UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

Ball Fetch Drone

Electrical & Computer Engineering

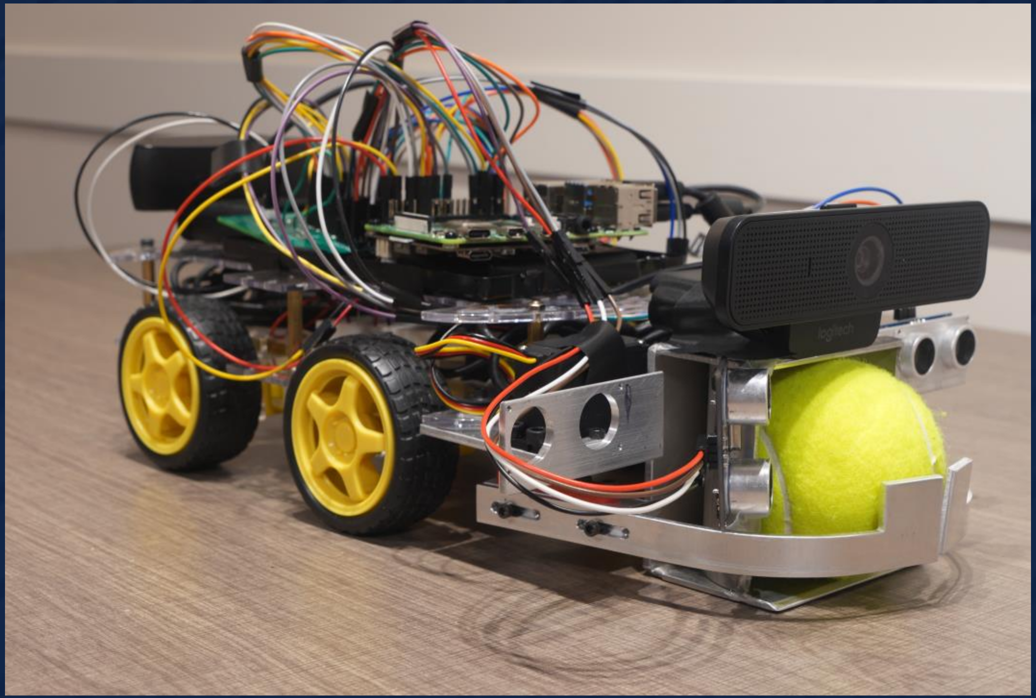
Patrick Sarad, Louie Davila, Yinshuo Feng

Team 34

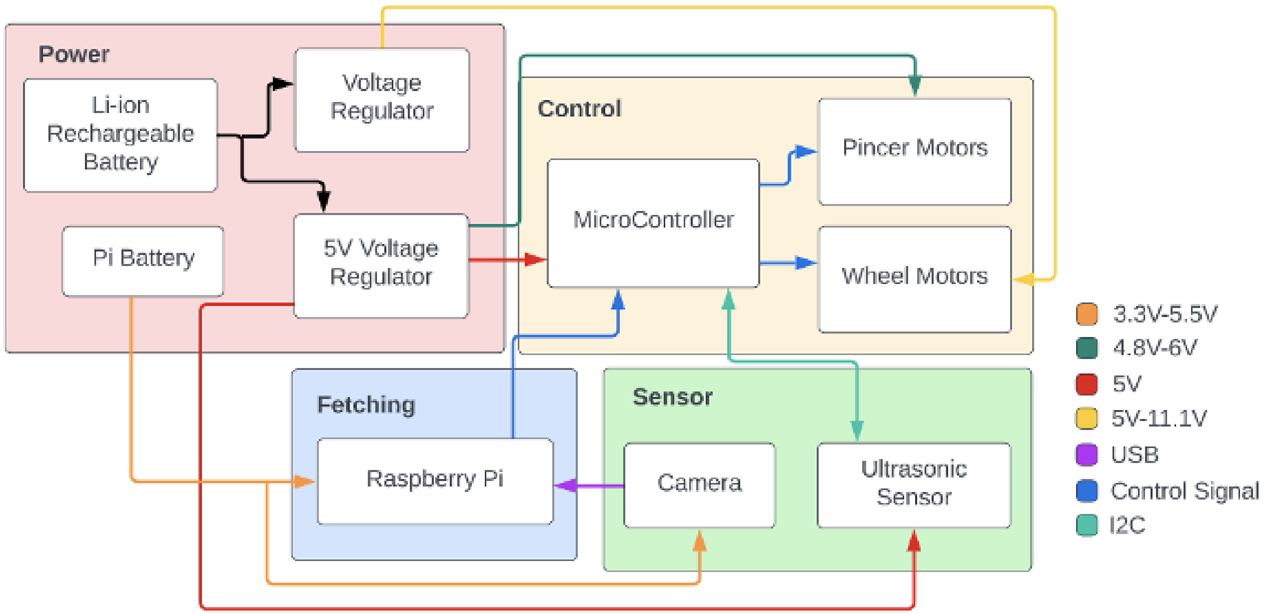
May 1st, 2023

Objective

Automatically Fetch the Ball
Save Your Time during Training



Block Diagram



Power Subsystem

- 11.1V battery connected to 2 buck converters
- Single 5v Pi battery

Control Subsystem

- Microcontroller connected to 2 H-Bridges and to 2 Servo Motors
- H-Bridges used for bidirectional control of motors

