

# Letter Shredder: Automatic Mail Sorting System

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## PROBLEM AND SOLUTION

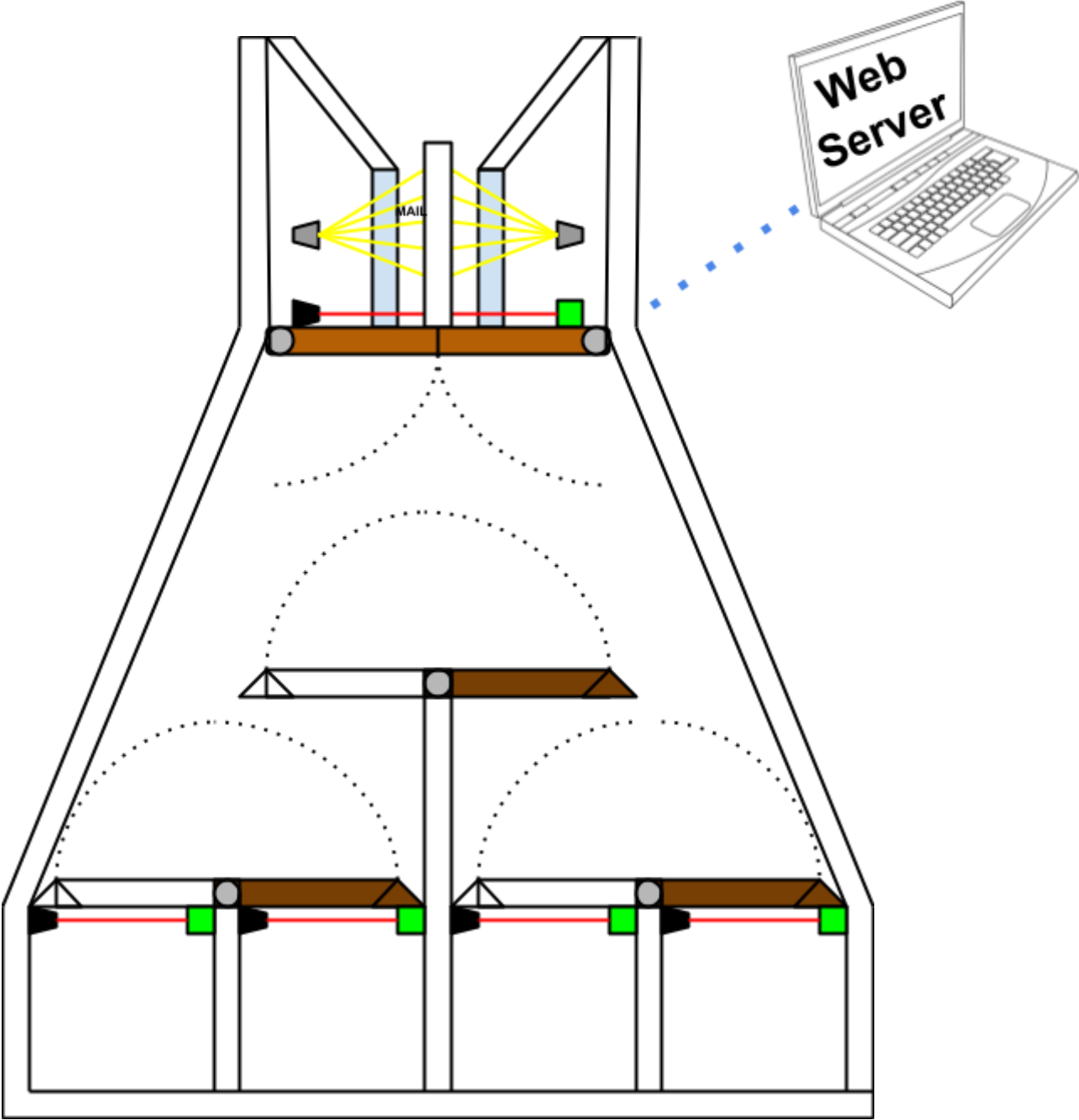
It is common for many residents to encounter mail that does not belong to them from prior tenants. The mail may contain personal information about that tenant that could risk security threats and negative legal implications. There are also many occasions where tenants currently living in apartments get unwanted mail from senders they would like to blacklist, or from advertisers. Moreover, in apartment complexes with many mailboxes for each resident, mail delivery workers have to tediously open and close every mailbox that receives mail. In some cases, the mail rooms in the apartment complexes have no option to selectively open and close individual mailboxes. Instead, there is a universal open button that opens up all the mailboxes at once giving thieves and vandals an opening to act. This has happened many times around the country. For instance, at a luxury apartment complex in Ooltewah, mail hasn't been delivered due to an "hostile environment" whenever the mail delivery worker arrives to deliver the mail.<sup>1</sup> This project can greatly decrease the time and resources taken to deliver mail by efficiently and effectively completing the task.

