbahi | Umer Badar | Karla Bonilla | Colston Leonard

The Goal - Hamburger Delivery Robot

- Use an automated robot to pick up and deliver “hamburgers”

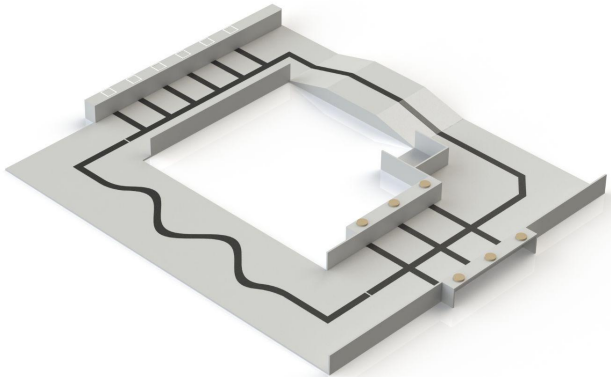


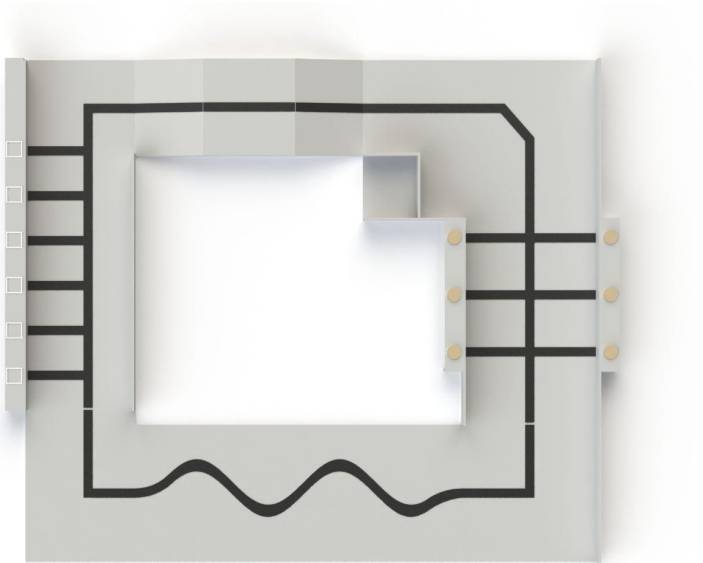
Design Requirements

- Follow a course marked by black lines on a white surface
  - Both gradual turns and sharp 90-degree corners
- Pick up and deliver disks at numbered locations, selected using dice
  - **Minimum requirement:** Pick up 2 disks and deliver them in a stack
  - **Stretch goal:** Pick up and deliver 3 disks instead of 2
  - **Stretch goal:** Detect the numbers from the dice without manually inputting numbers
- Detect obstacles placed along path and stop before hitting them
- Successfully climb and descend a hill while delivering patties
- Finish the course within 5 minutes

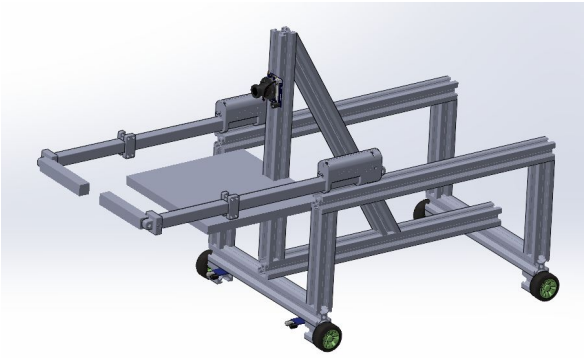
The Course

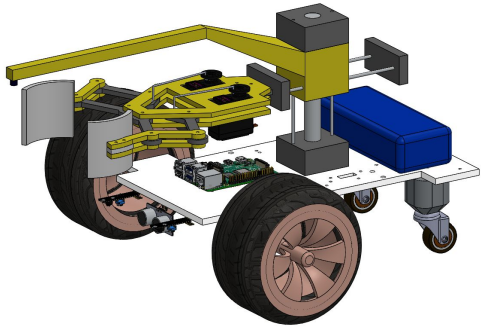
- Mix of gradual and sharp turns
- Completed in counter-clockwise direction
- 6 potential pick up locations
- 6 potential drop off locations

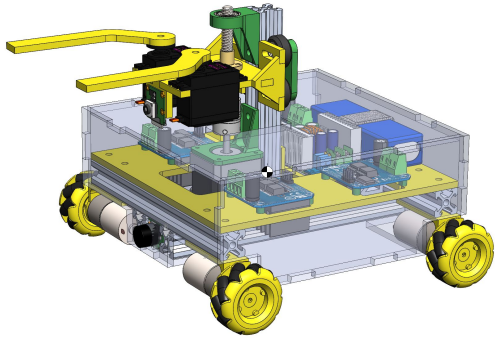




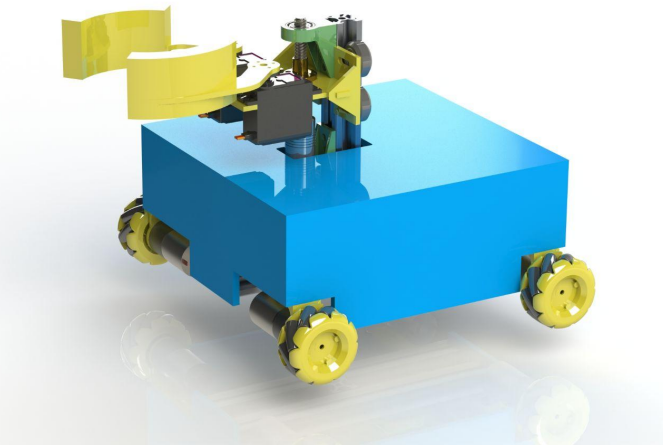
Initial Concepts:

