UMassAmherst

BuddyCam

Midway Design Review

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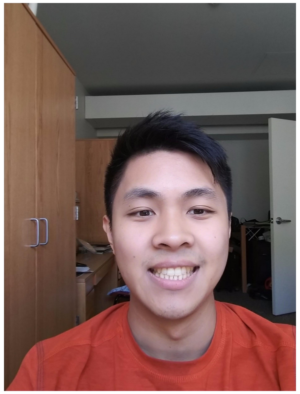
Meet the Team



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The Problem

There is growing concern in regard to the relationships between law enforcement officers and the public

- Shooting of unarmed civilians
- Excessive use of force
- Protests across the country
- Lack of reliable information
- Violence imposed on officers and public servants

The Problem: Improving Safety, Efficiency, and Accountability

The benefits of recording law enforcement interactions include

- Accurate reconstruction of incidents and gathering of evidence
- Decreases violence against police officers
Increases accountability and reduces complaints against officers
- Ability to analyze recordings of many incidents and develop department wide policies to effectively address situations

Our Original Solution

BuddyCam

Deployable Unmanned Aerial System (UAS) capable of autonomously identifying, tracking, and recording officers

- Quadcopter equipped with fixed camera
  - Aerial video capture of officer
  - Wirelessly transmit video to base station
- Base Station
  - Performs real time image processing
  - Object identification and tracking using computer vision
  - Allows UAS to move based on location of officer
  - Flight instructions sent back to UAS
  - Able to store received video