We propose a mail sorter and shredder that would organize mail based on the names of the tenants and the senders that are allowed/blacklisted from the mail system. Names on the allowlist are sorted into the respective bins. Blacklisted names are sent to the shredder. This would be done by scanning the mail, extracting the necessary information from the labels of the mail, and comparing all features to determine bin placement.

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<sup>1</sup>Ptimesadmin2015. "Post Office Says It Will Stop Delivering Mail to Luxury Ooltewah Apartment Complex; Cites 'Hostile Environment.'" Postal Times, 18 Aug. 2022, [postaltimes.com/postalnews/post-office-says-it-will-stop-delivering-mail-to-luxury-ooltewah-apartment-complex-cites-hostile-environment](https://postaltimes.com/postalnews/post-office-says-it-will-stop-delivering-mail-to-luxury-ooltewah-apartment-complex-cites-hostile-environment).

# VISUAL AID

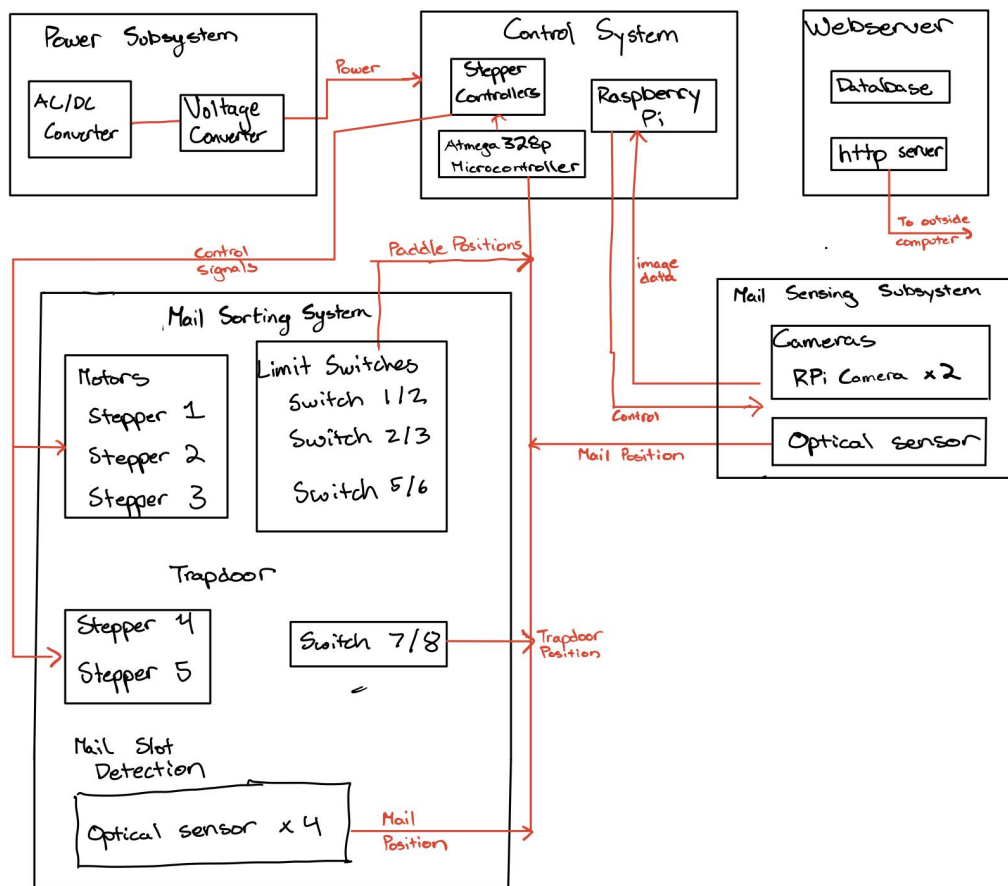


# HIGH-LEVEL REQUIREMENTS LIST

- Mail sorter can read mail and correctly sort into mailboxes based on the necessary information extracted like addresses/names from images of mail.
- Mail sorter settings can be set remotely
- Mail sorter can dispose of mail that doesn't fit the requirements necessary for any of the mailboxes

## DESIGN

### Block Diagram



## Power

The sorter will be powered through a 12v wall plug. The voltage will need to be adjusted for the small electronics, and the full 12 volts must be available to the motors and their drivers.

## Control

The microcontroller will send control signals to the motor drivers and read from the various sensors in the sorter. It will communicate over UART to the raspberry pi which runs the image analysis and hosts the webserver. The raspberry pi will tell the microcontroller which paddles to move, and the microcontroller will tell the rpi when to take a picture.

## Webserver

The webserver, hosted on the raspberry pi, is how users can set filters and monitor the sorter. It will also store pictures of all the mail processed through the sorter.

