Comparing the Land Use and Land Cover Changes Between the North and South Louisiana Using Data Mining

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Motivation

Background:
• The coastal Louisiana has endured multiple threats over the years.
• Significant land loss due to insufficient sediment supply and sea level rise.
• Observed contrast of population and economic growth between the south and north Louisiana.

Questions:
• Has the same type of economic and ecosystem functions in the south gradually migrated to the north?
• Is southern coastal Louisiana sustainable?
• What are the implications for the future planning?
About the Project

• A part of the NSF funded project:

CNH: Coupled Natural-Human Dynamics in a Vulnerable Coastal System
(2012 – 2016)

– More than 20 researchers (PI: Nina Lam and 4 co-PIs)
– 7 Research Components
  • community resilience
  • natural-human dynamics coupling
  • sediment rate analysis
  • hydrology and sediment interactions
  • biomass estimation
  • energy sustainability
  • adaptive governance and planning
Study Area

- Include two major metropolitan areas (i.e. Baton Rouge and New Orleans)
- Combines natural and political boundaries
- Diverse natural and human landscapes
- Diverse population and economic growth
Research Objectives

- Deriving the transitional rules of LULC changes in the study area using data mining
- Comparing the transitional rules between the north and south parts
- Predicting the LULC trend in the future, and compare the difference between the south and north
- Evaluate the different data mining methods for LULC modeling
LULC Changes

The South (1992-2001)

The North (1992-2001)

The South (2001-2006)

The North (2001-2006)

Spatial dimension

Temporal dimension

Km²/year

Loss

Gain

Balance

Urban Agr Grass Forest Water Wetland Barren

Km²/year

Loss

Gain

Balance

Urban Agr Grass Forest Water Wetland Barren

Km²/year

Loss

Gain

Balance

Urban Agr Grass Forest Water Wetland Barren

Km²/year

Loss

Gain

Balance

Urban Agr Grass Forest Water Wetland Barren

Loss

Gain

Balance
Research design

LULC change from $t_1$ to $t_2$

Input variables

Transition rules
IF <condition1> THEN becomes to LULC type 1
IF <condition2> THEN becomes to LULC type 2

Artificial neural network functions

Data mining
- Rule set learning
- ANN

Analyzing transitional rules
- Important factors/rules
- Compare the south and the north

Simulation (Cellular Automata)
- Predict the future scenario
- Compare the north and south

Input variables | Target
---|---
$s_1^1, s_2^1, s_3^1, ..., n_1^1, n_2^1, n_3^1, ...$ | LULC conversion
$s_1^2, s_2^2, s_3^2, ..., n_1^2, n_2^2, n_3^2, ...$ | LULC conversion
$s_1^3, s_2^3, s_3^3, ..., n_1^3, n_2^3, n_3^3, ...$ | LULC conversion

......

$s$: spatial variables,
$n$: number of certain LULC types in neighborhood
### Input and target variables

<table>
<thead>
<tr>
<th>Input variables</th>
<th>Target: LULC transitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Original LULC type</td>
<td>- Change to urban</td>
</tr>
<tr>
<td>- Spatial variables</td>
<td>- Change to agriculture</td>
</tr>
<tr>
<td></td>
<td>- Change to grassland/shrub</td>
</tr>
<tr>
<td></td>
<td>- Change to forest</td>
</tr>
<tr>
<td></td>
<td>- Change to water</td>
</tr>
<tr>
<td></td>
<td>- Change to wetland</td>
</tr>
<tr>
<td></td>
<td>- Change to barren</td>
</tr>
<tr>
<td></td>
<td>- Number of agriculture cells</td>
</tr>
<tr>
<td></td>
<td>- Number of urban cells</td>
</tr>
<tr>
<td></td>
<td>- Number of grassland/shrub cells</td>
</tr>
<tr>
<td></td>
<td>- Number of forest cells</td>
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<tr>
<td></td>
<td>- Number of water cells</td>
</tr>
<tr>
<td></td>
<td>- Number of wetland cells</td>
</tr>
<tr>
<td></td>
<td>- Number of barren cells</td>
</tr>
<tr>
<td>- Neighborhood cells</td>
<td>Use Data mining to find the transitional rules/functions</td>
</tr>
</tbody>
</table>

- Elevation
- Soil type
- Distance to urban area
- Distance to water body
- Distance to primary road
- Distance to secondary road
- Distance to pipelines
### Data mining methods