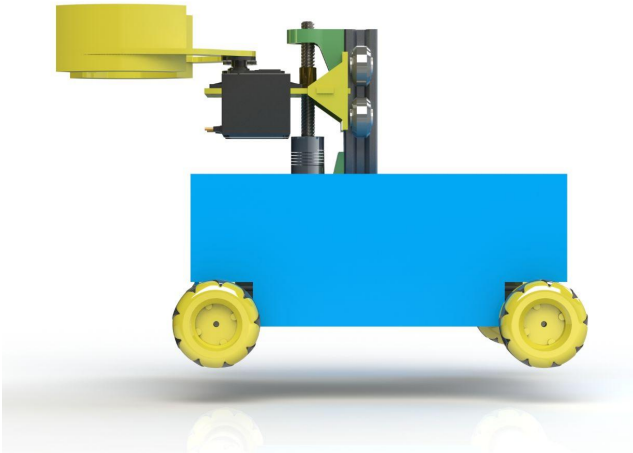






Final Design

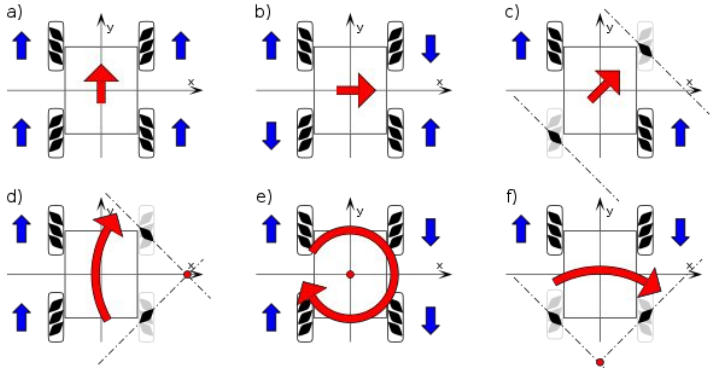




Mechanical Subsystems

Powertrain

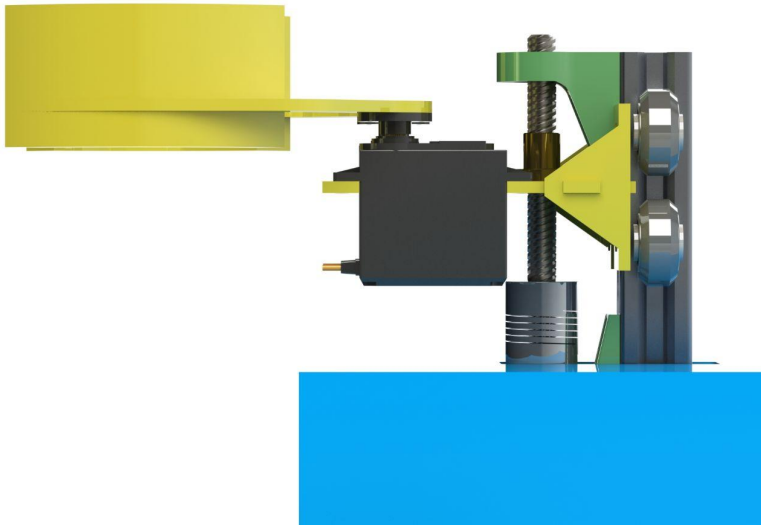
- 4 mecanum wheels
  - Omnidirectional
- Directly driven by 4 geared motors
  - Maximum speed: 34rpm
  - Stall torque: 110.20kgf-cm
  - Stall current: 3.85A



Mechanical Subsystems

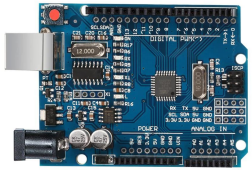
Claw

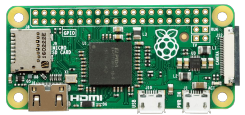
- Laser-cut claw and carriage
- 2 MG996R servos
  - Open/close claw
- NEMA 17 stepper motor
  - Raises and lowers carriage using lead screw assembly



