



A4: ShelfBuddy

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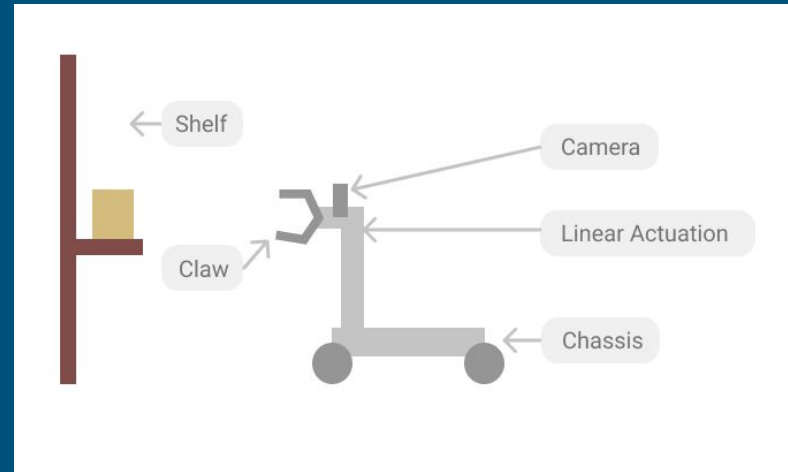
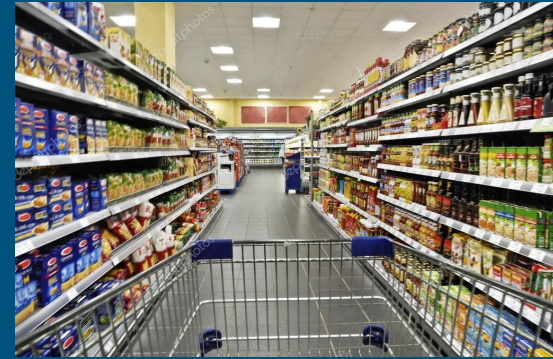


Use Case

- **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:
 - # times correctly navigates from basket → shelf / # attempts: 95%
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- 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

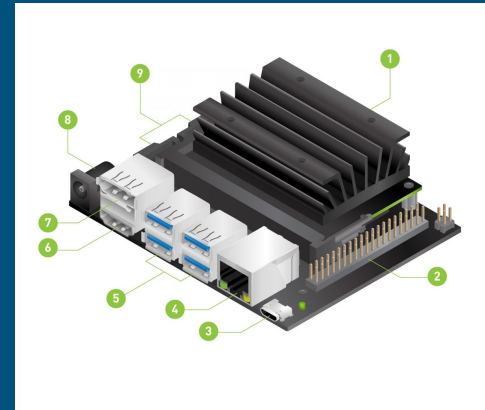
- Dimensions (Height x Length x Depth) of shelf:
 - 2 feet x 4 feet x 1 foot
- Accuracy:
 - # successful attempts / # total attempts of claw to grab an object: 95%
- Estimated width of claw:
 - 3-6 inches
- Estimated weight capacity of claw:
 - 3 pounds

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 grab 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

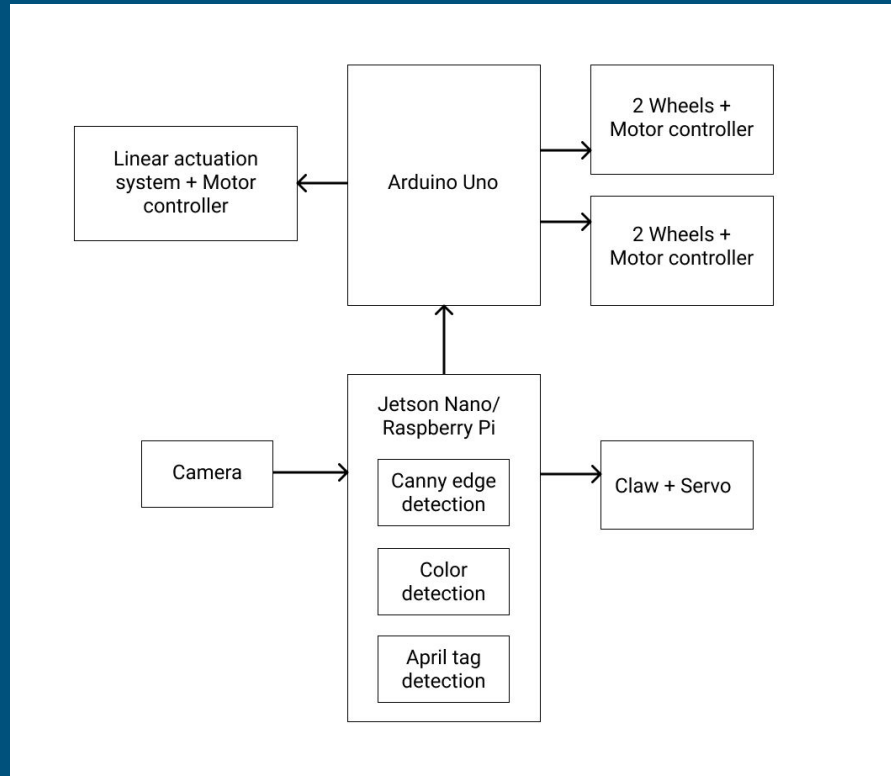


Solution Approach - Retrieval

- 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
<ul style="list-style-type: none">• Edge detection algorithm• Laser detection algorithm• April Tag detection• Camera configuration and setup• CV testing	<ul style="list-style-type: none">• Build wheel base system• Build base of robot and connection channels• Program drive system• Navigation system from shelf to basket	<ul style="list-style-type: none">• Build linear actuation system• Build claw system• Program linear actuation and claw systems• Collaborative work on navigation system

