Quadcopter Cameraman

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Website: http://sdmay19-42.sd.ece.iastate.edu/

Problem Statement

- The Descarga Latin Dance Club on campus is having difficulties recording themselves and other members during performances.

- The main issue is that a camera man can be obtrusive on a dance floor and get in the way of the dancers themselves or other dancers that may or may not be on the floor at the same time.

- To solve this issue our client has hired us to design, build, and program an **autonomous quadcopter**. This quadcopter will be able to identify the target dancers and record them at a preset distance.

System Design

Constraints

- Flight Time
    - Must be able to fly for at least 5 continuous minutes
- Budget
    - We are trying to keep the cost close to what team members contributed to the senior design pool
- Weight
    - An ideal thrust to weight ratio is 2:1 at full throttle that way the drone can hover at half throttle

Functional Requirements

- Video Quality
  - 480p or better
  - 24 Frames per second or better
- Flight Control
  - Must be autonomous
  - Must prioritize user control over autonomy
- Image Recognition and Tracking
  - Drone must follow target for full performance
  - Drone must keep target in frame for full performance

Nonfunctional Requirements

- Useability
  - Fit for non-tech savvy people
  - Responsiveness
- Reliability
  - Stability
  - Endurance

Constraint - Thrust to Weight Ratio

ML2212 MOTOR								
Item NO.	Volts (V)	Prop	Throttle	Amps (A)	Watts (W)	Thrust (g)	Efficiency (g/W)	Operating temperature(℃)
ML2212 920KV		APC10*4.5	65%	5.1	56.6	460	8.1	55℃
			75%	7.4	82.1	590	7.2	
			85%	10.1	112.1	730	6.5	
			100%	13.4	148.7	860	5.8	

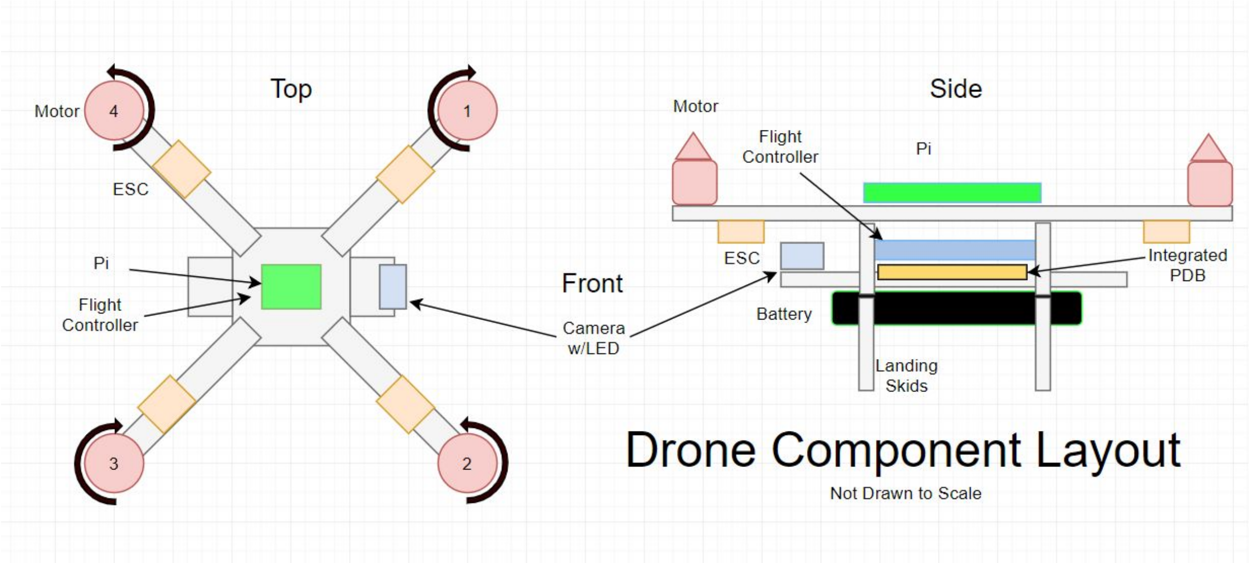
860(g) * 4 propellers at full throttle = 3,440 (g) of thrust