Electronics

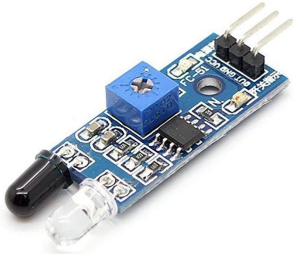
- Battery 1
  - 3s 2200mAh LiPo battery
  - 4 drive motors and NEMA 17 stepper motor in parallel
  - Allowed for increased current draw for motors and simple way to disable motors independent of other electronics
- Battery 2
  - 3s 2200mAh LiPo battery
  - Buck converter at 7.4V
    - 2 MG996R stepper motors
  - Buck converter at 5V
    - Arduino Mega - main control board
    - Arduino Uno - obstacle detection
    - Raspberry Pi - image processing
    - Sensors



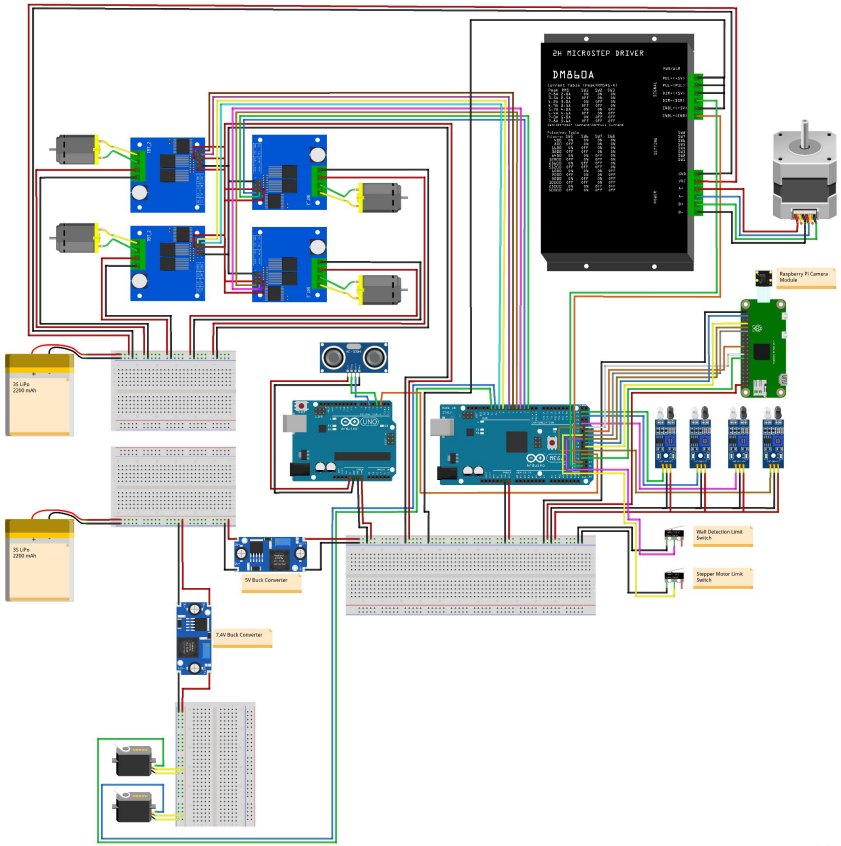


Sensors

- IR sensors
  - Array of 4 sensors centrally located in line along width of robot
  - For line following and intersection detection
  - Inner sensors used for line following
  - Outer sensors detect sharp turns and intersections
  - Sensors modified to have PCB on top of robot for easy tuning based on conditions
- Ultrasonic sensor
  - Dynamic obstacle detection
- Limit switches
  - Used to detect walls and home stepper motor
- Camera
  - Used to determine pick up and drop off locations based on dice rolls



