# Just a T.A.D. (Traffic Analysis Drone)

## Senior Design Project 2017: Midway Design Review

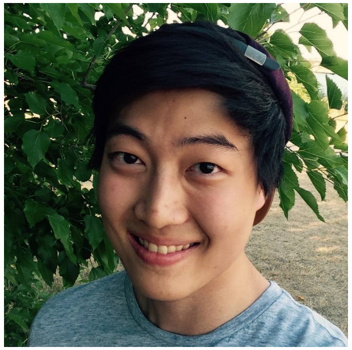
# Meet the Team

- Cyril Caparanga (CSE)

- Alex Dunyak (CSE)

- Christopher Barbeau (CSE)

- Matthew Shin (CSE)



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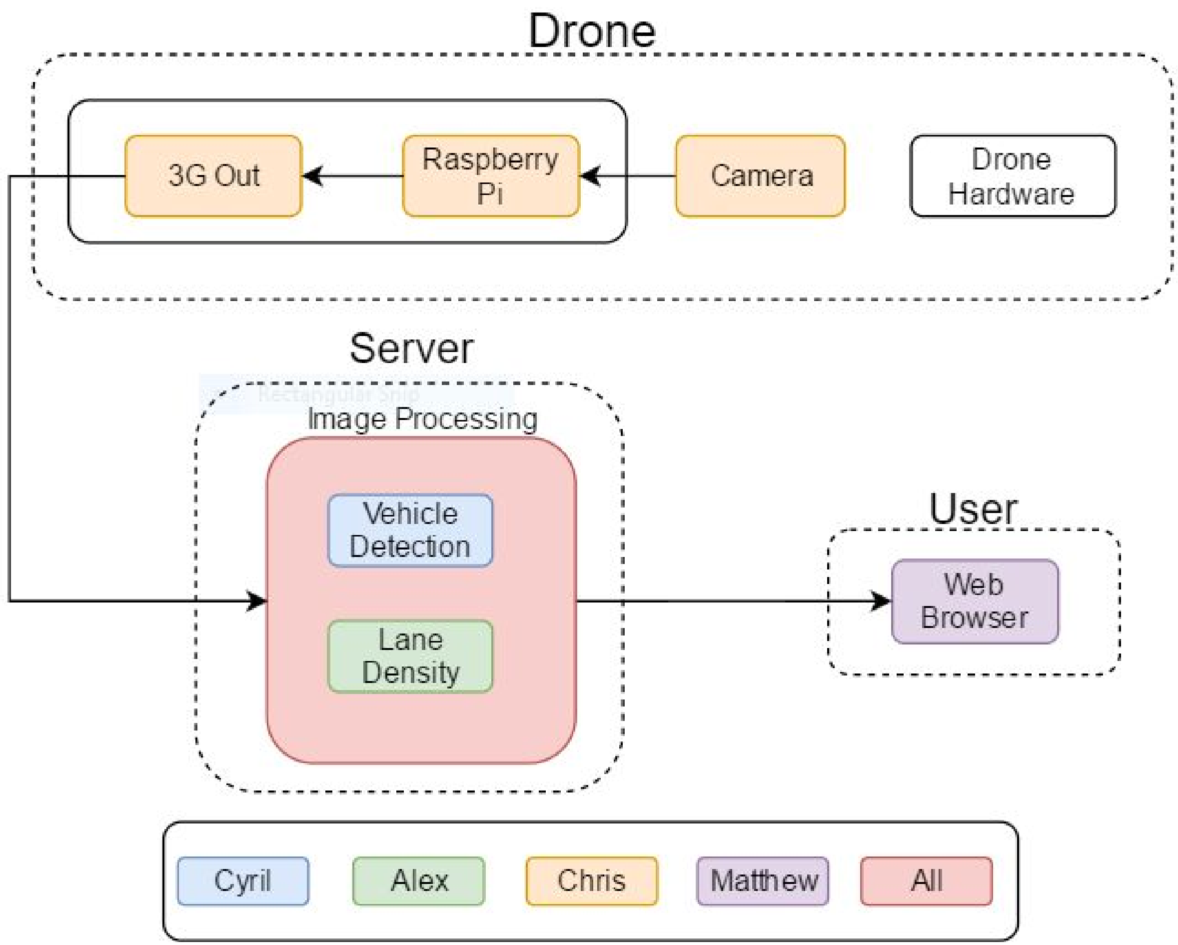
# System Requirements

