QUANTIFYING WETLAND TYPE AND ECOSYSTEM SERVICES WITH HYPERSPATIAL UAS IMAGERY

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GEOG 596A
Capstone Proposal
Fall 2016

Visser 2012
Louisiana is Experiencing a Coastal Crisis

Predicted Land Change over the Next 50 Years

- 4,870 sq. km of land lost since the 1930s (area of NJ)
- Potential to lose an additional 4,500 sq. km
- 18% of US oil and 24% of US gas production totaling $16B USD per year
- 1st in the nation in total shipping tonnage - 20% of the nation's waterborne commerce
- $2.8B USD fisheries industry in Louisiana - 16% of US fisheries come from Louisiana coast
Louisiana’s Comprehensive Master Plan for a Sustainable Coast

committed to our coast

US $50B - 50 year plan
2012 Master Plan Model Suite

Stage, Salinity, Water Quality

Stage, Salinity

Land Configuration, Elevation

Stage, Salinity

Dominant Vegetation

Elevation

Dominant Vegetation

Elevation

Dominant Vegetation

Elevation

Surge, Waves

Risk Assessment

Eco-hydrology

Wetland Morphology

Vegetation

Barrier Shoreline Morphology

Storm Surge/Waves

Ecosystem Services
Current Wetland Vegetation Information

Coast-wide Surveys

156 North/South transects spaced 7.5 minutes apart from the Texas state line to the Mississippi state line.

Vegetative data were obtained at predetermined stations spaced 0.5 miles along each transect.

• Species identified
• Five Cover classes
  • >75%
  • 50-75%
  • 25-50%
  • 5-25%
  • <5%

Photos: Greg Linscombe and Jenneke Visser
Coastwide Reference Monitoring System

390 Stations Coast-wide
TYPICAL CRMS SITE SAMPLING & DATA COLLECTION

Aspects of ecosystem structure and function are measured at each site including marsh elevation, vegetative assemblage, and hydrologic parameters.
What about Unmanned Aircraft Systems (UAS)?

i. Late 1970s – first use of a fixed wing remotely controlled aircraft in photogrammetry experiments (Przybilla and Wester-Ebbinghaus 1979).

ii. 2004 - first use of a commercial low-cost model helicopter with semiautomated navigation to create a high-resolution digital terrain model (Eisenbeiss et al. 2005).

iii. Chong (2007) used high definition video to map local beach erosion.

iv. Lejot et al. (2007) used very high spatial resolution imagery to map channel bathymetry and topography.

v. Lechner et al. (2012) utilized hyperspatial data provided by a UAS and object-based image analysis (OBIA) methods to classify upland swamp communities.


vii. UAS are now widely used in a host of environmental applications, such as land use mapping, wetlands mapping, LIDAR bathymetry, flood and wildfire surveillance, tracking oil spills, urban studies, and Arctic ice investigations (Klemas 2015).
Comparisons between satellite data, traditional aerial photography, and UAS imagery

i. UAS technology allows flexible deployments - high-temporal and hyperspatial resolution (<1dm) data (Niethammer et al. 2012).

ii. Rocchini (2007) demonstrated that higher resolution datasets from Quickbird satellite imagery showed highly significant correlations with species richness as opposed to coarser resolution datasets from Aster and Landsat imagery, which were not highly correlated.

iii. In Coastal Louisiana, UAS have the ability to fly the current helicopter transects and to collect hyperspatial aerial images at higher frequencies. Multispectral reflectance will help automate species richness and cover estimates. Photogrammetry can provide elevation estimates and Digital Surface Models (DSM).
Landsat derived DEM - 30m GSD
Landsat derived DEM - 30m GSD
Aerial Photography - 1m GSD

Aerial Imagery: Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA), 2008
Aerial Photography - 1m GSD

Aerial Imagery: Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA), 2008
UAS Aerial Photography - 2.5cm GSD

Spartina patens

Iva frutescens
Baccharis halimifolia

Phragmites australis
UAS Aerial Photography - 2.5cm GSD
UAS Aerial Photography - 2.5cm GSD
This project will design a pilot study to collect hyperspatial/multispectral aerial imagery from a UAS in a brackish marsh environment in coastal Louisiana.

The objective is to collect 2.5cm GSD RGB and NIR imagery of a 1 km² area.

Create raster datasets that are georeferenced and ready for object-based image analysis.

Project location in Terrebonne Parish, Louisiana. Coastwide Reference Monitoring System (CRMS) site in Cyan, Flight Blocks in yellow, GCPs are white crosses.
PROJECT GOALS AND OBJECTIVES

- Object-Based Image Analysis
  - Species composition and ecosystem service metrics
    - Land-water interface (edge habitat and fragmentation)
  - Species composition
  - Plant height
  - Aboveground biomass
  - Carbon Sequestration
  - Productivity (NDVI)

Project location in Terrebonne Parish, Louisiana. Coastwide Reference Monitoring System (CRMS) site in Cyan, Flight Blocks in yellow, GCPs are white crosses.
FIELDWORK
Trimble UX5

Sony NEX-5R camera and Voigtlander lens used in the Trimble UX5 Aerial Imaging Rover
Flight Plan

Sectional Aeronautical Raster Chart with project boundaries shown in red.