Our Revised Solution

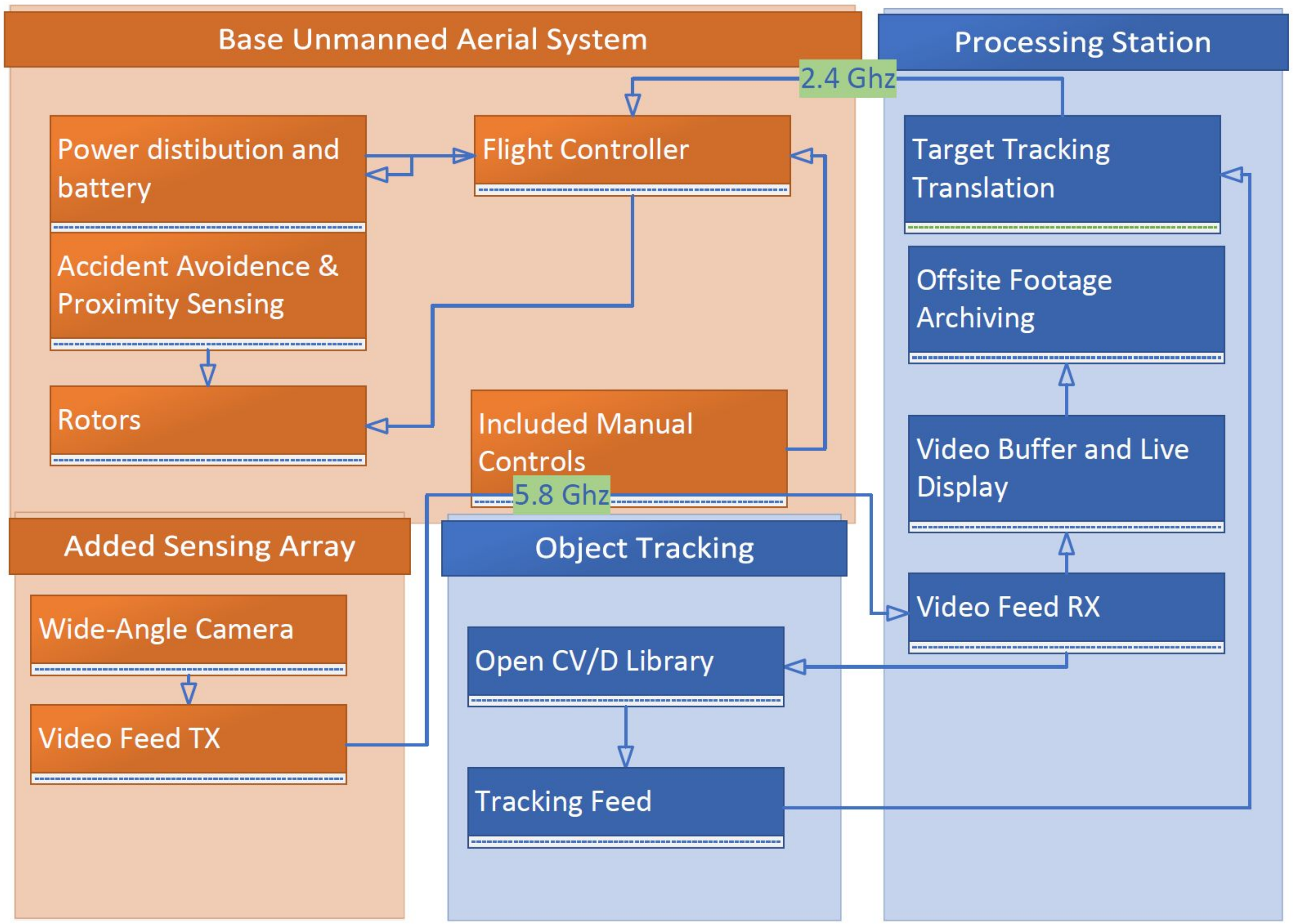
BuddyCam

Deployable Unmanned Aerial System (UAS) capable of autonomously identifying, tracking, and recording officers

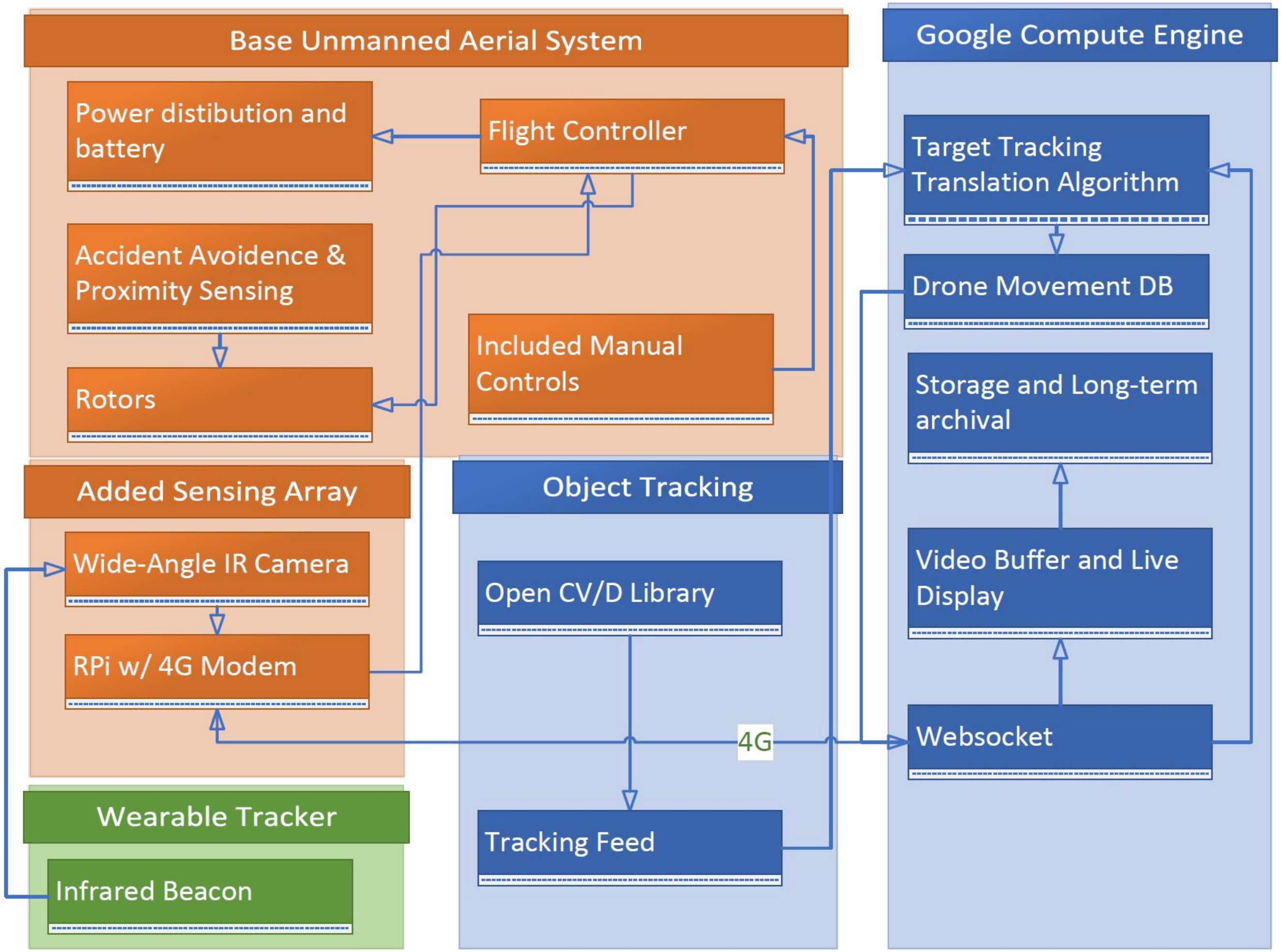
- Quadcopter equipped with fixed camera
  - Aerial video capture of officer
  - 4G wireless connection to Google server
  - Raspberry Pi3 for communication
  - IR beacon providing second opinion