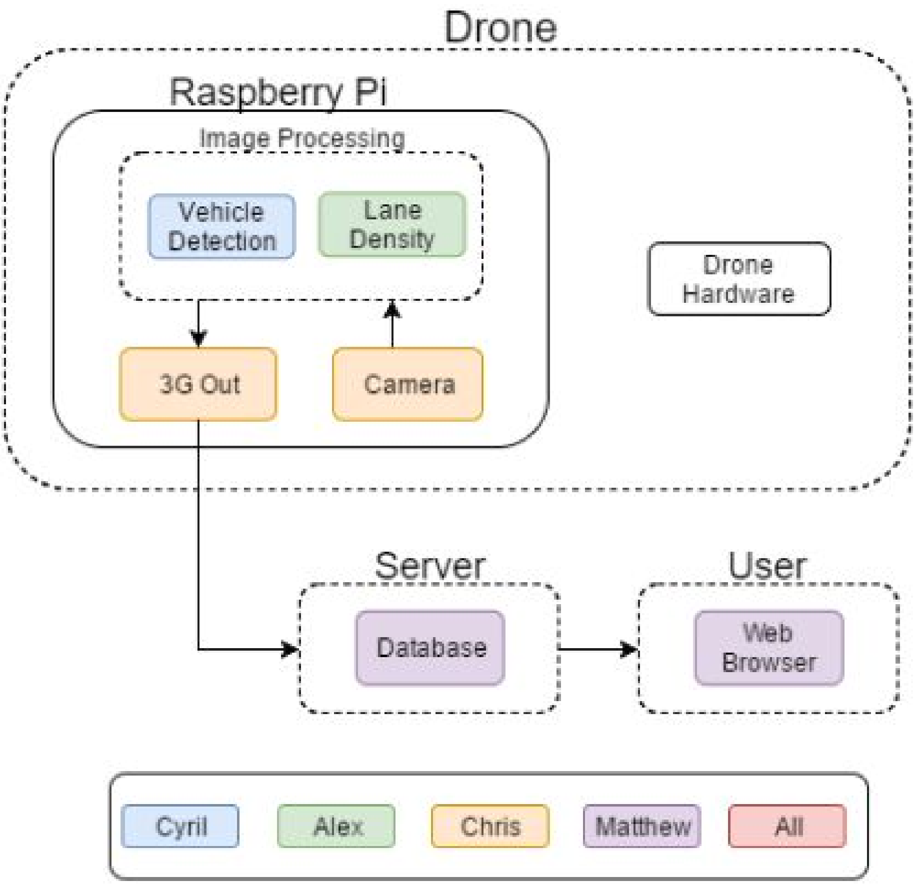
# Recap

- Traffic data needs to be more comprehensive as more and more cars are on the roads
- Current traffic data collection methods are expensive and/or insufficient
- An Unmanned Aerial Vehicle (UAV) can be used to provide aerial image and video
- Image processing will analyze the image/video for car density and spacing on the drone
- This data is sent to a server in the cloud for display

# Block Diagram - PDR



# Block Diagram - MDR

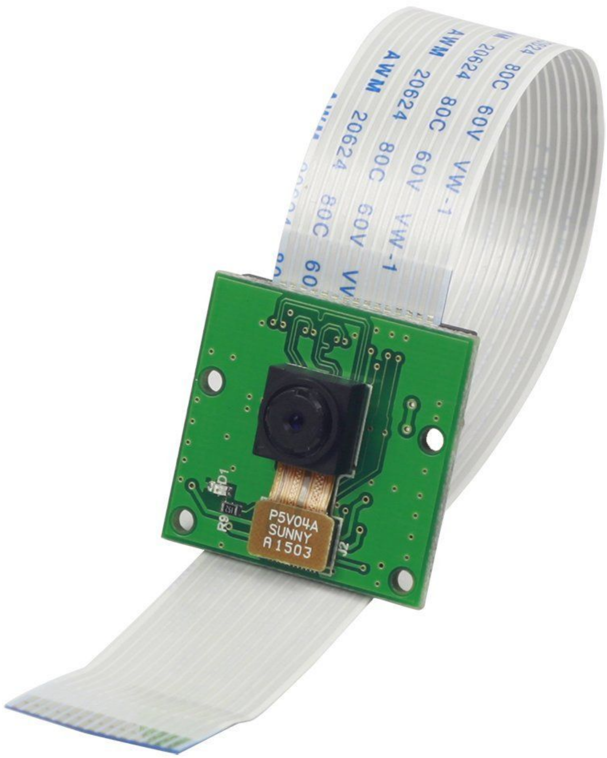


# Drone - 3DR Iris+

- Cost: $550
- Payload: 0.8lb
- Flight Time: 20 minutes
- Range: 1km
- Programmable Autopilot

# Camera - Arducam OV5647 Video Module

- Resolutions: 1080p30, 720p60, 480p60
- Weight: 0.3 ounces
- Field of view: 2.0 x 1.33m at 2m
- Angle of view: 54 x 41 degrees



# Demonstration of Deliverables

# MDR Deliverables

- Alex/Cyril: Image processing
  - Identifies 80% of visible cars in ideal conditions in sample tests
  - Identifies distances between cars to within one car
  - Has 35 distinct test cases for our image processing software
- Matt: Data server for performing image processing and storing data is set-up
- Chris: Camera and network system can send image data to data server via 3G

# Image Processing Requirements

- Detecting Cars from a top down view
- Counting the amount of cars in the picture
- Distinguishing between different lanes of a highway
  - Determining spacing between cars in each lane