Our theoretical drone weight is 1,643.217(g)

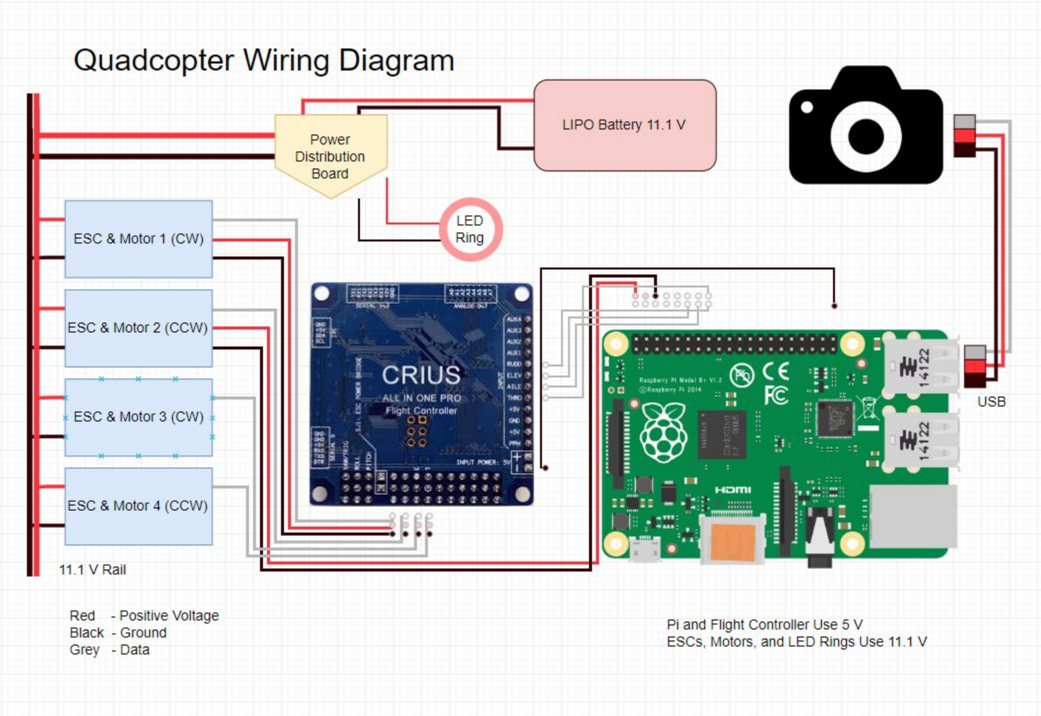
Achieves 2.09 : 1 Thrust to weight ratio

*Hovering should be achievable at ~59% throttle

Hardware Layout



Detailed Design



Cost Breakdown

Internal Components	Model		Price
Processor	Rspbry Pi 3 Model B		$34.99
PI power	KMASHI External Battery		$10.99
Motor System			
Battery O-2	Gens Ace		$56.05
Flight Controller	ZnDiy-BRY CRIUS All in One Pro		$53.36
Power Distribution Board	Lumenier Mini 4		$11.99
Motors	Gartt4 x 2212		$135.72
ESC	Hobbywing Skywalker		$0.00
Props	Ray Corp Gemfan		$13.99
Video System			
Frame	JRLEC		$16.90
Camera	Fosa USB Camera		$8.99
MicroSD	Kingston 16GB		$5.75
External Components			
Battery Charger	Passport P1 Mini (DYNC3015)		$44.99
Total Cost			$393.72