Wiring Diagram

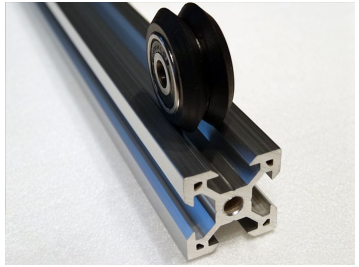


Bill of materials

Part	Qty	Unit Price	Net Price	Link	Notes	Manufacturing method	Purchased
Raspberry Pi Zero 2 W	1	$15.00	$15.00	Raspberry Pi		N/A	Arived
Raspberry Pi Camera Module 3	1	$35.00	$35.00	Camera		N/A	Arived
30cm FPC Camera Cable	1	$3.95	$3.95	Camera Cable		N/A	Arived
MG996R Servos (2-pack)	1	$14.99	$14.99	Servos (2-pack)	Servos (4-pack)	N/A	Arived
IR Sensor (20-pack)	1	$9.99	$9.99	IR Sensors		N/A	Arived
Screws, Nuts, Bolts (1440pcs)	1	$18.84	$18.84	Hardware		N/A	Arived
Turnigy 2200mAh 3S 40C Lipo	2	~~$24.49~~	~~$48.98~~	Battery		N/A	Arived
20A 300W CC CV Step Down Module Adjustable DC 6-40V to 1.2-36V Voltage Regulator Buck Converter (3-pack)	1	$19.99	$19.99	Buck Converter		N/A	Arived
Stepper Motor	1	$10.99	$10.99	Stepper Motor		N/A	Arived
Stepper motor driver	1	$6.99	$6.99	https://www.amazon.com/WWZMDiB-St	For stepper motor (includes 3 only need one)		Arived
V-Slot 20x20 Aluminum Rail	1	$36.99	$41.93	Aluminum Rail	2x 190mm, 2x 200mm, 1x 165.5mm	Lathing	Arrived
46 RPM Econ Gear Motor	4	$14.99	$59.96	Motors	46 RPM Econ Gear Motor - SOLD OUT - 43 RPM available	N/A	Arrived
BTS7960 43A High Power Motor Driver	4	$10.99	$43.96	Motor Drivers		N/A	Arrived
Mecanum Wheels (4-pack)	1	$17.84	$17.84	Mecanum Wheels		N/A	Arrived
Lead Screw and Coupler Kit	1	$9.99	$9.99	Lead Screw		N/A	Arrived
Accelerometer	1	$8.98	$8.98	Accelerometer		N/A	Arrived
Motor Driver Plate	1					3D Print PLA	
Panel walls	4					3D Print PLA	
Usongshine Tb6600 stepper motor driver	1	$9.99	9.99	STEPPER DRIVER		N/A	Arived
Ultrasonic sensor	1			Ultrasonic sensor	Aiden provided it	N/A	N/A
Mini Sd Card	1	$7.65	$7.65	Mini sd			
Micro usb to arduino cable	1	$10.94	$10.94	Micro usb to arduino		N/A	Arrived
mini hdmi to hdmi	1	$8.86	$8.86	mini hdmi to hdmi		N/A	Arrived
micro usb to male usb	1	$5.46	$5.46	Micro usb to male usb		N/A	Arrived
Arduino Uno	1			Arduino uno	Provided in kit	N/A	Arrived
		Total Price	$410.28				

Fabrication

- Chassis constructed using 20x20mm V-slot aluminum rail
  - Strong, rigid, simple mounting for other components
  - Dolly wheels available for stabilizing claw carriage
- 3d printed brackets and M5 hardware
- Laser-cut 1/8in cast acrylic sheet
  - Claw, carriage, body panels, and electronics mounting plates
  - Rapid manufacturing and assembly
  - Allowed for many modifications with low turnaround time



Overall State Machine Logic

Line Following

- Inner right and left IR sensors for basic line following, robot turns toward sensor if detecting line
- Outer left IR sensor for detecting 90° left turns
- Outer right IR sensor for detecting intersections

Object Detection

- Ultrasonic sensor used for detecting obstacles, will immediately stop moving
- Ultrasonic sensor disabled when in pick up mode and drop off mode

Pickup

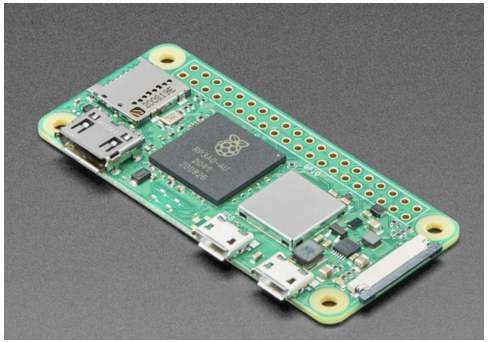
- Once the first intersection is detected, counts intersections and makes 90° turns to reach pick up site
- Moves until switch hits wall, lowers stepper motor, releases servos to grab disks, backs up to return to intersection

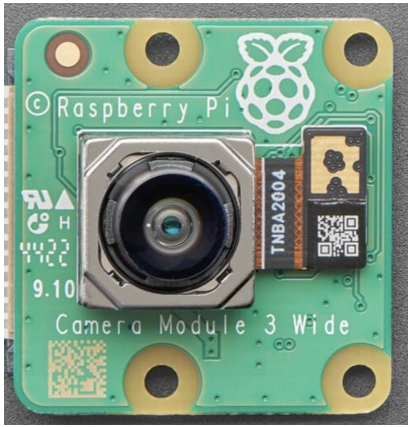
Drop Off

- After pickups, counts intersections until drop off location is reached
- Makes 90° turn to selected drop off site
- Moves until switch hits wall, lowers stepper motor, releases servos to drop disks, backs up to return to intersection

