CDR Presentation: **Red Owl Book Organization Tool**

Group 15

Meet the Team

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Overview

01 Introduction

02 Requirements

03 Implementation

04 Device and Component Selection

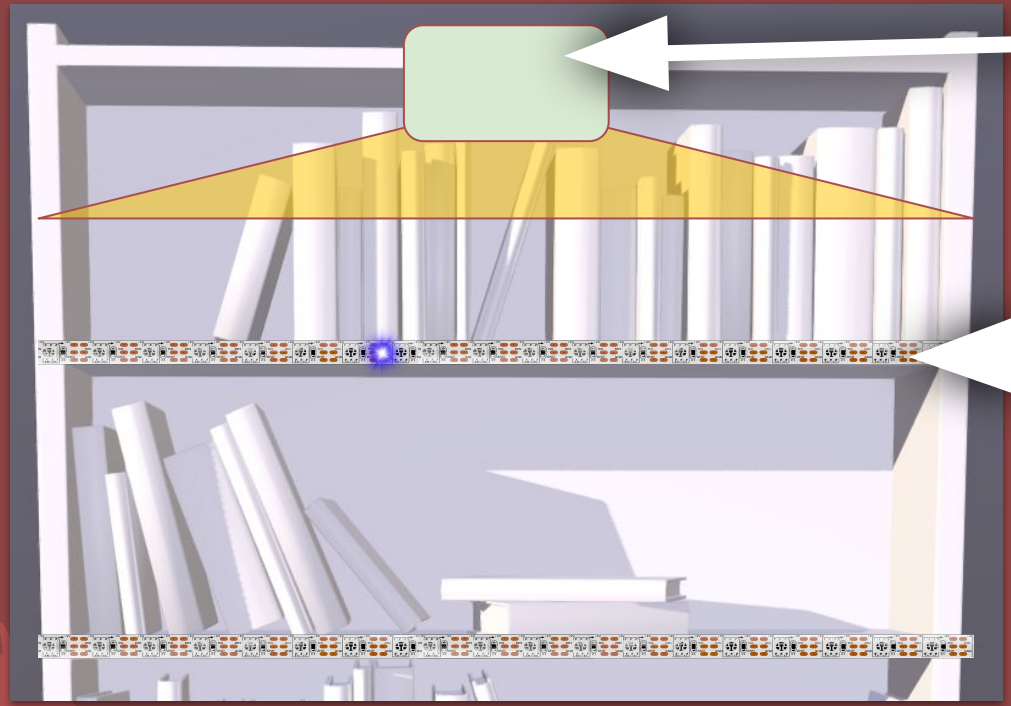
05 Successes and Difficulties

06 Budget and Planning

01

Introduction

What does ROBOT look like?



Camera with wide angle view of shelf width

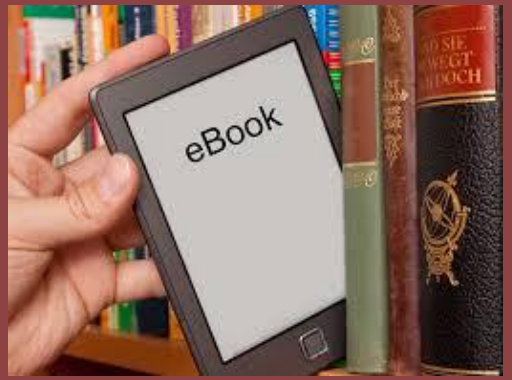
LEDs to track book locations

02

REQUIREMENTS AND SPECIFICATIONS

Project Motivation

- Public libraries and physical book retailers have been decreasing in popularity in recent years
- Digitization and pirating has decreased need for physical books
- People seek services that are “place and go”
- We feel making the process of checking books out more “virtual” would encourage more people to visit such places



Goals and Objectives

Inventory Organization

Help to automatically update location of books, if they are checked out, and when they were last seen.

Check-in Management

Make it simple for librarians and users to determine when a book is checked out and needs to be returned. Also help to find books on shelves easier through the use of LEDs.

Theft Prevention

By live updating and tracking books, items can quickly be flagged with suspicious activity.

