

By Hojun, Omar, Andy



Use Case

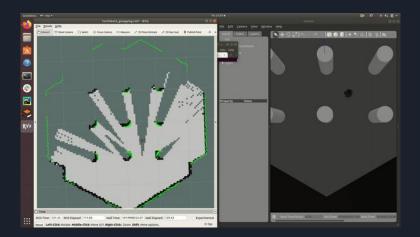
- Workshops frequently have tools and items falling onto the floor
 - Scattered tools and debris are safety hazard
 - Manual collection long and tedious
 - \circ $\,$ Tools hard to see and identify
- No specialized solutions





Solution Approach - Software

- Use color thresholding to detect tools
 - Ambient light calibration
- Steer robot to have object be center of the image
 - Drive until the object is close enough to grab
- Perform set arm movement



Simulation to test motion planning



Solution Approach - Hardware

- Computer
 - Jetson AGX Xavier
 - Arduino Uno
- Robotic base
 - iRobot Create 4400
 - 2 servos
 - Electric air pump
- Depth camera
- Battery
- Aluminium
 - Arm



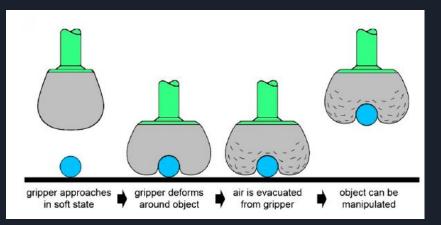


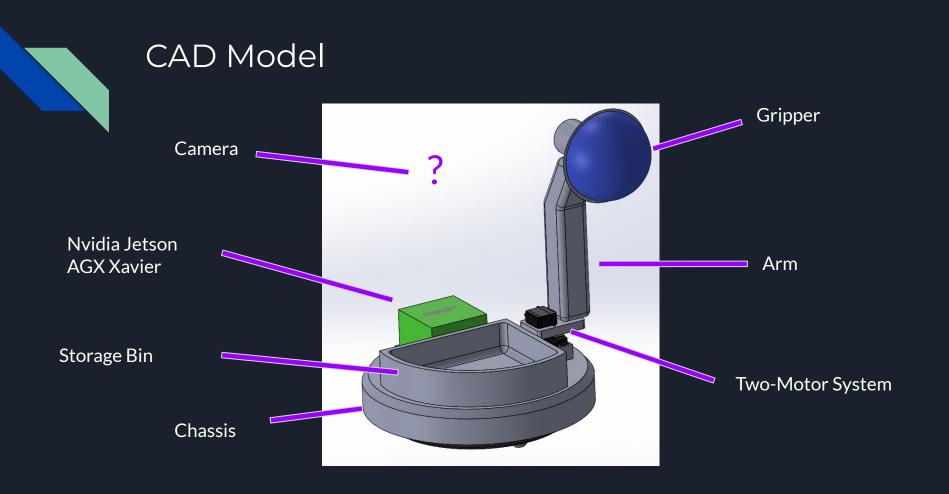


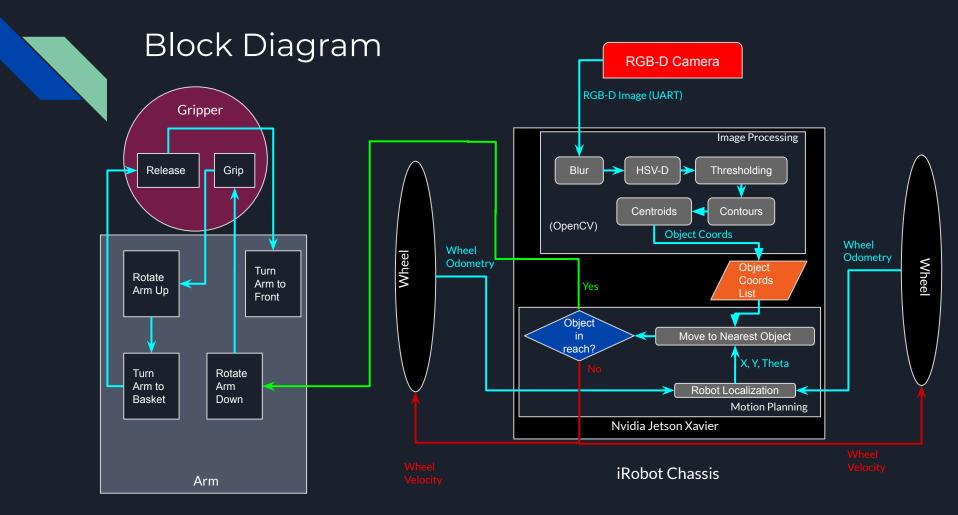


Gripping Mechanism











Implementation Plan

- Tool Tracking
 - Use Xavier and depth camera
 - OpenCV functions
 - Wheel odometry to orient and drive robot to tool
 - Differential drive motion model
- Robot
 - Model arm parts in CAD
 - 3D print the chassis and funnel design for gripper
 - Buy servos, aluminum, thick balloons, electric pump, depth camera
 - Obtain Xavier, Arduino, iRobot from course parts list
 - Assemble gripping mechanism and robot separately for testing



Risk Factors / Unknowns

Risks	Solutions
Variance in lighting could affect the visual recognition and CV algorithm performance	Use auto calibration to adjust color threshold every use
Tool weight/shape affects gripping ability	Select best material based on gripper tests
Universal gripper doesn't work out	Use a solenoid to pick up only magnetic objects
Robot stability when center of mass shifts due to arm movement	Use less mass for arm or add a counterbalance



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 that are < 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 AGX Xavier and iRobot
- Andy
 - Tool Detection (color-marked tools)
 - **Tool Distance Algorithm**
 - Computer Vision