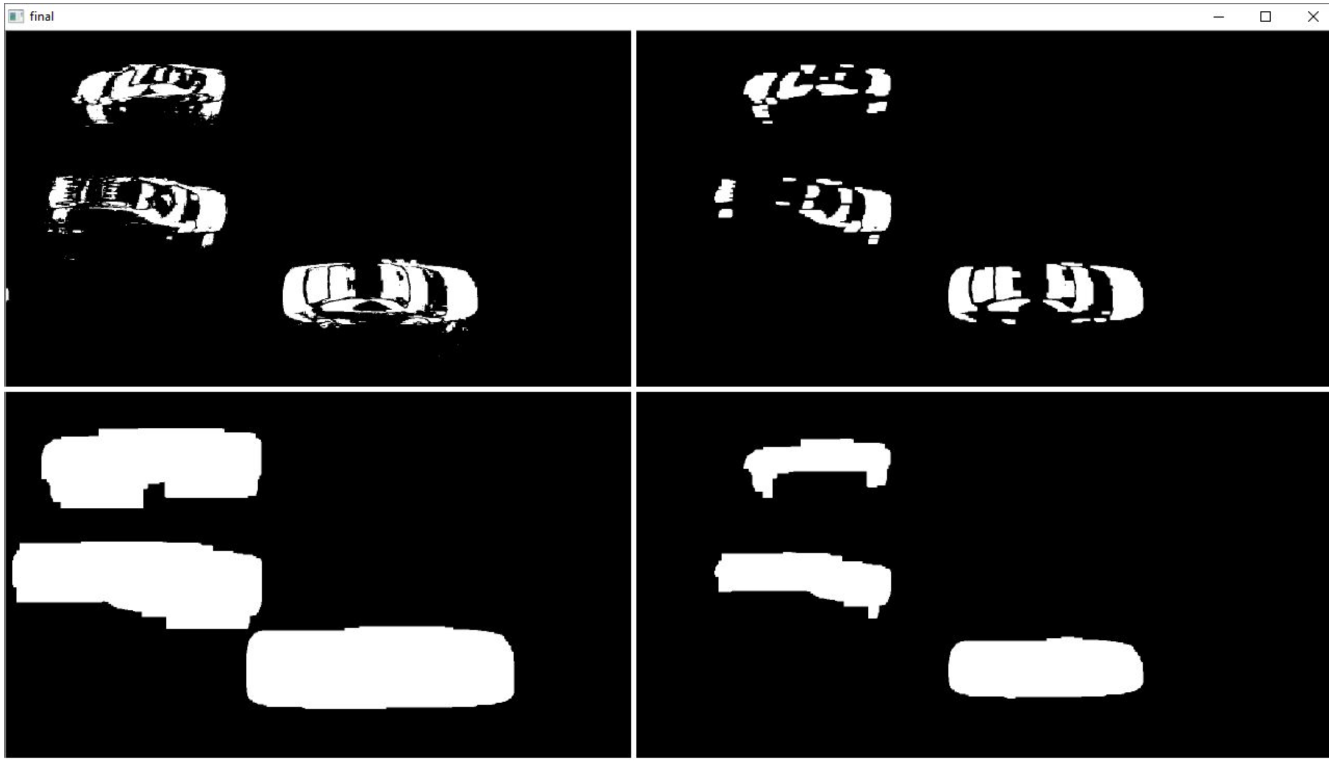
# Image Processing Approach

- Background Subtraction
  - Drone takes images as initial “background”
    - Recursive averaging to estimate background
- Cropping
  - Remove traffic in opposite direction
  - Remove extraneous roads (ramps) and nonroad components
- Vehicle Detection
  - Use background subtraction as vehicles are only moving objects
  - Vehicles can be better segmented from background through thresholding

# Image Processing Techniques

- Dilation
  - Rectangular kernel increases white regions in image via convolution
- Erosion
  - The opposite of dilation, decreases white region in the image via convolution
- Opening/Closing
  - Opening is erosion followed by dilation - noise reduce
  - Closing is dilation followed by erosion - gap fill
- Contour detection
  - Find curve containing group of points, essentially an outline of a shape
  - Can limit contour by size to filter shapes

