Fixed-Wing Survey Drone

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Outline

- Project Summary
- The Drone Market
- Performance Specifications and Subsystems
- Research
- Hardware and Software Components
- Data
- Conclusions

Project Summary

- Create an autonomous drone to survey a field
- Stitch GPS-registered images into one image
- Precision Farming
- Low-cost

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The Drone Market

Growing Market

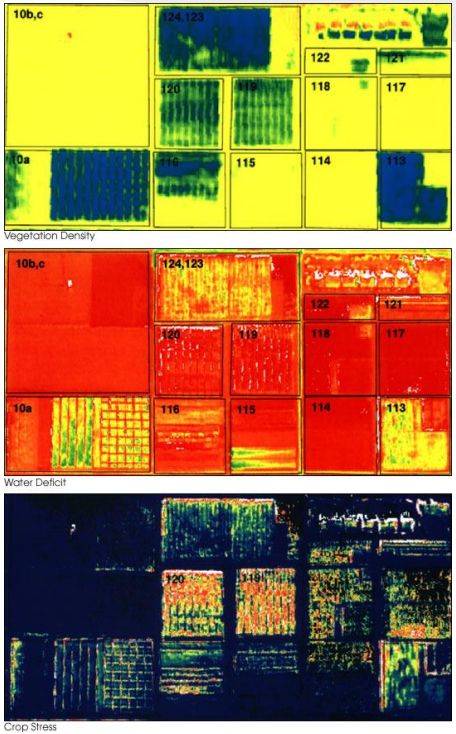
- Precision Agriculture and UAVs

Existing Products

- CropCam - $7,000

FAA Regulations

- Below 400 ft
- Manual Override



http://en.wikipedia.org/wiki/Precision_agriculture

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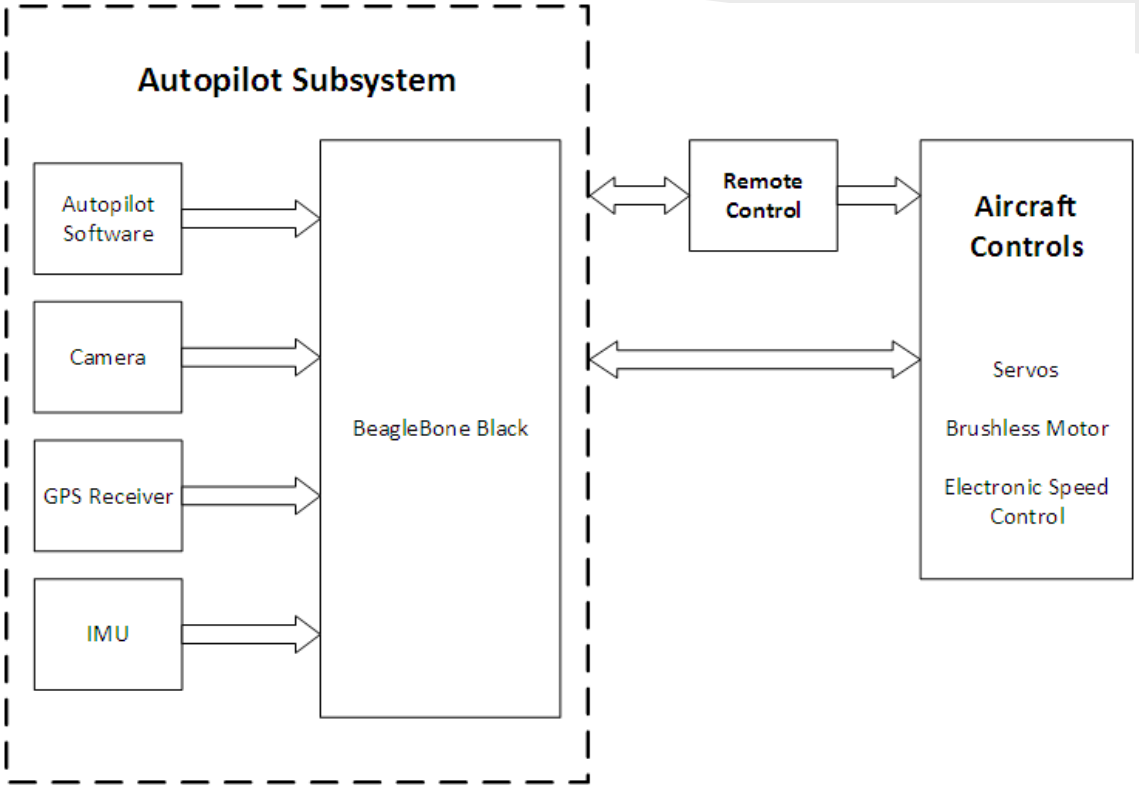
Project Description

