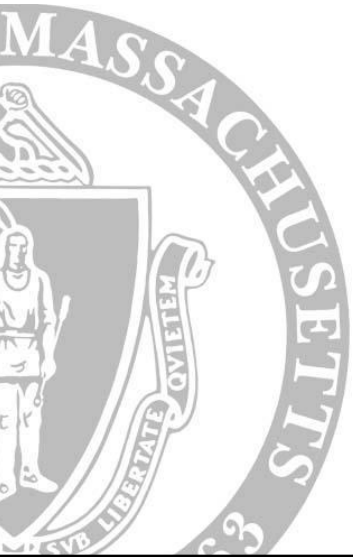


Comprehensive Design Review

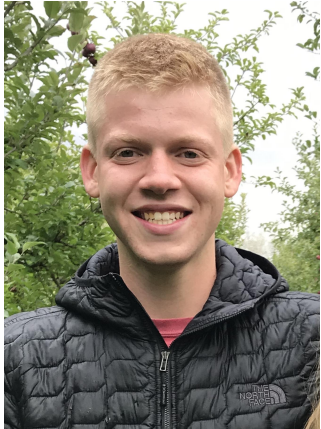
Team 14

Dan Emerson, James Finn,
Harrison Liu, Long Nguyen

Advisor: Professor Holcomb



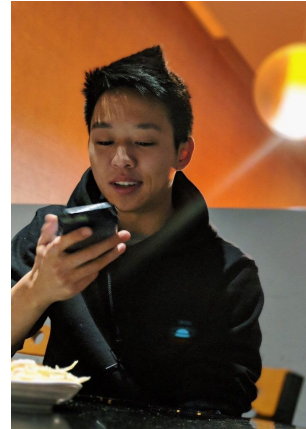
Team 14



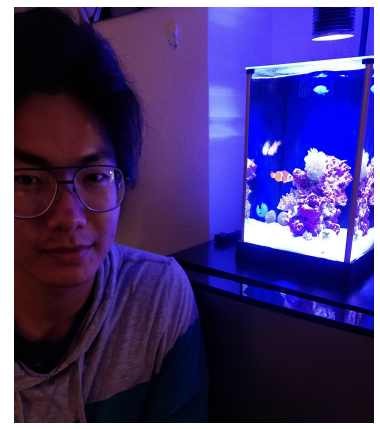
Dan Emerson
ME



James Finn
CSE



Harrison Liu
CSE



Long Nguyen
CSE

Problem Statement

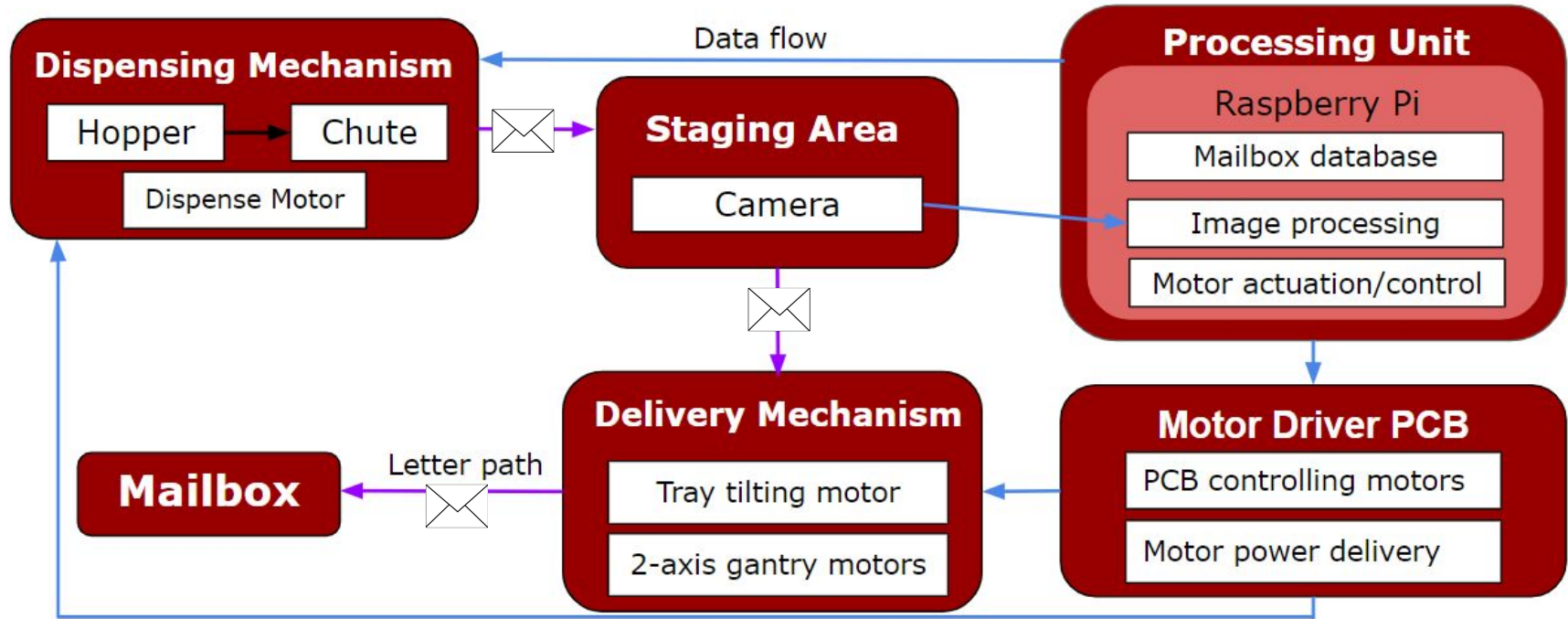
Sorting mail is a mundane and routine task that can be significantly enhanced through automation. Automation would improve the cost efficiency compared to a traditional mail carrier.

Currently there are no automated last-mile delivery implementations available on the market. We plan to fulfill this gap by designing a small scale automatic mail sorter for individual office mailbox arrays.

System Specifications

1. Support standard envelope size of 4 $\frac{1}{8}$ in x 9 $\frac{1}{2}$ in
2. Hopper dispenses exactly 1 letter to be processed with 95% accuracy
3. Identify correct letter destination by reading with 99% accuracy (QR/typed/handwritten)
4. Deliver letter into correct mailbox by tilting mechanism with 95% accuracy
5. Capable of sorting 1,000 letters per day