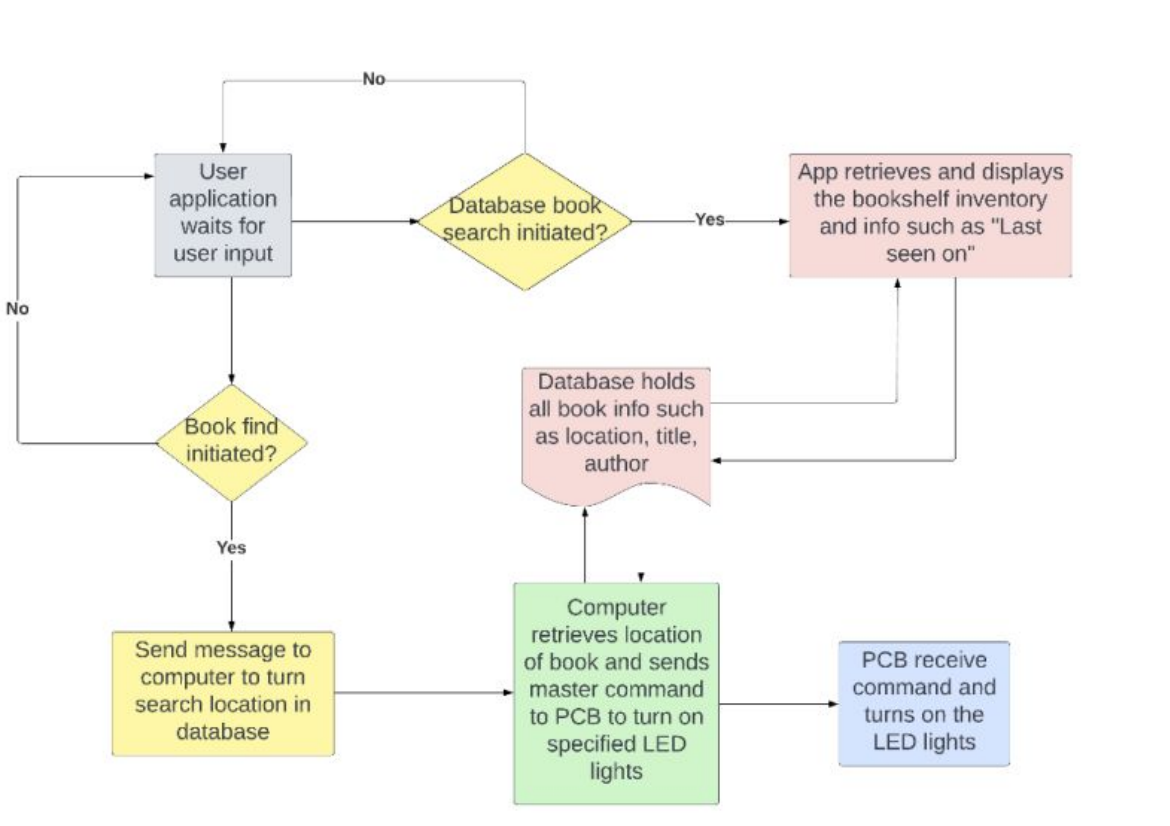
Engineering Specifications

Accuracy of detection of books titles on shelf	≥ 90%
Accuracy of book location detection on shelf	≥ 90%
Database will update within a reasonable amount of time	≤ 10 seconds
Ability to maintain a fair amount of books	≥ 30 books
Low power consumption when all features are in use	≤ 30 watts

03

IMPLEMENTATION

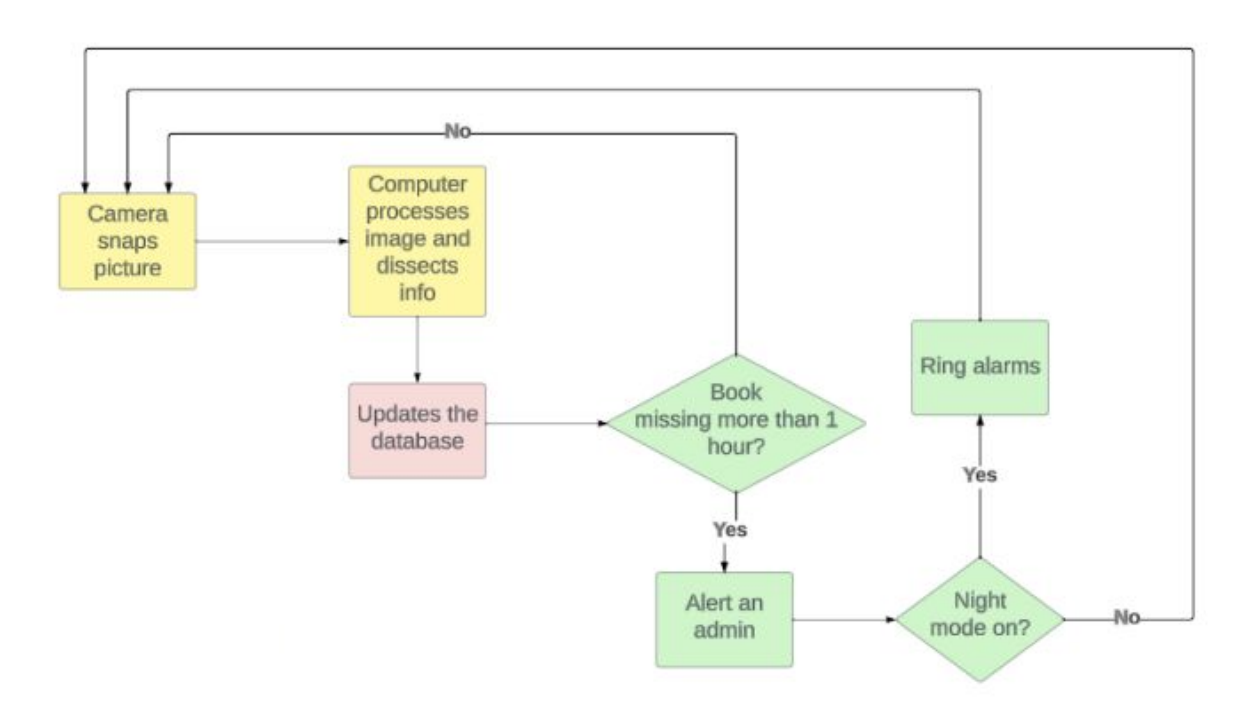
Overall System Implementation



Main three components of system:

- Jetson Nano
- Application
- Custom PCB

Software Interactions



Interactions between the computer vision, embedded, application, and database software

Application & Database

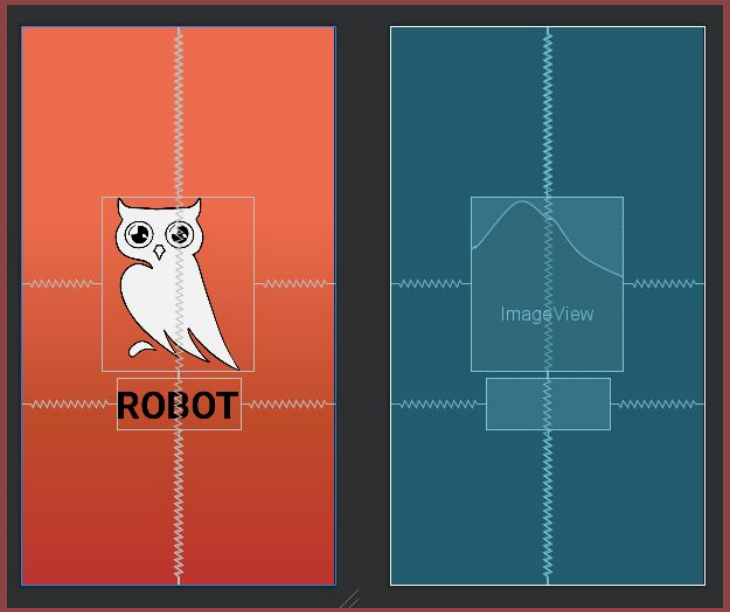
- Using Android Studio with Firebase to implement application
- Learning Kotlin and Android Studio through Udemy
- Currently building intro screen, logos, and implementation of user sign up and login
- Testing on a Samsung Galaxy S8
- Adobe Illustrator used for vectorizing images

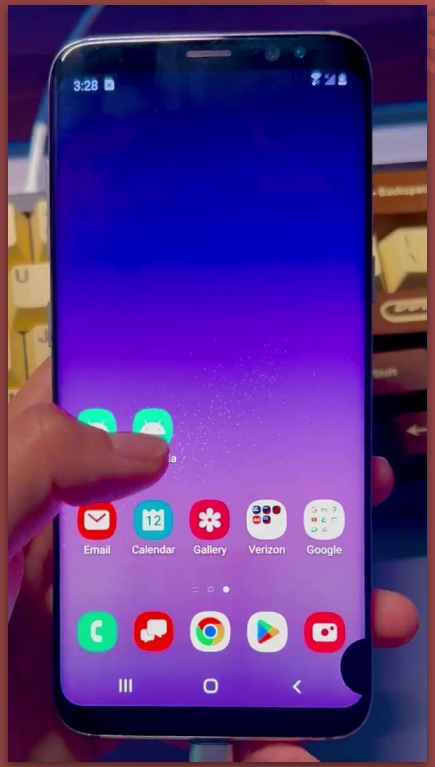
Firebase

udemy

Kotlin

Application & Database





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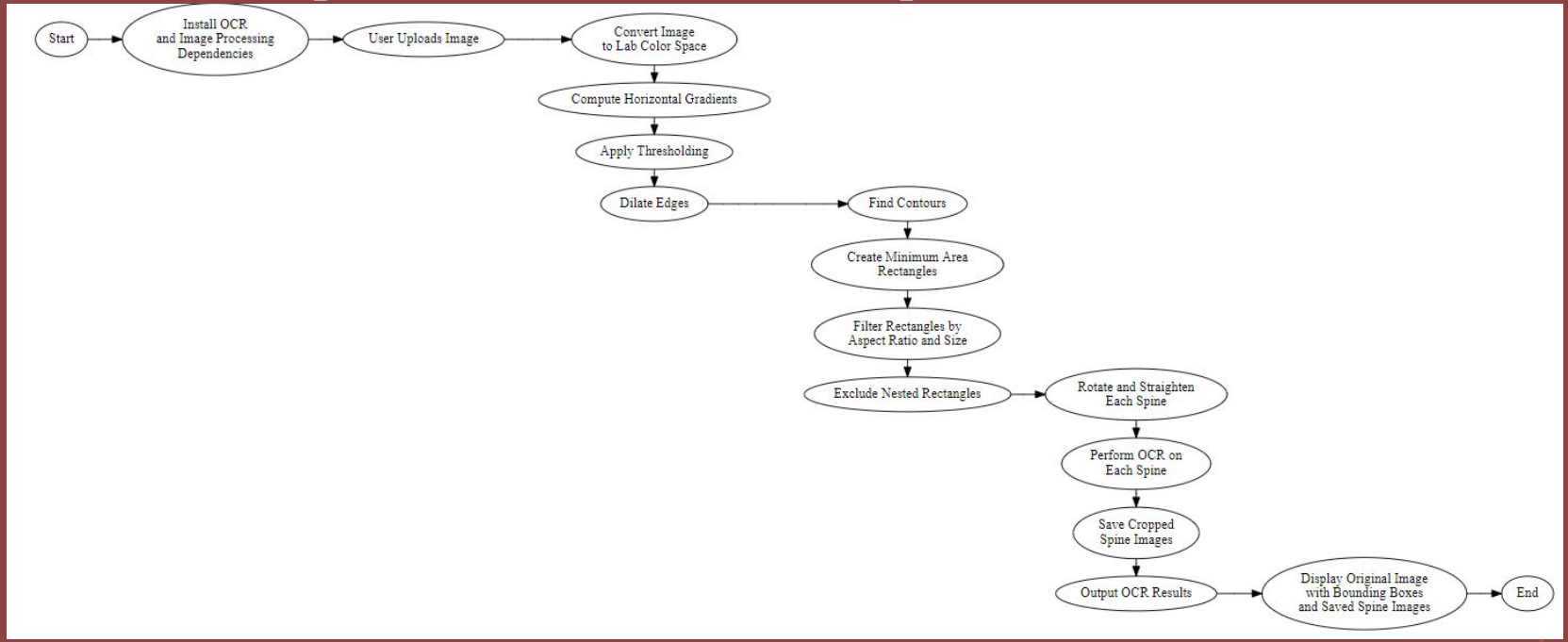
Computer Vision Implementation



