Autonomous Debris Collector

Hojun Byun, Andy Zhang, Omar Alinur

Introduction and Motivation

- Tools fall on the floor all the time
- People have to pick up the tools themselves
  - Physical labor
  - Lots of different types of items
  - Attention is taken away
  - Potential hazard
- Solution: Autonomous Robot that picks up items off the floor
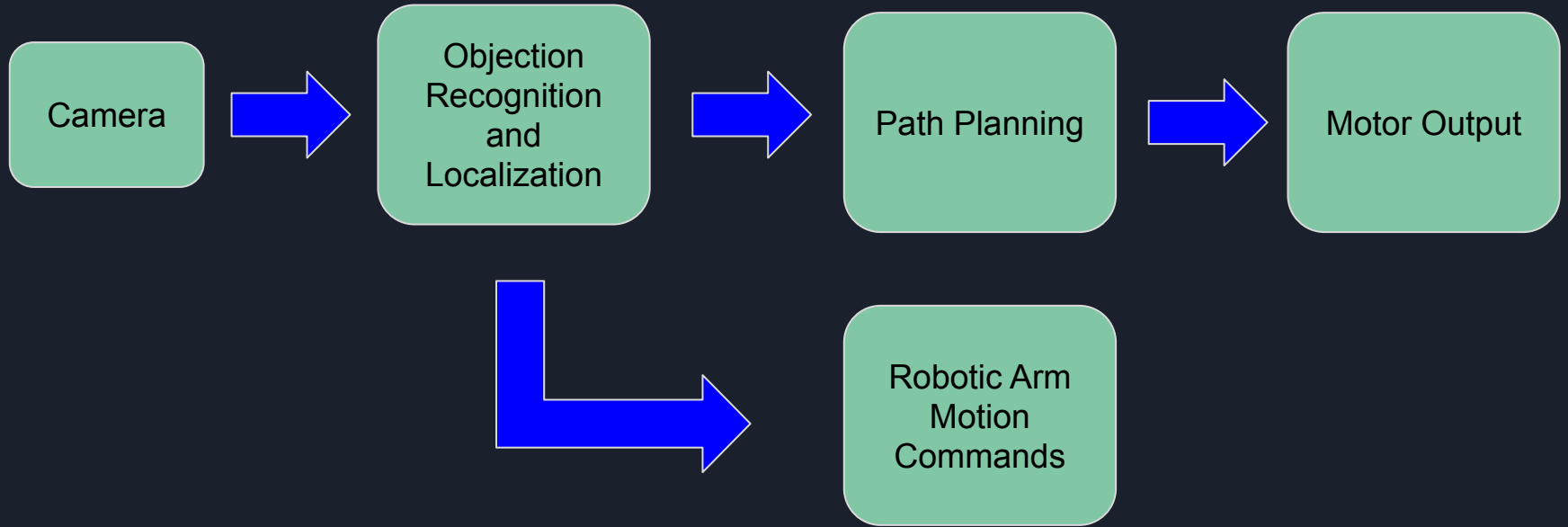
Project Scope

- Robot will pick up objects autonomously and place them into its wagon
  - Detect location to move
    - Well-lit
    - Flat surface
  - Detect location of object to grab
    - Small objects
  - Gripping Motion

- ECE Areas:
  - Software
  - Signals
  - Hardware

High-level Requirements

- Allow utility in carrying dropped marked tools/screws off the floor

- Can pick up items on the ground autonomously

- Average response time: 0.5 second

    - Average item pick-up time: 10 seconds

    - Single item weight capacity: 0.5 kilogram

- Battery life of at least 15 minutes

- Total carrying capacity: 5 kilograms

- Weight: Less than 10 kilograms

High-Level Block Diagram

Camera → Objection Recognition and Localization → Path Planning → Motor Output

Objection Recognition and Localization → Robotic Arm Motion Commands

Technical Challenges

- Able to detect and identify color-marked tools on workshop floor
- Keeping track of all the tool locations
- Move to identified tools
- Can pick up the tools using gripper
- Carrying capacity
- Accounting for lighting conditions