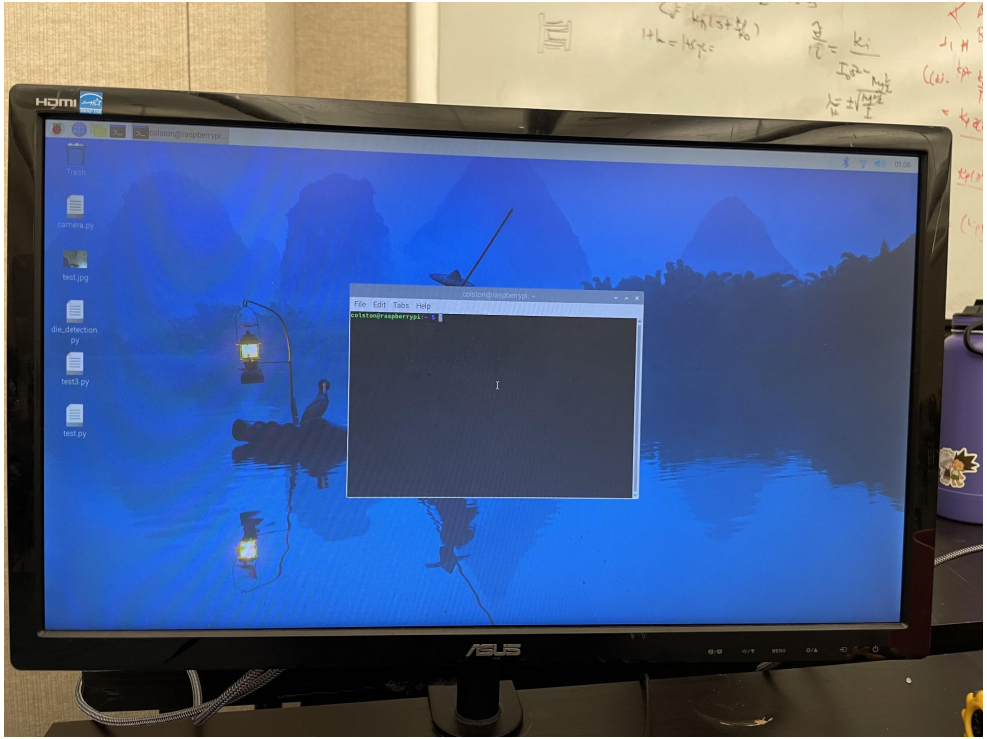
Raspberry Pi

- Raspberry Pi Zero 2 W and Raspberry Pi Camera Module 3
  - Used for Dice Detection to communicate to arduino the 3 pickup locations and the dropoff location
- Requires 5V via buck converter