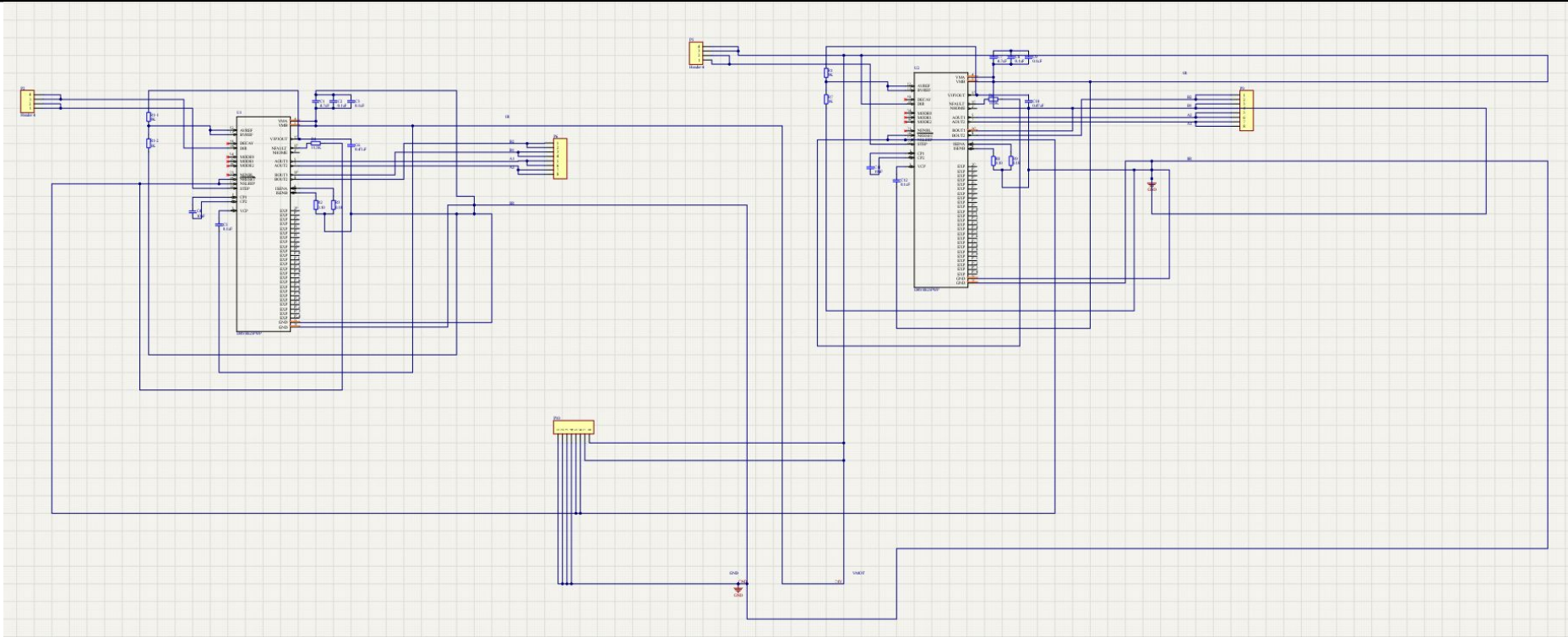
Block Diagram



CDR Deliverables

1. Identify correct letter destination by reading typed fonts
2. Deliver letters to mailboxes across 2-axes
3. Establish and fabricate housing location for Raspberry Pi and camera
4. Implement motor driving circuit on PCB
5. Implement tray tilting mechanism that deposits letter into box