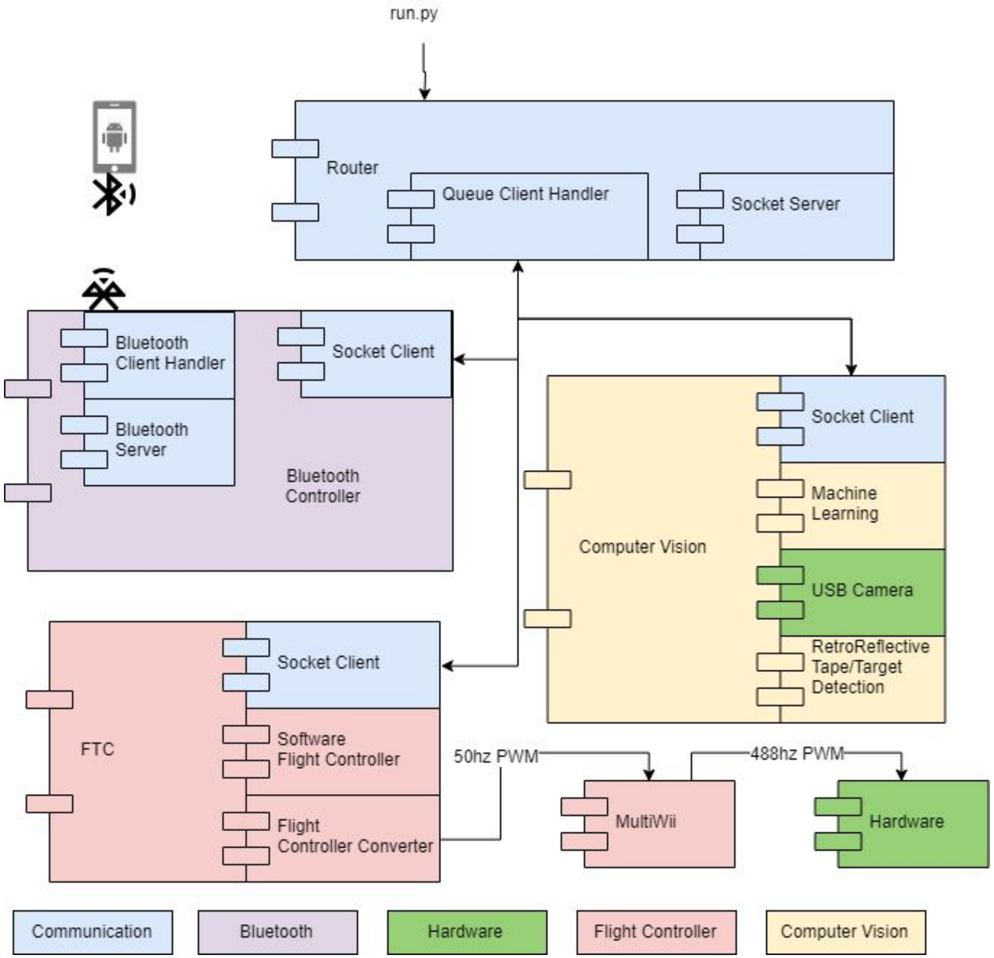
Additional Developmental Costs

- Used as replacements or to better test system
- Some items provided and paid for by client

Transmitter/Receiver	$60
Ring LED + Tape	$13
Propellers x 32	$24
Wireless Bluetooth USB Port	$13
Landing Skids	$9