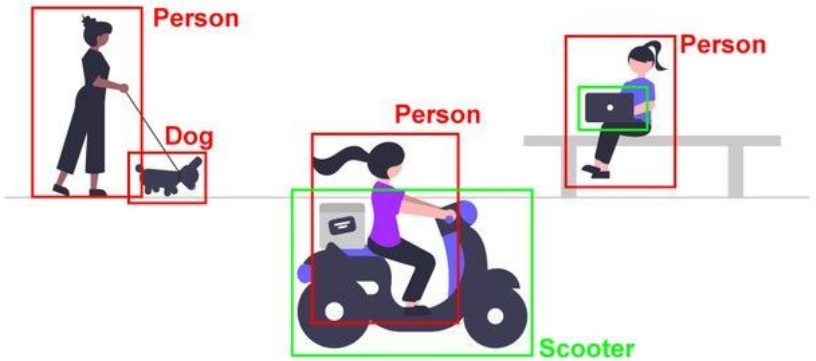
Raspberry Pi Overview



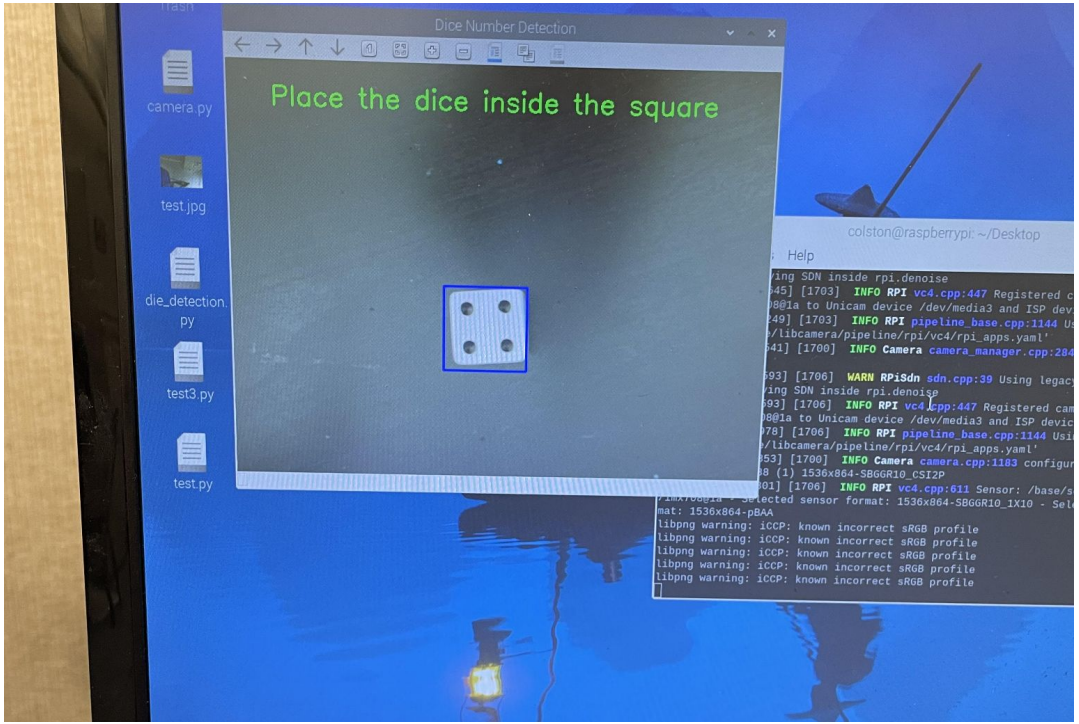
OpenCV

About OpenCV

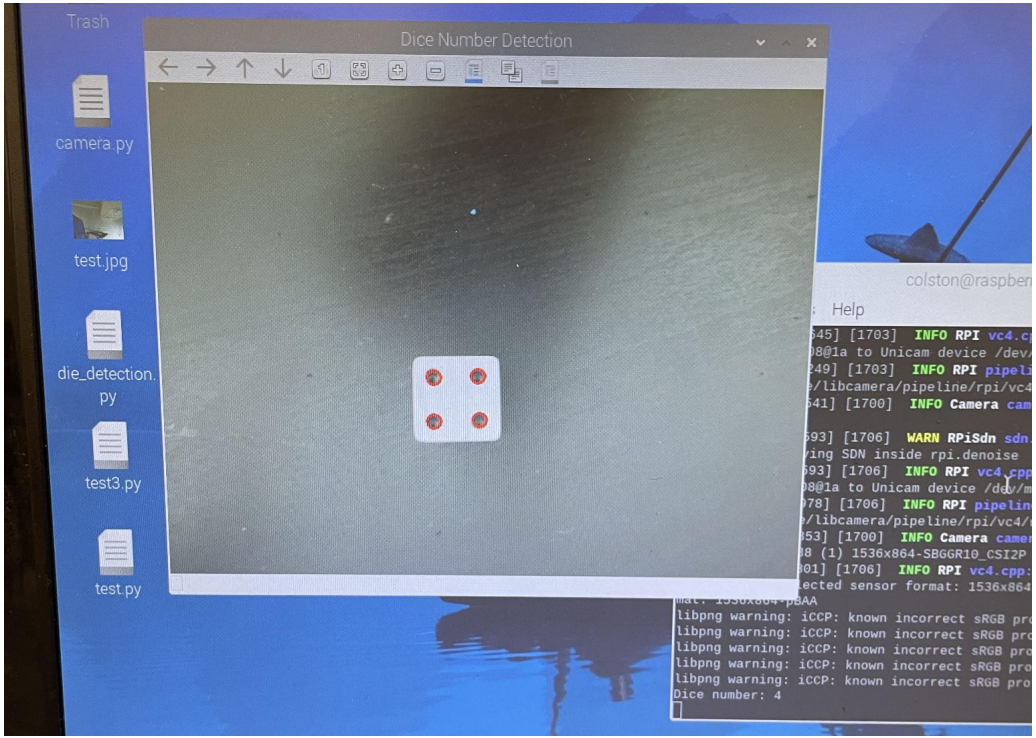
- Open source computer vision library
- Python, C, C++
- Fast image processing
  - Frame by frame video processing
- Wide range of uses
  - Image processing
  - Object detection
  - Facial recognition

