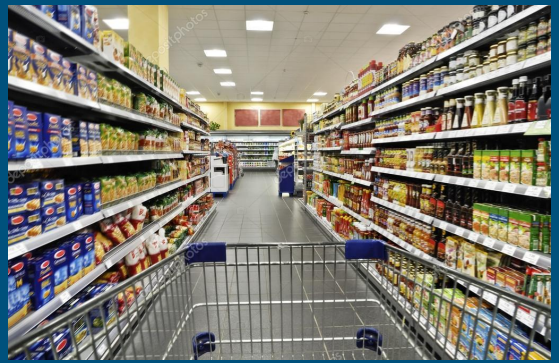
Shelf Buddy
Team A4: Bhumika Kapur, Esther Jang, Ludi Cao

Use Case:

Problem: People with disabilities have difficulty accessing objects on shelves in grocery stores

- Time consuming (Asking others for help)
- Accessibility (Paying for grocery delivery services)



Areas: Software, hardware, signals & systems

Requirements - Navigation

- Accuracy:
  - # times correctly navigates from basket → shelf / # attempts: 39/40
  - # times correctly navigates from shelf → basket / # attempts: 39/40
- Speed:
  - Speed of robot to travel from basket to shelf (or vice versa): 1m/2 sec

Requirements - Item Recognition

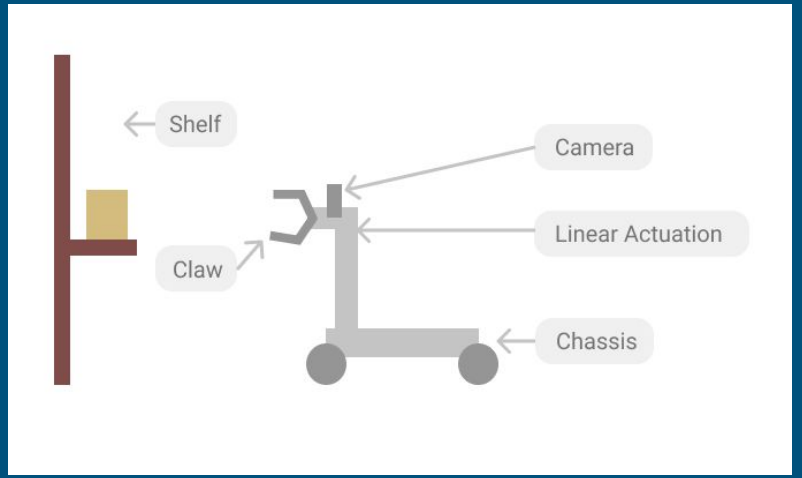
- Accuracy:
  - # attempts finds pointed object correctly / # total attempts: 19/20
- Latency of processing snapshot:
  - Unselected object: 1 sec
  - Selected object: 3 sec
- Distance robot drives between each snapshot: 1 in
- Distance between objects on shelf: 2 in

Requirements - Retrieval

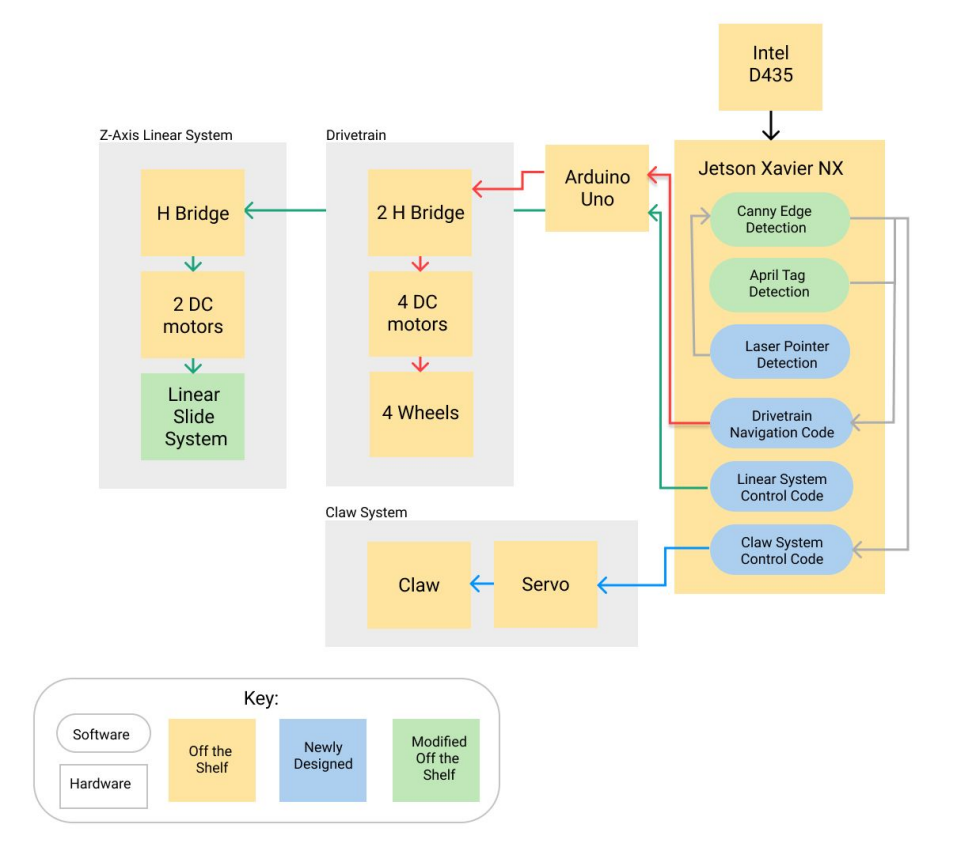
- Dimensions (Height x Length x Depth) of shelf:
  - 3 feet x 4 feet x 1 foot
- Accuracy:
  - # successful attempts / # total attempts of claw to grab an object: 19/20
- Estimated width of claw:
  - 3-6 inches
- Estimated weight capacity of claw:
  - 1.5 pounds