Sensor Subsystem

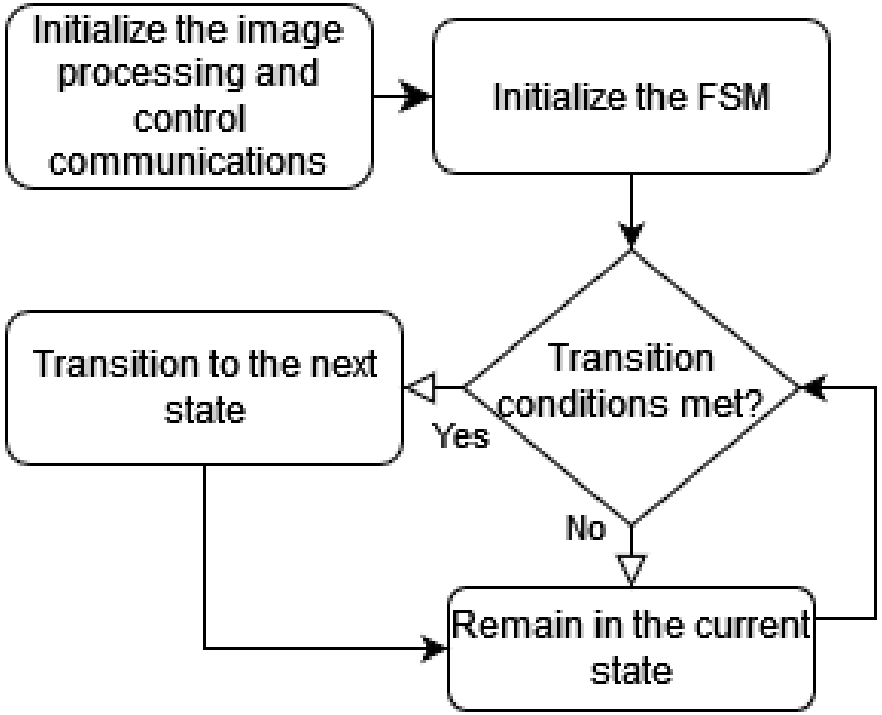
- 2 Ultrasonic sensors (Microcontroller)
- 2 Cameras (Raspberry Pi cameras)

