WHERE'S THE MILK?

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TECHNOLOGY TODAY

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.

TECHNOLOGY WE PROPOSE

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

CV DETECTION

- Humans in motion
- objects in different orientations, sizes, and distances i.e. rotation and scale invariance required
- Efficient algorithm for time requirements
- Timing of detection i.e. only detect objects in empty aisles after someone has left

CAMERA TRIGGER MECHANISM

- Data transfer between hardware and end user
- People can and exit enter from both sides of the aisle

CAMERA SUBSYSTEM TO MACHINE FOR PROCESSING

- Need a wireless transfer protocol

ACCURACY AND SPEED

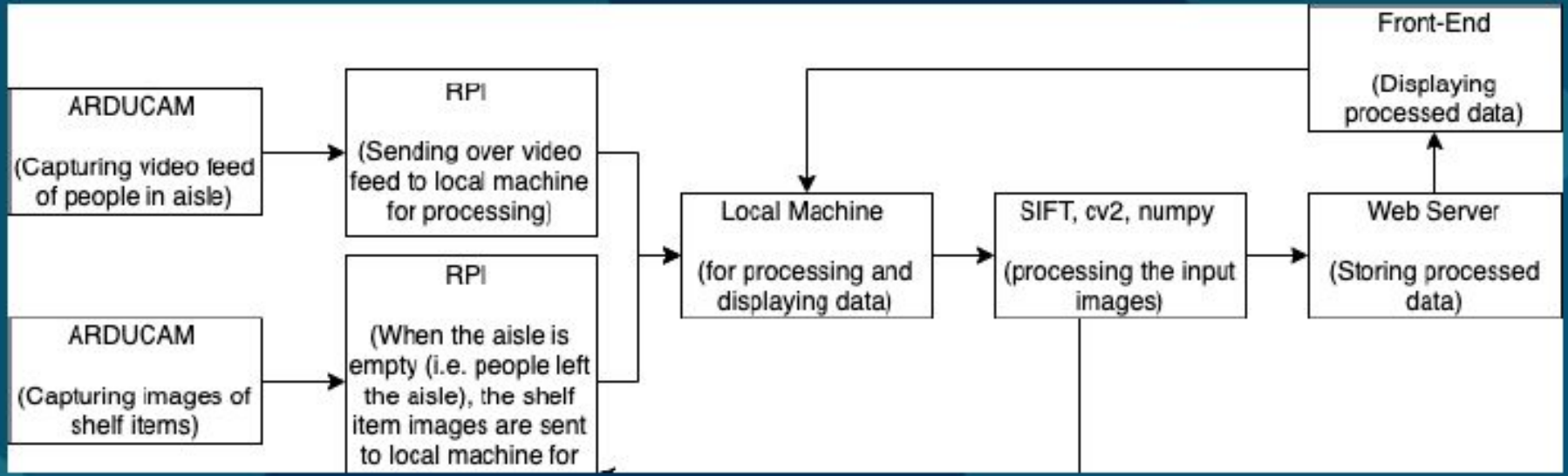
- Accurate triggering from people leaving aisle
- Fast enough to process objects on shelves before new people block the view
- User Interface must have up to date accurate information

CAMERAS DETECTING HUMANS AND OBJECTS

- Goal: detect if a person has left the aisle, detect number of people
- 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
  - 3. Trigger 2nd ARDUCAM LN05101 camera controlled by 2nd RPI 4 dedicated for object detection
  - 5. Repeat step 2

IMAGE PROCESSING

- Use SIFT (Scale Invariant Feature Transform) detection and SVM in Opencv in python
  - SIFT enables us to detect objects in images with higher accuracy with varying rotations, distances and sizes (i.e. scale invariant)
  - Estimated accuracy 60-70% in 5-6 seconds
  - We may transition to SURF (Speeded-Up Robust Features) which is a sped up version of SIFT if computation efficiency is an issue at the cost of some accuracy
- Local machine operating system will be either windows or Mac OS
- Web App will be built using Django framework and AWS



CAPTURE PROCESS DETECTION DISPLAY RESULTS

TESTING, VERIFICATION, AND METRICS

- Camera: Field of view
  - Manual testing to check how far/wide objects can be seen.
- Object Detection
  - Size: Make objects smaller and smaller till the OpenCV software stops detecting the object in question. (Goal is 5 in * 5in area) [Because smaller than that typically isn't individual objects]
  - Accuracy: Test for a variety of objects and check for how many objects are detected correctly versus incorrectly. (Target is 70%)
    - Testing detection rate for objects facing directly at the camera, rotated, misplaced, and missing versus at an angle.
- People Detection
  - Standing, Walking, jogging, sprinting (i.e. test if camera can detect different speeds): We'll have people (probably ourselves) move through the detection zone at various speeds, and we'd like to detect each instance. (Target is 70% accuracy)