- Omar
 - Path Planning
 - Localization
 - Final Testing and Performance Tuning



Schedule

		Andy		Entire Team		February March											April											M	May			
		Hojun		Completed		MV	VF	М	WF	M	W	FN	1 W	F	М	W	F A	W N	F	М	WF	M	W	FI	ми	F	м	W	FM	W		
		Omar		In Progress		22 2	4 26	1	3 5	8	10	12 1	5 17	19	22	24 3	26 2	9 31	2	5	7 9	12	14	16 1	19 2	1 23	26	28 3	0 3	5		
	Tasks	Start	End	Team Member	Status	Ho	jun	0	Dmar		Andy		Hoju	ın	0	mar		And	ly	H	ojun		Omar		An	dy	ł	lojun	On	nar		
1	Phase 1 : Project P	roposal and Plan	ning																													
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	Completed																											
1.6	Finalize Mechanical Design	2/15/2021	2/22/2021	Entire Team	Completed																											
2	Phase 2 : Learning, De	sign, and Impleme	entation																							-						
	Milestone 1 : Proof of Concept & Ha	ardware Obtainme	ent																													
2.1.1	Order Hardware and Mech. Parts	2/22/2021	2/22/2021	Entire Team	In Progress																											
2.1.2	Learn how to use OpenCV	2/22/2021	2/26/2021	Andy	Completed																											
2.1.3	Learn how to program iRobot	2/22/2021	2/26/2021	Hojun	Completed																											
2.1.4	Determine motion model	2/22/2021	2/26/2021	Omar	Completed																											
2.1.5	Assemble gripping mechanism	3/1/2021	3/5/2021	Hojun	in Progress																											
2.1.6	CAD robot	3/5/2021	3/12/2021	Hojun	in Progress																											
2.1.7	Reserach color detection algorithm	3/1/2021	3/12/2021	Andy	In Progress																											
2.1.8	Create Path planning algorithm	3/1/2021	3/15/2021	Omar	In Progress																											
	Milestone 2 : Basic Inte	egration																														
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 : Fu	Il 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																															
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 Rep											_			-									-					-			
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																												