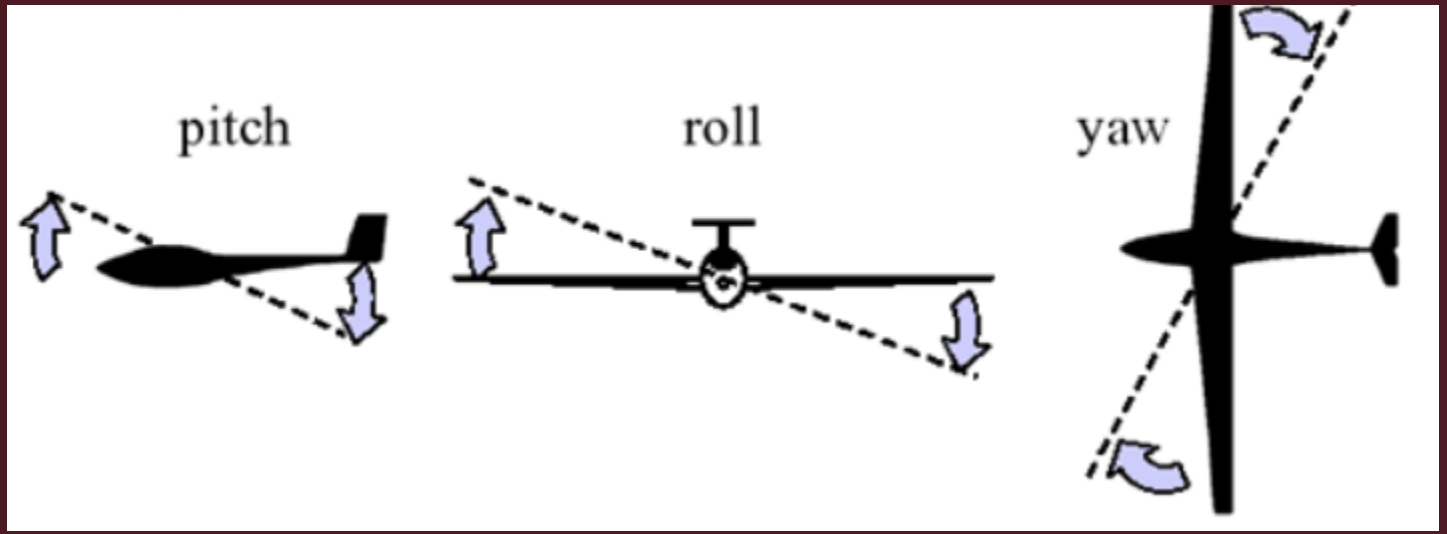
Autopilot System

- Entirely autonomous UAV
- Follows an imported set of waypoints
- PID flight stabilization
- Manual override available at all times during flight