TESTING, VERIFICATION, AND METRICS

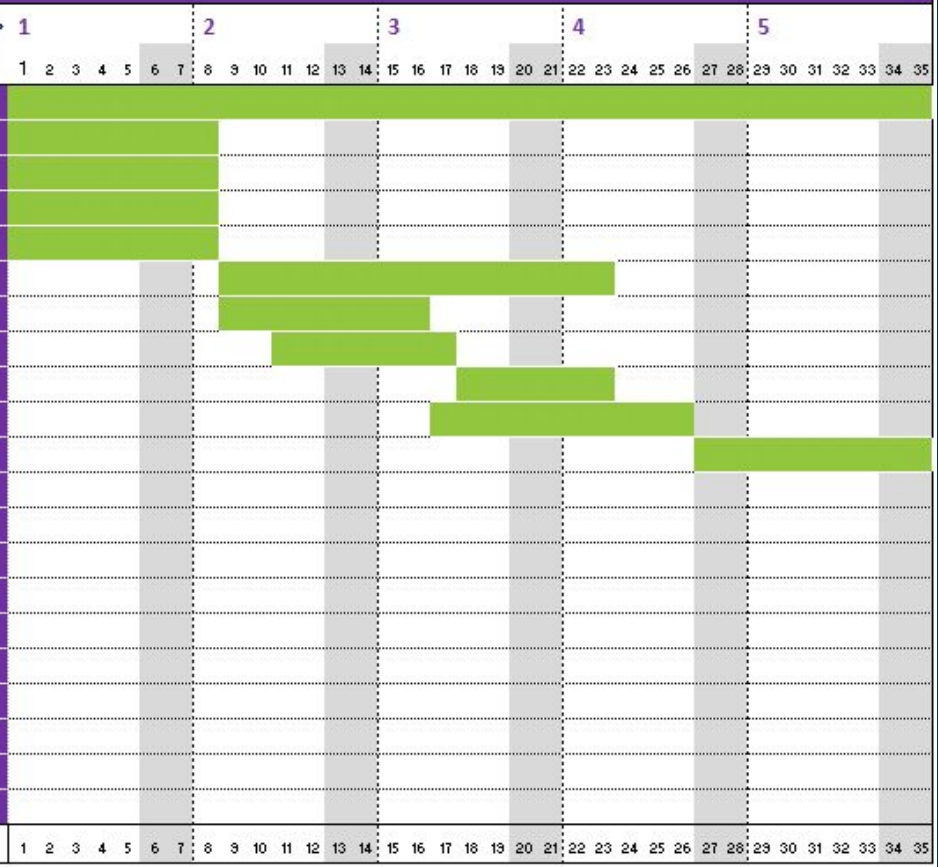
- Web App User Interface
  - Ensure all links work properly
  - Ensure no errors such as 404 when performing desired actions

TASKS AND DIVISION OF LABOR

- Takshsheel: OpenCV and help wireless transfer
- Lucky: Wireless transfer and help with webapp/OpenCV
- Allen: Webapp and help with OpenCV

ACTIVITY PLAN

#	Activity			Start	End
1	**TOTAL TIME FRAME**	07/02/22	24/04/22	1	77
2	**INITIAL RESEARCH**	07/02/22	14/02/22	1	8
3	OpenCV algorithm research	07/02/22	14/02/22	1	8
4	Research into wireless transfer of information and data	07/02/22	14/02/22	1	8
5	Determining framework and usage of webapp	07/02/22	14/02/22	1	8
6	**WEBAPP SETUP/HARDWARE SETUP**	15/02/22	01/03/22	9	23
7	Initialize backend and frontend	15/02/22	22/02/22	9	16
8	Connect hardware and check for correctness	17/02/22	23/02/22	11	17
9	Design webapp to MVP design	24/02/22	3/1/2022	18	23
10	Implement SIFT for people	23/02/22	04/03/22	17	26
11	Implement SIFT for objects	05/03/22	15/03/22	27	37
12	Extend both to multiple of one kind (people,objects)	16/03/22	25/03/22	38	47
13	Raspberry Pi and webapp integration	26/03/22	08/04/22	48	61
14	**Final Testing**	09/04/22	20/04/22	62	73
15	Final Presentation	20/04/22	24/04/22	73	77



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.