Solution Approach - Hardware

- Computer
  - Jetson Nano
- Robotic base
  - iRobot
  - 1 servo
  - Electric air pump
- Depth camera
- Battery
- Aluminium
  - Storage bin
  - Arm
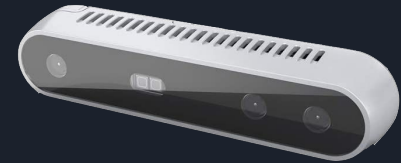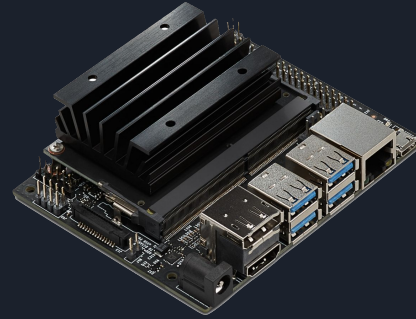
Solution Approach - Software

- Use color thresholding based off our marker color
  - Ambient light calibration
- Steer robot so that the object centroid is in the center of the image
  - Drive until the object is close enough to grab
- Perform set arm movement
- Simple simulation to test path planning

Gripping Mechanism

robot arm moving at maximum speed

gripper approaches in soft state ➡ gripper deforms around object ➡ air is evacuated from gripper ➡ object can be manipulated
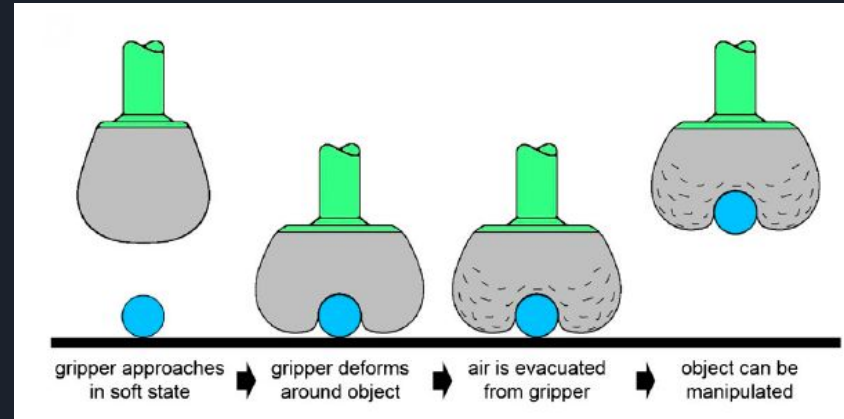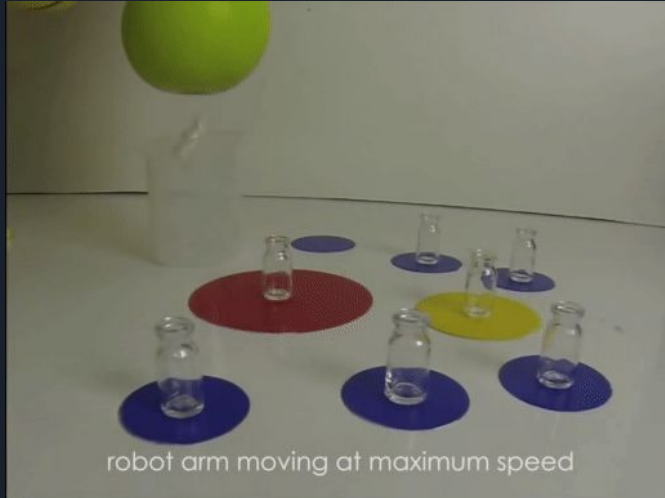
Testing, Verification, and Metrics

Requirements	Testing	Metrics
Fast and Reliable Image Processing	Item recognition code testing	Runtime = 10ms 0% false positive rate < 7% false negative rate
Reliable item pickup	Robot picks up item on attempt	< 90% success rate picking up items < 0.7kg and 10cm in length
Item collection	Robot can carry multiple items	15 Items picked up
Fast path planning algorithm	Measure run time	50 ms to make path decision
Robot speed .4m/s	2m dash	Completes the dash within 5 seconds
Accurate arm control	Arm hover over items in a circle	5cm arc length accuracy