Aircraft Subsystems

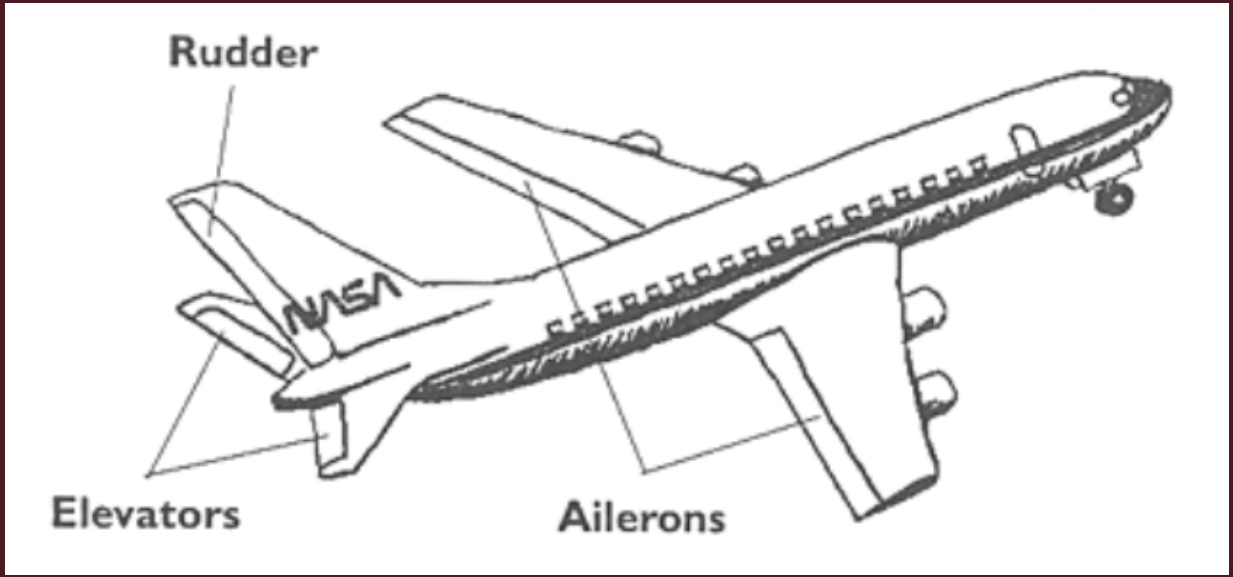


Pitch, Roll, and Yaw



http://toronto-soaring.ca/wordpress/?page_id=30

Ailerons, Elevator, and Rudder

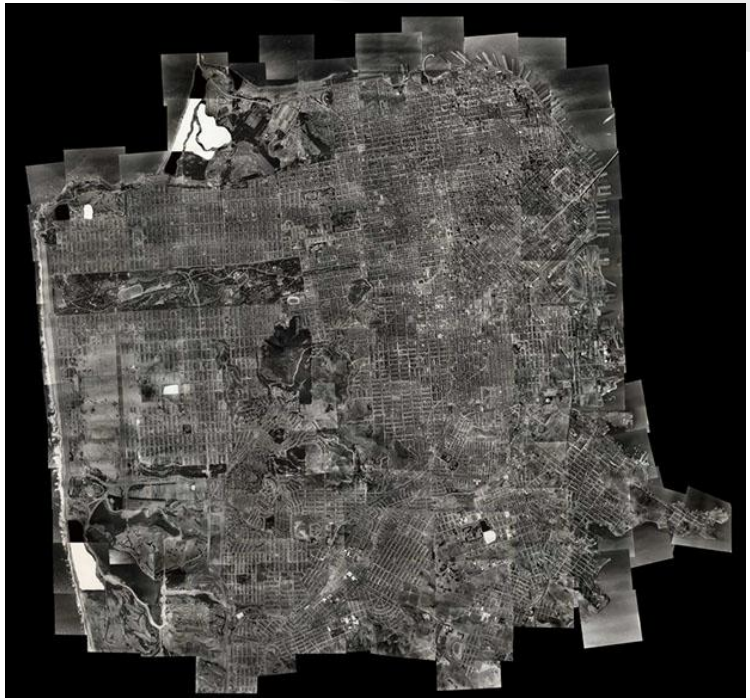


http://quest.nasa.gov/aero/planetary/atmospheric/control.html

Project Description

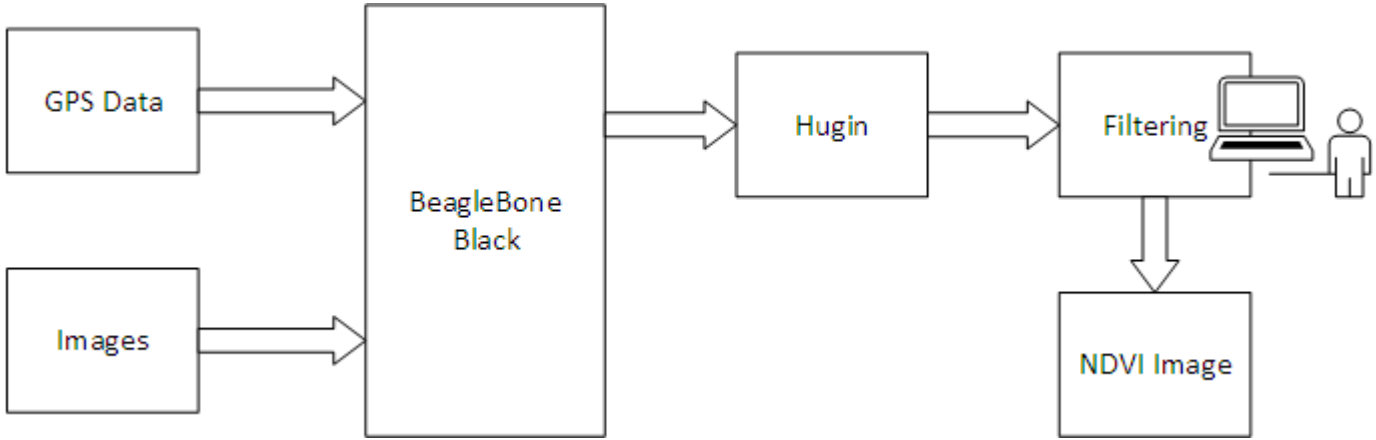
Image Processing

- Tag images with GPS data
- Stitch together all images
- Filter for NDVI image



http://petapixel.com/2013/06/06/this-zoomable-composite-aerial-photo-of-san-francisco-is-like-a-1938-google-earth/

Image Processing Subsystem



Components

RC Airplane	Bixler Aircraft
RC Receiver and Control	Turnigy 9x 2.4GHz 9 Channel
2 BEC Power Converters	Turnigy 5V 5A
LiPo Battery	Turnigy 2.2
RC Servo Multiplexer	Pololu 4-Chan
Microcontroller	BeagleBone Black
IMU	Adafruit 10 dof
GPS Receiver	Adafruit MTK3339 Chip
PWM Servo Driver	Adafruit 16 Channel 12-bit Driver
Flight Controller	Implemented in software
Near-Infrared Camera	Infragram Plant Analysis Webcam

Performance Specifications

- Electrically powered
- Hand launched
- Battery life long enough to complete a survey in one charge (~20 minutes)
- Capable of carrying the weight of all components

http://www.hobbyking.com/hobbyking/store/catalog/mainbix(6).jpg

Performance Specifications

- Near-Infrared Camera
  - 5 Megapixel
  - Captures near infrared pictures
  - Tags all ground images with GPS information

http://cdn.shopify.com/s/files/1/0198/8618/products/Filter-1_1024x1024.jpg?v=1373565426