Solution Approach

- We plan on building a small autonomous robot that can navigate from the user to the shelf
- It can then scan the shelf and pick the object the user is pointing the laser at with the claw
- Once the robot has the object, it would navigate back to the user and drop it off into the user’s basket



Block Diagram



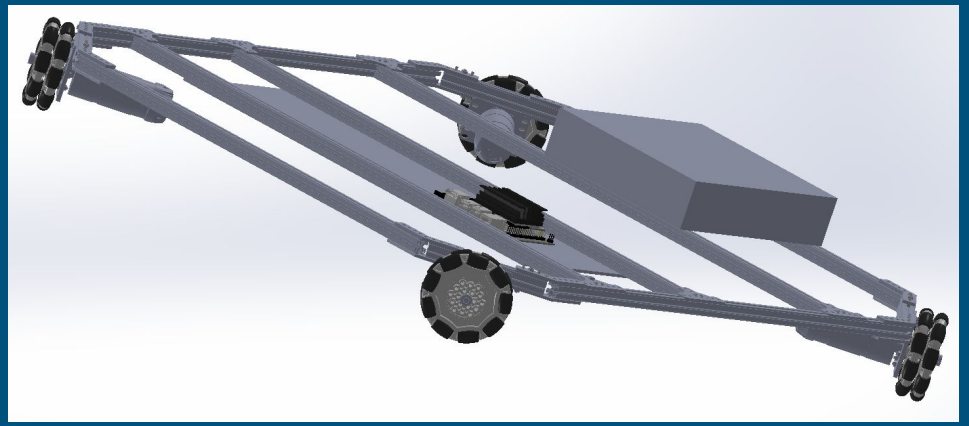
Implementation Plan - Wheel Base

Omniwheel Drivetrain:

- Easier for robot to move in multiple directions

Infrastructure

- Design chassis from parts ordered from single vendor

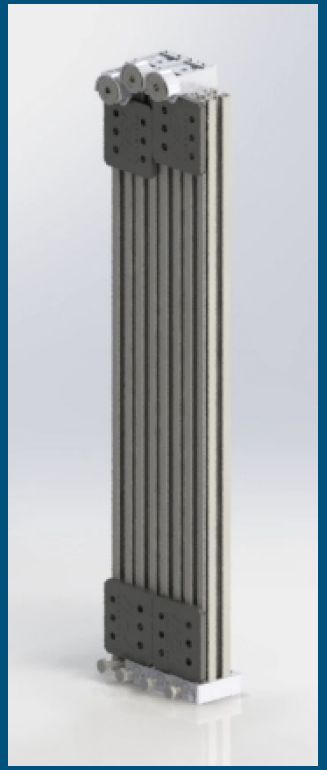


Implementation Plan - Item Recognition

- Intel D435 depth and tracking camera
  - For high resolution and depth information
- April Tags + April Tag Software
- Canny edge detection
- Laser detection CV

Implementation Plan-Retrieval

- Servo-controlled claw system
  - Did not use vacuum suction gripping system due to limited availability
- Motor-powered pulley linear slide system
  - Allow robot to occupy smaller area of space when not in use