Motor Driver PCB



Motor Driver PCB

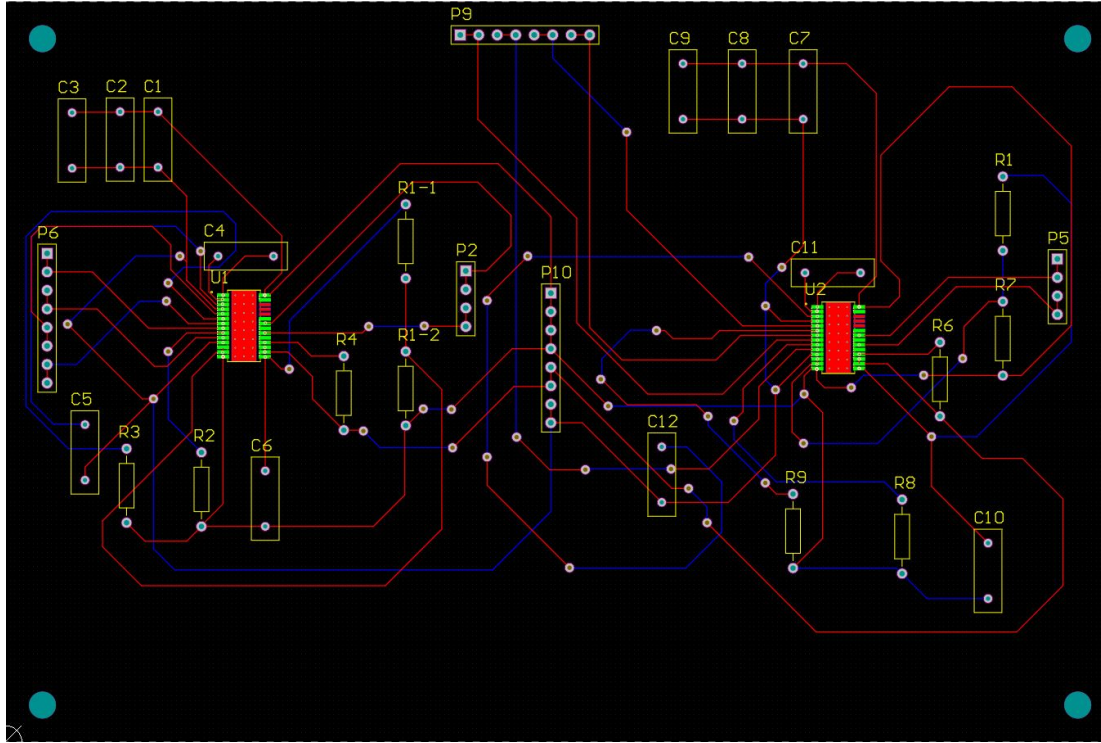


Image Processing

- Using a Raspberry Pi camera v2, takes picture of envelope with the picamera and time libraries
- OpenCV and Tesseract OCR are used to process the image, detect the text, and read it
- First, the image is preprocessed through cropping and downsampling to remove excess pixels
- Then uses a deep learning-based text detector (EAST: Efficient and Accurate Scene Text detector) to locate the region of text
- Loops through bounded region and pad area of interest
- Feed padded area to image_to_string function which returns recognized text