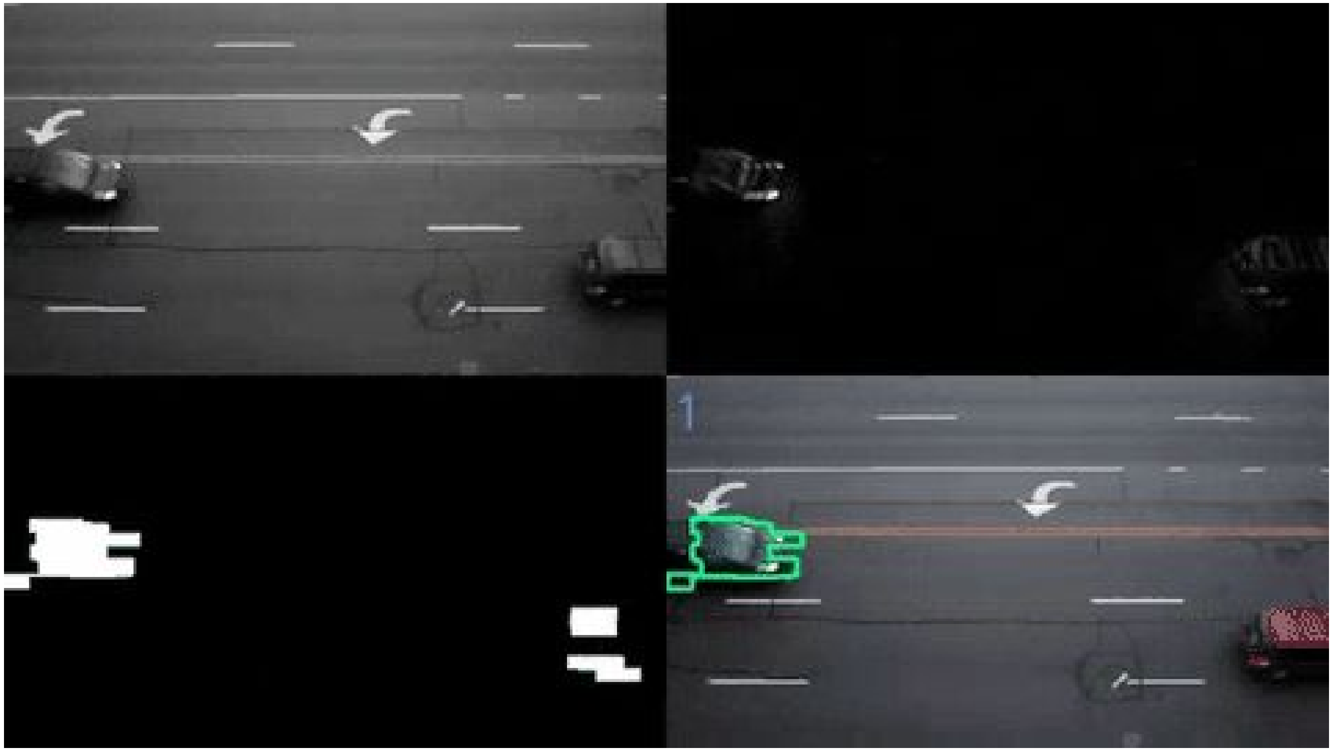
# Example - Opening/Closing




Top Left - Thresholding
Bottom Left - Dilation

Top Right - Opening
Bottom Right - Erosion

# Example




Top Left - Gray Scale
Bottom Left - Closing

Top Right - Thresholding
Bottom Right - Contoured Original Image

# Our motion detection algorithm - High level

- Background subtraction is very sensitive to camera motion
- Overcome this by considering the fact that the drone moves relatively slowly
  - We can find a mapping from each frame to another frame a set amount of time (⅓ or ⅙ of a second) later.
  - By making this mapping, we can find the homography matrix that shifts the earlier frame onto the new frame.
  - The shifted image does not account for movement outside of drone movement, so we can feed it into a standard background subtraction algorithm.

# Our motion detection algorithm - Cont.

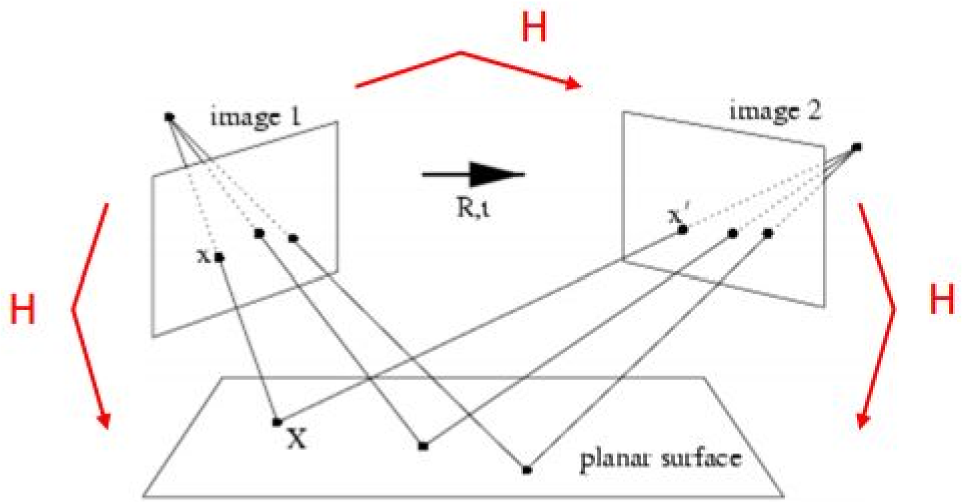
- Background subtracted image can be passed to contour detection, which gives point descriptions of the motion found.
- Using a few more assumptions about the heading of the drone and the compass orientation of the road, we can find the distance between contours

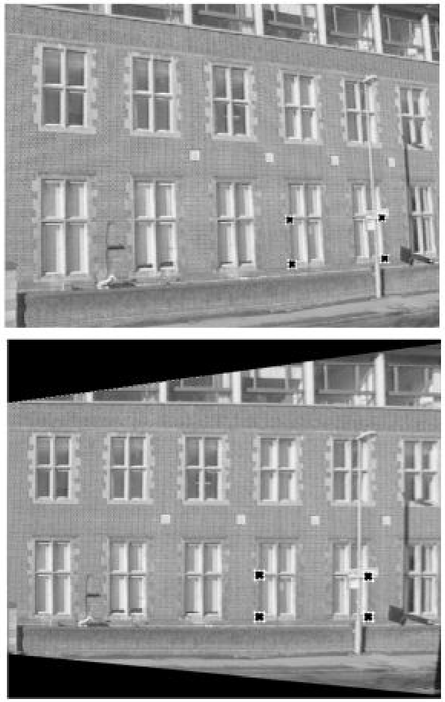
# Finding keypoints between images

- SIFT - Scale Invariant Feature Transform
  - (Lowe, 1999, International Journal of Computer Vision)
  - Allows robust image recognition

# Finding the homography matrix

- A homography matrix is a 3x3 matrix describing the transformation from one perspective to another, such that lines are mapped to lines.