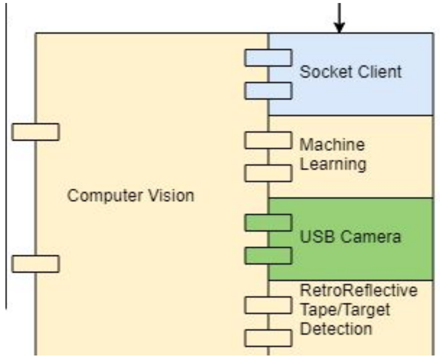
Software Layout

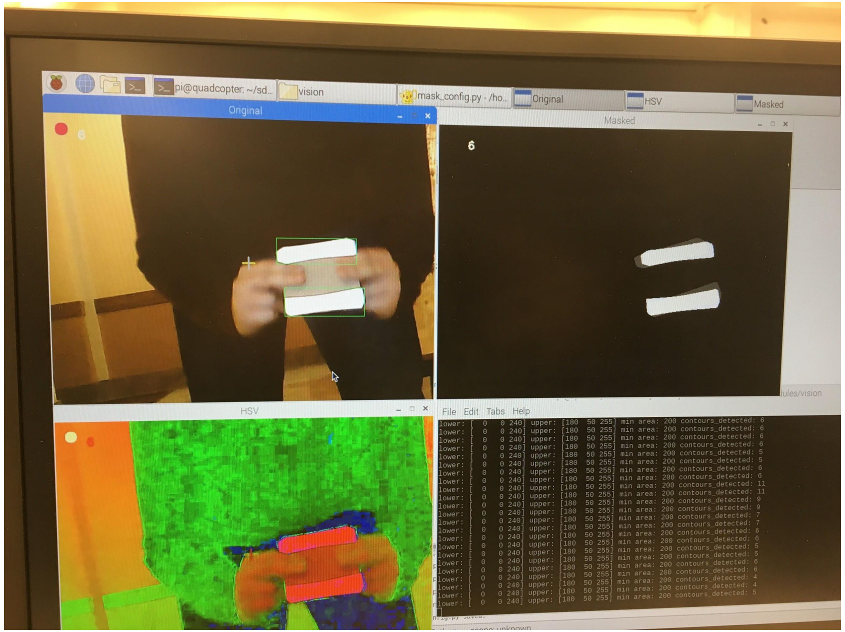
- Languages
  - Python 3
  - Java
  - C
- Platforms
  - Android
  - Raspbian
  - Atmega2560 Microcontroller
- Benefits
  - Extensible
  - Maintainable
  - interoperability



Computer Vision

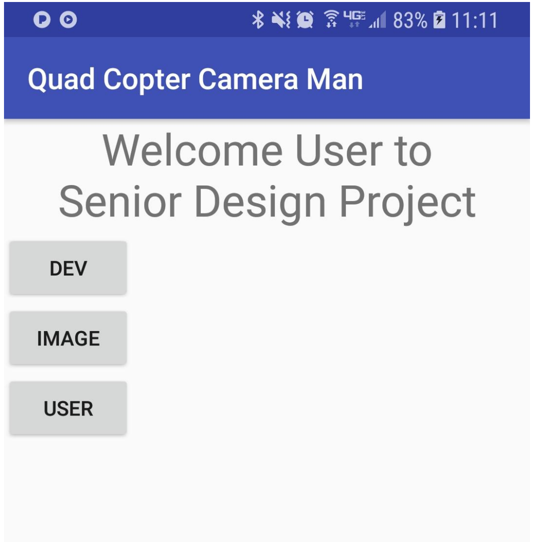
- Retro Reflective Tape
- USB Camera
- LED Ring
- Microprocessor (Raspberry Pi 3b+)



