USE CASE

Existing inventory management systems don't always have real-time analysis of information such as traffic and where items are. They also typically require expensive heavy infrastructure

- Robotic hardware that maneuvers around the store sensing for the desired information such as the Marty robot ($35,000 each)
- Inventory Management Systems scan products when received at the backdoor. Then keeps track of what gets sold through the register.

OUR PROPOSED SOLUTION

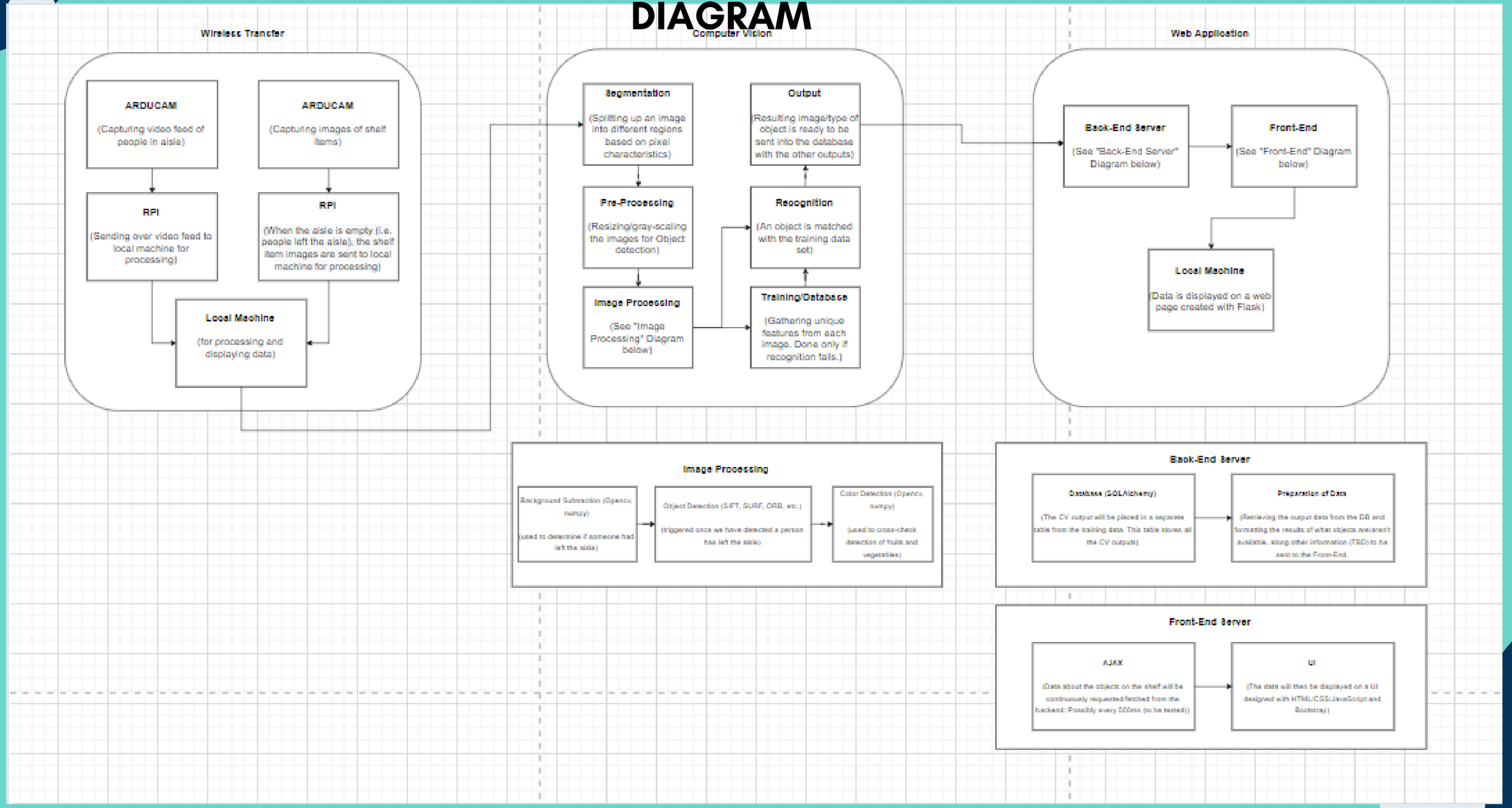
Focus on a cv camera system of one shelf section in one aisle