Fetching Subsystem

- Raspberry Pi used for image processing and state machine control

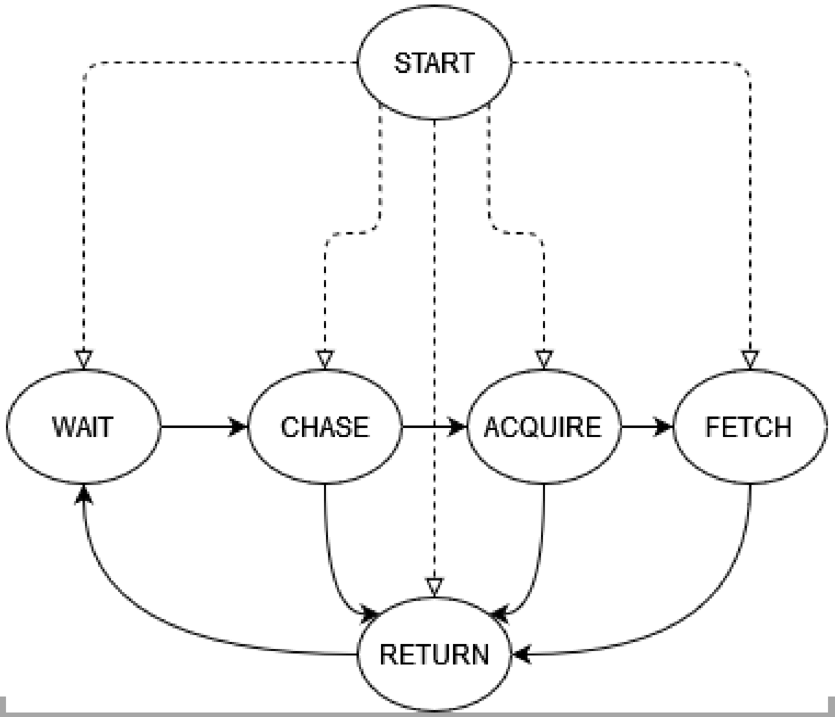
Software

Control Flow

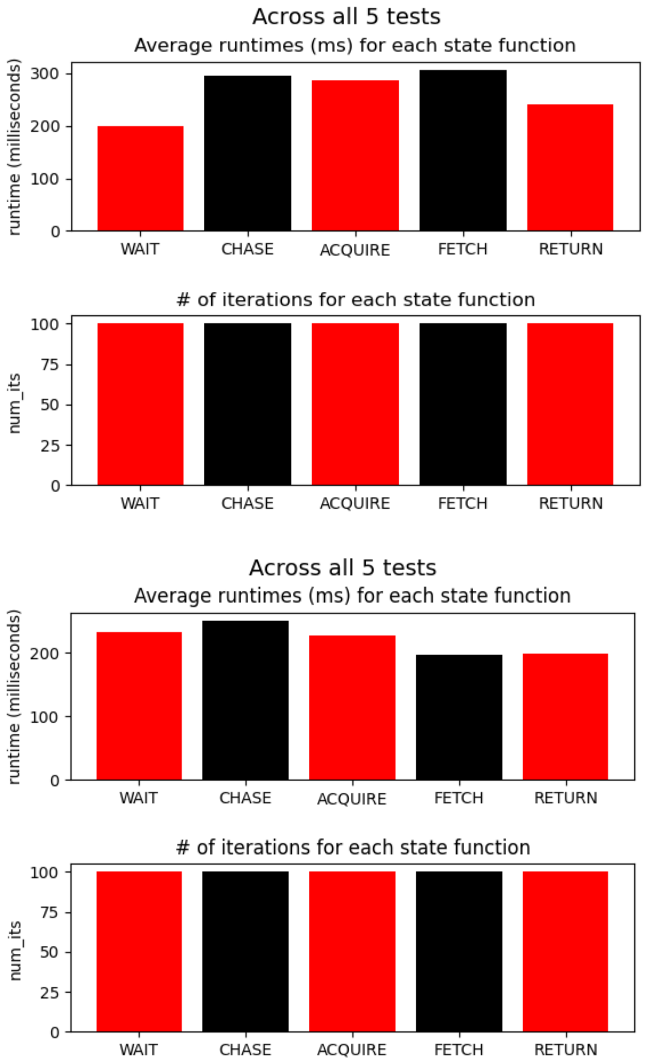


Raspberry Pi

FSM



Evaluation of the Software



Microcontroller

- ATMega328
- Basic loop for reading sensors and updating motors

Runtimes (us)