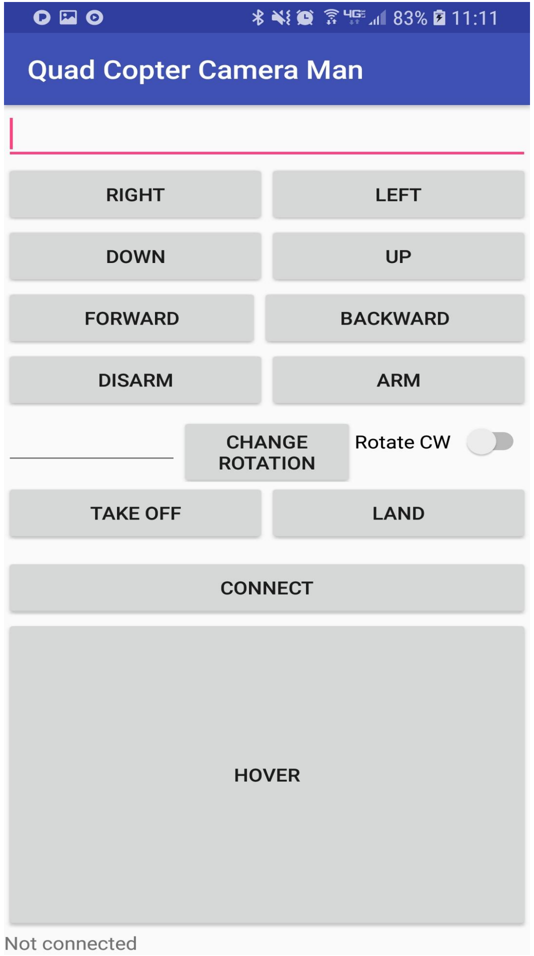


Target Detection Demo

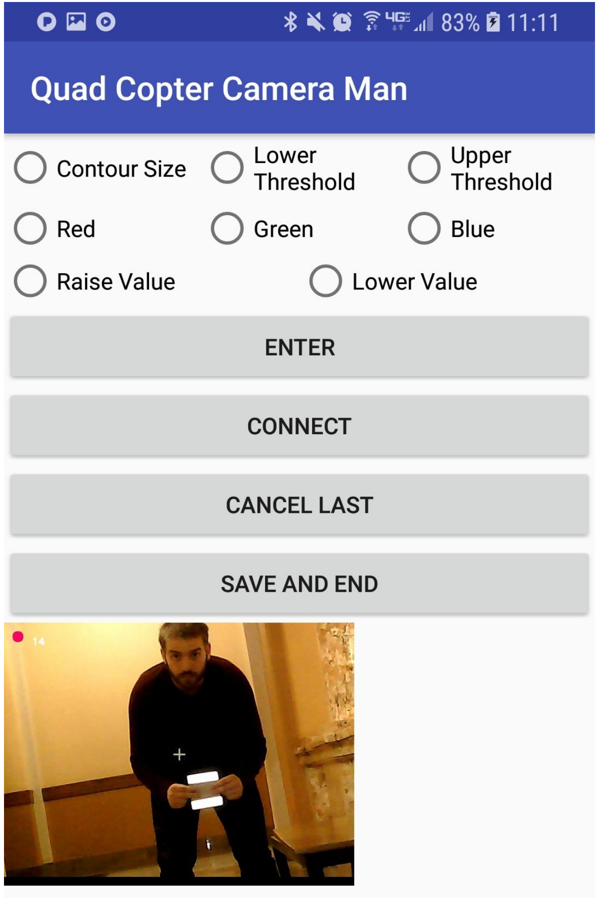
Main Page



Developer Page



Android Design - Mask Calibration



Problems Encountered

Risks and Safety Measures

- Drone propellers and Motors Incorrectly set up or secured
    - Test motor spin and orientation before adding propellers
    - Eyewear
    - 3 members present when testing flight
- Drone crash or erratic flight
    - Manual override through ssh or user application
    - Teathers
    - Safety perimeter

Issues

- Multithreaded communication
  - Synchronous Message Module
- MultiWii Startup Sequence
  - Steps to activate ESC’s and MultiWii software
- ESC Frequency/MultiWii
  - Confusion on how MultiWii worked and the need for a startup sequence
- Hardware Delivery
  - No hardware until end of Fall semester
- Propellers
  - Damaged/Destroyed

Current Flight Status

Can get airborne, trims appropriately, and can be controlled manually sticks

Problem Surrounding Roll Accelerometer

- GUI shows minimum value indicating the drone is rotated 90 degrees on its side
  - Not sure if this is a broken piece hardware or a GUI issue
  - We’ve had issues with both
- A controlled untethered flight test of the drone lead to crash
  - We suspect either a trim issue or an overcorrection PID in response to the faulty sensor

Project Results

Testing

Software

- Test Flight Controller Input/Output
- Test Router Module
- Test Computer Vision
- Test Android Communication