- One camera will be placed to monitor the single shelf section to track whether or not desired items are on the shelf
- One camera will be placed in view of the aisle to track when people enter the aisle
- A web application will be populated with information such as whether not certain items are on the shelf and how many people went into the aisle at specific time periods

USE-CASE REQUIREMENTS

- Detect when there are people in the aisle and how many people are in an aisle
- Detect the presence of objects that should be on the shelf
  - These objects should be scanned for when people have left the aisle.
- Information must be transmitted and displayed to the manager's local machine within 15 seconds of someone entering/leaving the aisle
  - From various research papers we found that experiments with SIFT were on average 3-6 seconds per experiment. We are detecting people then multiple objects, so doubled the experiment time and added 3 seconds of leeway for the multiple object detection and information transfer

SYSTEM SPECIFICATION: BLOCK DIAGRAM



SOLUTION APPROACH: WIRELESS TRANSFER

- Goal: Transfer of data from camera to machine for openCV wirelessly.
- Process:
  - 1. ARDUCAM LN05101 camera controlled by 2nd RPI 4 dedicated to human detection captures footage.
  - 2. Transfer raw data to local machine for processing via a raspberry pi.
  - 3. Trigger 2nd ARDUCAM LN05101 camera controlled by 2nd RPI 4 dedicated for object detection
  - 5. Repeat step 2, then perform the computer vision steps.

SOLUTION APPROACH: COMPUTER VISION

- Segmentation
- Pre-Processing
- Image Processing
  - Recognition
  - Training/Database addition
- Recognition
- Output Transmission into a webapp.

COMPUTER VISION: IMAGE PROCESSING

The primary part of our CV system. This part has 3 subparts that would execute in sequence:

- Background Subtraction: Using openCV and numpy, detect motion of people. Works by looking for motion in the foreground of a stationary background.
- Object Detection: If aisle is empty through detection of a person leaving, then using BRISK or ORB, we detect objects in the shelves.
- Color Detection: If nevessary after object detection (eg: apple vs orange), use CV color detection to aid with distinguishing the objects.

SOLUTION APPROACH: WEBAPP

This step has 2 servers communicate with each other which we are calling the front end and backend servers respectively, and these then display the results of our project in a web page which we shall create using flask.

Backend Server

- Database (SQLAlchemy): We store the CV output in a database using SQLAlchemy.
- We retrieve the output data from the dB and format the results of what is and is not available on the shelves.
- Communication to frontend server during fetches/requests.

Frontend Server

- Ajax: Using Ajax, we fetch the data about objects on the shelf from the backend server.
- UI: We take the data we have received and present it on a UI we'll design with HTML/CSS/JS.
- Repetition of step 1 periodically.

