A4: ShelfBuddy

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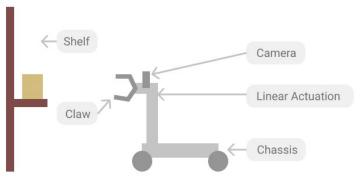
Use Case

- **Problem:** People with disabilities have difficulty accessing objects on shelves in grocery stores
 - Time consuming (Asking others for help)
 - Expensive (Paying for grocery delivery services)
- **Solution:** A robot that will retrieve an object off of a shelf when users shine a laser pointer on the object

Areas:

• Software, hardware, signals & systems





Requirements - Navigation

• Accuracy:

- \circ $\ \ \,$ # times correctly navigates from basket \rightarrow shelf / # attempts: 95%
- \circ $\ \ \,$ # times correctly navigates from shelf \rightarrow basket / # attempts: 95%
- Latency:
 - Time taken for robot to travel from basket to shelf (or vice versa): 5 sec

Technical Challenges:

- Detecting the basket and the shelf from multiple orientations
- Autonomously drive to face the basket/shelf in reasonably efficient time

Requirements - Item Recognition

- Accuracy:
 - # attempts finds pointed object correctly / # total attempts: 95%
- Latency:
 - For detecting laser point in current frame: 1 sec
 - For detecting object bounds: 2 sec
- Distance robot drives between each snapshot: 1 in
- Number of objects on shelf: 6

Technical Challenges:

- Detecting the laser and boundary in different conditions (lighting, box colors, etc.)
- Detecting the object while scanning the shelf

Requirements - Retrieval

- Dimensions (Height x Length x Depth) of shelf:
 - \circ 2 feet x 4 feet x 1 foot
- Accuracy:
 - # successful attempts / # total attempts of claw to grab an object: 95%
- Estimated width of claw:
 - 3-6 inches
- Estimated weight capacity of claw:
 - 3 pounds

Technical Challenges:

- Claw grips on object throughout entire retrieval process
- Robot is oriented correctly towards shelf so claw can grasp object
- Calculating the precise distance for robot to move forward to grad the object

Solution Approach - Navigation

- Label shelf and shopping basket with April tag for robot to detect the distance and orientation
- 4 omni-directional wheel chassis
 - 4 DC motors
 - 2 motor controllers
- Jetson Nano & Arduino Uno





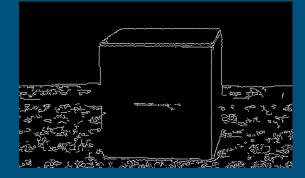
Solution Approach - Item Recognition

• Camera

- High quality of RGB detection
- High pixel resolution
- CV
 - OpenCV Canny edge detection library
 - OpenCV color detection to detect laser

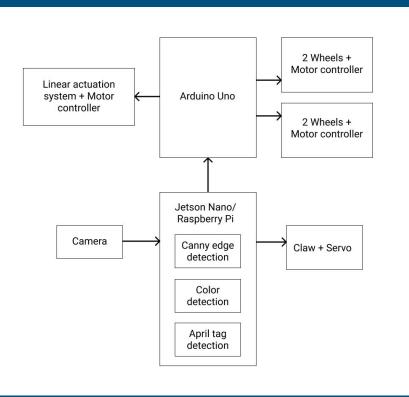
Solution Approach - Retrieval

- Linear actuation system for moving along z-axis
- Claw
 - Servo
 - Servo driver





Solution - Block Diagram



Testing, Verification, and Metrics

1) Laser and Edge Detection:

- a) Test on boxes with white background, gradually adding in different lighting conditions (dark to light colored boxes, adjust lighting environment)
- b) Detect edges/laser in 95% of tests
- 2) Robot Movement:
 - a) Verify that robot can travel across the shelf and to the basket (pass 19/20 trials)
- 3) Retrieval:
 - a) Ensure that the claw is able to retrieve a standalone object
 - b) Start with light objects (.5 lbs), gradually increasing weight to 3lbs

Testing, Verification, Metrics

- 4) Delivery:
 - a) Verify that the robot can deliver the object to correct basket using April Tag (pass 19/20 trials)
 - b) Start from close to basket, 6 in, gradually increasing distance to 3 ft
- 5) Detection while moving:
 - a) Test the stability of snapshot robot takes during each pause while scanning shelf
 - b) Configure number of pauses robot makes while scanning + camera instability
 - i) Start with more pauses every 1 inch, increase to 3+ inches

Division Of Labor

Bhumika	Ludi	Esther									
 Edge detection algorithm Laser detection algorithm April Tag detection Camera configuration and setup CV testing 	 Build wheel base system Build base of robot and connection channels Program drive system Navigation system from shelf to basket 	 Build linear actuation system Build claw system Program linear actuation and claw systems Collaborative work on navigation system 									

Color key system																													
	Team																												
	Ludi Cao																												
	Esther Jang																												
	Bhumika Kapur	r																											
	WEEK 1 (8/30)	WEEK 2 ((9/6)	WEEK 3 (9/13)	WE	EK 4 (9/20)	WE	EEK 5 (9/27)	WEE	K 6 (10/4)	WE	EK 7 (10/3	a) (a	WEEK 8 (10/18)	WEE	K 9 (10/25)) V	VEEK 10 (11/1)	WEEK 1	11 (11/8)	WE	EK 12 (1	1/15)	WEEK 13	(11/22)	WEEK	14 (11/29)
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Research																					_								
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Design Presentation																													
Interim Demo																													
Final Presentation																											1		
Navigation																													
Research wheel base and design requirements																													
Research motor / mobor board specifications																													
Desgin (CAD) physical model of robot																													
Build physical robot																													
Program drive system of robot																													
Testing of drive system																													
Impmentation for navigation system																													
Integration and incremental testing																													
Item recognition																													
Research cameras																													
Research edge detection technique																													
Research laser detection technique																													
Write edge detection algorithm																													
Write laser detection algorithm																													
Test laser detection																													
Test edge detection																													
Configure and setup camera																													
Test detection with moving camera																													
Item retrieval																													
Research linear actuation systems																													
Research claw grabbing systems																													
Design/CAD linear actuation + claw system													1																
Order Parts																													
Build linear actuation system																									_				
Build claw grabbing system																													
Program linear actuation + claw grabbing system																													
Test linear actuation system																											++++		
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Integration																				_									
Integrate together chassis and retrieval systems																													
Test integration																													
Integrate item recognition and robot systems																													
Testing of overall robot																											1 M 1		