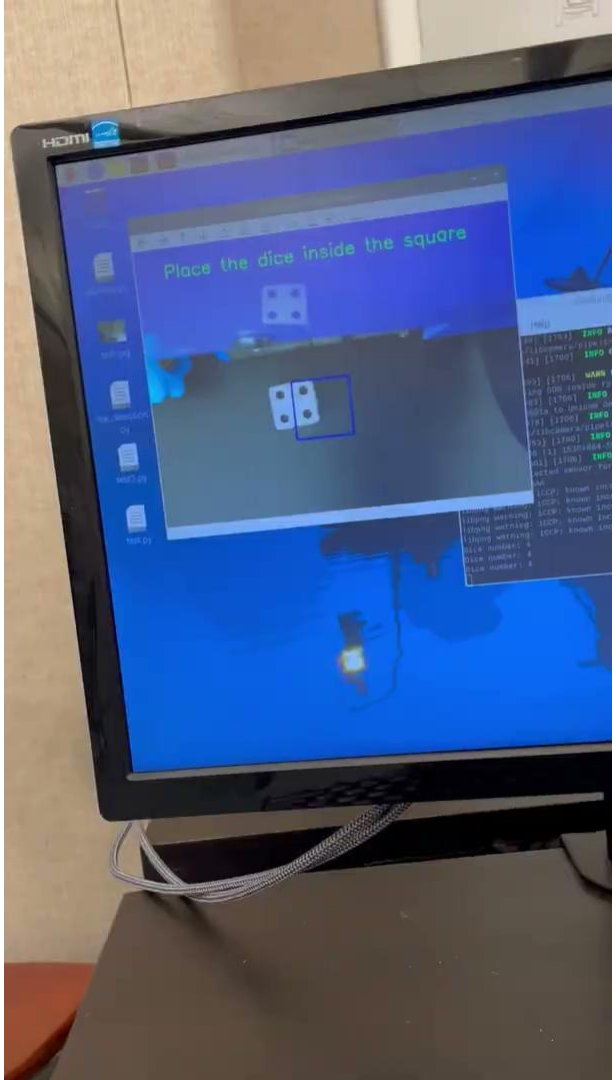


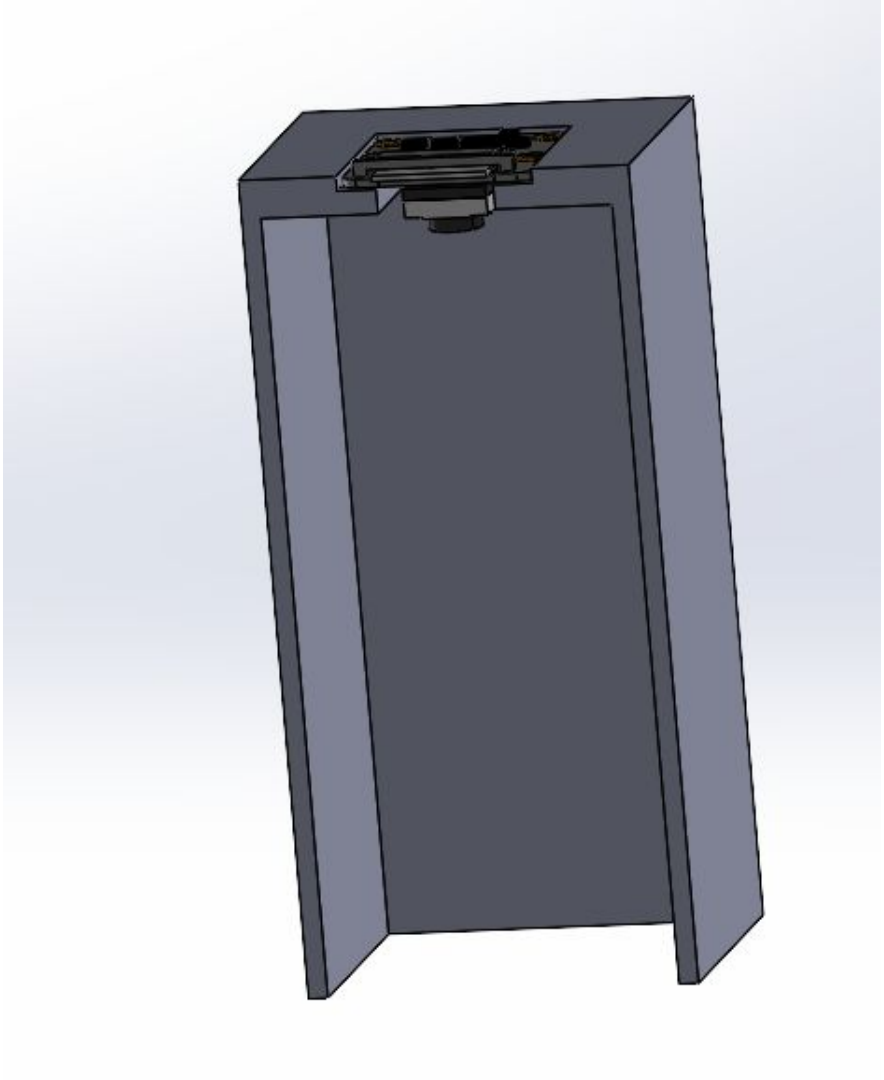
Dice Detection Program



Dice Detection Program




Place the dice inside the square



Communication between Raspberry Pi and Arduino

- 1 GPIO pin on Raspberry Pi wired to digital output pin on Arduino
  - Used by the Arduino to request die detection from the Raspberry Pi when the switch is pressed
- 6 GPIO pins on Raspberry Pi wired to digital input pins on Arduino
  - Each pin represents one of the six possible numbers from the die
  - The Raspberry Pi determines the die value and sets the corresponding pin to high
  - The Arduino reads the pins and gets the pick up or drop off location based on that
- Arduino uses this process to request 4 target locations from Raspberry Pi
  - 3 pick up locations
  - 1 drop off location
- Arduino then proceeds to calculate which intersection numbers to turn at to reach those locations and which directions to turn