- Google Compute Engine
  - Perform remote image processing

Original Block Diagram



Revised Block Diagram



Original Specifications

- Fully autonomous after lift-off
- Track and keep subject in frame
  - maximum of 1.6 s out of frame
- Maintain minimum height of 8 ft after initial lift-off, variance of 2 ft
- Maintain line of sight of subject within a radial distance of 15-20 ft
- Operate and record for at least 10 minutes
- Max operational distance from base station 0.25 miles

Revised Specifications

- Fully autonomous after lift-off
- Track and keep subject in frame
  - maximum of 1.6 s out of frame
- Maintain minimum height of 10 ft after initial lift-off, ~~variance of 2 ft~~
- Maintain line of sight of subject within a radial distance of 15~~-20~~ ft
- Operate and record for at least 10 minutes
- ~~Max operational distance from base station 0.25 miles~~

Specifications -- Analysis and Justification

"Maintain minimum height of 10 ft / distance of 15ft"

- Initial tests with the drone show that altitude settings are extremely precise, += approximately 1 inch, and thus this measurement can be set to a value seen fit by the user

"Maximum of 1.6s out of frame"

- Based on a median throughput limit of 22.3 Mbps on 4G networks (IEEE Research Publication)

"Operate and record for 10 minutes"

- Based on the specifications and size of battery included with the drone we are using. This can be easily upgraded as seen fit, budget allowing, by law enforcement agency

PDR Recommendations Addressed

Physical Base Station

Concerns:

- Flight restricted to a small radius from police car
- Live video transmission over radio frequency may not be reliable

Results:

- This concern has been addressed by implementation of cloud processing

PDR Recommendations Addressed

Raspberry Pi Processing Capability

Concerns:

- Raspberry Pi may not have processing capability to handle live video processing and subject tracking

Results:

- This concern has been addressed by implementation of cloud processing

PDR Recommendations Addressed

Image Processing Feasibility

Concerns:

- Image Processing may not be able to accurately detect and track subject in frame
- May not be able to be implemented by MDR

Results:

- Current implementation is relatively accurate and fully implemented
- Image processing will be joined with hardware beacon to ensure accuracy and efficiency

MDR Deliverable: Team Roles

Saswati

Wireless transmission of analog video from board camera to Raspberry Pi, using RF.

Joseph

Object recognition through use of Raspberry Pi, image processing python libraries

Kyle & Steven

Object tracking through use of Raspberry Pi, image processing python libraries

MDR Deliverable: Team Roles Revised

Saswati

~~Wireless transmission of analog video from board camera to Raspberry Pi, using RF.~~

Set up of IR Beacon

Joseph

Object recognition through use of Raspberry Pi, image processing python libraries