(Gava, Bleser)

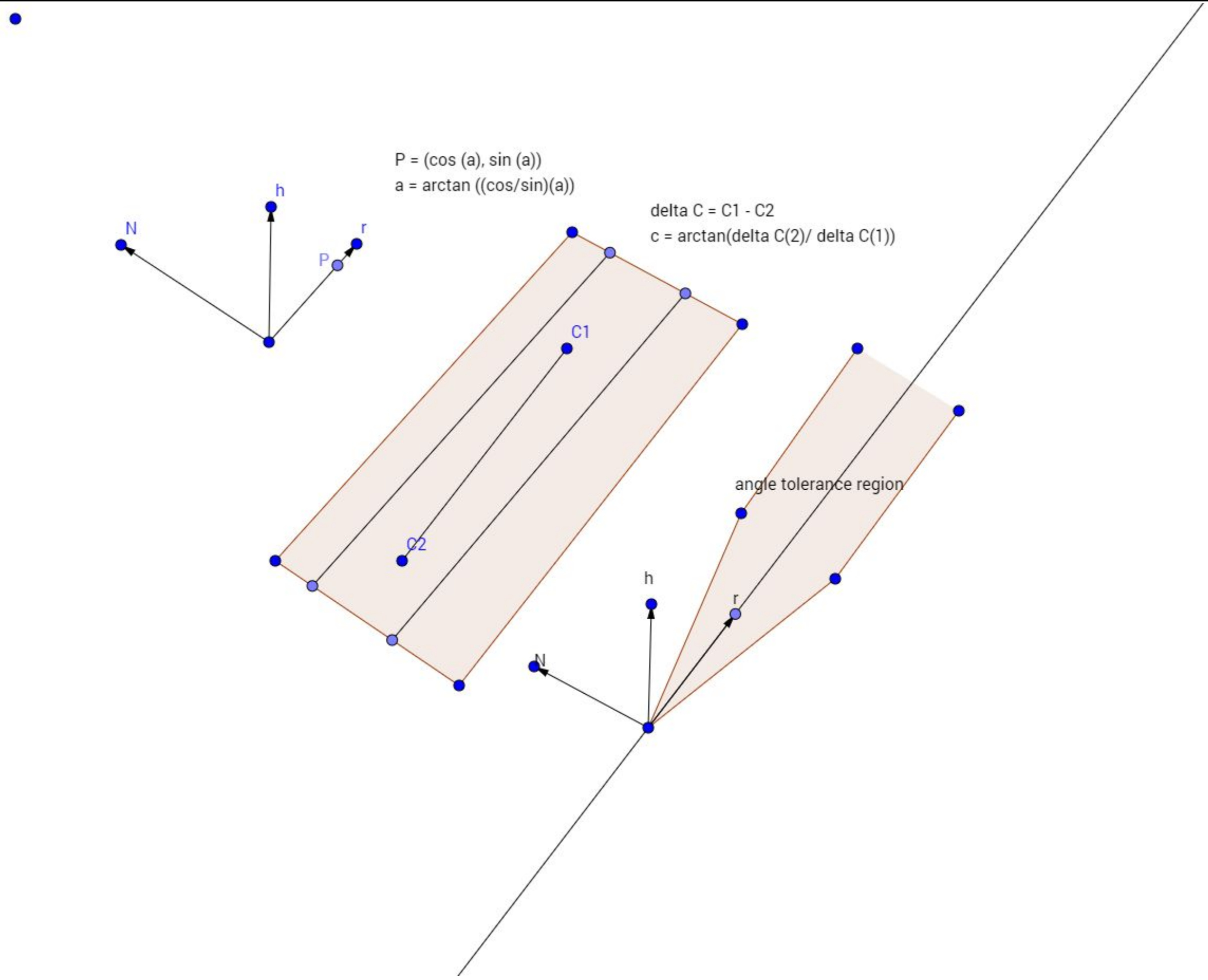
# Background Subtraction

- Uses the algorithm outlined in Zivkovic's "Improved adaptive Gaussian mixture model for background subtraction" (Conference on Pattern Recognition, 2004)
- Uses per pixel probability distributions to determine if an object is in the background (and static) or in the foreground (and moving)

