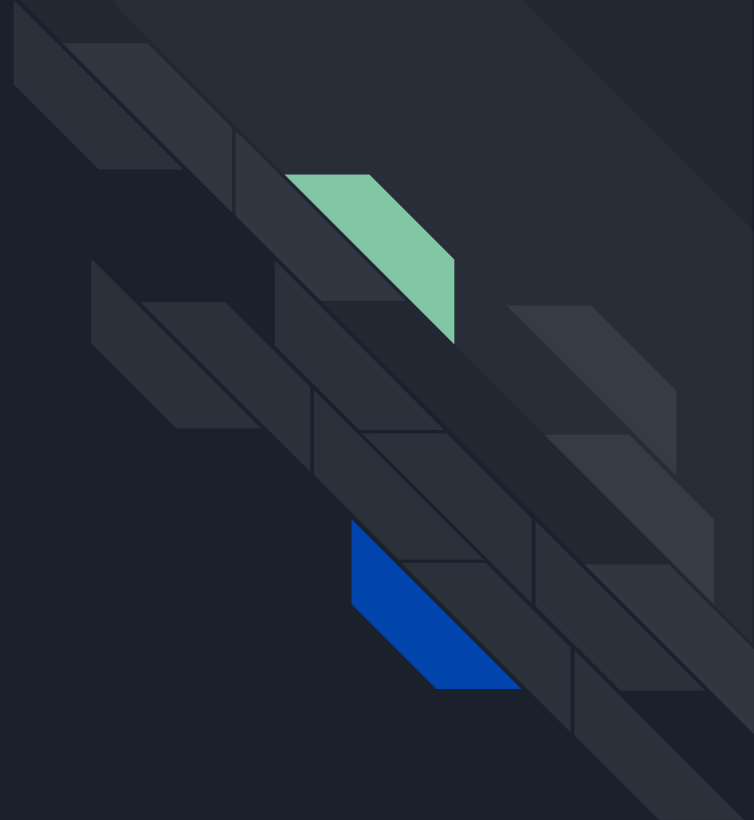# Detecting Disease Contacts

Circuit Breakers

Introduction

- COVID-19 showcased the importance of tracking diseases
  - Researchers played an important role in reducing the spread of the disease.
  -

- We are aiming to find a better solution to track how many contacts a single person makes.

Objective

- Our objective is to create a camera and sensor-equipped vest to track the number of contacts within a two meter radius
  - Sends data to the cloud
  - Has a mobile app to view data
  - Data includes: number of contacts, location, closest distance.
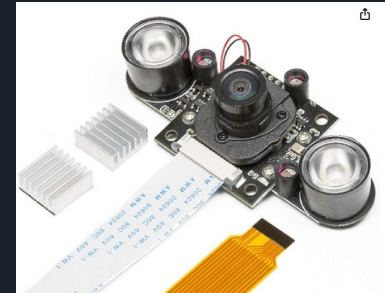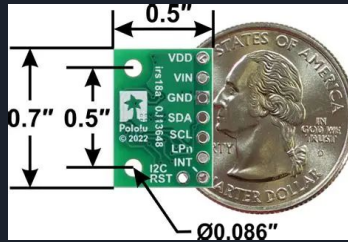
Design - Subsystems

Distributed Architecture:

Four subsystems equipped with Raspberry Pi Zero 2W

Multi-Sensor Fusion for Contact Detection:

- VL53L7CX ToF sensor
- MLX90640 thermal camera
- Arducam day/night camera

Design - Central System

Centralized Processing:

- A Raspberry Pi 5 acts as the system hub, receiving video data from the four subsystems for unified processing.

Automated Computer Vision Analysis:

- An Computer Vision model analyzes incoming visual data streams to identify and track subjects of interest.

Metrics Collection

- The system combines incoming visual + thermal data in order to track the duration and closest approach of every encounter

Design - Mobile App

Companion Mobile App as User Interface:

- A cross-platform mobile app acts as the main interface for viewing data collected by the vest.