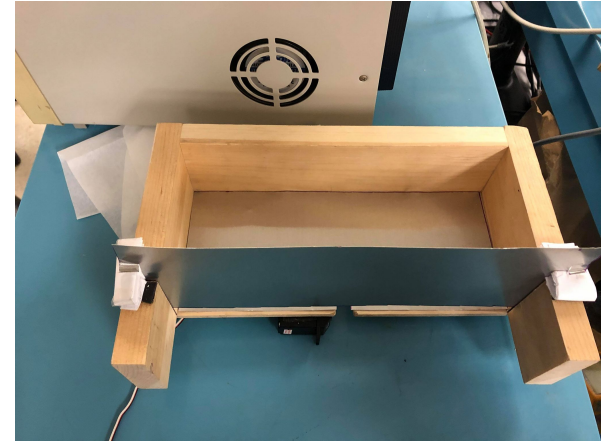
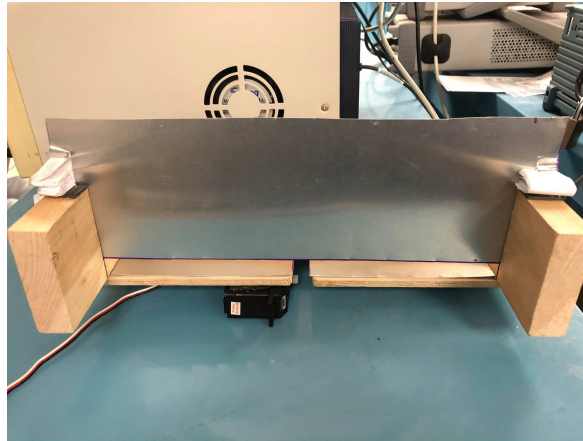
Processing Speed

Sans serif fonts are standard for USPS printing labels. Tested in Arial and Times New Roman across varying sizes (16-48pt)

Image Processing Implementation	Raspberry Pi Version	Average Address Processing Time (Across 20 trials)
Barcode	3	20.5 seconds
Barcode	4	3.6 seconds
Typed text	4	10.7 seconds
Typed text + preprocessing	4	8.1 seconds

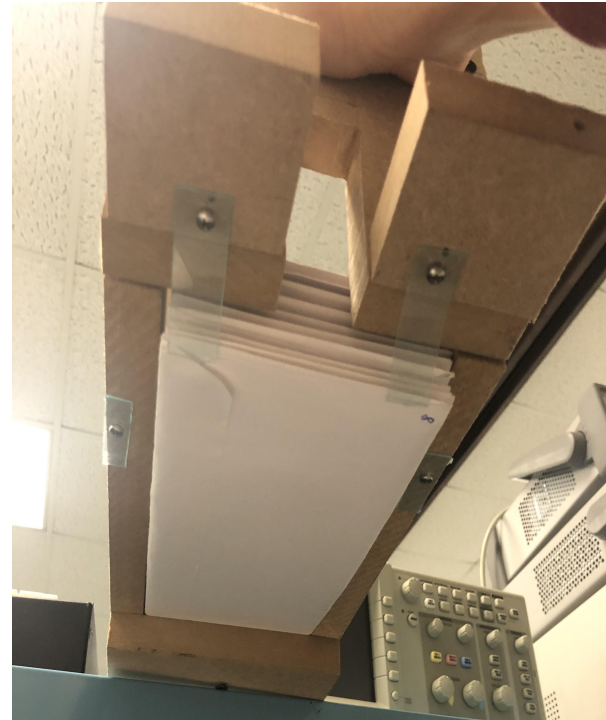
Dispense Mechanism V1

- V1: Wheel pulls letter under fixed gate, long side forward
 - Letters unbalanced
 - Prone to jamming or dispensing 2 letters at once