# Interval detection

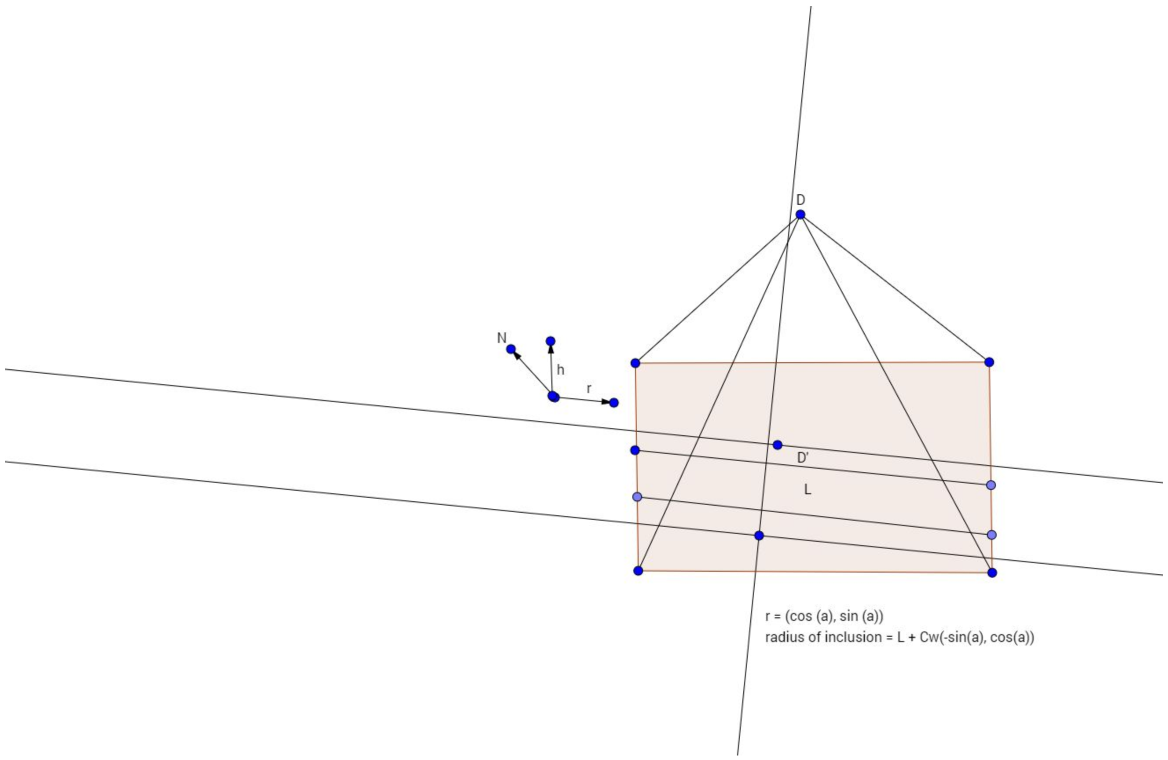
- By assuming we know the heading of the drone from the internal compass and the compass direction of the road to a reasonably accurate degree before takeoff, we can find the vector between detected contours, and compare that angle to the expected road angle.
- If the angles are in a cone nearby and within two boundaries at a distance, then consider the number of pixels between the two the interval.

# Interval Detection Diagram



# Road Cropping

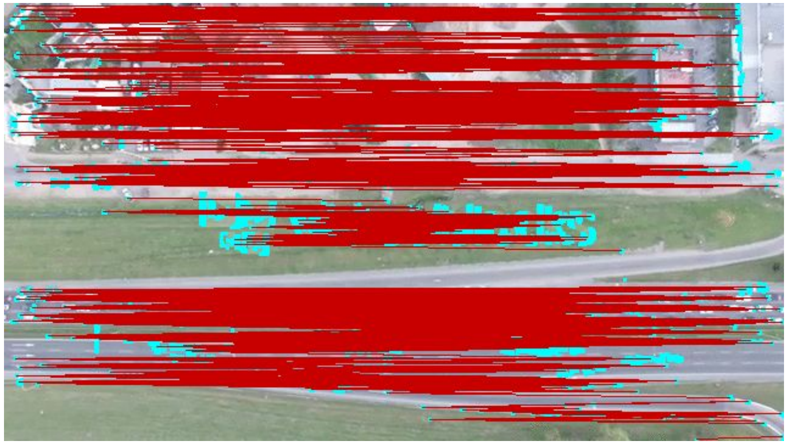
- Assume we know the heading of the drone and the road



# Results


# Results

In this sample, detects 28/30 cars in the lower lane.
Sample collection troubles make a more rigorous analysis of lane detection difficult.