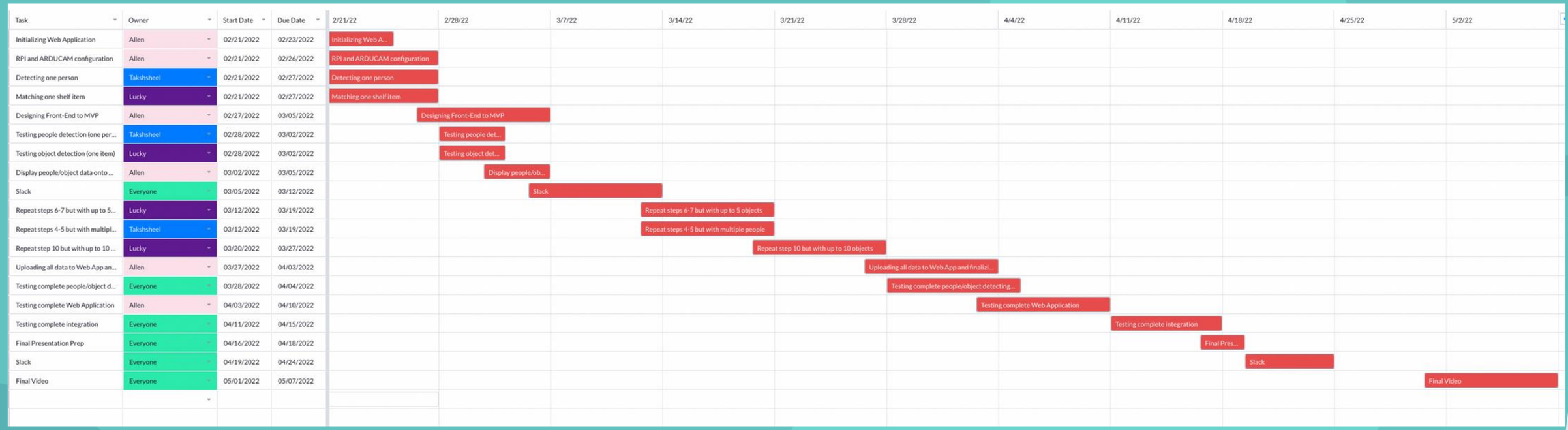
IMPLEMENTATION PLAN

- From our block diagram, the arducam and the raspberry pi will be purchased, and we would program them ourselves to communicate with each other and the local machine.
- For the openCV section. we shall be using algorithms that are available to public along with their documentation, eg: BRISK.
- For our webapp we shall use a flask framework instead of a django framework since a django framework would be very comprehensive. We can use a faster and more lightweight framework and achieve what we need from our webapp which is a display of information.

TESTING, VERIFICATION, AND METRICS

- Web App User Interface
  - Ensure all links work properly
  - Ensure no errors such as 404 when performing desired actions
- OpenCV
  - Testing for different background subtraction as well as object detection algorithms
  - Checking performances of various algorithms with their accuracies and speeds to check whether they meet our initial timing and accuracy requirements (90% correct detection rate, 15 seconds communication time)
- Wireless Data Transfer
  - Unit tests for the communication between arducam and Raspberry Pi, and the local machine.

Schedule and division of labor: Gantt Chart



Task	Owner	Start Date	Due Date
Initializing Web Application	Allen	02/21/2022	02/23/2022
RPI and ARDUCAM configuration	Allen	02/21/2022	02/26/2022
Detecting one person	Takshsheel	02/21/2022	02/27/2022
Matching one shelf item	Lucky	02/21/2022	02/27/2022
Designing Front-End to MVP	Allen	02/27/2022	03/05/2022
Testing people detection (one per...	Takshsheel	02/28/2022	03/02/2022
Testing object detection (one item)	Lucky	02/28/2022	03/02/2022
Display people/object data onto ...	Allen	03/02/2022	03/05/2022
Slack	Everyone	03/05/2022	03/12/2022
Repeat steps 6-7 but with up to 5...	Lucky	03/12/2022	03/19/2022
Repeat steps 4-5 but with multipl...	Takshsheel	03/12/2022	03/19/2022
Repeat step 10 but with up to 10 ...	Lucky	03/20/2022	03/27/2022
Uploading all data to Web App an...	Allen	03/27/2022	04/03/2022
Testing complete people/object d...	Everyone	03/28/2022	04/04/2022
Testing complete Web Application	Allen	04/03/2022	04/10/2022
Testing complete integration	Everyone	04/11/2022	04/15/2022
Final Presentation Prep	Everyone	04/16/2022	04/18/2022
Slack	Everyone	04/19/2022	04/24/2022
Final Video	Everyone	05/01/2022	05/07/2022

CONCLUSION

- Imagine a store with an integrated camera, inventory management, and navigation system.
  - Imagine a system that told …
    - You how many packs of oreos are left on aisle 6?
    - You exactly where to find the milk to go with those oreos?
    - The store manager and customers navigating the store after you that you cleaned out their stock of oreos
    - The store manager what people actually like to buy and when
  - No more looking for an attendant because you can’t find an item. Then walking with the attendant to the location only to find that it is not there. Then waiting for the attendant to check “the infamous back of the store” only to come back and tell you they are out of stock. All the while the item is in stock just placed in the wrong location by someone who changed their mind.
- This semester we will attempt to take steps towards that store of the future with our project.