Connection to Central System:

The mobile app connects to the Pi 5, allowing data to be sent to an AWS server to be stored. The app can also retrieve data from the server to be displayed.
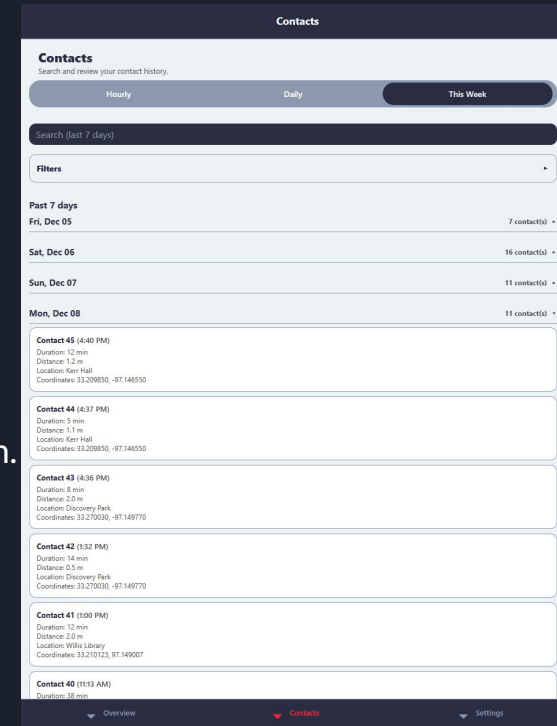
Intuitive Data Views:

- Daily summary cards
- Timeline view
- Map view

Filtering & Insights :
Data can be found through the search bar and/or through the filtering option.

Privacy-Aware Design:
Each contact is displayed in an anonymous manner.

Implementation - Subsystems

```
jared@raspberrypi:~/VL53L7CX $ ls
buzz.py         main_pipeline.py      __pycache__          tof_ascii_8x8      tof_lib.c      VL53L7CX_ULD_API
libdistance.so  Platform              thermal_module.py    tof_ascii_8x8.c    tof_wrapper.py
```

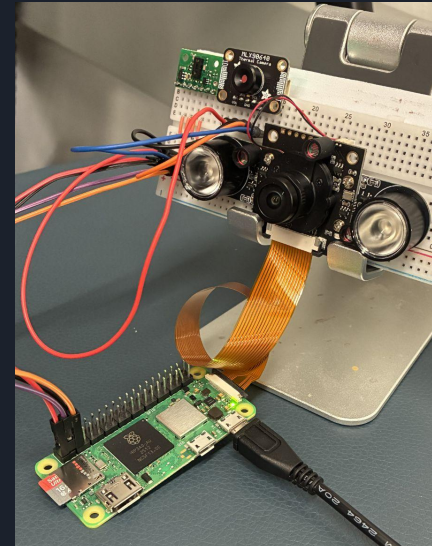ToF < 2m → Thermal frame → Video capture

TOF: Captures full 8x8 depth map, polling at 2 Hz

```
VL53L7CX 8x8 Distance Map (mm)
(0 means no valid target)

  ---   ---   ---   ---   ---   ---   ---   ---
  ---   ---   ---   ---   1176  1061  ---   ---
  ---   ---   ---   ---   1176  1061  ---   ---
  2346  ---   ---   ---   1218  1077  1101  1055
  ---   ---   ---   ---   1284  ---   1117  1092
  ---   ---   ---   ---   ---   ---   ---   ---
  ---   ---   ---   ---   ---   ---   ---   ---
```


Thermal: 24×32 thermal frame, apply warm-pixel thresholding

- Single frame capture for human presence detection

```
[thermal] Center: 27.64 C | Min: 23.01 C  Max: 30.91 C  Avg: 24.39 C | Warm px: 12 | HUMAN DETECTED
```

Camera: 3 second video @ 3 FPS -> send this video to Pi 5 via TCP Sockets

Implementation - Central System

Nano-based model

- Runs and performs inferences for human subjects on video data at 4 FPS
- When a subject crosses the 2 meter limit, the system begins tracking their position with a bounding box

Camera Bouncing

- When a subject exits the frame on any one camera → the edge of every camera overlaps in FOV with only one other camera edge → A specialized algorithm is run on the exiting camera and entering camera to see if who entered the new camera is the same as the person who exited the previous camera → Distance and encounter data are rolled over onto the new bounding box