Hardware - Incremental Functional Testing

- Multiwii GUI
- Flight Controller Output
- Pi Output
- Motors Spin Up
- Motors Respond Appropriately
- Manual Tethered Flight
- Manual Untethered Flight

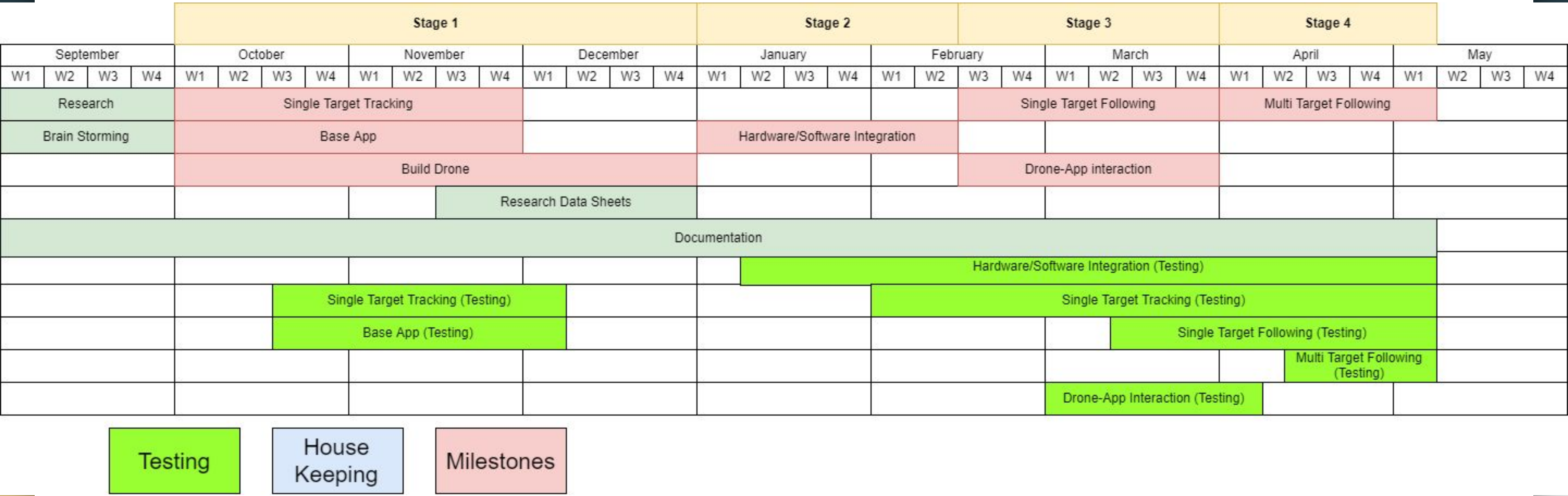
Hardware Results

- Manual Flight Achieved
  - Transmitter
  - Bluetooth Commands
- Unstable Flight
  - Cyclical Overcorrection
  - Trimming
- Props damaged or destroyed during testing
  - Prevented further development and testing

Drone Flight

Conclusion

Schedule


Stage 1
Stage 2
Stage 3
Stage 4
September
October
November
December
January
February
March
April
May
W1
W2
W3
W4
Research
Single Target Tracking
Single Target Following
Multi Target Following
Brain Storming
Base App
Hardware/Software Integration
Build Drone
Drone-App interaction
Research Data Sheets
Documentation
Hardware/Software Integration (Testing)
Single Target Tracking (Testing)
Single Target Tracking (Testing)
Base App (Testing)
Single Target Following (Testing)
Multi Target Following (Testing)
Drone-App Interaction (Testing)
Testing
House Keeping
Milestones

Results

Metric	**Goal**	**Result**
Flight Time	≥ 5 minutes	Unable to obtain
Budget	≤ $550	$512
Film Quality	-	-
Resolution	≥ 480p	480p easily upgraded
FPS	≥ 24 fps	19 fps
Flight control	Autonomous and Stable	Manual with Issues
Image Recognition and Tracking	Identify, Track, and Follow Multiple Targets	Identify and Track Single Target
Thrust to weight ratio	2 : 1	>2 : 1