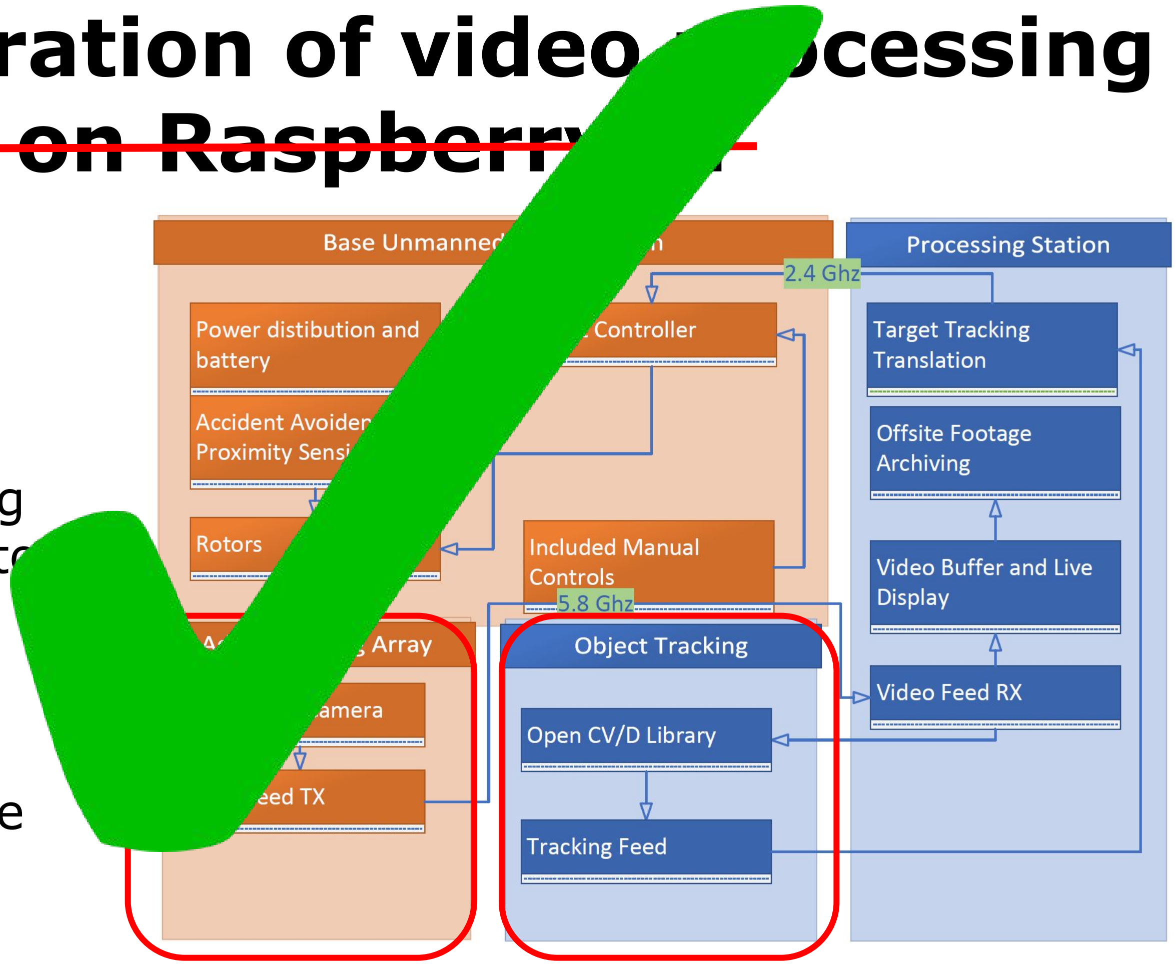
Kyle & Steven

Object tracking through use of Raspberry Pi, image processing python libraries

Proposed MDR Deliverables

Demonstration of video processing ~~on Raspberry Pi~~

- Stationary camera
- OpenCV processing on RPi connected to a camera
- Object recognition & tracking in frame



Current Progress

- Full implementation of Image Processing Functions using stationary camera
  - Raspberry Pi
  - Google Compute Engine
  - Personal Computer
- Preliminary implementation of infrared hardware beacon
- Preliminary implementation of communication between flight controller and processing unit

Image Processing

1. Frame is segmented using image thresholding: This creates a mask segmenting the correct shade of blue in the frame
   a. Each pixel value in image is recalculated according to a mask matrix
   b. Color blue in HSV color-space is segmented