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Research

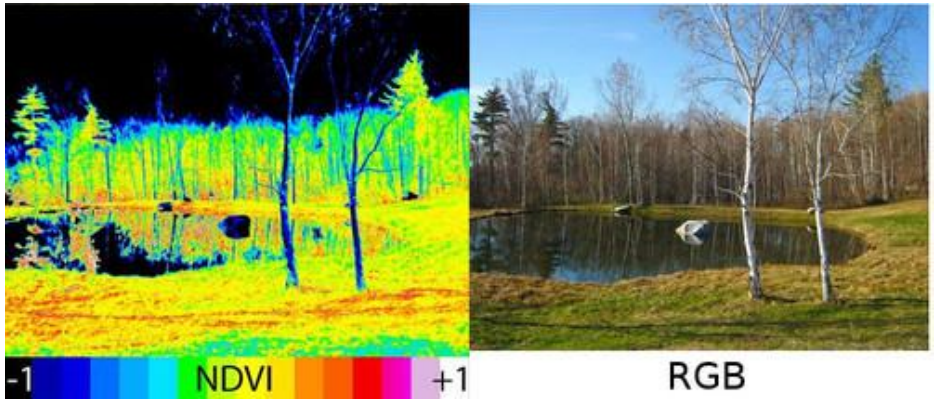
Finding products

- Plane
- GPS
- Controllers
- Autopilot
- IMU
- Cameras
- Obstacle Avoidance

Research

Image Processing

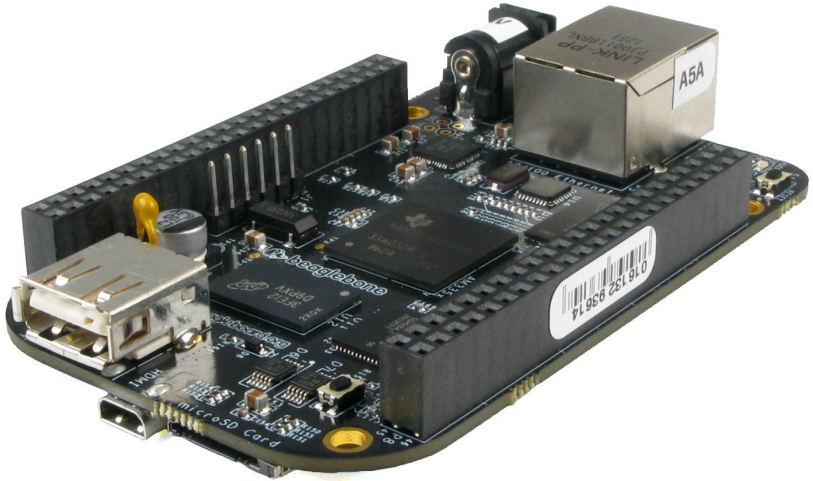
- Images that assess crop health
- Requires a camera without an infrared filter
- Plants absorb visible light and reflect infrared
- Normalized Difference Vegetation Index



http://publiclab.org/wiki/near-infrared-camera

Preliminary Lab Work

- BeagleBone Black and Atmel board robotics labs
- Aircraft construction
- Test flight of manual controls



http://ozancaglayan.com/2013/11/14/ubuntu-13-10-for-beaglebone-black-part-1/

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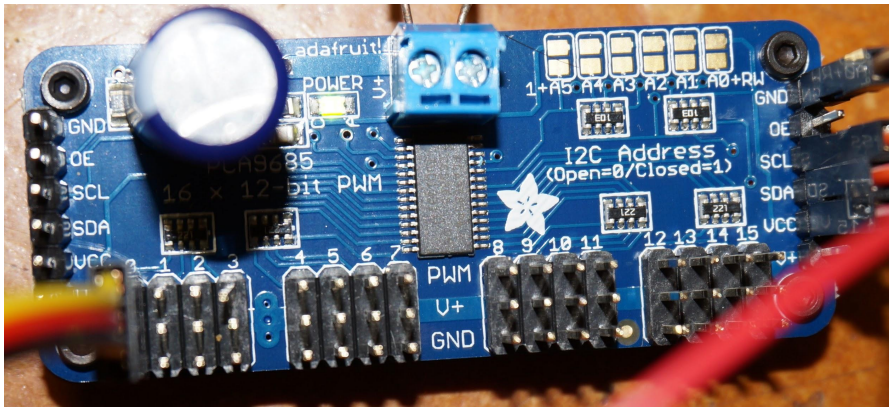
Linux and Python

- Linux
  - BeagleBone Black
    - Angstrom
- Python
  - PWM servo driver
  - IMU
  - GPS
  - Waypoint Navigation
  - PID Flight Stabilization
  - Open Source

Hardware I/O

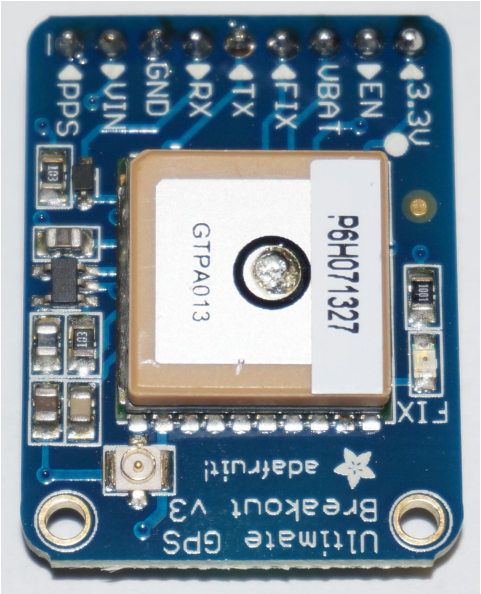
Familiarization with hardware I/O

- I2C
  - PWM servo driver
  - IMU
- Serial
  - GPS
- USB
  - Camera



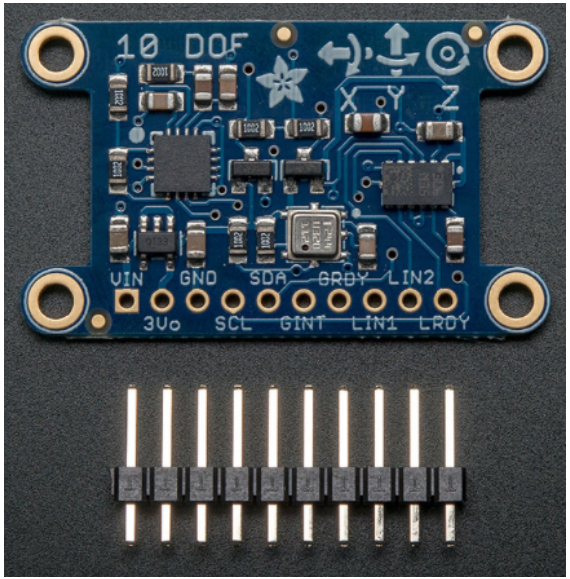
GPS Data Retrieval

- Adafruit MTK3339 chipset
  - NMEA protocol
  - GGA Sentence Identifier
  - Python