Implementation - Mobile App

Connects to Pi 5 via bluetooth

Transmits encounter data to an AWS server via wifi, cellular data, or hotspot
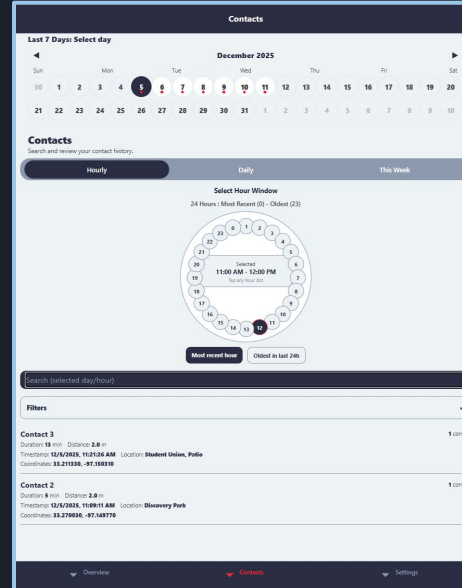
Receives data from AWS server along with information such as

- Encounters per hour / day / week
- Encounter durations
- Encounter locations

Almost all computing is done in the cloud

Local Filtering is Implemented :
- Timestamp Filtering
- Duration Range Filtering
- Distance Filtering
- Location Based Search
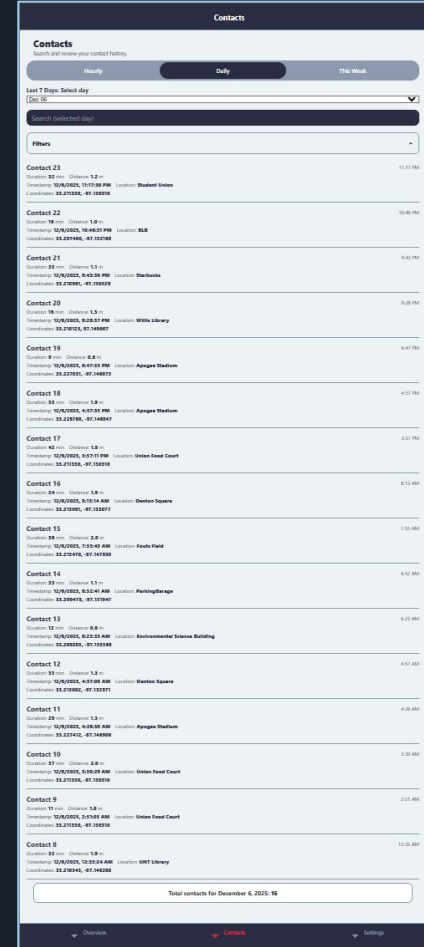
Constraints & Bottlenecks – Subsystems

Limited Processing Power (Pi Zero 2W)

- Multithreading

Power Consumption

- Battery powered

Thermal Detection Accuracy

- Ambient temperature affects warm-pixel thresholds.

Integrating 4x Subsystems to work in tangent

- Avoid duplicating contact instances

Constraints & Bottlenecks – Central System

High Computational Load (OpenCV + Data Fusion) - Running inference models becomes expensive very quickly with increased resolution and framerate

Concurrent Data Streams - The system must remain performant processing four video streams at once → The streams must be the lowest resolution and framerate possible that doesn't break the detection algorithm

Advanced Detection Model - Introduces a momentary spike in computational load → it should not cause a noticeable slowdown or any discontinuity error in tracking