Division of Labor

- Hojun
    - Build Arm + Gripper
    - Programming iRobot
    - Integrate Jetson Nano and iRobot
- Andy
    - Tool Detection (color-marked tools)
    - Tool Distance Algorithm
    - Computer Vision
- Omar
    - Path Planning
    - Localization
    - Final Testing and Performance Tuning

Schedule

		Andy			
		Hojun		Completed	
		Omar		In Progress	
#	Tasks	Start	End	Team Member	Status
1	Phase 1 : Project Proposal and Planning				
1.1	Identify Project Idea	2/15/2021	2/22/2021	Entire Team	Completed
1.2	Project Abstract	2/15/2021	2/22/2021	Entire Team	Completed
1.3	Setup WordPress Blog	2/15/2021	2/22/2021	Entire Team	Completed
1.4	Project Proposal Presentation	2/15/2021	2/22/2021	Entire Team	Completed
1.5	Research and Finalize Parts List	2/15/2021	2/22/2021	Entire Team	In Progress
1.6	Finalize Mechanical Design	2/15/2021	2/22/2021	Entire Team	In Progress
2	Phase 2 : Learning, Design, and Implementation				
	Milestone 1 : Proof of Concept & Hardware Obtainment				
2.1.1	Order Hardware and Mech. Parts	2/22/2021	2/22/2021	Entire Team	
2.1.2	Learn how to use OpenCV	2/22/2021	2/26/2021	Andy	
2.1.3	Learn how to program iRobot	2/22/2021	2/26/2021	Hojun	
2.1.4	Determine motion model	2/22/2021	2/26/2021	Omar	
2.1.5	Assemble gripping mechanism	3/1/2021	3/5/2021	Hojun	
2.1.6	CAD robot	3/5/2021	3/12/2021	Hojun	
2.1.7	Reserach color detection algorithm	3/1/2021	3/12/2021	Andy	
2.1.8	Create Path planning algorithm	3/1/2021	3/15/2021	Omar	
	Milestone 2 : Basic Integration				
2.2.1	Assemble arm and attach to iRobot	3/15/2021	3/19/2021	Hojun	
2.2.2	Jetson Nano can read images from camera	3/15/2021	3/19/2021	Omar	
2.2.3	Identify colors from camera images	3/15/2021	3/24/2021	Andy	
2.2.4	Track colors during live camera footage	3/15/2021	3/24/2021	Andy	
2.2.5	Motor control with Arduino + Jetson Nano	3/19/2021	3/31/2021	Hojun	
	Milestone 3 : Full Implementation				
2.3.1	Adjust simulated motion model to represent the real model	3/15/2021	3/26/2021	Omar	
2.3.2	Detection of marked tools on floor using single image	3/24/2021	4/2/2021	Andy	
2.3.3	Detection of marked tools on floor during live camera footage	3/24/2021	4/2/2021	Andy	
2.3.4	Arm Movement + Suction Procedure	4/2/2021	4/9/2021	Hojun	
2.3.5	Test and adjust path planning algorithm	3/29/2021	4/14/2021	Omar	
3	Phase 3 : Performance Testing and Refinement				
3.1	Color Recognition Fine Tuning	4/2/2021	4/21/2021	Andy	
3.2	Testing on single tool on floor	4/9/2021	4/21/2021	Omar	
3.3	Multiple types tools on floor	4/9/2021	4/21/2021	Omar	
3.4	Test movement speed	4/9/2021	4/21/2021	Entire Team	
3.5	Test with different lighting	4/9/2021	4/21/2021	Omar	
3.6	Test grabbing speed	4/12/2021	4/21/2021	Hojun	
3.7	Adjust suction power of gripping mechanism	4/12/2021	4/21/2021	Hojun	
3.8	Real simulation (dropping tools)	4/12/2021	4/21/2021	Entire Team	
3.9	Test on tools without identifiers	4/16/2021	4/21/2021	Entire Team	
4	Phase 4 : Final Report and Presentation				
4.1	Record Final Project Video	4/23/2021	5/30/2021	Entire Team	
4.2	Final Presentation	4/23/2021	5/30/2021	Entire Team	
4.3	Finalize Project Video	4/23/2021	5/30/2021	Entire Team	
4.4	Turn Project in	???	???	Entire Team	