Project Achievements

- Hardware
  - Flight Controller can talk to pi and ESCs
  - PDB distributes sufficient power to each component
  - Manual flight achieved
- Target Tracking
  - Camera is able to detect target via retroreflective tape
  - Distance and angle calculations available for further use in drone movement
  - Target Detection can be configured for different ambient lightings
- Android Application
  - Developer UI
    - Sends commands to pi
    - Remote control available
  - Image Alteration
    - Receives image and sends commands to Pi for alteration

Lessons Learned

- Order equipment ASAP
  - Flight Controller
  - Propellers
- Research
  - Explore others' ideas and not just our own
- We were ambitious with scope

- Integrating the individual project components was our easiest part
- Each learned new technologies

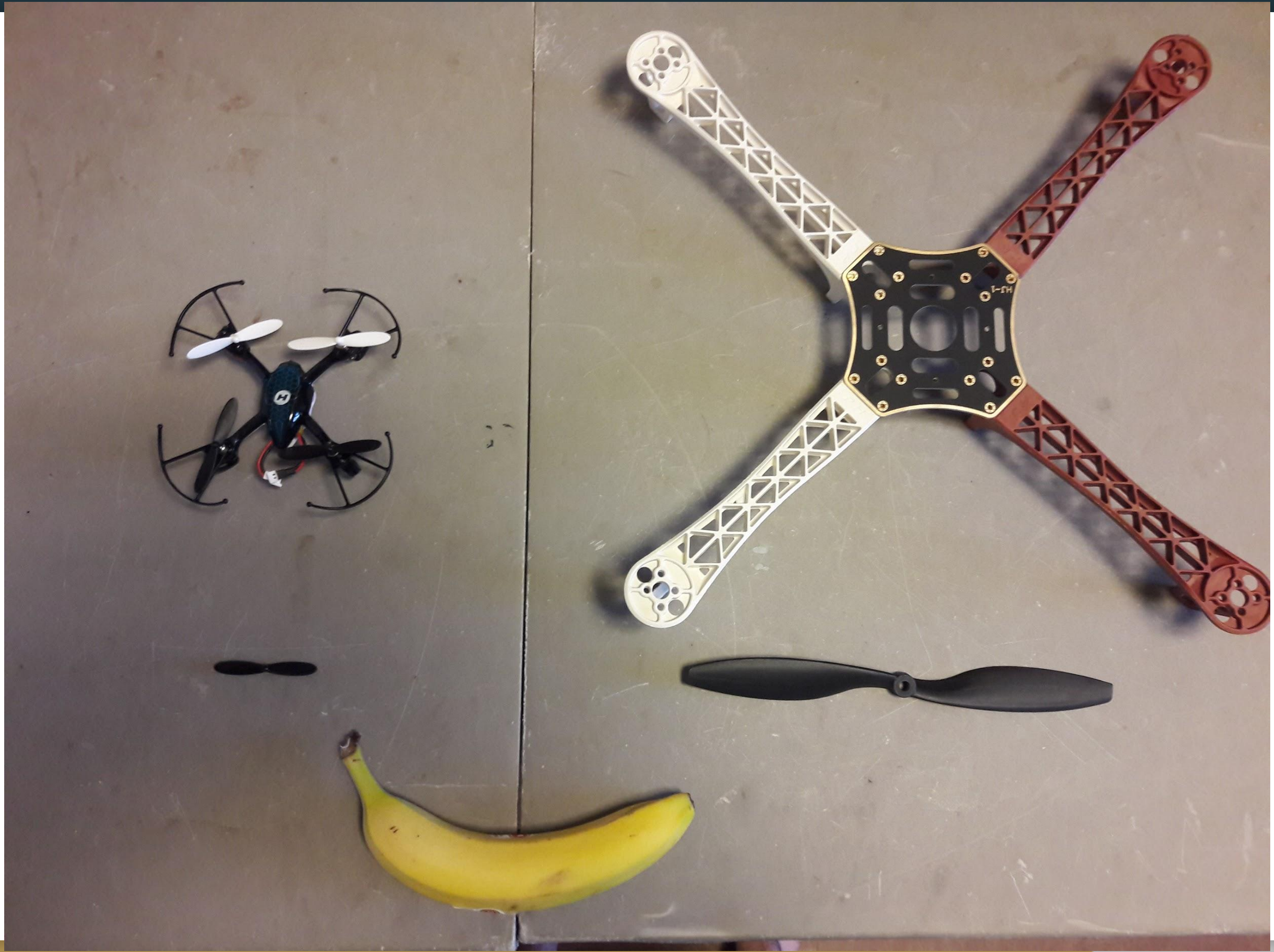
Suggestions for improvement

Lessons learned and future suggestions

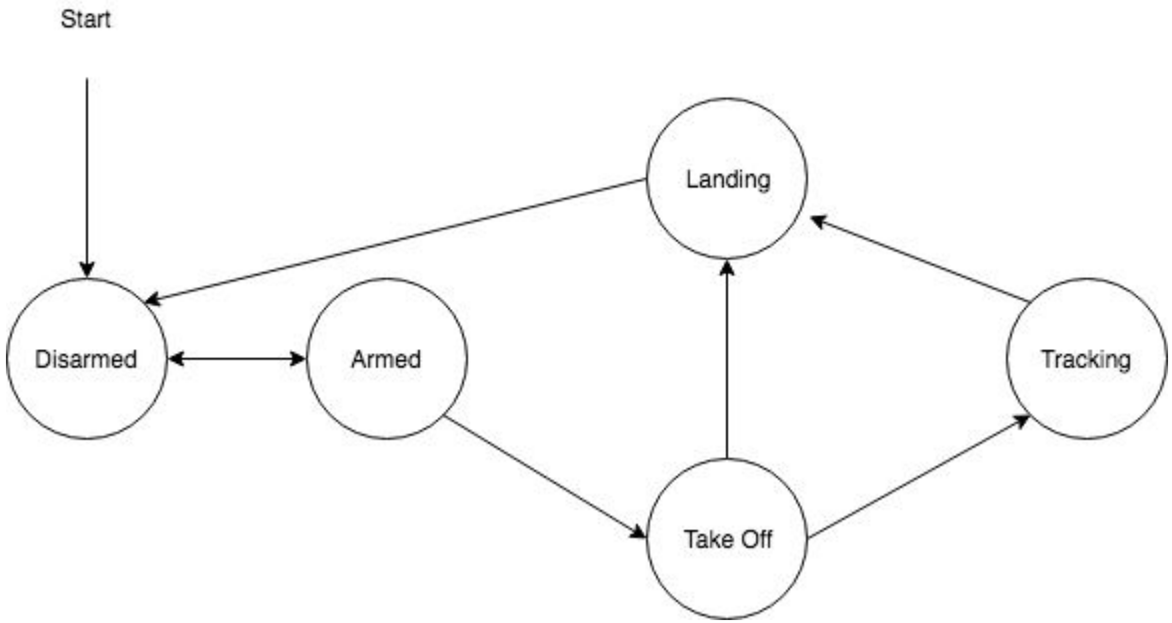
- Hardware Upgrades
  - Camera - Higher resolution
  - Camera - More Compatible with Raspberry Pi
- Have spare parts
  - Propellers
  - Drone legs
- Refactor Communication to encode commands
  - No need for commands to be human readable.

Contributions

- Luke
  - Android App
  - Drone Communications
  - Facial Encoding
- Nate
  - Image Utility Libraries
  - Retro Reflective Target Detection
  - ML Target Distance Estimation
- Alex
  - Physical Drone R&D
  - Multiwii Code
  - Physical Domain Elicitation
- Isaac
  - Android App
  - Drone Communications
- Aamid
  - Hardware Design
  - Physical Drone R&D



State Machine Diagram



Questions?