Metrics and Validation

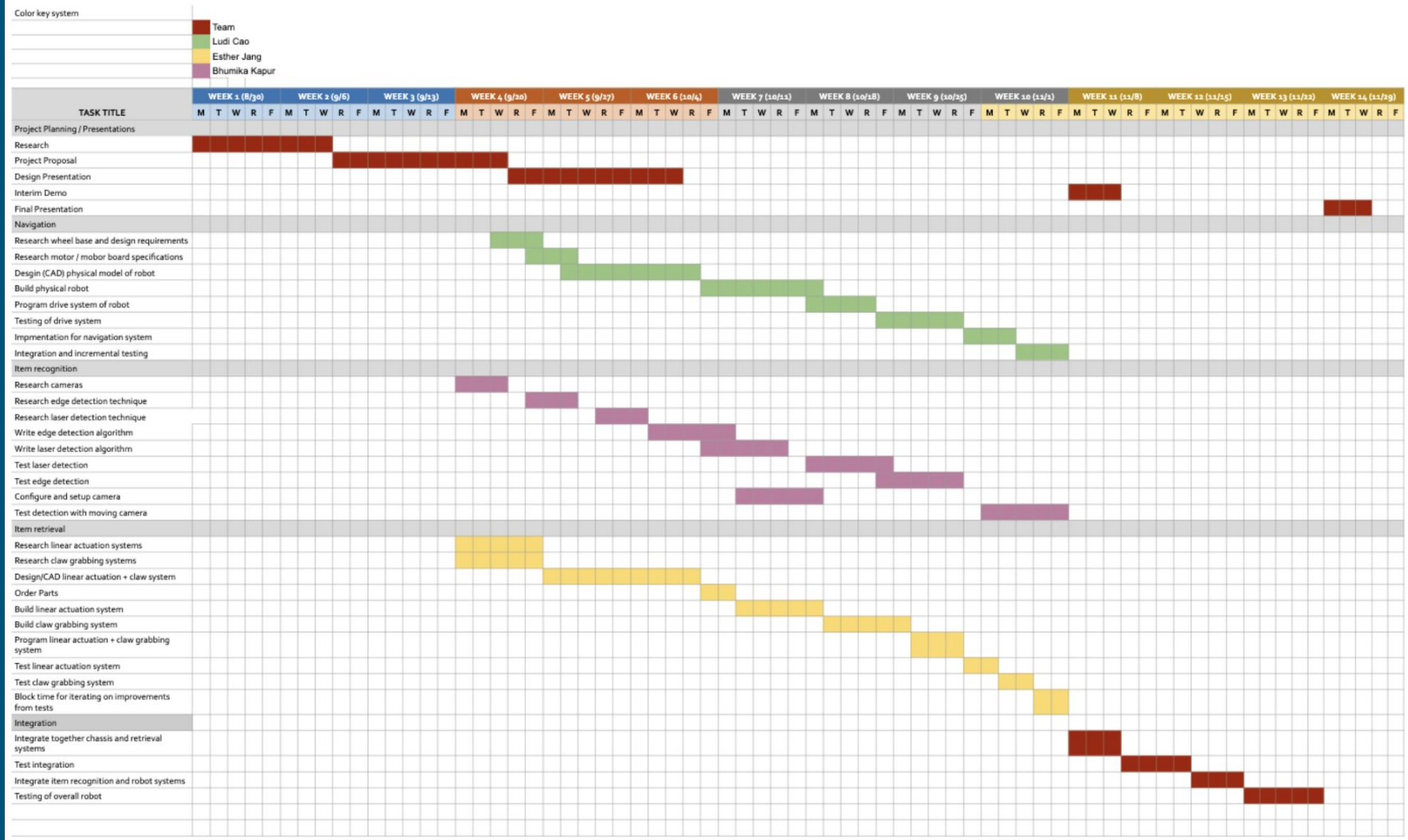
Requirements	Metrics	Test Plan
Navigation accuracy	97%	40 trials: shelf → basket→ shelf Error Rate: 1 trial
Navigation speed	1m/2s	Measure time for robot to navigate from shelf from various distances
Item recognition accuracy	95%	20 trials of laser pointing to object and detects object Error rate: 1 trial
Snapshot processing latency	1s for unselected object 3s for selected object	Feed a snapshot of the shelf to robot and record average time taken

Metrics and Validation Cont.

Requirements	Metrics	Test Plan
Gripping ability of various object (sizes + weights)	Width: 3-6 in Weight capacity: 1.5 lbs	Record whether robot can continue gripping object while navigating
Initial grabbing accuracy	95%	20 trials of claw reaching in the shelf to grab a detected object Error rate: 1 trial

Risk Mitigation

Risk	Mitigation
Laser cannot be detected	Robot makes several interval stops while scanning Use a larger / brighter light source
Claw cannot grab or hold onto object	Add material with high coefficient of friction to gripper Use target objects that are claw-friendly in shape
Robot cannot navigate to goal position	Add additional April Tags to environment


Color key system
Team
Ludi Cao
Esther Jang
Bhumika Kapur
TASK TITLE
WEEK 1 (8/30)
WEEK 2 (9/6)
WEEK 3 (9/13)
WEEK 4 (9/20)
WEEK 5 (9/27)
WEEK 6 (10/4)
WEEK 7 (10/11)
WEEK 8 (10/18)
WEEK 9 (10/25)
WEEK 10 (11/1)
WEEK 11 (11/8)
WEEK 12 (11/15)
WEEK 13 (11/22)
WEEK 14 (11/29)
M T W R F
Project Planning / Presentations
Research
Project Proposal
Design Presentation
Interim Demo
Final Presentation
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
Order Parts
Build linear actuation system
Build claw grabbing system
Program linear actuation + claw grabbing system
Test linear actuation system
Test claw grabbing system
Block time for iterating on improvements from tests
Integration
Integrate together chassis and retrieval systems
Test integration
Integrate item recognition and robot systems
Testing of overall robot