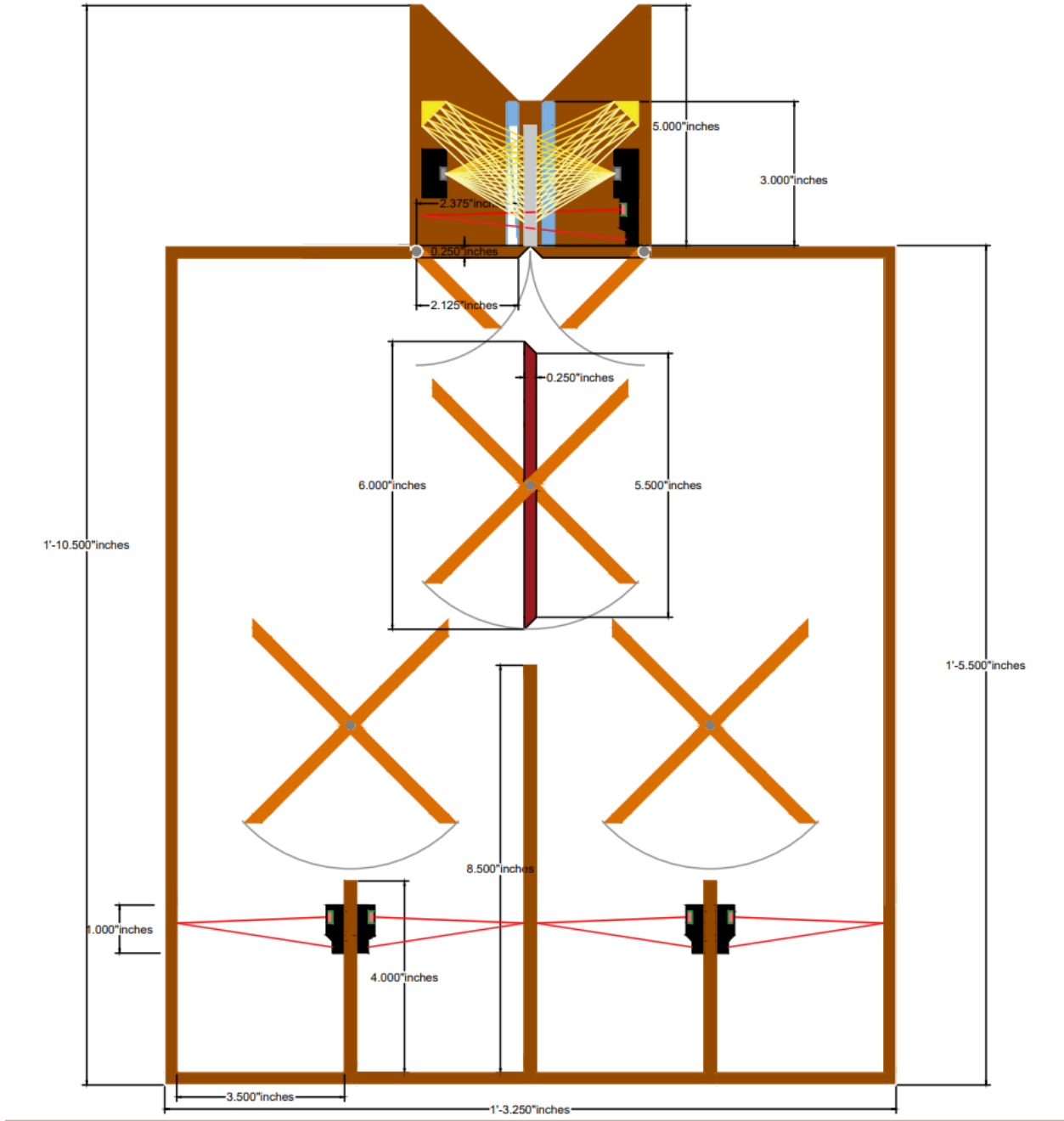
## Mail Sorting

The paddles that control where the mail falls are controlled by stepper motors. They receive their instructions from the control unit. Limit switches are placed at the desired paddle angles for safety, and allow the microcontroller to guarantee the position of the paddles.

## Mail Sensing

To read any information on both sides of the mail, 2 raspberry pi cameras will communicate with the raspberry pi. When the mail is in the slot and ready to scan, the laser break sensor will signal the microcontroller.

# PHYSICAL DESIGN



For our physical design, the overall build will be composed of wood with a base dimension of 22.5 inches x 15.25 inches. The front of the apparatus will be covered with a see-through acrylic or plastic to be able to see the workings of the motorized parts and to make debugging much simpler. At the entryway of the mail, there will be a 0.5 inch opening to fit the size of our mail and have it sit upright for the picture to be taken properly. At the bottom, on both sides of each

mailbox, there will be a 1 inch gap saved for the sensors to be placed. As can be seen in the diagram, there is more than enough space in the corners of the module to fit the power source input, and raspberry pi. This setup will include at least 5 inches of space in length to support wiring between the components

## **SUBSYSTEM 1: MAIL RECOGNITION/DETECTOR**

This component will consist of an optical switch connected to the main control unit that will determine if mail is placed properly in the scanner. It will also contain 2 cameras and light sources to capture images of both sides of the mail.

### **Requirements:**

Two standard definition cameras and lighting sources should capture an image given a control signal and send the data from these cameras to the main control unit for processing.

The optical sensor must be capable of detecting when mail has entered the scanning peripheral, and send the appropriate signal to the control unit.

### **Tolerance Analysis:**

The main issue that may arise from this subsystem is the accuracy of the image to text converter. We may have to rely on pre-trained parameters from prior research to determine the letters and numbers hand written on mail items accurately.

## **SUBSYSTEM 2: CONTROL UNIT**

Controls the image capturing of the camera based on the optical switch, and runs an OCR to determine the sender and receiver from the printed or handwritten text. It will then compare the data to names/aliases within a local database to determine the destination of the mail being processed. It will also host the web server that can allow the host to append or change the database externally. Further, it will send control signals to different electric motors in the organization system.

### **Requirements:**

The raspberry pi will be the main source of control signals for the entire system. It should be able to load and store the data coming from the cameras and optical subsystem and send the appropriate signals to these systems for camera capturing and motor controls. Based on the name and references from the database, it should create an operational code for the motors controlling the direction faced by the paddles in the mail sorting system.

The raspberry pi should host a webserver that will interact with this database to update the names of the users that are meant to receive the mail along with the destinations in terms of the mailbox number. It should also be able to update and modify the blacklisted senders for each of the users dynamically to allow user control for mail.