Computer Vision Implementation

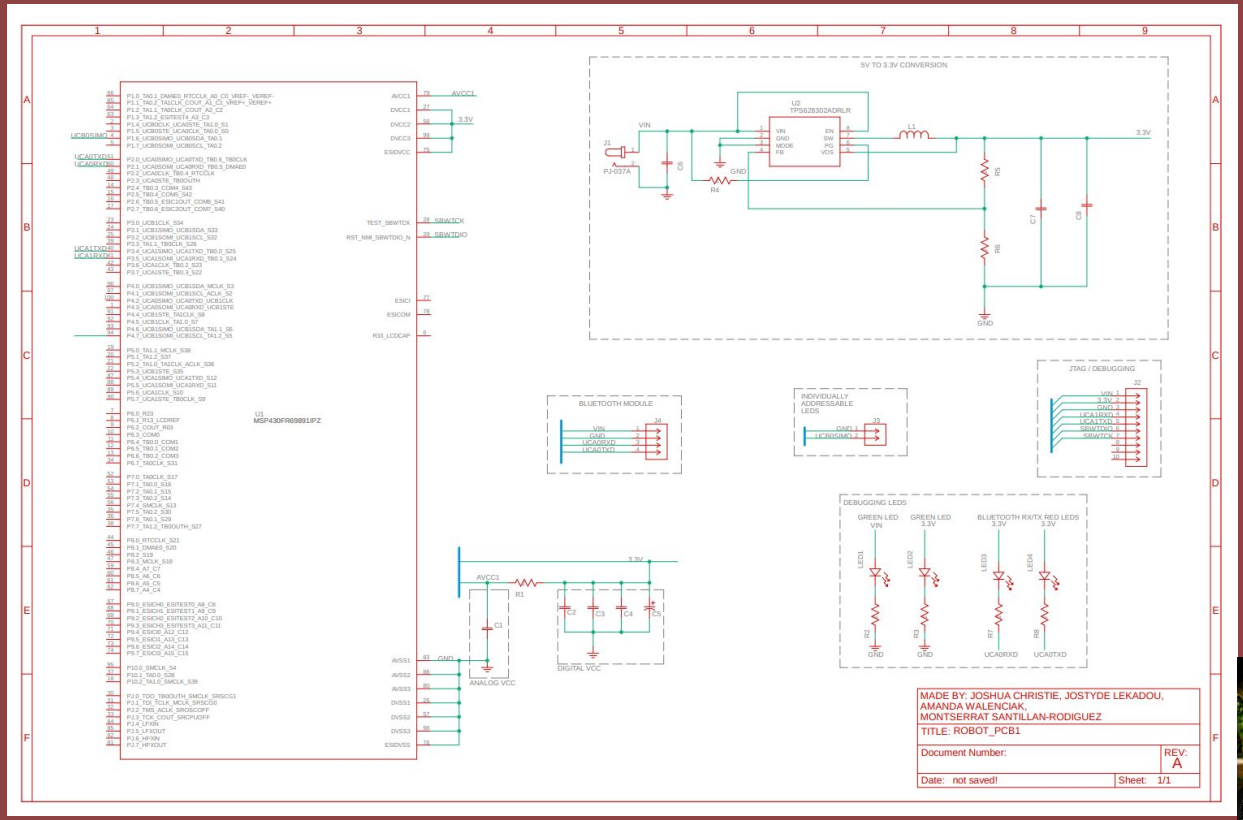
find_book_spines(): Converts the image to Lab color space, identifies vertical edges, and then detects contours to find potential book spines. It filters these by size and aspect ratio and removes any nested contours to ensure each spine is correctly identified.

ocr_book_spines(): Processes each detected spine, rotating and straightening it as needed, then uses OCR to extract text, saving the images and text results for further use.