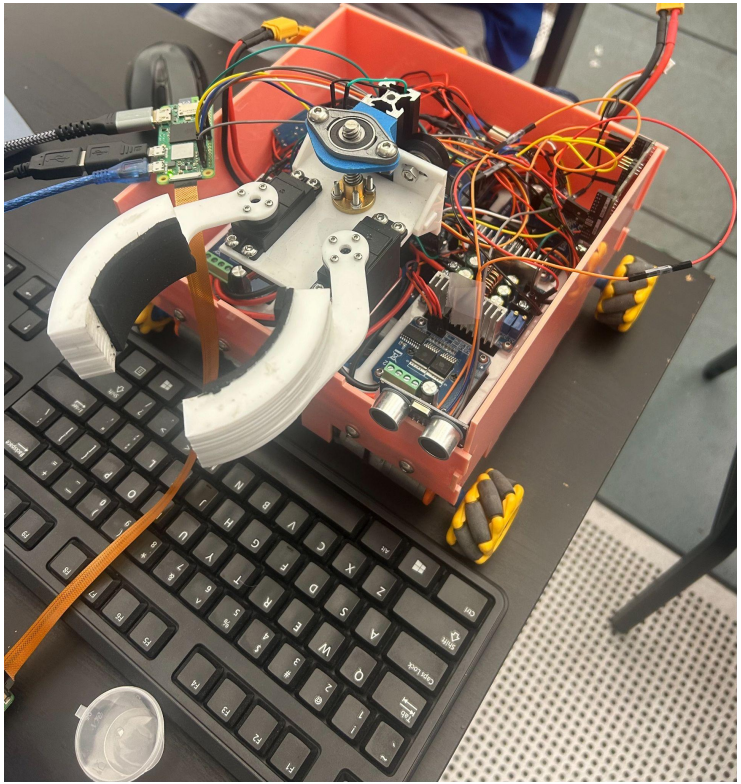
Lessons Learned

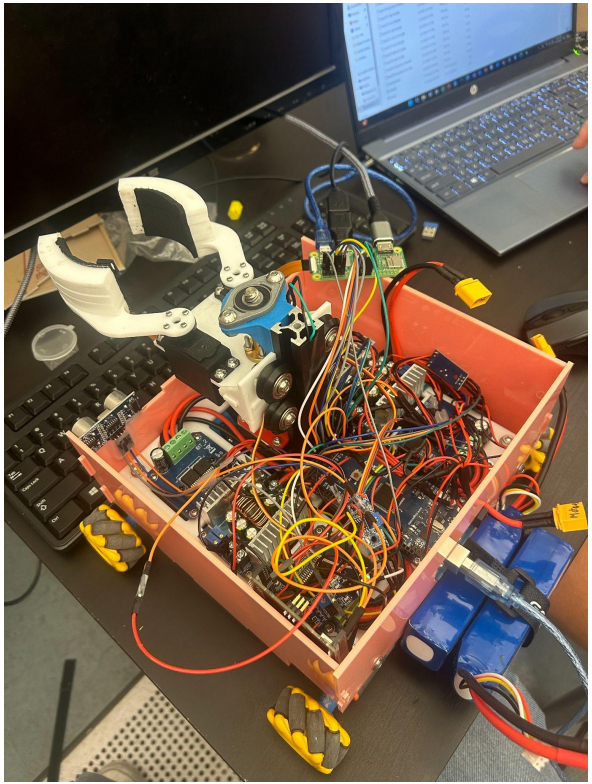
- During line following, rover would stall all of a sudden, activate stepper motor and servos unexpectedly, and lose track of the line. (Going rogue)
  - Re-wrote code to minimize use of delay functions
  - Used second Arduino for ultrasonic sensor, which set a pin on the main Arduino either high or low at all times depending on if obstacle was detected - main Arduino experienced no delay when reading from sensor

- Second Arduino was initially powered through the main Arduino - robot only functioned while plugged into laptop
  - Second Arduino was pulling too much current and triggering over-current protection on main Arduino
  - Fixed by powering second Arduino directly from buck converter in parallel with main Arduino

- Difficulty on 90 degree left turns using standard line following - slow and jittery, would sometimes lose line
  - Used outer left sensor to detect 90 degree turns
  - Programmed all wheels to turn clockwise for a set time before resuming standard line following

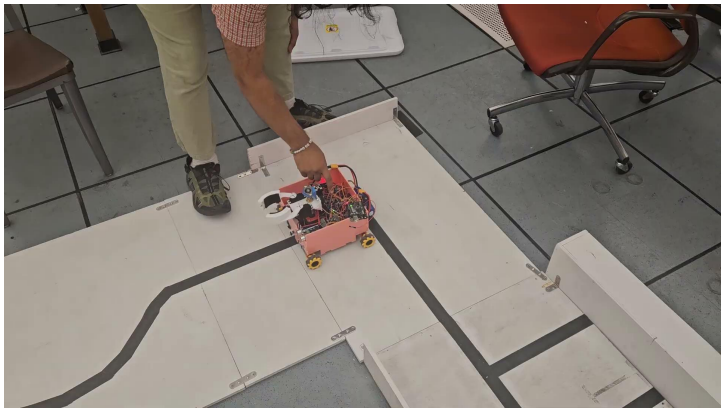
Final Rover

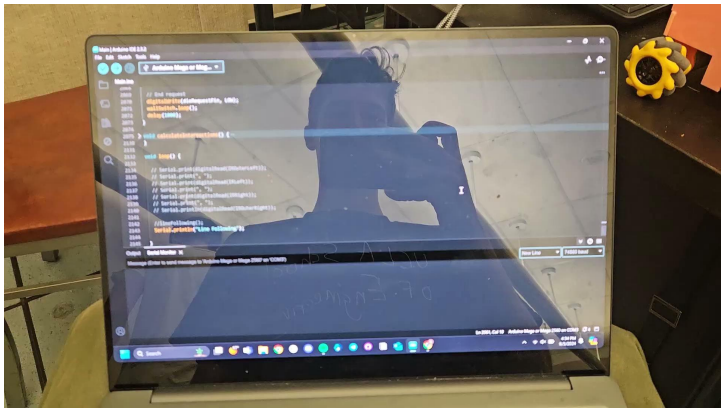




Final Demo Videos

- Final packaging and integration will be completed in time for competition





Questions?