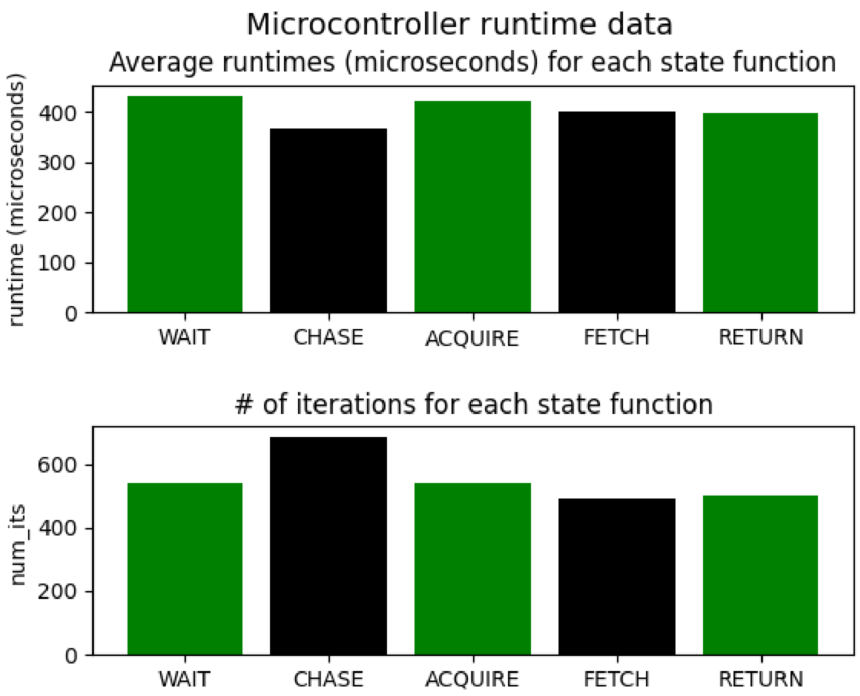
WAIT: 432.88

CHASE: 368.21

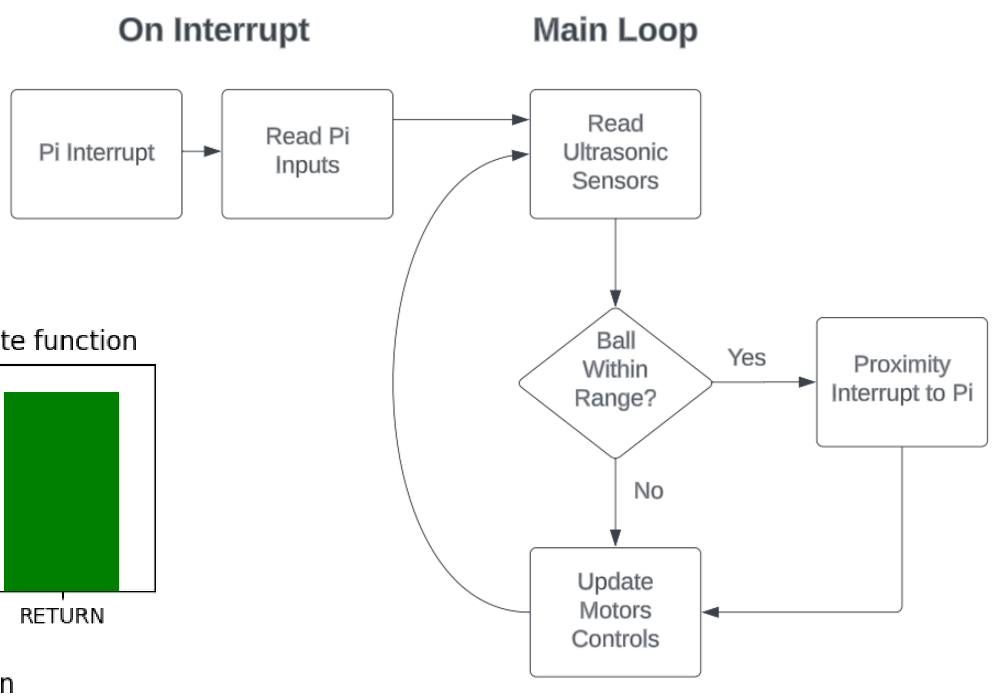
ACQUIRE: 423.21

FETCH: 402.27

RETURN: 396.78



Flow Chart



Control Subsystem

Microcontroller

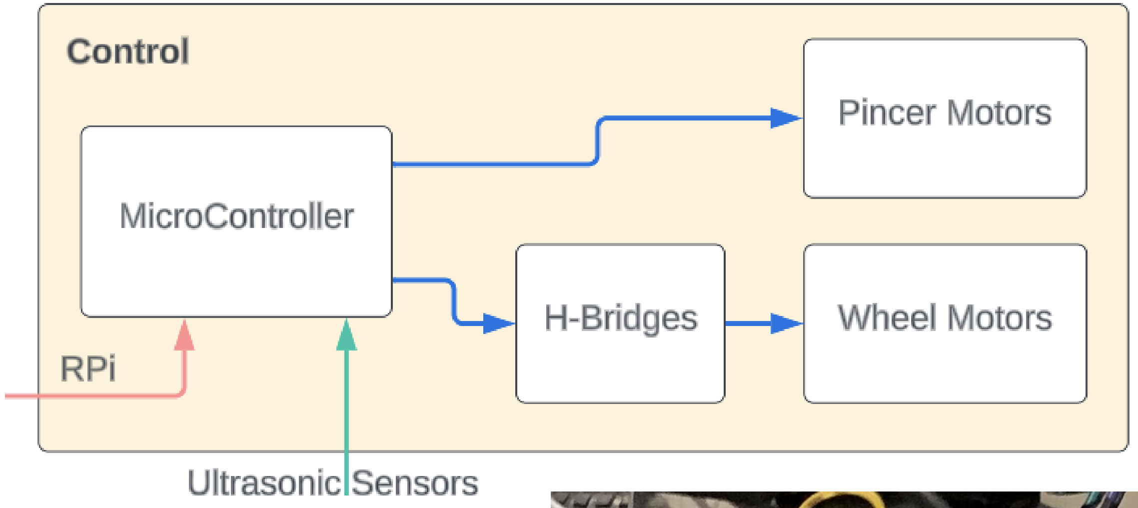
- PWM outputs to motors
- Digital signal to/from Pi