2. Distance between center of subject and center of frame is calculated

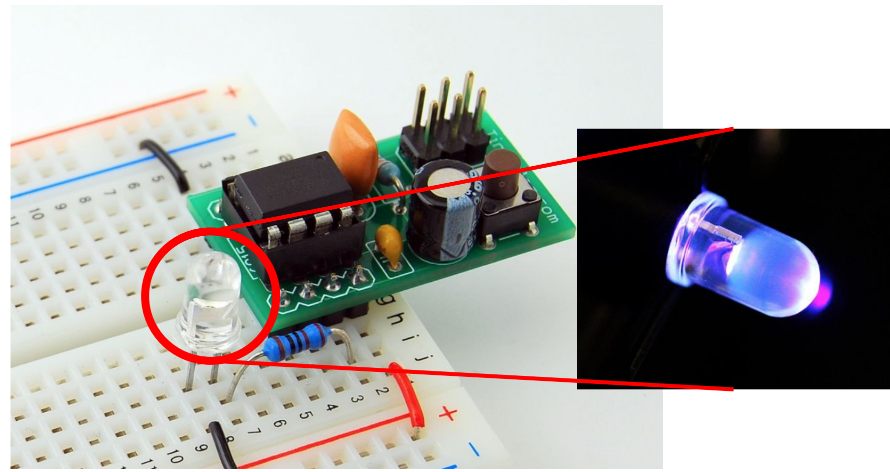
3. Necessary logic is derived to maintain the center of the subject in the center of the frame

IR LED Beacon Technology

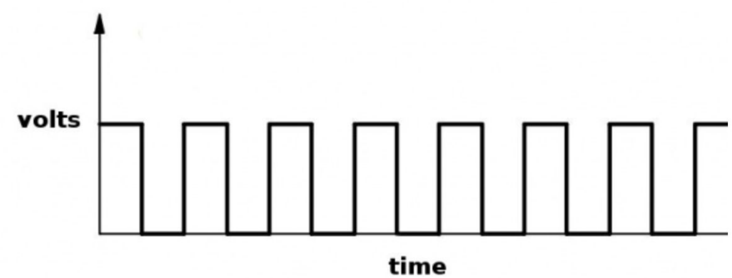
- Used hand in hand with image processing
- IR LED will be sending Pulse Modulated Signals

Pros:

- Can be detected in the dark
- Signal is Unique



Courtesy of: TinkerLog



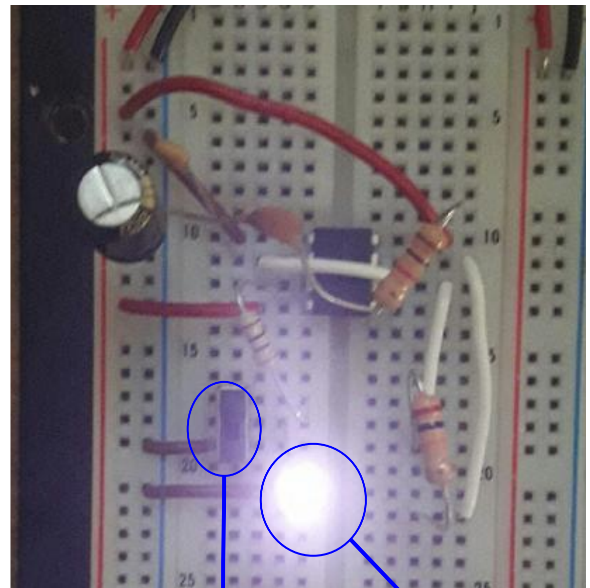
Courtesy of: TinkerLog

Our Current IR Transmitter

- Transmits at 38 KHz
- Switch for on/off
- Can be detected from 10 ft (Weak)

Next Steps:

- Portable
- High power LEDs
- Pulse Transmission



IR LED - ON

Switch for on/off

High Power IR LED

Google Compute Engine

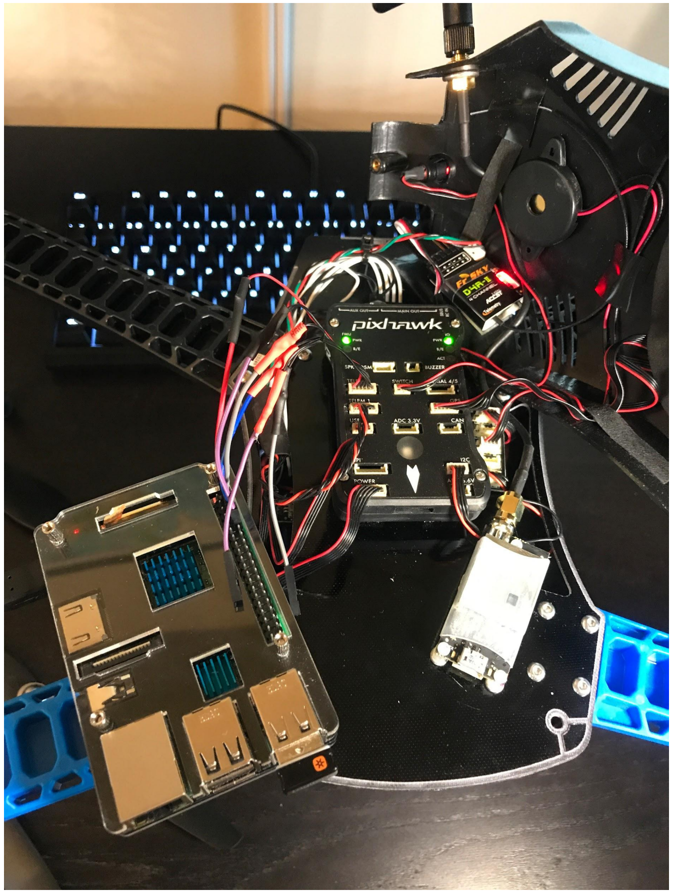
- Debian cloud server running Python OpenCV
- Scalable computation performance, more powerful than mobile solution
  - Google has a robust fiber network
- Eases implementation and provides modularity/reliability
- Rasp. Pi can query for commands from server output

Utilization of 4G

- 4G modem interfaced with RPi on drone
- A stream application running on Pi, push video to Compute Engine
- Need to address latency concerns: test video codec (ffMPEG, H.264), use of existing 4G streaming cameras (SkyDrone FV2)

Raspberry Pi 3

- Serves to process communication between flight controller and remote server
- 4G modem directly interfaced
- Relay instructions to flight controller



Proposed CDR Deliverables

- Portable IR Beacon
- Video of Subject with IR Beacon
- Image Processing through Google Compute Engine
- Network RaspPi to 4G
- Formatting Flight Controls Based on output of Code

CDR Deliverable: Team Roles

Saswati

- Rearranging breadboard IR Beacon parts to be Portable
- Adding in High Power IR LED onto Beacon

Joseph

- Interfacing Google Compute Webservices with Raspberry Pi
- Database storage

Kyle

- Interfacing Raspberry Pi with flight controller for autonomous movement

Steven

- Google Compute Engine configuration
- 4G Communication, Database Queries

Planned Schedule of Activities - Saswati

Portable IR Beacon

- Achieved through soldered hardware parts attached to battery source
- Beacon will operate through on/off switch

Stronger signal

- Achieved through the attachment of High Power IR LED
- Allows for detection for long distances, and low light

Courtesy of: Own The Night

Planned Schedule of Activities - Joe

Interfacing Google Compute Webservices with RPi

- Develop reliable subsystem for delivering flight controls to RPi over 4G
- Integrate with other Google Compute components

Instruction storage

- Store processed flight commands for analysis and optimization
- Long-term archival of footage

Planned Schedule of Activities - Kyle

Interface Raspberry Pi with Pixhawk flight controller

- MAVlink communication from serial bus on Raspberry Pi to Telemetry port on Pixhawk flight controller