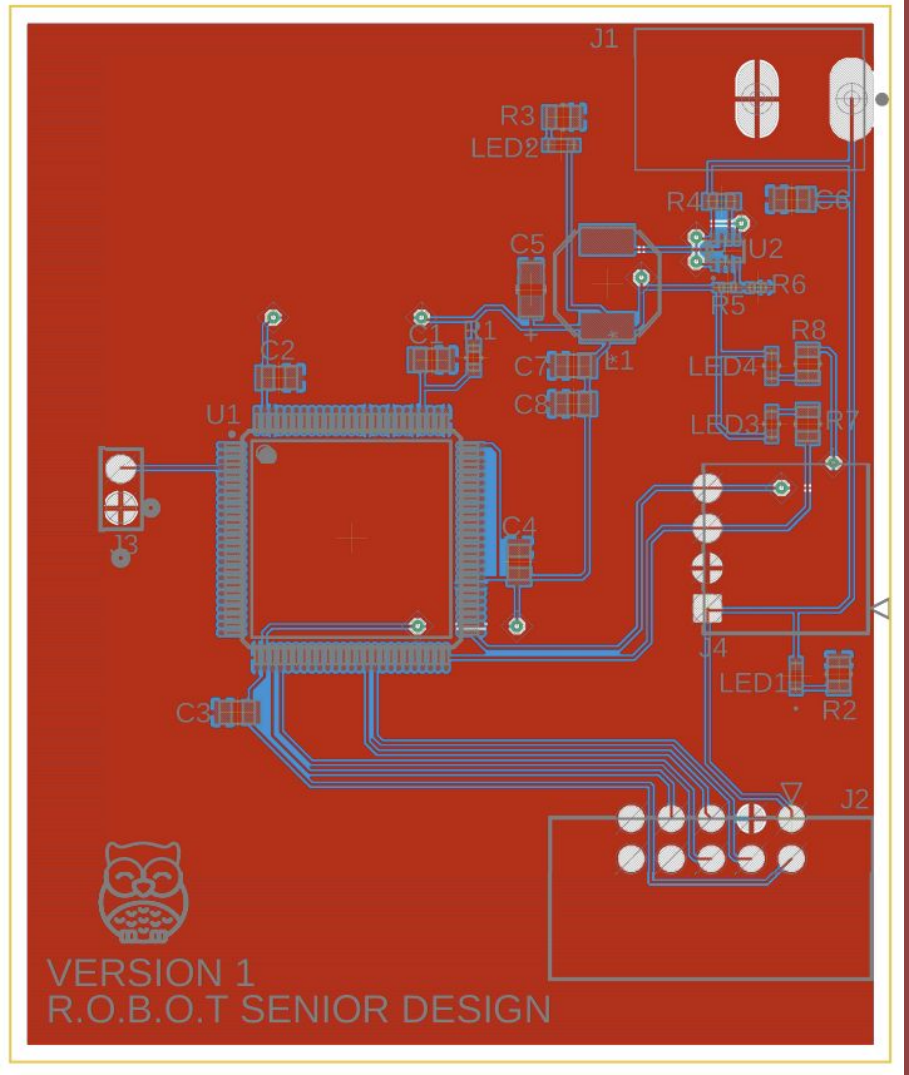
upload_and_process_files(): Handles the image upload, calls the spine detection and OCR functions, and displays the results.

PCB Design/Schematic

- Eagle was used to design first PCB prototype
- Manufactured and delivered by JLCPCB
- Design includes:
  - MCU
  - Bluetooth
  - Voltage Convertor
  - Individually addressable LEDs
  - JTAG
  - Debugging LEDs
  - Power Connection



PCB Board


J1
R3
LED2
R4
C6
C5
U2
R6
R5
C2
C1
R1
C7
L1
R8
LED4
C8
U1
LED3
R7
J3
C4
J4
LED1
R2
C3
J2
VERSION 1
R.O.B.O.T SENIOR DESIGN

04

DEVICE AND COMPONENT SELECTION

Software Selection

Python was selected for the computer vision portion of the project due to having more online community and support compared to Matlab.

Python provides support and capabilities of deploying projects on online platforms like databases.

Additionally, the Jetson Nano Developer kit, which we will use for the project, mainly provides support for Python and C++ as opposed to Matlab.