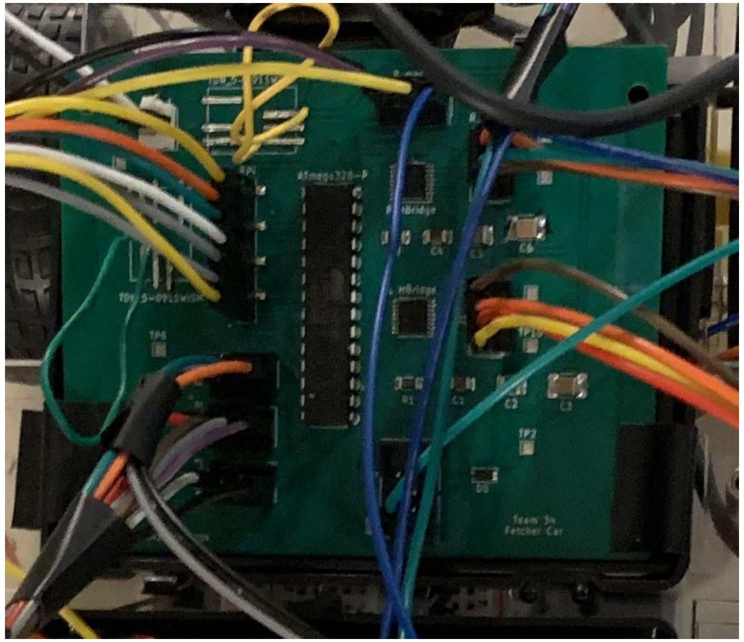
Servo Motors

- Used for control of pincers

DC Motors

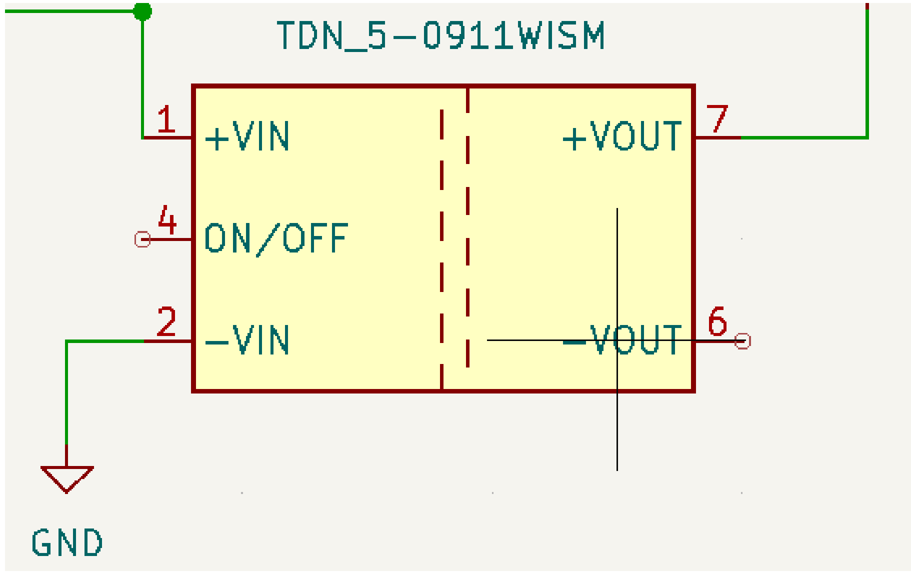
- Used for the wheels
- Controlled by DRV8848 H-Bridge





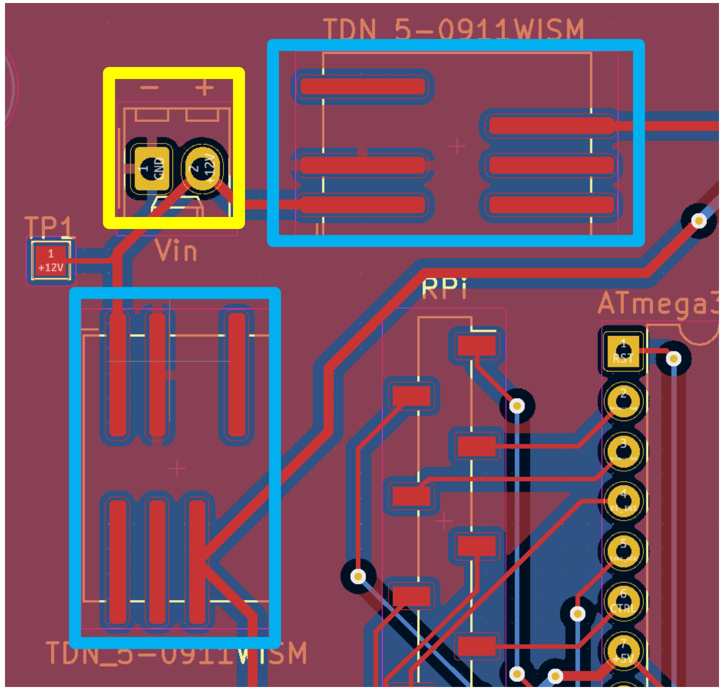
Buck Converters

- Misunderstanding of data sheet
- Lack of converter meant we needed battery with lower voltage