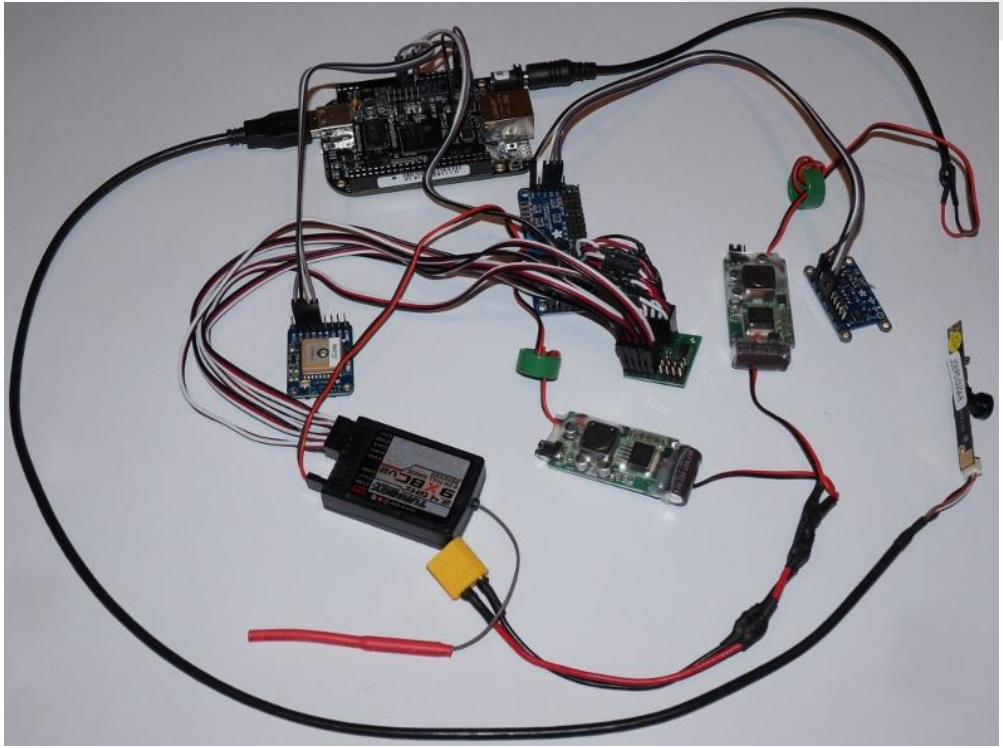
IMU Data Retrieval

- Adafruit 10 DOF IMU
  - L2GD20 gyroscope
  - LSM303 accelerometer+compass
  - BMP180 barometer and temperature

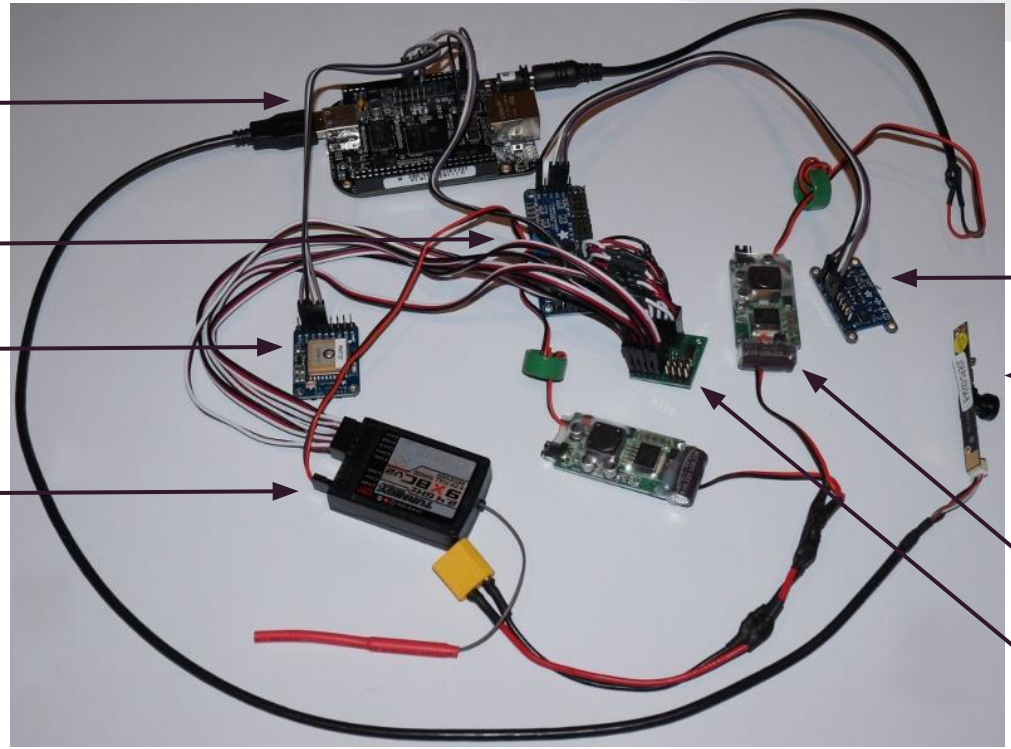


https://www.adafruit.com/products/1604

Mounting Hardware



Mounting Hardware



Google Earth Waypoints

Google Earth “GUI” - waypoint input interface

1. Open Google Earth
2. Locate survey area
3. Draw path of waypoints
4. Save path as a .kmz file
5. Transfer file to BeagleBone Black
6. Input file name to navigation program