Take off and landing located north of the project area.

FAA Part 107 compliant operations (DO NOT UNDERESTIMATE!)
Compute the Ground Coverage of Each Image

Ground Coverage = (6000 pixels $\times$ 1in) $\times$ (4000 pixels $\times$ 1in)
= 6000in $\times$ 4000in
= 500ft $\times$ 333.3ft

Compute the Number of Flight Lines

Line Spacing (SP) = Image coverage (w) $\times$ ((100 − Sidelap)/100)
= 500ft $\times$ (100 − 60/100)
= 200ft

Number of Flight Lines (NFL) = (Width of Project/SP) + 1
= (3,281ft/200ft) + 1
= 17.4

NFL rounds up to 18.

Number of Images to be Acquired

Airbase (B) = Images Coverage (H)$\times$((100 − Endlap)/100)
= 333.3 $\times$((100 − 80)/100)
= 66.6

Number of Images (NIM) = (Length/B) + 1 + 4
= (3,281ft / 66.6ft) + 1 + 4
= 54.3
NIM rounds up to 55.

Total Number of Images = NFL $\times$ NIM
= 18 $\times$ 55
= 990

Flying Altitude

Flying Height (H) = \frac{\text{focal length (f)} \times \text{Ground Sample Distance (GSD)}}{\text{Pixel Width (ab)}}
= \frac{15.6mm \times 2.54cm}{3.9\mu m}
= \frac{15.6mm \times 25.4mm}{0.0039mm}
= 101,600mm
= 101.6m

Time Between Images

Time (t) = \frac{\text{Airbase (B)}}{\text{Aircraft speed (v)}}
= \frac{66.6ft/80 km hr^{-1}}{66.6ft/262467.2 ft hr^{-1}}
= .000254 hr
= 0.9 sec
Ground Control Points
Take Off

Chase home
Belly land

Control Station
A screenshot of the Basic Editor and the GCP/Manual Tie Point Table showing the location of a ground control point 20000 in image DSC01165_geotag.JPG.
A screenshot of the processing quality report showing the summary and quality check information.

Post-Processing: Trimble UAS Master

<table>
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<th>Summary</th>
<th>Wiregrass_Broussard</th>
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<tr>
<td>Processed</td>
<td>2016-04-07 23:19:42</td>
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<tr>
<td>Average GSD</td>
<td>1.96 cm / 0.72 in</td>
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<tr>
<td>Area Covered</td>
<td>0.0684 km² / 1.8379 ha / 0.0264 sq. mi / 0.01055 acres</td>
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<tr>
<td>Time for Initial Processing (without report)</td>
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Quality Check

| Images          | median of 33179 keypoints per image |
| Dataset         | 89 out of 89 images calibrated (100%), all images enabled |
| Camera Optimization | 1.29% relative difference between initial and optimized internal camera parameters |
| Matching        | median of 14165 matches per calibrated image |
| Georeferencing  | yes, 8 GCPs (3D), mean RMS error = 0.024 m |

Localization accuracy per GCP and mean errors in the three coordinate directions.

<table>
<thead>
<tr>
<th></th>
<th>Error X (m)</th>
<th>Error Y (m)</th>
<th>Error Z (m)</th>
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<tr>
<td>Mean (m)</td>
<td>+0.007065</td>
<td>-0.000724</td>
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<td>Sigma (m)</td>
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<td>RMS Error (m)</td>
<td>0.032686</td>
<td>0.018169</td>
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Orthomosaic and the corresponding sparse Digital Surface Model (DSM) before densification
i. Hyperspatial sub-decimeter imagery acquired using UAV platforms is commonly analyzed using OBIA classification methods (e.g. Laliberte and Rango 2009, Laliberte and Rango 2011).

ii. For medium and low spatial resolution imagery acquired by satellites, such as Landsat or MODIS, the target is usually smaller than the pixel size. Pixel-based remote sensing classification schemes, like maximum likelihood classifiers that use spectral information, are often unsuitable for classifying hyperspatial data resulting in a lower overall classification accuracy (Blaschke 2010).

iii. As spatial resolution increases, variance in observed spectral values within target classes increases, making spectral separation between the classes more difficult to specify and classify (Marceau and Hay 1999, Blaschke 2010).

iv. OBIA methods address these scaling issues by segmenting the finer pixels into image objects that are made up of multiple neighboring pixels sharing similar spectral values (Blaschke, 2009)
Workflow

Explanation
Source data is Purple. Derived data is Green

UAS data collection
OBIA
Land-Water Classification
Dominant Species
NDVI Plant height

Accuracy Assessment
CRMS survey data

Land-water, species classes with NDVI values and plant heights
Biomass, C sequestration, productivity
Products and Timeline

i. The purpose of this project is to investigate the efficacy of using UAS technology to monitor wetland vegetation species composition and to quantify ecosystem services. The final deliverable will be a published paper that reports on the methods developed and lessons learned.

ii. Timeline:
   - Post-Processing UAS imagery  December-January 2016
   - OBIA and Derived Products  January-February 2017
   - Draft of Methods and Results  End of February 2017
   - Final Report for Publication  March 2017
   - Submit for Publication  April 2017
References


THANK YOU!

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