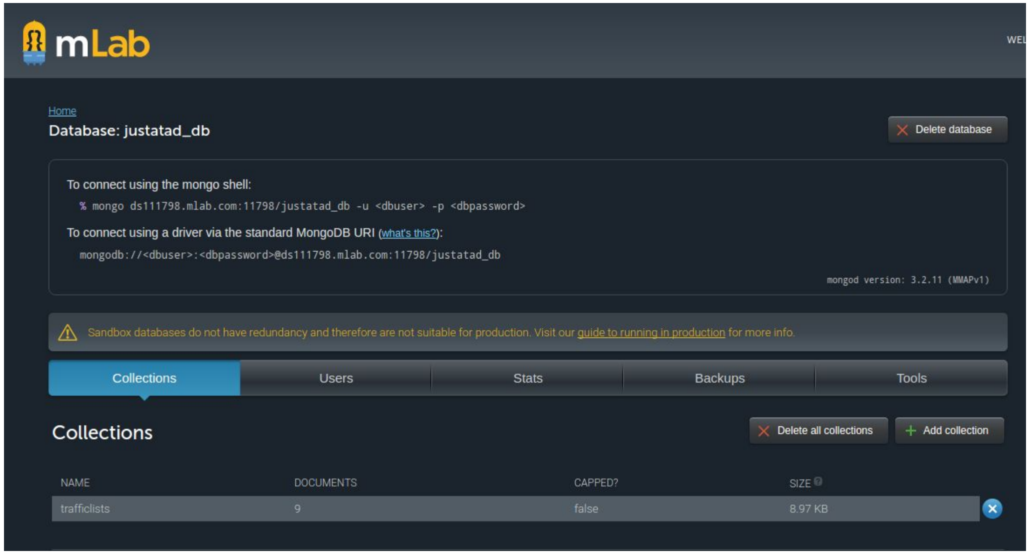


# Internet Connection

- Take pictures at one second intervals
- Transmit processed image data over 3G to data server

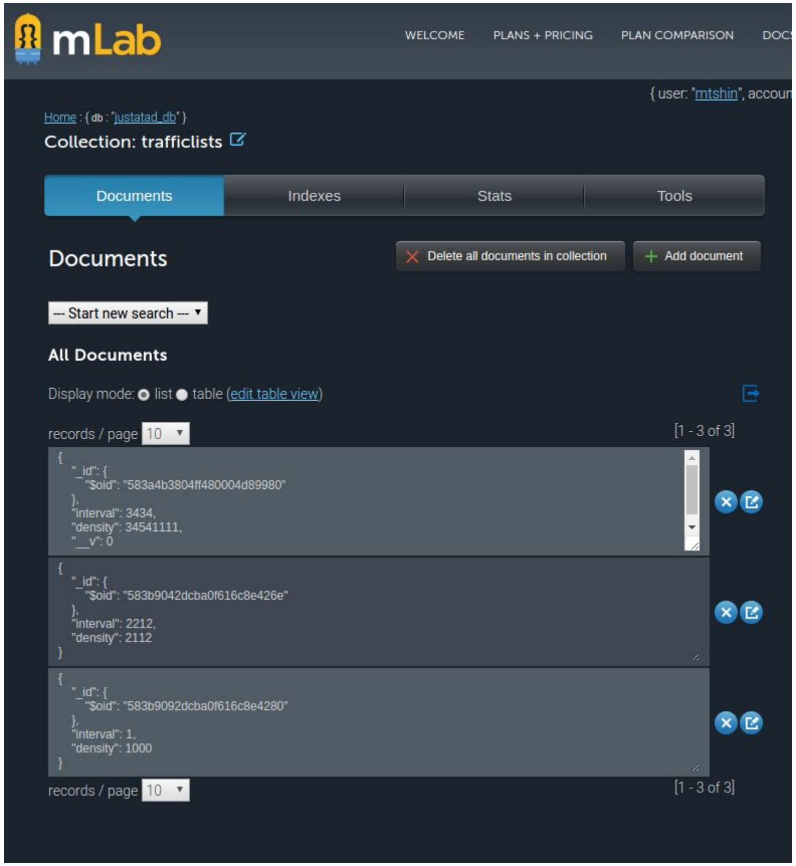
# Data Server

- Server receives processed data (Density, Interval)
- Displays data on web page



# Data Server Implementation

- Remove as much load from Raspberry Pi as possible for image processing
- Database hosted on cloud (mongolab)
  - Deployed on AWS (Reliable, free up to 500 MB)
  - Database visualization
- mongoDB
  - JSON documents allow for varying structure
  - Flexible (dynamic schemas)