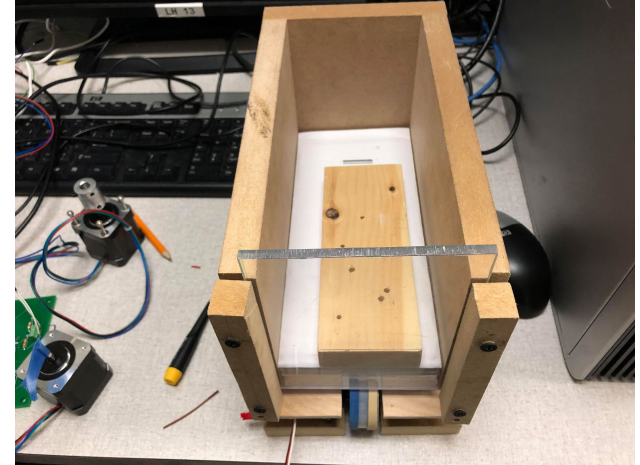
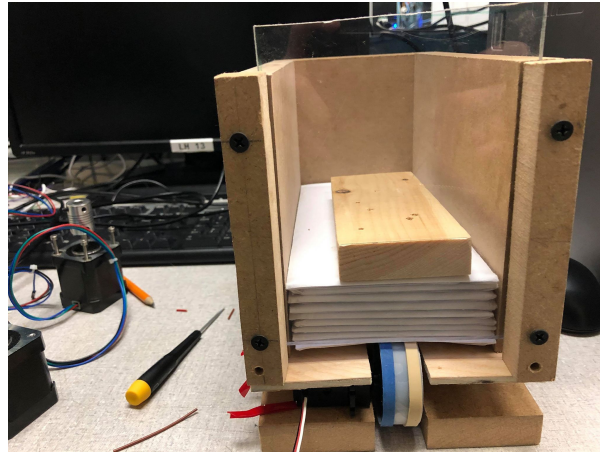
Dispense Mechanism V2

- V2: Compliant Mechanism, letters rest on stack, pull through with motor
 - Difficult to grab only bottom letter
 - Dependent on weight of stack



Dispense Mechanism V3

- V3: V1 → Thicken wheel, orient short side forward, rigid gate, keep weight on top of stack \sim constant



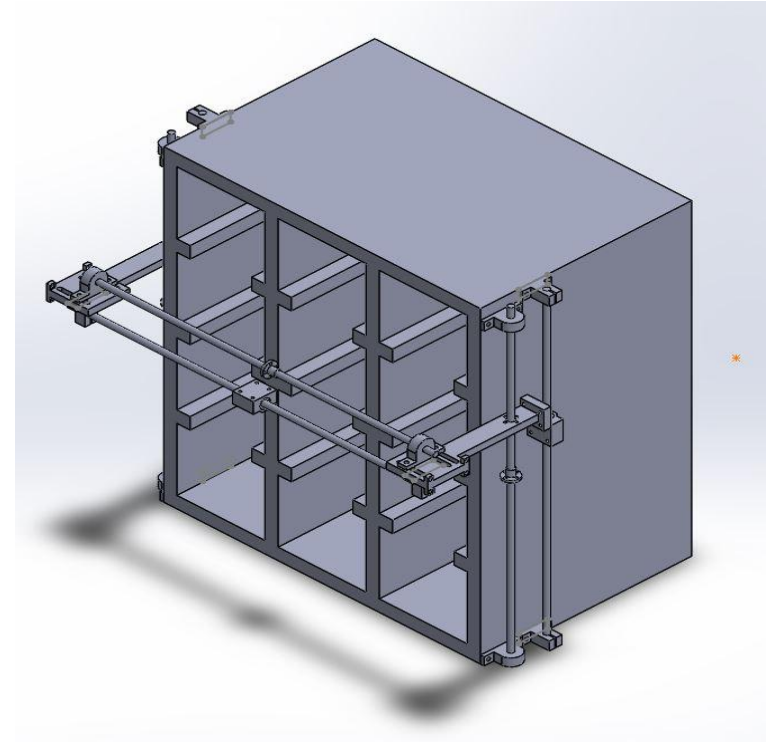
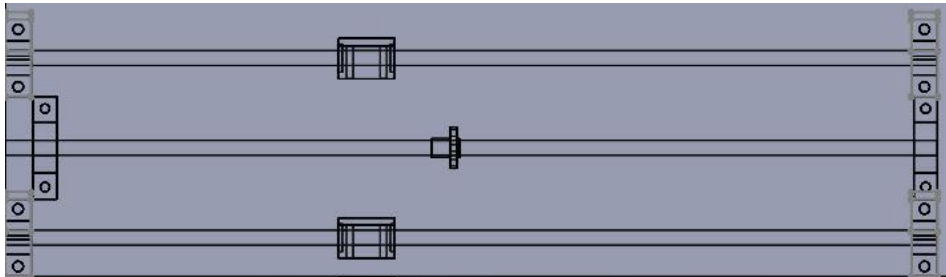
Dispense Mechanism