## **SUBSYSTEM 3: MAIL SORTING SYSTEM**

This is the physical system that controls the directional movement of the documents such that it reaches the intended destination.

### **Requirements:**

This subsystem will consist of multiple paddles along with a dropoff chute for the mail once it has been scanned. The main requirement of the motor dropoff is that it only releases the mail once it has been successfully scanned, and when the paddles are in the precise orientation that allows the mail to enter its respective box. The paddles must allow for consistent routing to the appropriate boxes, even under a significant load.

### **Tolerance:**

This subsystem may fail mechanically due to the physical limitations of the materials used to construct the sorter. If there are any unwanted gaps in the system for the mail to fall into the wrong chute, it may diminish the use of our system. This can be mitigated through design choices and calibration of the motors controlling the paddles/latches. We will also have to run tests for the optimal timing of the mail release and paddle movement.

## **SUBSYSTEM 4: POWER SUBSYSTEM**

This is the subsystem that will provide the power for the entire project.

### **Requirements:**

This subsystem must be able to take in power from an AC to DC converter connected to an outlet. The voltage and energy provided from this converter must be enough to provide stable power to all the components, along with the appropriate voltages needed by any of the devices.

## **COST AND SCHEDULE**

Hourly Rate: \$20/hr

Estimated Hours to complete: 100 hrs

Labor Cost:  $\$20 \times 2.5 \times 100 = \$5,000$

Parts:

Raspberry Pi	1	\$135	Image analysis + Webserver
Pi Camera	2	\$15	Image analysis
ATMega328p Microcontroller	1	\$3	Main Control Unit
Stepper Motor Controller L298N	4	\$10	Motor Control Unit
Stepper Motor	4	\$11	Motor Control Unit
Laser Break Sensor ADA2169 x5	4	\$10	Main Control Unit
¼" Plywood	1	\$20	Physical Construction
¼" Acrylic	1	\$20	Physical Construction
3.5x5 Envelopes (100 pack)	1	\$11	Testing

Parts total cost: \$343

Project Total Cost (Labor + Parts): \$5343

#### Schedule

- Design Dimensioning + Verification w/ Machine Shop - Week of 2/27
- Design PCB - Week of 3/6
- Buy parts for Image Analysis+Testing - Week of 3/6
- Write code for image analysis and categorization - Week of 3/20
- Create Web Server - Week of 3/20
- Buy parts for Main Control Unit + Motor Control Unit - Week of 3/20
- Interface Microcontroller with Stepper Motors and Laser Break Sensors - Week of 3/20
- Test integration of Raspberry Pi with Microcontroller - Week of 4/3
- Integrate Prototype with Build from Machine Shop - Week of 4/10
- Prepare Demo - Week of 4/10



# DISCUSSION OF ETHICS AND SAFETY

We believe that this project is fairly ethical, safe to the public and is beneficial for everyone involved. Referencing the IEEE Code of Ethics, our project would comply with all of the requirements, however, we can see some possible violations if this project is carried out as intended. The first foreseeable issue comes into play when unauthorized users try to access the residents' private data from our database such as name, address, and the photos of the mail received. Another similar issue can arise as an unauthorized user could change the dataset for residents in terms of what mail they block and receive. This could be a possible violation of the IEEE Code of Ethics Section I-1<sup>2</sup>. We strive for our project to be non-discriminatory, lawful, and well-cited. Overall, we seek to create a product that can be efficient and helpful for mail industry workers.

We see no physical safety concerns in regard to this machine other than general concern for the in-wall plug. General wall power safety measures should be taken when plugging the machine into the wall and keeping wall sockets out of reach of children. The only openings accessible to the customer would be the mailbox slots and which are safe and have no hazardous parts in them. The entry point of the mail would only be big enough for the width of the mail causing no concern for the person inserting the mail into the machine.

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<sup>2</sup> IEEE. "IEEE Code of Ethics." IEEE, Institute of Electronics and Electrical Engineers, <https://www.ieee.org/about/corporate/governance/p7-8.html>.