Battery powered

Constraints & Bottlenecks – Mobile App

Data Sync Latency

Large Data Volume Over Time

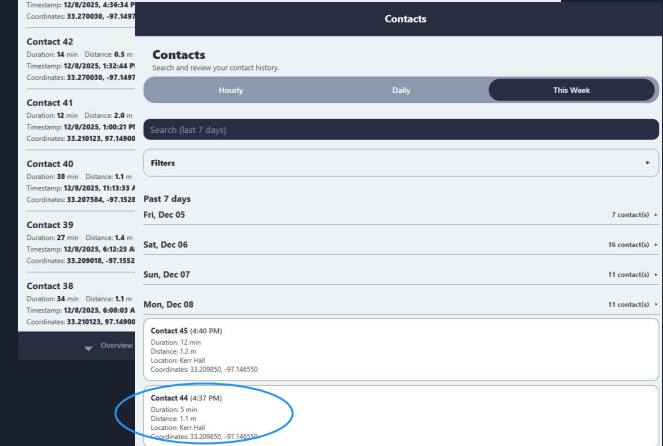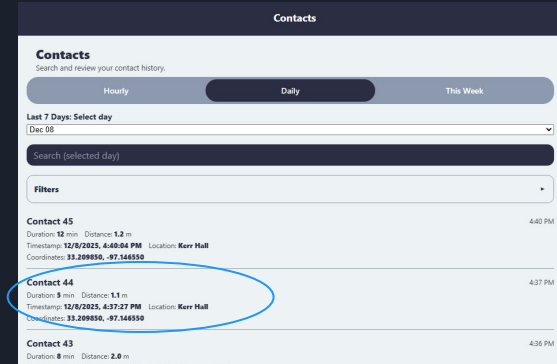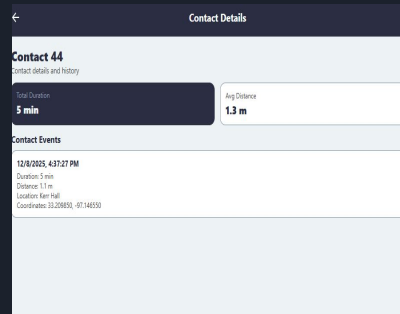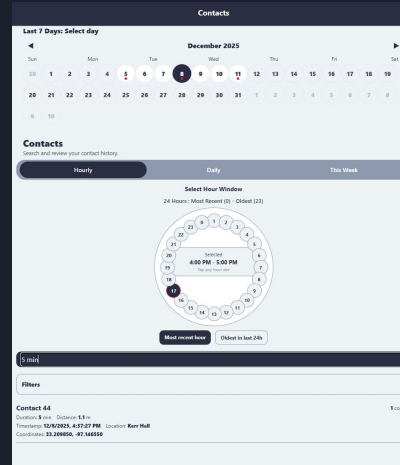**Security & Privacy Requirements**

Map Rendering Limitations

Battery Usage on Mobile Device

AWS server issues

Designing a flexible Filtering System

Ensuring Data Consistency Across Screens

Preliminary Results - Subsystem

Reliable ToF Distance Measurement (VL53L7CX)

- Achieved stable and accurate 8x8 depth readings at 2 Hz polling rate.

Working Human-Presence Detection via Thermal Camera (MLX90640) threshold detection:

- Human detection accuracy ~95% in indoor tests at <2 m (stationary human)

Day and Night camera reliability.
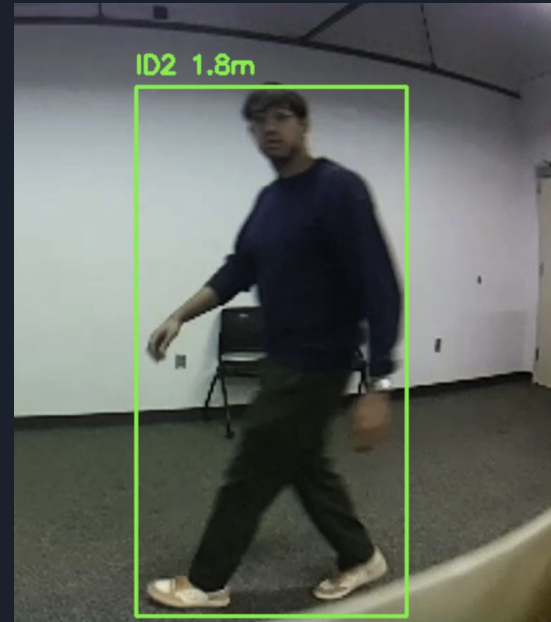- IR cut filter

End-to-End cycle: 6 seconds

TCP Sockets successfully transmitted
data from Pi Zero to Pi 5
- Allows for both videos and JSON to be sent