Power Source

- Originally 11.1V supply
- Success with 5V supplies
- Can run for 1-1.5 hours



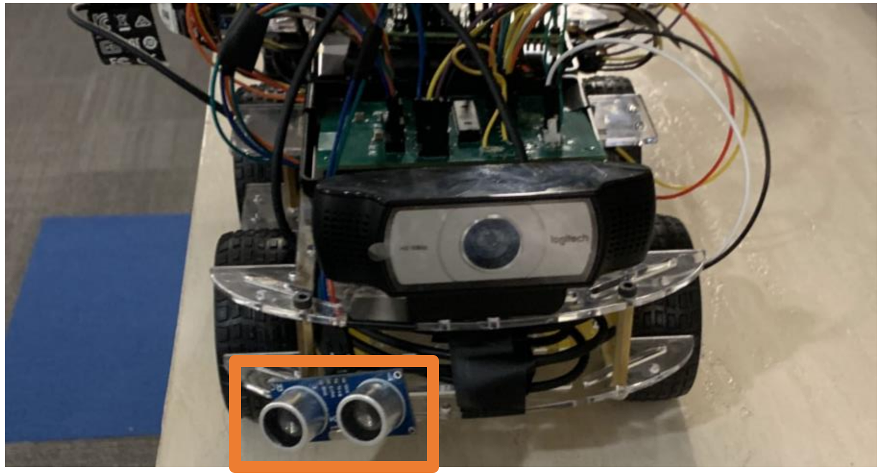
Sensor Subsystem

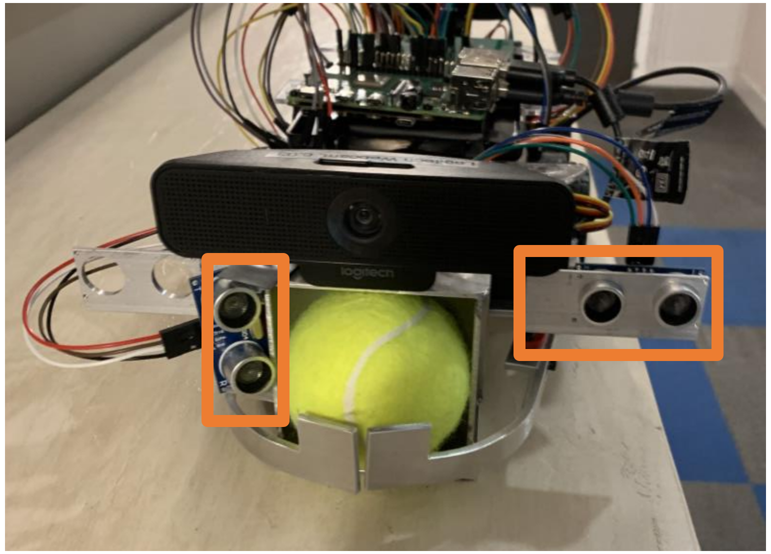
Ultrasonic Sensors

- Placement of 2 sensors on front for ball and wall detection
- Placement of 1 sensor on the back for detection of waypoint and user

Cameras

- 1 camera in the front of the car and 1 camera in the back
- Front camera has narrower FOV than camera in the back





Camera

Success Rate
- Mostly reliable in clear environment and 3 meters
- At least 3 fps at 1080P
- 90% within 0.5 meters, 50% at 3 meters