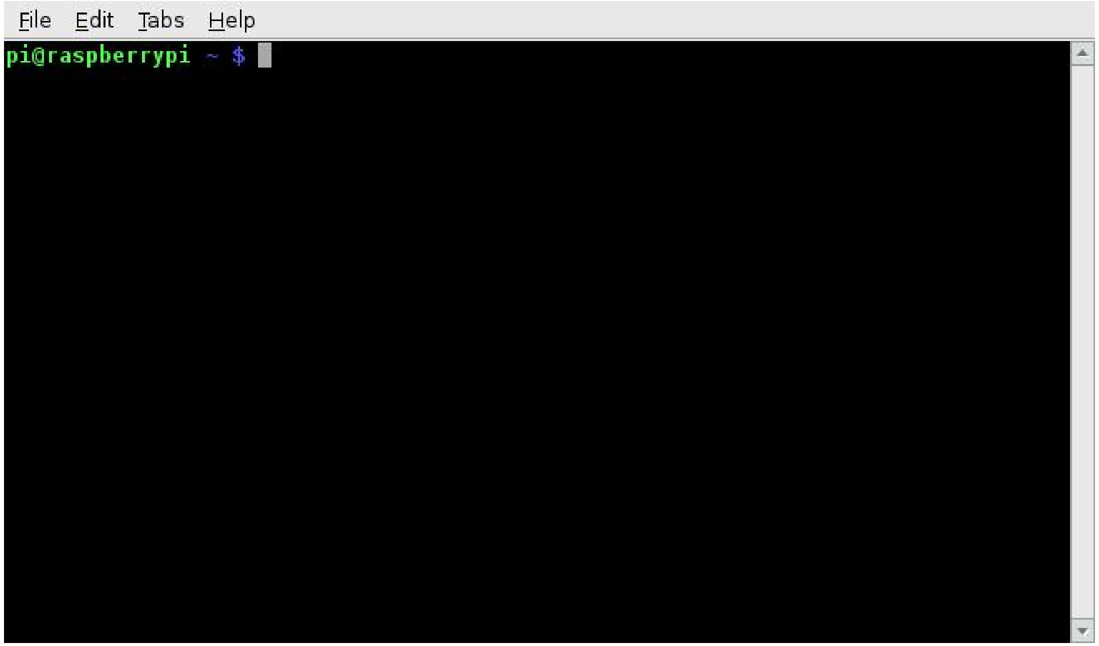


# Web App UI

- MEAN (MongoDB, Express, Angular, NodeJS) Stack web application to query database
- Hosted on cloud (Heroku)
- CRUD (Create, Read, Update, Delete) functionality for development

# Raspberry Pi- Initial Setup

- Unpacked and Assembled
- Acquired a micro SD card and downloaded raspbian
- Installed Raspbian



# 3G Dongle

- Must Acquire 3G subscription
- Installed Drivers
- Hot Plugging
- Device Switching
- Sending HTTP Packets
- Dealing with Firewalls

# Current Pricing - 3DR Iris+

| | |
|---|---|
| Drone | $598 |
| Camera | $15 |
| Raspberry Pi | $50 |
| 3G Dongle | $34 |
| 3G Subscription | $25 |
| FAA Registration | $5 |
| Total (with drone) | $727 |
| Total (without drone) | $129 |

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# Team Responsibilities and Schedule

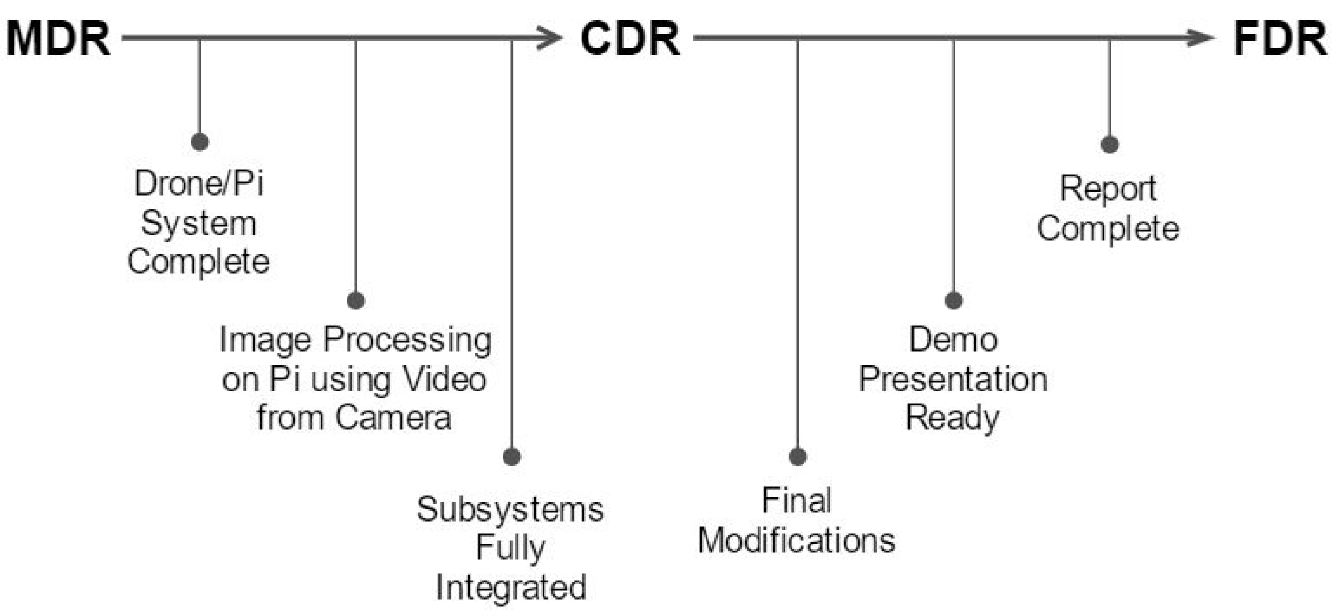
# CDR Deliverables

- Alex/Cyril: Image processing
  - Identifies visible cars in own test images
  - Calculates density of cars as cars per distance or as car to road ratio
  - Integrate camera and server
- Matt: Data Server
  - Automatically update web app to display most recent database content
  - Assemble and test the 3DR Iris+
- Chris: Raspberry Pi
  - Camera interfaces with image processing software
  - Send image data to server via 3G

# Expected for Project Completion

- Alex/Cyril
  - Alex: Completion and debugging of software
  - Cyril: Debug integration of software with camera and sending to server
- Matt
  - Become proficient in piloting the drone for demo
  - Test and debug webapp
- Chris
  - Ensure Pi/drone system is ready for testing/demo
  - Assist in final design testing and demo
- All
  - Assist with final report

# Team Schedule



# Thank You!

Questions?