- V1: Wheel pulls letter under fixed gate, long side forward
 - Letters unbalanced
 - Prone to jamming or dispensing 2 letters at once
- V2: Compliant Mechanism, letters rest on stack, pull through with motor
 - Difficult to grab only bottom letter
 - Dependent on weight of stack
- V3: V1 → Thicken wheel, orient short side forward, keep weight on top of stack \sim constant

Dispense Mechanism Version	Accuracy in Dispensing Exactly 1 Letter (Across 20 trials)
V1	80%
V2	67%
V3	95%

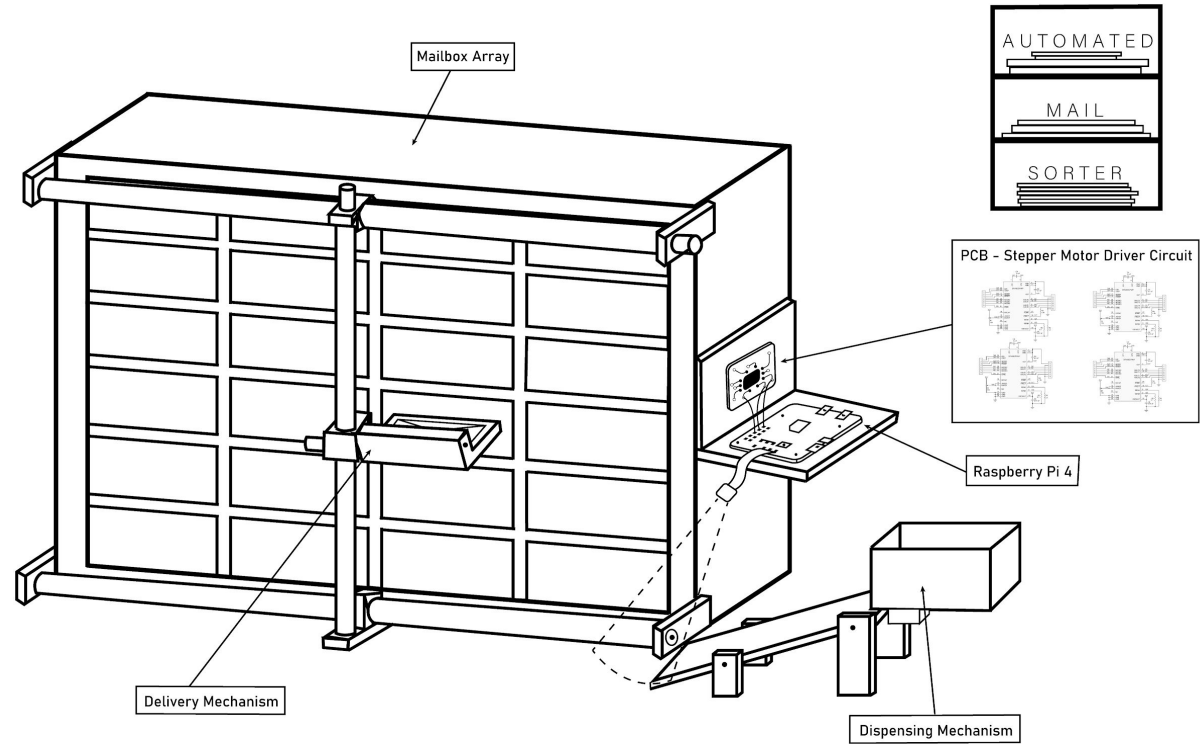
2 Axis Gantry

- Implemented horizontal and vertical axes
- 2 lead screws needed, one on each side of vertical gantry
 - High weight of horizontal stage weights down the vertical axis
 - Uneven torque lead screw of vertical stage
 - Rails on each side of lead screw help even out torque on stepper motors



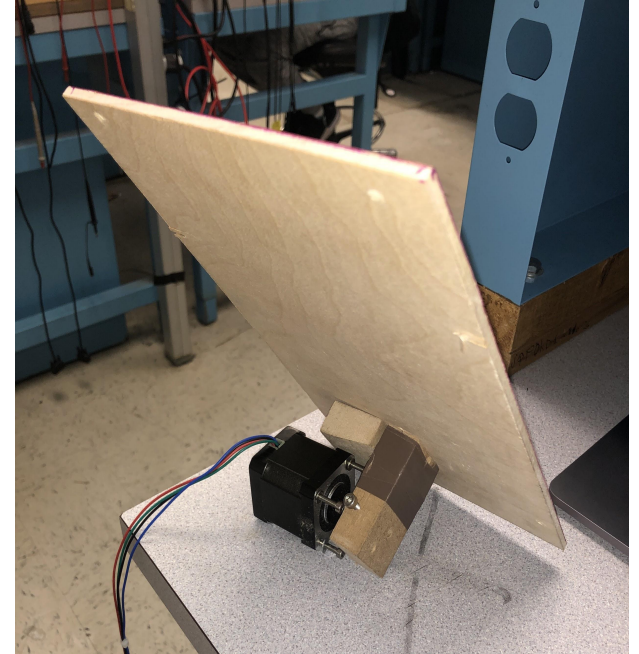
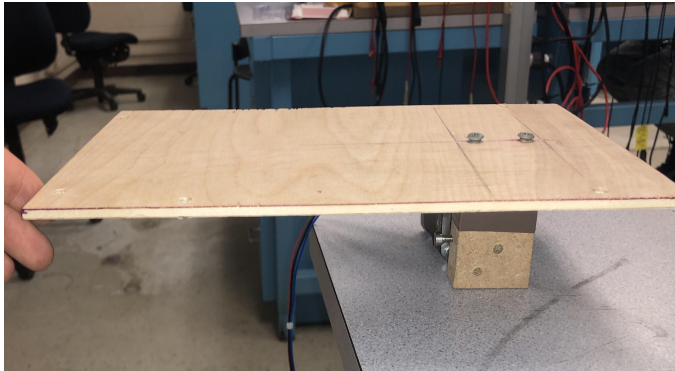
Alternative 2 Axis Gantry

- Switch double beams to horizontal axis.
- Less load on vertical axis.
- Need to raise mailbox on stilts to mount horizontal lead screw and rails on underside.
- More natural position for tilt tray