Limitations
- Different lighting conditions
- Complex environment

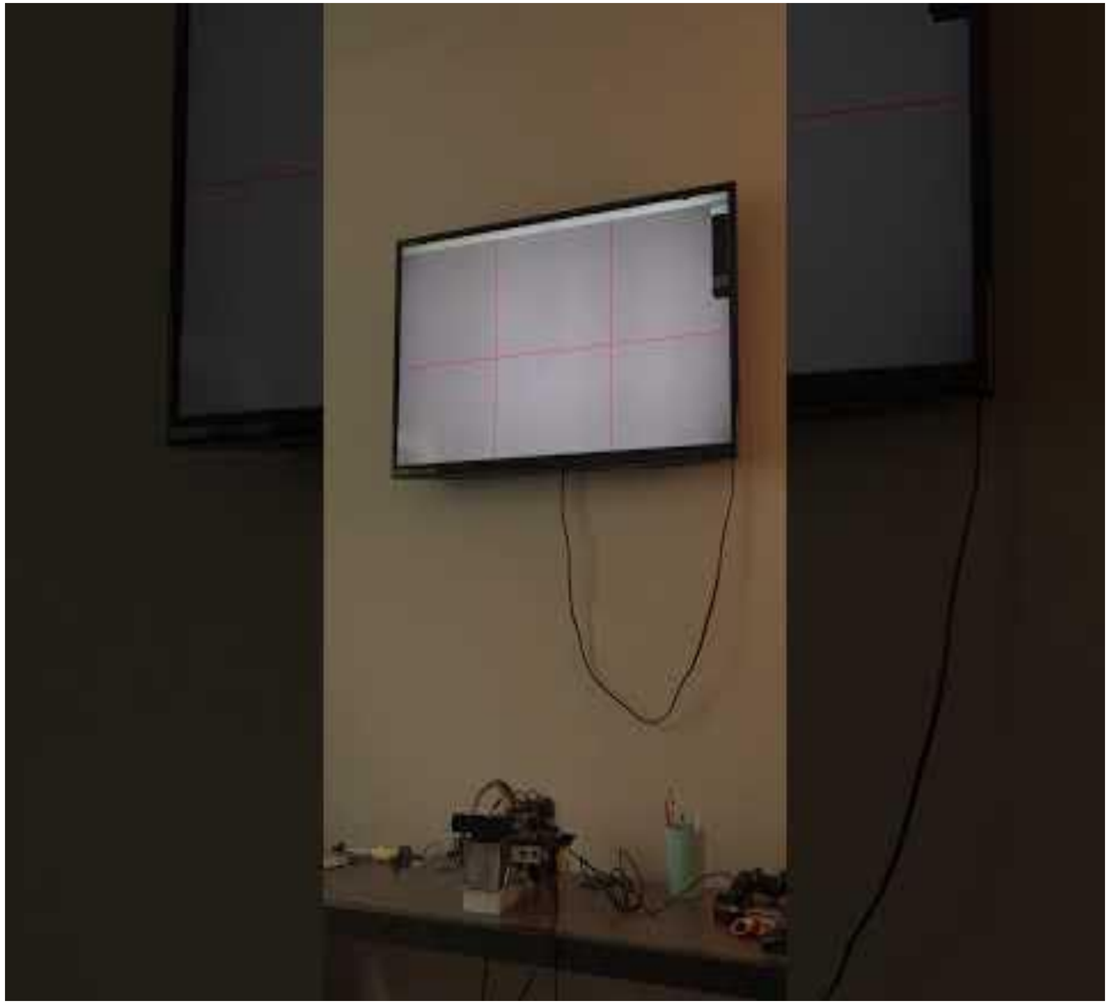
Successes

Sensor subsystem
- Color detection to track the ball, user, and wait point

Fetching subsystem
- Displayed expected behavior for each state

Control Subsystem
- Moved the motors as expected for each state of the design software

Power Subsystem
- Pi Sugar battery supplies enough power to meet high-level requirements



Failures

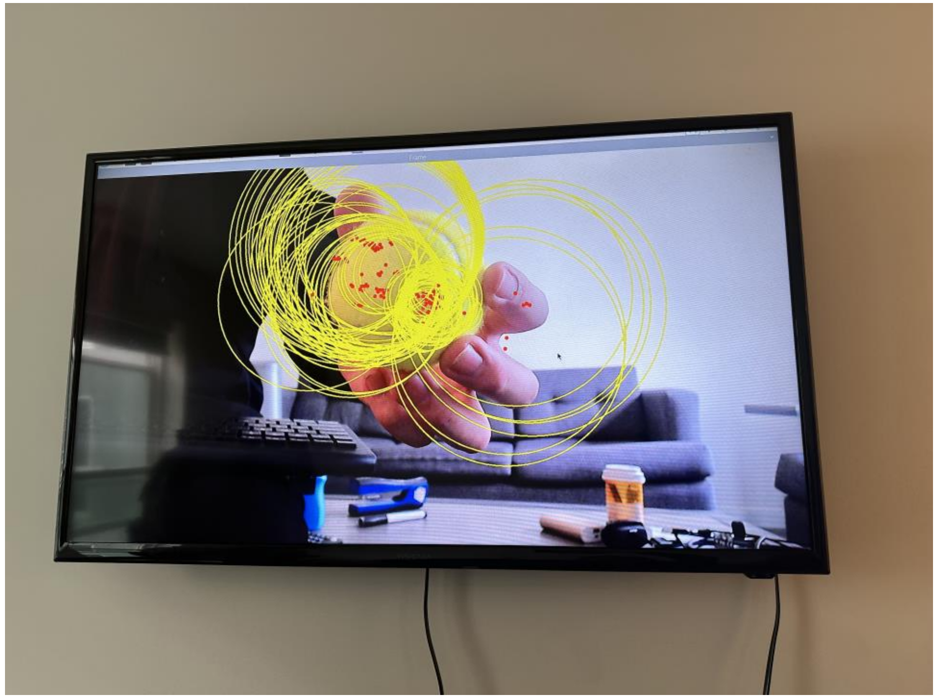
Sensor subsystem
- Camera can't detect well in messy environment / long range