Camera Module

Camera	Price ($)	Horizontal FOV (Degrees)	Focal Length (mm)	Fixed Focus or Adjustable	Still Image Resolution (Megapixels)
Raspberry Pi Camera Module v2	25	62.2	3.04	Adjustable	8
IMX219-130 8MP Camera	20	104	1.88	Fixed	8
IM219-77IR 8MP IR Night Vision	21	70	2.96	Fixed	8

Microcontroller

Specifications	MSP430FR6989	MSP430G2553	ATmega328P
Architecture	16-bit RISC	16-bit RISC	8-bit AVR
Operating Voltage	1.8V to 3.6V	1.8V to 3.6V	5V
Flash Memory	128KB	16KB	32KB
RAM	2KB	512 Bytes	2KB (Includes 1KB EEPROM)
ADC Resolution	High-resolution ADC	10-bit ADC	10-bit ADC
Peripheral Support	- GPIO pins - Timers - ADC - UART - I2C - SPI	- GPIO pins - Timers - ADC - UART	- PWM - SPI - I2C - Timers
Active Mode Current	100 µA/MHz	300 µA/MHz	6 mA (at 16MHz)
Price	$3.60	$1.10	$2.89

LED Requirements

- Voltage required to operate is at or below 12V
- Little to no need for Power Injection
- LEDs must be addressable either individually or in groups for a assisted book-find
- Compatibility with our microcontroller of choice (FR6989)

LED Selection

LED Strip	WS2811	WS2812B	WS2813	SK6812
Operating Voltage (V)	12	5	5	5
Color Channels	RGB	RGB	RGB	RGBW
Individually Addressable	No (3 LEDs)	Yes	Yes	Yes
Power Injection Needed	No	Optional	Yes	Yes
Price ($)	$16.99	$15.99	$30.99	$27.99

Display Selection

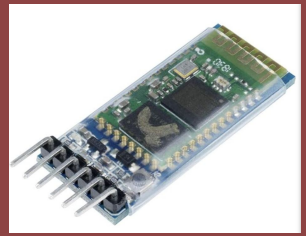
- The Display will be used to check books in and out
- It will be attached to the shelf eliminating the need for library patrons to check out books from the counter
- It is a touch display to eliminate unwanted bulk
- The display will run the web version of the mobile application

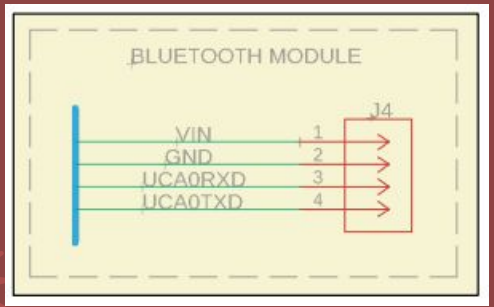
Display	Resolution	Price
HAMTYSAN	1024 x 600 Pixels	$59.99
YLSHRF	1024x600 Resolution	$70.15

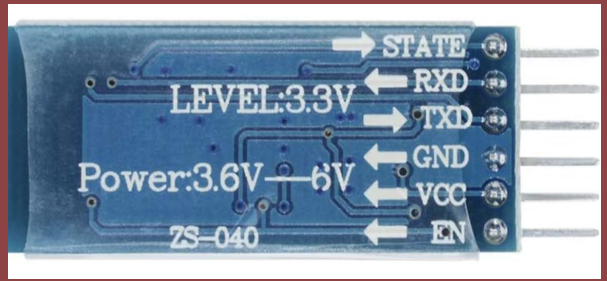
Bluetooth

- HC-05 Bluetooth sensor

HC-05 Bluetooth Sensor		connects to	Printed Circuit Board
Pin number	Pin functionality		Signal / Trace
1	VCC	→	VIN
2	GND	→	GND
3	TX	→	UCA0RXD
4	RX	→	UCA0TXD

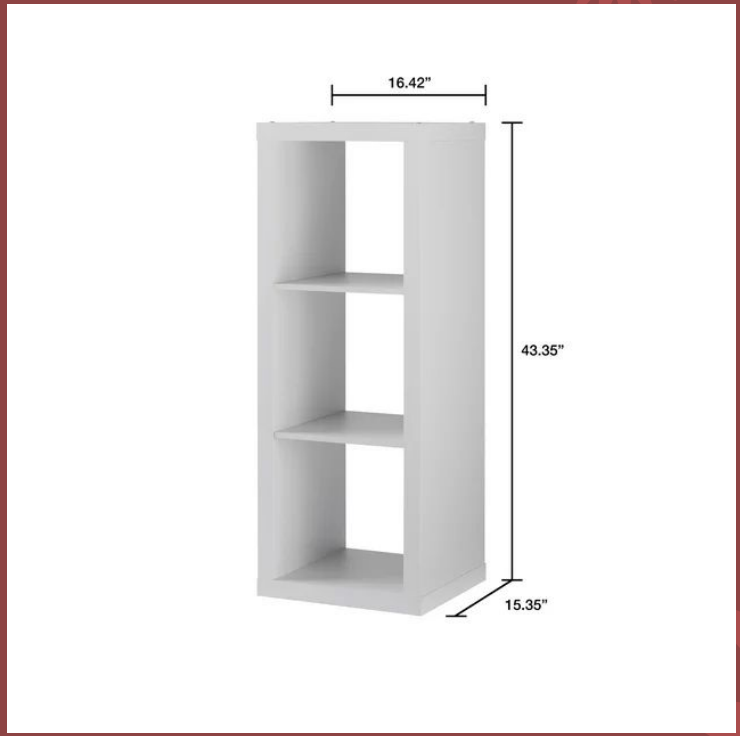






Bookshelf Selection

- The dimensions of the bookshelf we choose for showcasing is important
  - Must be large enough to test our system's ability to manage large amounts of books
  - Must be deep enough for cameras to get a full-width view of the shelf
  - Must be made of wood so we can easily cut and poke to fit our system
- We currently decided to the bookshelf shown below
  - Best depth we could find with reasonable pricing
  - Short and narrow width
  - Might not prove complexity of our final project
- Currently looking for alternatives