Delivery Mechanism

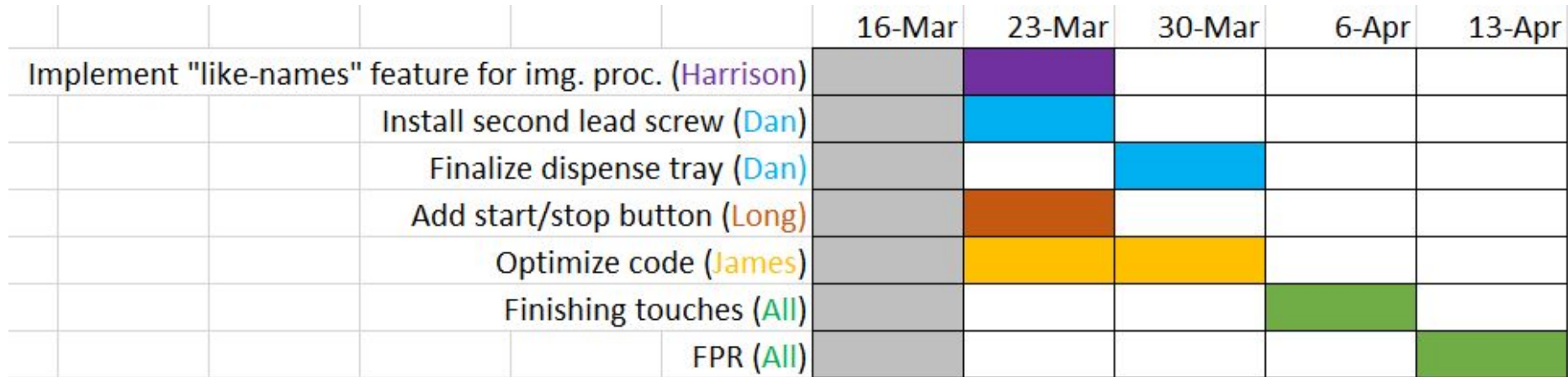
- Holding torque of stepper motors not strong enough to support off center mount
- Lightest delivery tray could hold equilibrium but could not reset position after delivering letter
- Plan: Implement dispense mechanism style wheel to push letter into mailbox rather than tipping



FPR Specifications

1. Support standard envelope size of 4 $\frac{1}{8}$ in x 9 $\frac{1}{2}$ in
2. Hopper dispenses exactly 1 letter to be processed with 95% accuracy
3. Identify correct letter destination by reading with 99% accuracy (QR/typed/handwritten)
4. Deliver letter into correct mailbox by tilting mechanism with 95% accuracy
5. Capable of sorting 1,000 letters per day

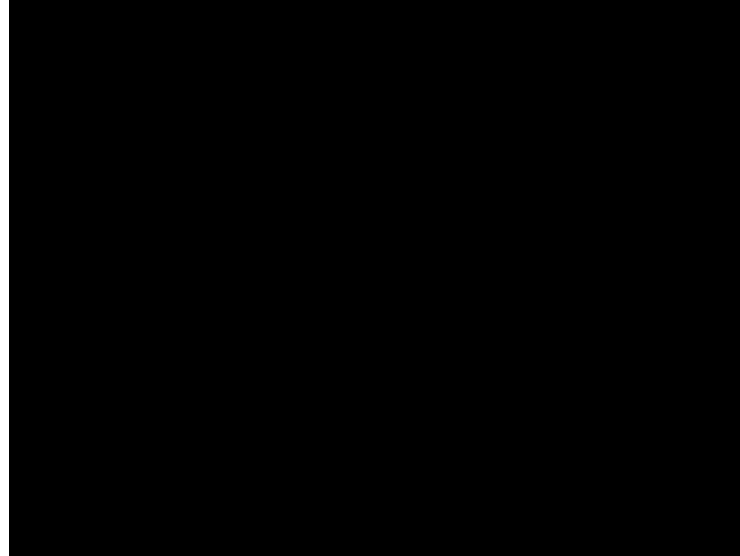
Gantt Chart

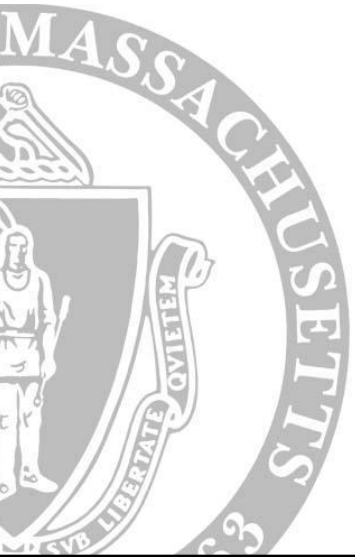




Demo

Demo Video





Questions?