Autopilot

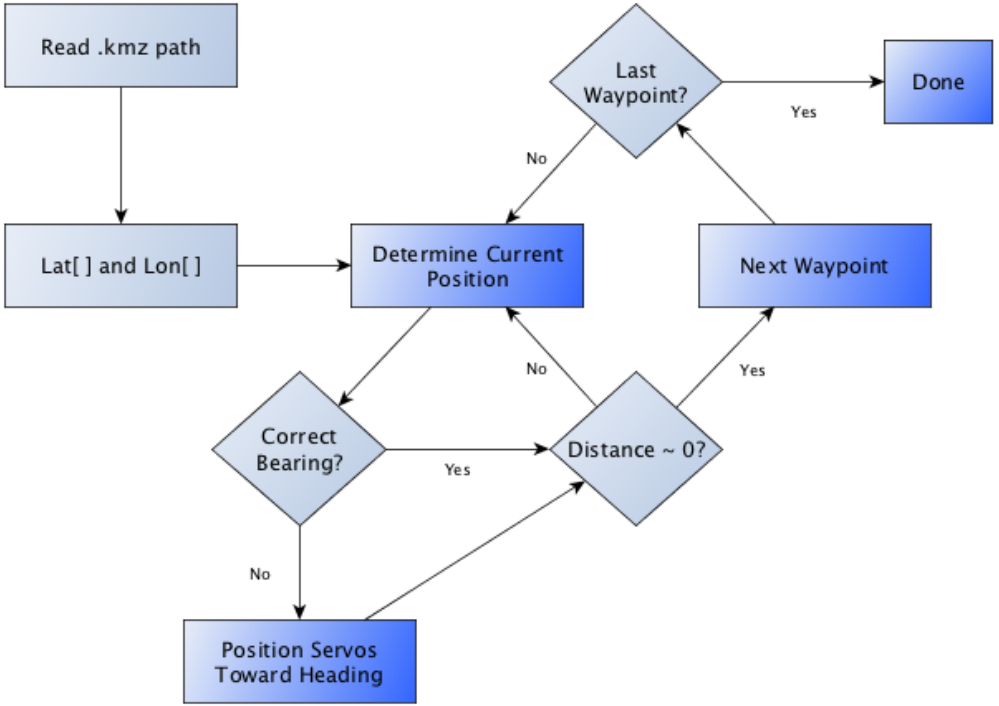
GPS Navigation System

1. Reads .kmz file to determine waypoints
2. Reads current GPS location
3. Calculates distance and bearing to next waypoint
4. Switches to next waypoint

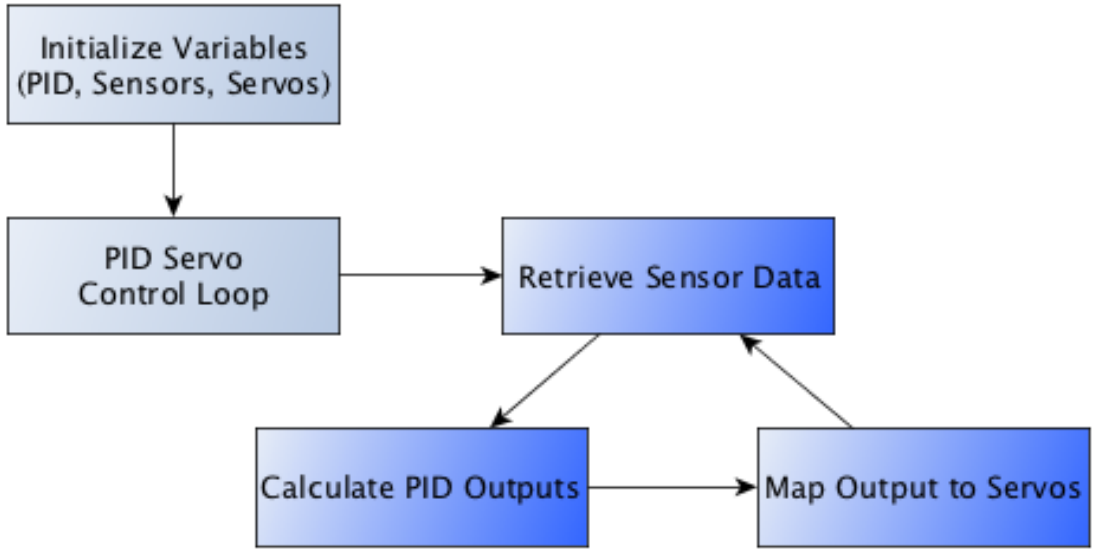
PID Flight Control System

Maps changes in IMU sensor data to servo positions in PID loop

GPS Navigation System

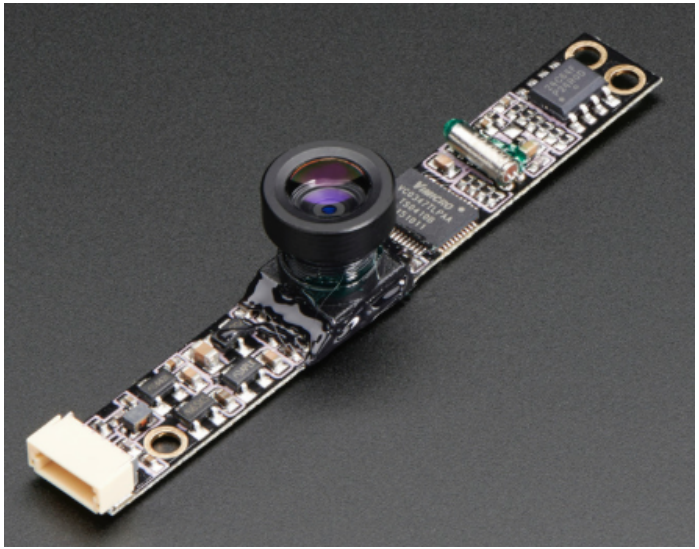


PID Servo Control System



Crop Image Capture

- Infragram Plant Analysis Webcam
  - USB interface
  - Infrared - red channel
  - Visible - blue channel
  - Measures Photosynthetic activity
  - *Infrapix* converts to NDVI

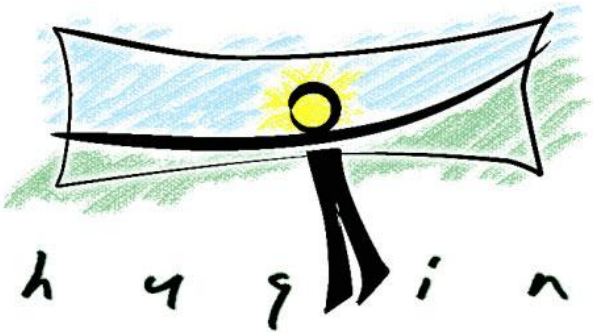


https://www.adafruit.com/products/1722

Hugin

Image stitching software

- Open source
- Automatic control point generator
  - Autopano-sift-c plugin



In Assistant:

1. Load all images
2. Select “Align”
3. Select “Generate Panorama”

Aircraft Equipment List

Bixler Aircraft		50
Turnigy RC Controller and Receiver		60
BeagleBone Black		45
Adafruit MTK3339 GPS		40
Adafruit IMU		50
Adafruit PWM servo driver		15
BEC power converter (x2)		10
Turnigy 2.2 LiPo Battery		8
Pololu RC Servo Multiplexer	10	
Infragram DIY Plant Analysis Webcam		55

$343
(+ shipping)

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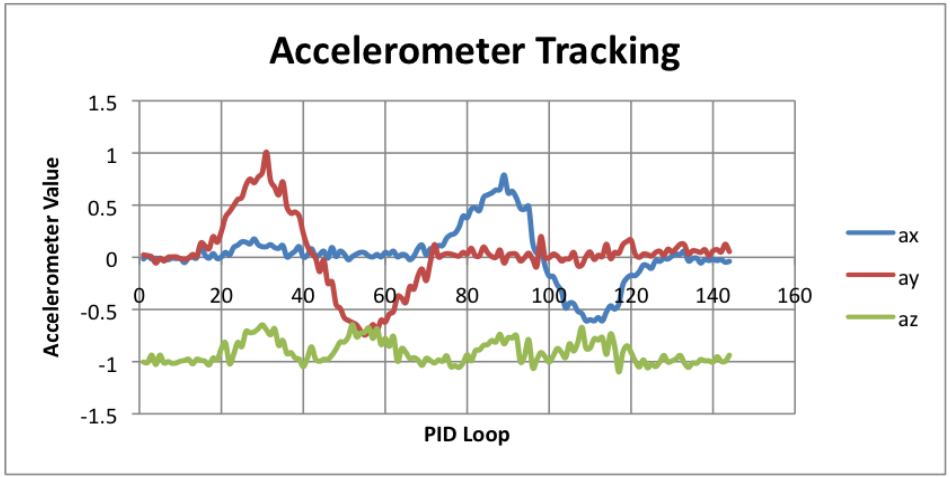
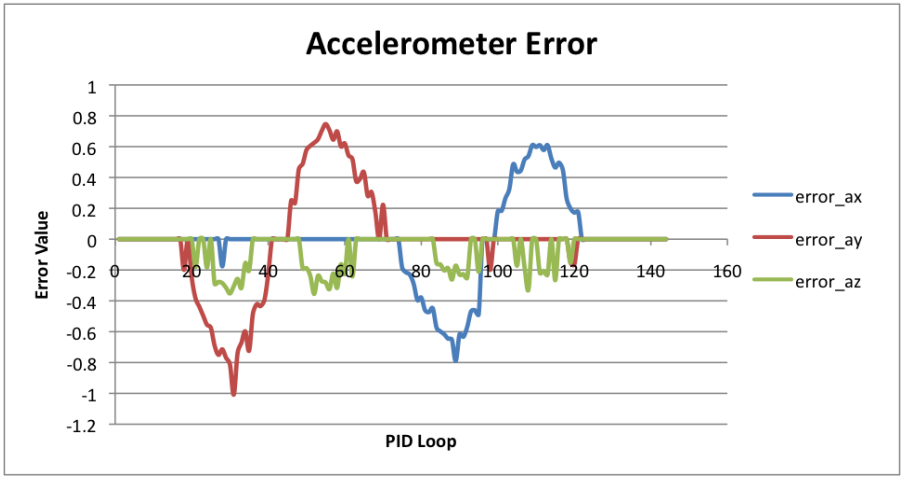
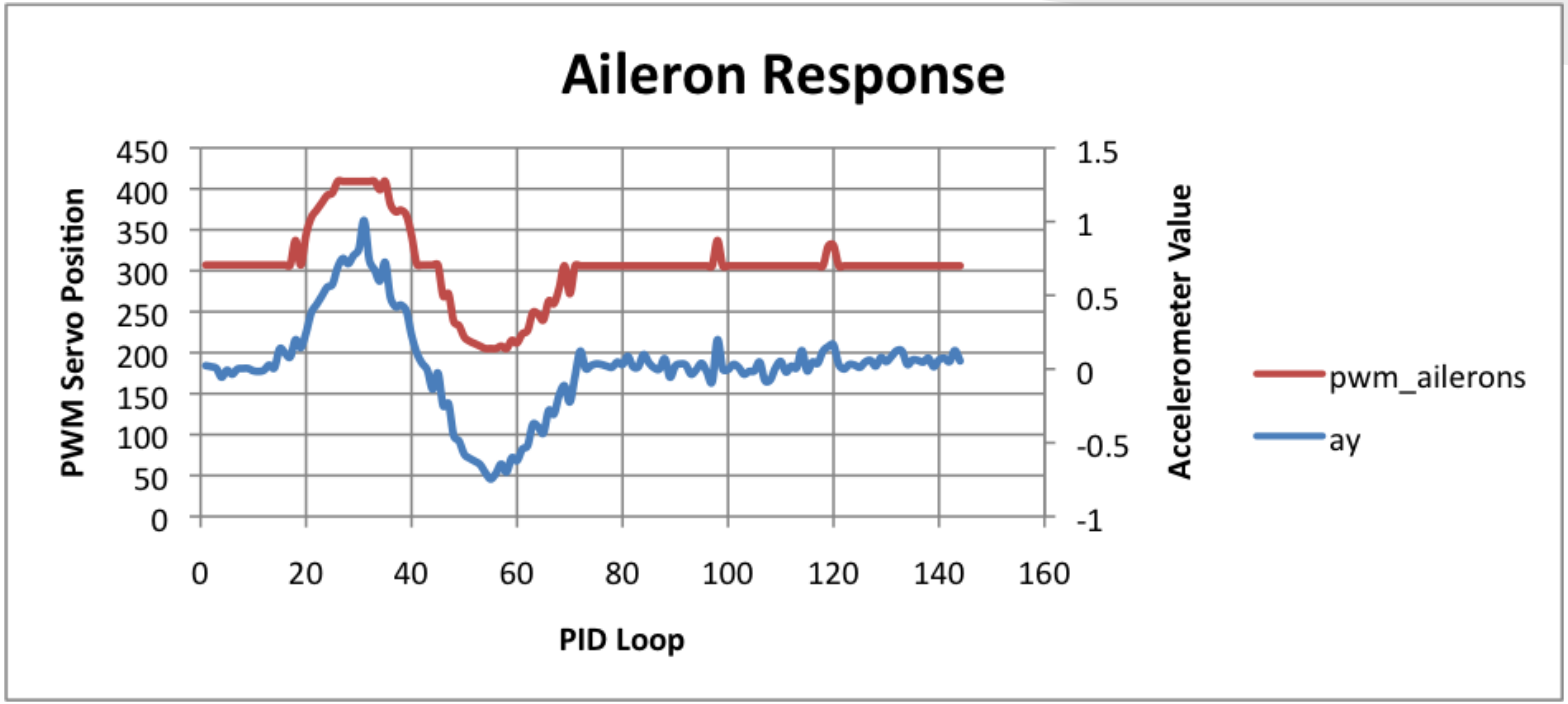
Data