05

SUCCESSES AND DIFFICULTIES

Computer Vision Issues

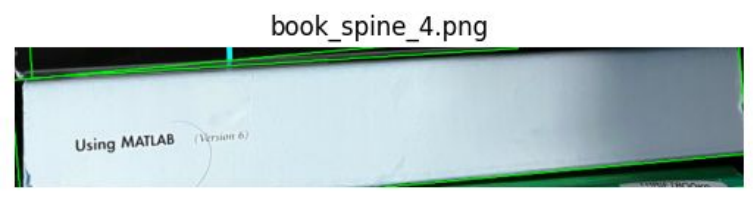
- Spine Identification

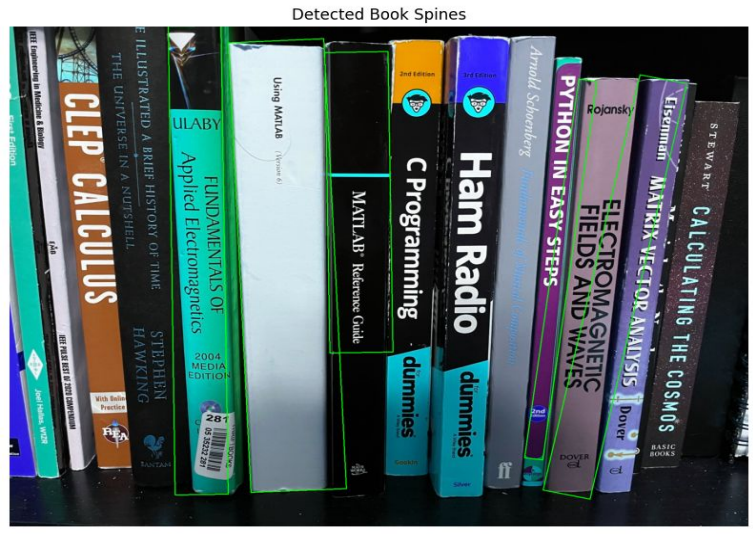
  -Difficulty creating bounding boxes

  -Multiple methods attempted: k-means clustering and edge detection

- Optical Character Recognition

  -Difficulties extracting text

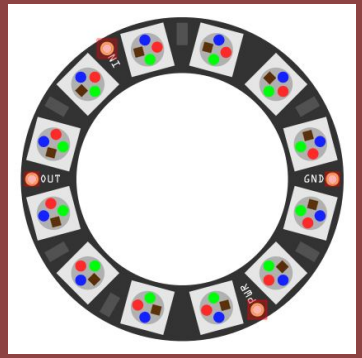




Embedded Programming Issues

- Issues configuring SPI and MCU clock to correctly communicate with the LEDs
- LEDs use WS2812B protocol
- Tested with proper functionality on MSP430G2553
- Working to figure out correct configurations for the MSP430FR6989

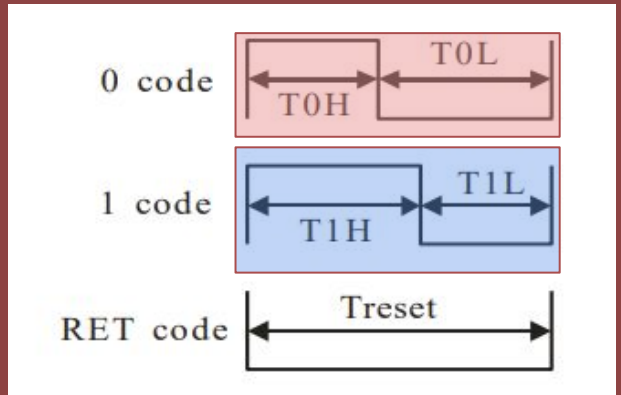
GitHub



Embedded Programming Issues

Data transfer time(TH+TL=1.25μs±600ns)

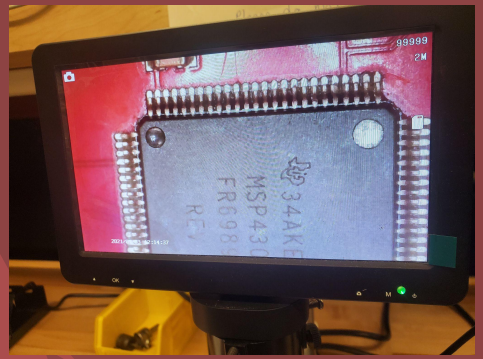
T0H	0 code ,high voltage time	0.4us	±150ns
T1H	1 code ,high voltage time	0.8us	±150ns
T0L	0 code , low voltage time	0.85us	±150ns
T1L	1 code ,low voltage time	0.45us	±150ns
RES	low voltage time	Above 50μs	