Control Subsystem
- Unexpected delay when power on

Power Subsystem
- Unable to utilize a second power supply

Fetching subsystem
- Unable to debug with field testing

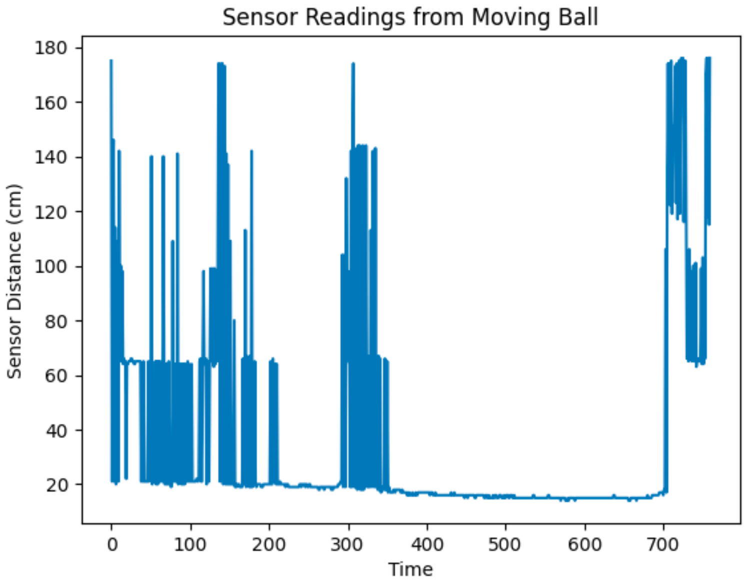
- Unable to increase granularity of image processing code

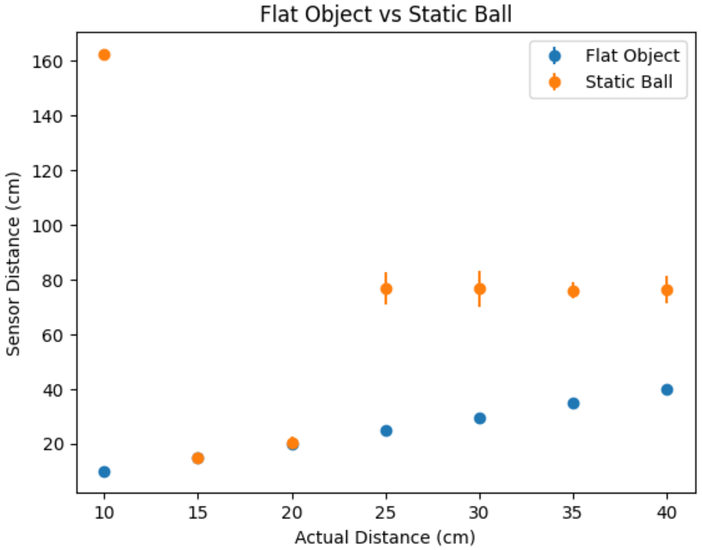


Ultrasonic Failures

Ultrasonic Sensors

- Tennis Ball Absorbs Sound
- Consistency varied with Distance and Positioning
- Attempt to use inconsistency (Partially Worked)

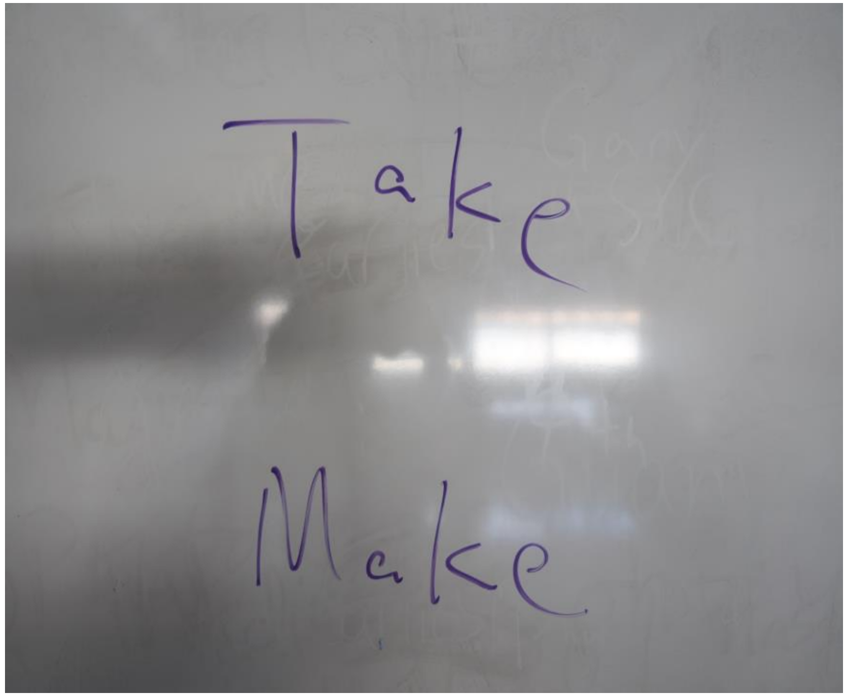




Future Work

- Consider Lidar as an alternative
- Parallelize Raspberry Pi code
- Avoid using python for non-image-processing tasks
- AI model for better edge case handling
- Replace the PiSugar battery with the PCB battery
- Space and weight for optical zoom lenses
- Hybrid Detection Method
- Camera Manual Exposure

Conclusion



Lessons Learned

- Plan and review for requirements & verification more carefully
- Take the limitations of key components into closer consideration
- Prepare for hardware failure by including redundancies in the PCB design

What should've been done differently

- Connect the Pi to the output of extra buck converters to simplify the power subsystem.
- More research on the PCB components
- Earlier work on System Integration