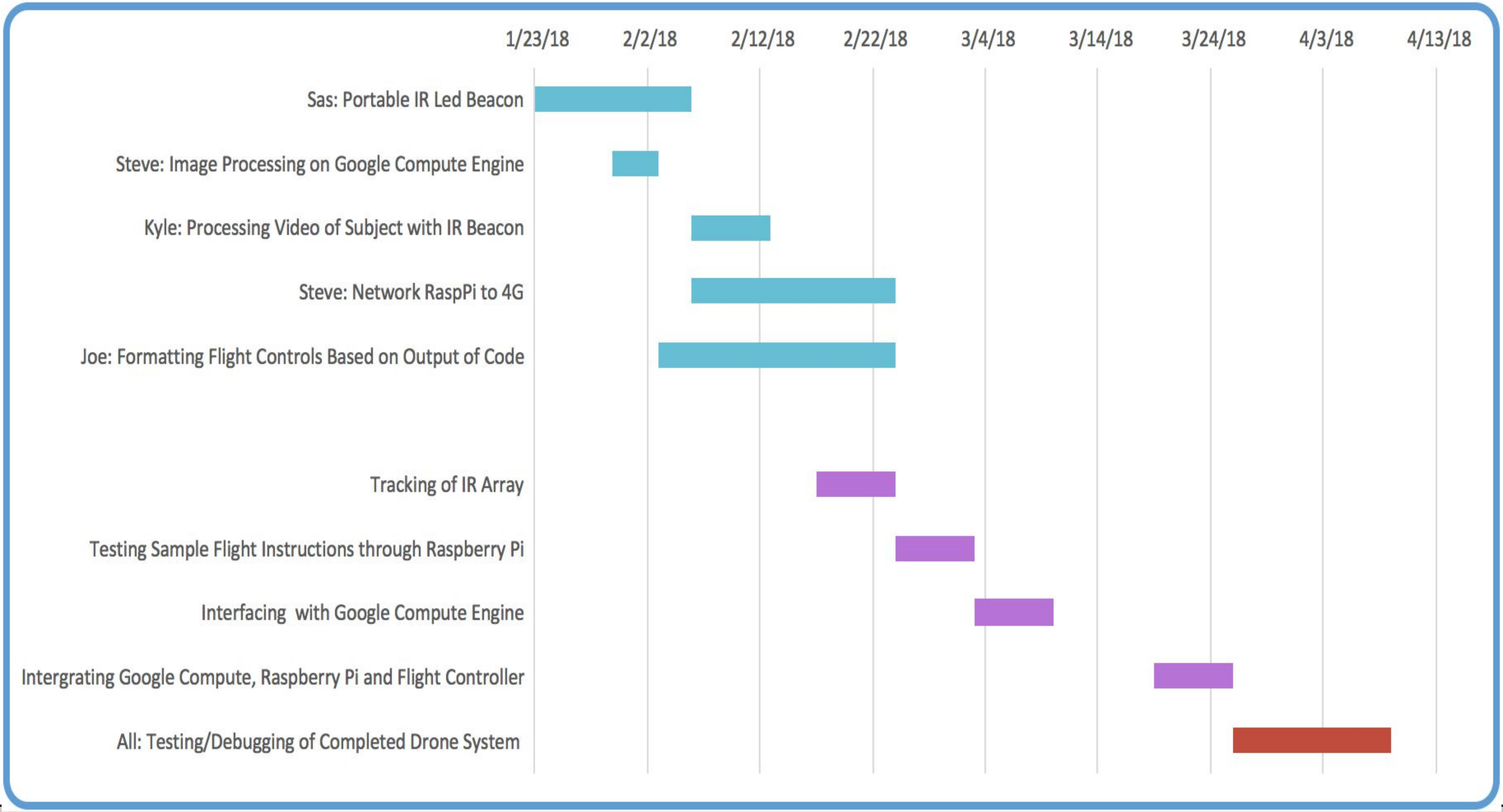
Tangible progress towards converting logic from subject tracking into autonomous movement

- "down left" from image processing → rotate left 3 degrees; move backwards 4 feet