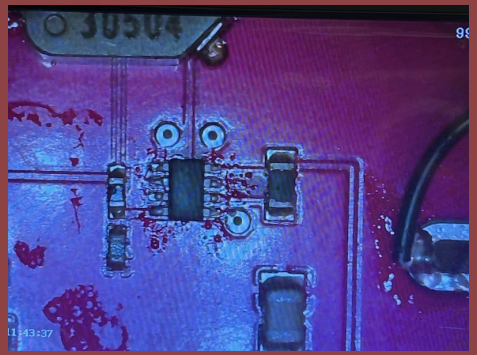


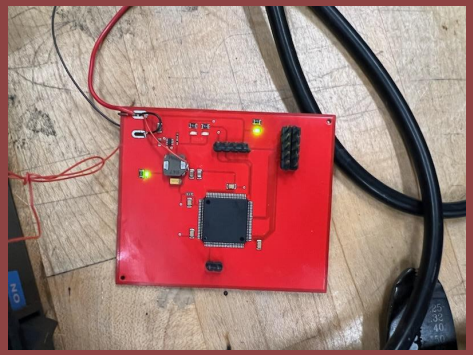

```
// Transmit codes
#define HIGH_CODE    (0xF0)      // b11110000
#define LOW_CODE     (0xC0)      // b11000000
```

PCB Issues

- Ordered PCB without silk screen.
- Voltage converter was out of stock for a while.
- Had to hand solder the 100 pin MCU and voltage regulation with the help of Professor Weeks.
- 1st prototype does not have a reset button.
- Add ESD protection.







Project Constraints

Ethical Constraints

May intrude on the privacy of the library patrons due to the live camera feed

Manufacturing Constraints

PCB manufacturers may not have components needed for our design

Time Constraints

Unexpected lead times may lead to delays in project progression

06

BUDGET AND PLANNING

Budget

Expenses

Aa Name	# Amount	Source	Person
First PCB draft	$59.52	JLCPCB	M Monse S
IR sensors	$5.79	Amazon	M Monse S
Microprocessor	$18.46	Digikey	M Monse S
1 LED strip	$11.62	Amazon	M Monse S
Prototyping boards	$11.99	Amazon	M Monse S
Jetson Nano	$60.00	Facebook Marketplace	M Monse S
Bluetooth module	$9.99	Amazon	M Monse S
Voltage regulators	$14.36	Texas Instruments	M Monse S
Solder flux	$8.99	Amazon	Joshua Christie
Solder paste	$9.99	Amazon	Joshua Christie

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+ New

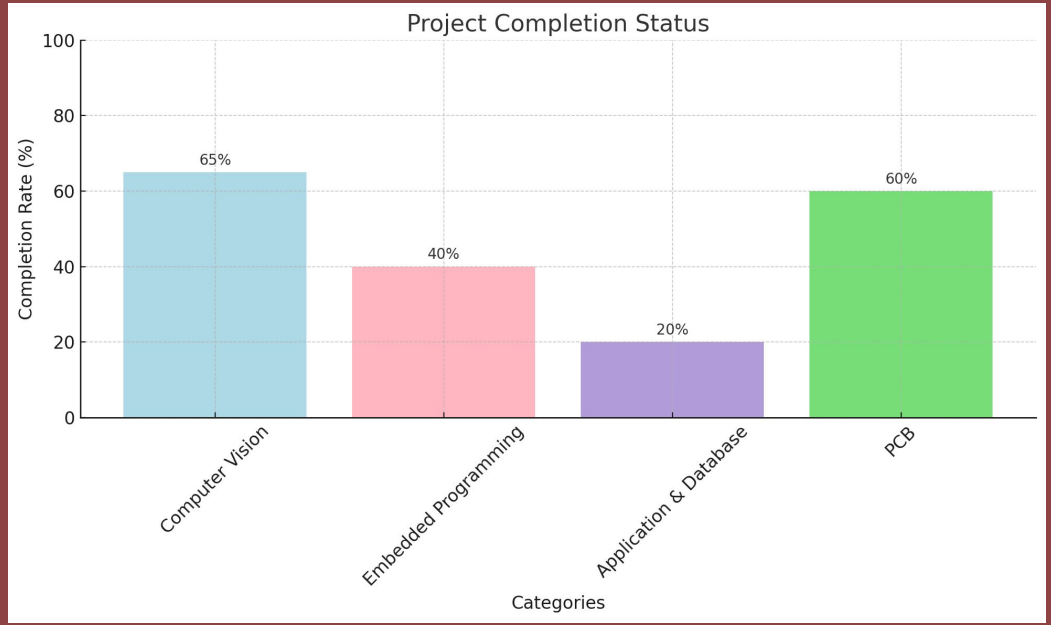
Calculate SUM $248.46

Statement of Progress

Ordered and are testing the first PCB draft

Improved the robustness of the Computer Vision Code

App homepage and login currently being implemented



Group Management Tools

GitHub

Plans for Immediate Future

Design final PCB and order for testing

Test Python and Kotlin communication with database

Testing CV code on Jetson Nano

Testing camera angles and bookshelf depths

Questions?