Multi-Scale Ground Filtering of Dense Lidar Point Clouds for Modeling Shrub Mangrove Canopies in Coastal Environments

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Presentation Outline

• Why Mangroves Are Important
• Research Issues
• Project Goals
• Study Area & Data
• Methodology & Workflow
• Results & Deliverables
• Q & A
Why Mangroves?

Mangrove Food Web

Figure 2. Mean carbon storage above and belowground in coastal ecosystems versus terrestrial forest (Fourqurean et al. 2012; Pan et al. 2011; Pendleton et al. 2012).

Sediments Larvae Adults Phytoplanckton Flood Ebb Sediments Detritus Nutrients Larvae
Shrub Mangrove Locations in the US

Locations of Shrub Mangroves in Southeastern US

Map Source: https://databasin.org/maps/new#datasets=6ec804f5250a483abd9bdb2009939247f

Data for map derived from "Increase in Black Mangrove Abundance in Coastal Louisiana," Michot, et. al (2010)
https://www.researchgate.net/publication/319579389_Increase_in_black_mangrove_abundance_in_coastal_Louisiana
Research Issues

Carbon Stock Monitoring for Coastal Mangroves

Allometric measurements commonly used by Biologists & Ecologists studying shrub mangroves in the wetlands. (Image Source: CIFOR)

Allometric Measurements Collected at Large Scale

Automated feature extraction methods can potentially allow researchers to collect allometric data remotely at large scale for regional analyses of mangrove stocks. (Image Source: Heenkenda, et al., PE&RS, 2015)
Object-Based Image Classification

Object-Level Image Segmentation

Object-Based Image Classification

Original Image

Object Outlines

Classified Image

Original Image
Canopy Height Models

Lidar point cloud over vegetated area collected

Digital Surface Model (DSM) and Digital Terrain Model (DTM) created

DTM subtracted from DSM to create a Canopy Height Model (CHM)

Lidar point cloud processed and classified
Vertical Return Structure Issues

Open ground point among several mangroves

Mangroves
Goals of the Project

• Goals of the Project:
  • Develop an accurate method for extracting mangrove features over coastal wetlands using Object-Based Imagery Analysis (OBIA) in eCognition Developer.
  • Develop an accurate method for creating Canopy Height Models (CHM) of shrub mangroves using feature extraction tools and lidar data in LP360.
  • Determine the degree of influence that scale plays in OBIA image classification and point cloud classification of shrub mangroves.
  • Determine if these methods could be used to improve the study of global carbon budget estimates for coastal environments.
Study Area

Coastal Louisiana

Image Source: Google Earth

Port Fourchon AOI

Image Source: USDA NAIP
## Data Sources

<table>
<thead>
<tr>
<th><strong>NAIP Imagery</strong></th>
<th><strong>Lidar Point Cloud</strong></th>
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<td><strong>Sensor:</strong></td>
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<td><strong>Platform:</strong></td>
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<td><strong>Vertical Accuracy Class:</strong></td>
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Software Packages & Tools

**ArcGIS Desktop v10.6**
- Reclassify Raster
- Raster to Polygon Conversion
- Raster Calculator
- Surface Volume

**eCognition Developer v9.3**
- Multi-Resolution Segmentation
- Image Object Classification
- Object Merge
- Region Grow
- Threshold Class Assignment
- Export Vector Layer

**LP360 Advanced**
- Point Cloud Task (PCT) Macro
- Classify by Feature PCT
- 2D/3D Breakline Tools
- Classify by Statistics PCT
- Conflation PCT
- Filtering PCTs
- Export Wizard (DSM/DEM Products)
Workflow Overview

1. **Segment NAIP Image into Large Scale Objects and Classify Image**
2. **Segment Large Scale Objects into Smaller Scale Objects and Classify Mangroves**
3. **Export Mangrove Shapefile for Use in LP360**
4. **Accuracy Assessment of Classification**
5. **Classify Mangrove Points by Feature Using Polygons from OBIA Export**
   - In LP360
6. **Generate DSM & DEM Using Classes 2, 9, and Custom Mangrove Class**
   - In LP360
7. **Generate nDSM for Mangrove Canopy Height Model**
8. **Calculate Area Coverage & Above Ground Biomass Volume for Tables**
9. **Generate Derivative Cartographic Products**
10. **In ArcGIS**
Image Classification Methodology

1. Multi-Resolution Segmentation (Initial Objects)

2. Classify Initial Objects

3. Multi-Resolution Segmentation (Wetland Objects)

4. Export Classified Polygons: Final Merged Objects Exported as Polygon Shapefile

5. Import Polygons in ArcGIS
## Preliminary Classification Accuracy

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<th>Mapped Class</th>
<th>Reference Class</th>
<th>Class Value</th>
<th>Beach</th>
<th>Built</th>
<th>Earth/Grass</th>
<th>Mangrove</th>
<th>Water</th>
<th>Total</th>
<th>User's Accuracy</th>
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<td>100.00%</td>
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<td>93.60%</td>
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Canopy Extraction Methodology

1. Classify Ground Seed Points
2. Classify By Feature
3. Generate DEM
4. Generate DSM
5. Generate Canopy Height Model

Export Elevation Models
Export DEM & DSM in .img format

Import to ArcGIS
Canopy Height Model Comparison

Surface Volume Differencing Operation in ArcGIS
Develop an accurate method for extracting mangrove features over coastal wetlands using ground filtering of dense point clouds and OBIA.

- **Expectation:** *The methods developed will successfully extract mangroves.*

Define the degree of influence that scale plays in generating an accurate CHM.

- **Expectation:** *Unknown*

Define the degree of influence that scale plays in generating an accurate CHM.

- **Expectation:** *Unknown*

Determine if these methods could be used to improve the study of global carbon budget estimates for coastal environments.

- **Expectation:** *In theory, these methods should indeed improve the study of global carbon budget estimates for coastal environments.*
References

OBIA & Mangrove Forests


OBIA & Mangrove Forests Continued


Lidar & Mangrove Canopy Models


References

Estimating Carbon Sequestration