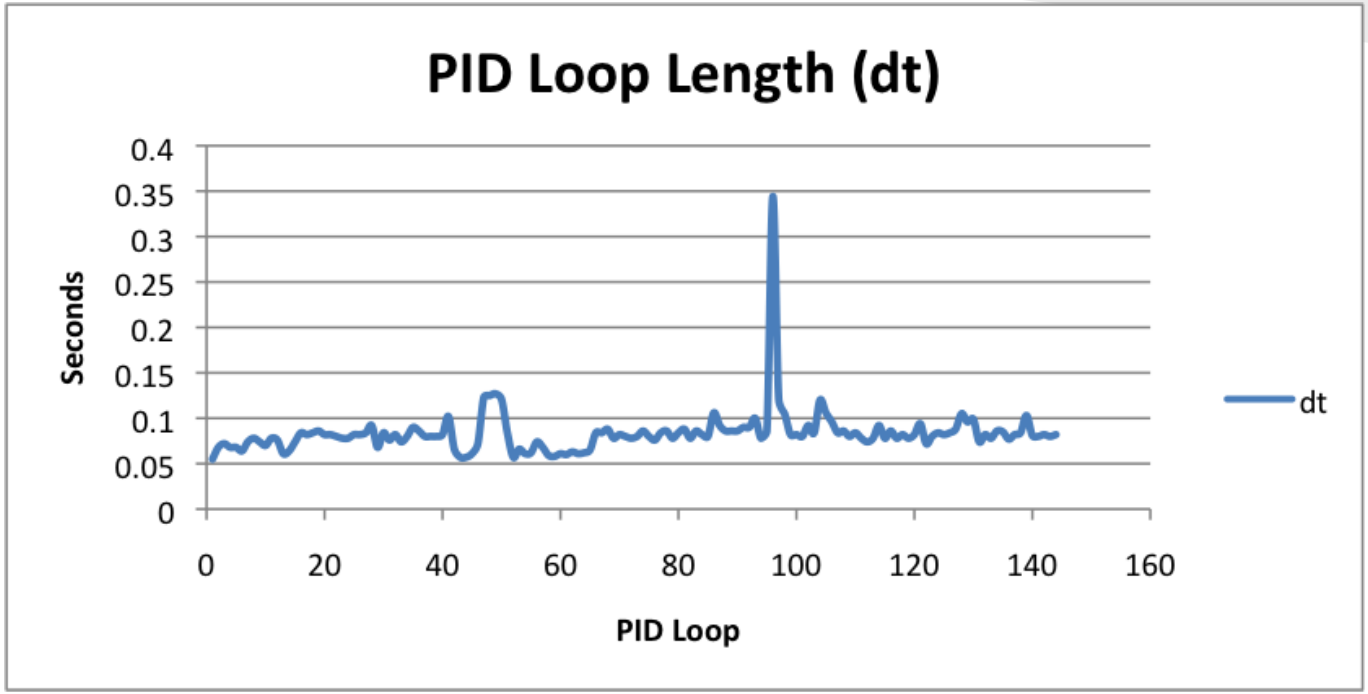

Accelerometer Tracking
Accelerometer Value
1.5
1
0.5
0
-0.5
-1
-1.5
0
20
40
60
80
100
120
140
160
PID Loop
ax
ay
az


Accelerometer Error
Error Value
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
0
20
40
60
80
100
120
140
160
PID Loop
error_ax
error_ay
error_az

Data


Aileron Response
PWM Servo Position
450
400
350
300
250
200
150
100
50
0
0
20
40
60
80
100
120
140
160
PID Loop
1.5
1
0.5
0
-0.5
-1
Accelerometer Value
pwm_ailerons
ay

Data


PID Loop Length (dt)
Seconds
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
20
40
60
80
100
120
140
160
PID Loop
dt

Data

Data

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Completed Plane Specs

- Prototype Autopilot System
- GPS Waypoint Entry
- Near-Infrared Image Retrieval and Filtering
- Image Stitching

Moving Forward with UAVs

Platform for Future Work

- Delivery
- Search and Rescue
- Multi-Drone Collaboration

Questions?