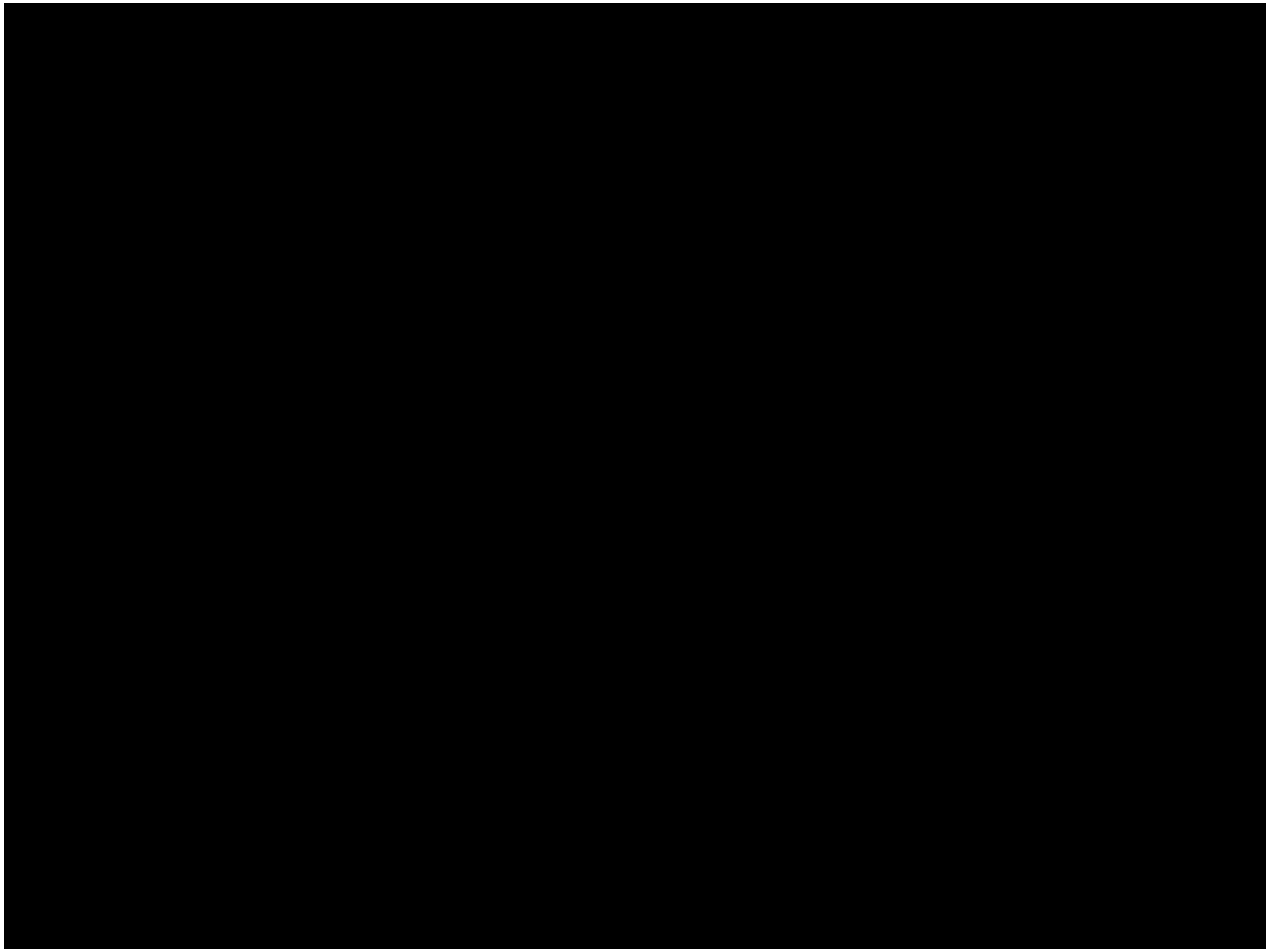
Planned Schedule of Activities - Steven

- Configure Google Compute Engine for OpenCV
  - Investigate necessary computation requirements
- 4G Communication
  - Interfacing 4G modem with Raspberry Pi
  - Communication and latency testing
- Instruction Querying
  - Raspberry Pi requests to server
  - Eventually used to request next instruction

Gantt Chart


1/23/18
2/2/18
2/12/18
2/22/18
3/4/18
3/14/18
3/24/18
4/3/18
4/13/18
Sas: Portable IR Led Beacon
Steve: Image Processing on Google Compute Engine
Kyle: Processing Video of Subject with IR Beacon
Steve: Network RaspPi to 4G
Joe: Formatting Flight Controls Based on Output of Code
Tracking of IR Array
Testing Sample Flight Instructions through Raspberry Pi
Interfacing with Google Compute Engine
Intergrating Google Compute, Raspberry Pi and Flight Controller
All: Testing/Debugging of Completed Drone System

DEMO



Thank you

Questions