Preliminary Results - Central System

- Basic tracking algorithm is implemented on one camera
- System loops over the bounding boxes and periodically prints the distance for each one
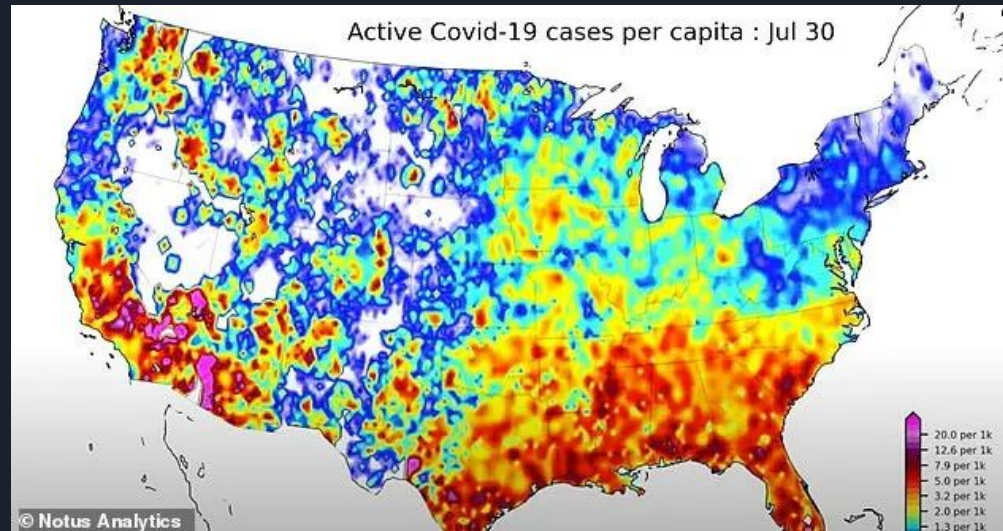- System only begins tracking when subject of interest is closer than 2 meters

Schedule

Jan

Feb

March

April/May

System Integration

4x subsystem integration

Refinement

Testing
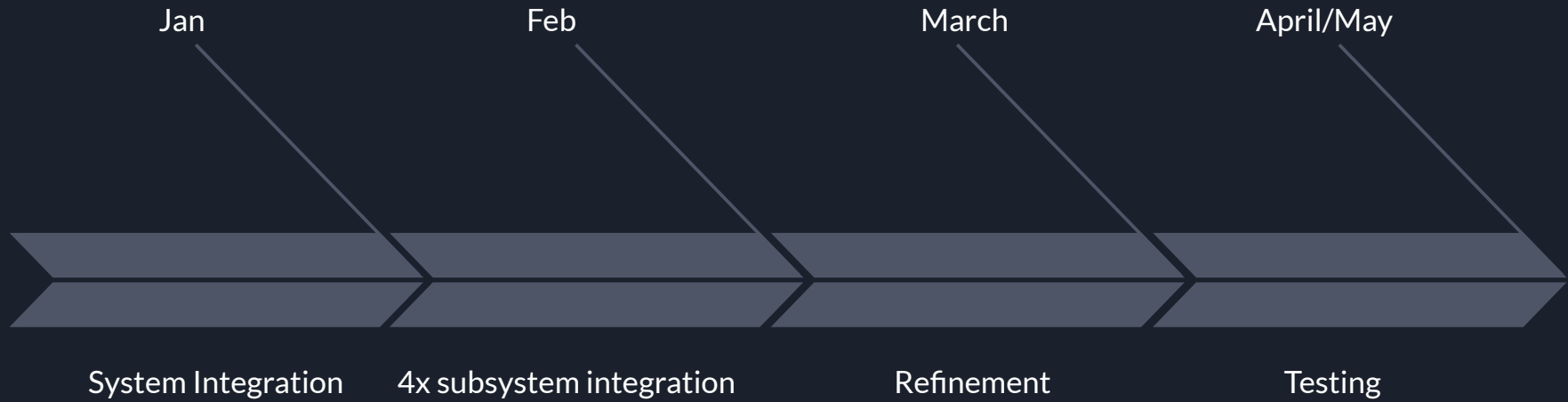
Conclusion / Summary

This project was born out of a need to collect data that has historically been very difficult to collect. With this data, health agencies can implement policies that could save lives in the event of another COVID-19 style pandemic. Through hard work, this project is on track to be completed.

Active Covid-19 cases per capita : Jul 30

© Notus Analytics

20.0 per 1k
12.6 per 1k
7.9 per 1k
5.0 per 1k
3.2 per 1k
2.0 per 1k
1.3 per 1k

Acknowledgements

- Lab Manager Udayasai
- Dr. Robin
- Friends and Family
- Specifically Tarod's wife

References

- Quickstart - AWS Amplify Gen 2 Documentation. (n.d.).
  https://docs.amplify.aws/react-native/start/quickstart/
- Host a Wi-Fi hotspot with a Raspberry Pi (n.d.).
  https://www.raspberrypi.com/tutorials/host-a-hotel-wifi-hotspot/
- Compile C code into callable function
  ctypes — A foreign function library for Python — Python 3.14.2 documentation
- Expo
  https://docs.expo.dev/

Any Questions?

Thank you!