**Goal:** deriving the relations between input variables and target LULC transitions

<table>
<thead>
<tr>
<th></th>
<th>Rule set learning</th>
<th>Artificial neural network (ANN)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Common</strong></td>
<td>• Deal with complex relations (non-linear)</td>
<td>• Uninterpretable functions (black box)</td>
</tr>
<tr>
<td></td>
<td>• Compatible with non-numerical variables</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Based on heuristic algorithm</td>
<td></td>
</tr>
<tr>
<td><strong>Different</strong></td>
<td>• Interpretable rules (write box)</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>IF</strong> Elevation &lt;= 46</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Distance to urban</strong> &lt;= 3454</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Distance to pipelines</strong> &lt;= 6249</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>THEN</strong> becomes urban</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Generally less accurate</td>
<td>• Generally more accurate</td>
</tr>
<tr>
<td></td>
<td>• Computationally efficient</td>
<td>• Computationally intensive</td>
</tr>
<tr>
<td></td>
<td>• Single vector target</td>
<td>• Multiple vector target</td>
</tr>
<tr>
<td></td>
<td>• Tool: See5</td>
<td>• Tool: Matlab Neural Network toolbox</td>
</tr>
</tbody>
</table>
Analyzing Transitional Rules

- Rule 1: (264/1, lift 2.0): IF Elevation <= 53 AND DistToUrban <= 3367 AND DistToWater > 1782 AND SoilType = 13
  THEN becomes urban [0.992]

- Rule 2: (358/2, lift 2.0): IF Elevation <= 53 AND DistToUrban <= 3367 AND DistToSecRoad <= 1039 AND SoilType = 13
  THEN becomes urban [0.992]

- Rule 3: (394/2, lift 2.0): IF UrbanCellNumber > 0 AND Elevation <= 23 AND SoilType = 7
  THEN becomes urban [0.992]

- Rule 4: (346/2, lift 2.0): IF UrbanCellNumber > 0 AND GrasslandCellNumber <= 0 AND ForestCellNumber <= 0 AND WetlandCellNumber <= 4 AND Elevation <= 55 AND SoilType = 13
  THEN becomes urban [0.991]

- Rule 5: (112, lift 2.0) IF OriginalType = 2 AND Elevation <= 181 AND DistToUrban <= 3367 AND DistToWater > 2034
  THEN becomes urban [0.991]

- Rule 6: (204/1, lift 2.0) IF ForestCellNumber > 1 AND Elevation <= 24 AND DistToUrban <= 8055 AND SoilType = 7
  THEN becomes urban [0.990]

- Rule 7: (86, lift 2.0) IF ForestCellNumber <= 0 AND DistToUrban > 3367 AND DistToWater > 980 AND DistToPrmRoad <= 713 AND DistToSecRoad <= 699
  THEN becomes urban [0.989]

- Rule 8: (79, lift 2.0) IF ForestCellNumber > 1 AND Elevation <= 177 AND DistToWater > 7547
  THEN becomes urban [0.988]

- Rule 9: (79, lift 2.0) IF Elevation <= 6 AND DistToPrmRoad <= 1075
  THEN becomes urban [0.988]

......
Analyzing Transitional Rules

- Most frequently referred variables (1992-2001):

<table>
<thead>
<tr>
<th>Change to</th>
<th>Region</th>
<th>North</th>
<th>South</th>
</tr>
</thead>
</table>
| Urban          | • Urban neighbor cells  
                | • Forest neighbor cells  
                | • **Elevation**  
                | Urban neighbor cells  
                | Elevation  
                | Dist. to primary road |
| Agriculture     | • Agriculture neighbor cells  
                | • Dist. to secondary road  
                | • **Elevation**  
                | Agriculture neighbor cells  
                | Dist. To secondary road  
                | Water cell number |
| Grassland/Shrub | • **Dist. to primary road**  
                | • Dist. to secondary road  
                | • **Elevation**  
                | Dist. To urban  
                | Dist. to secondary road  
                | Elevation |
| Forest         | • Wetland neighbor cells  
                | • **Dist. to primary road**  
                | • **Elevation**  
                |  
                |  
                |  

| Water          | • Water cell numbers  
                | • Distance to water  
                | • **Elevation**  
                | Dist. To pipelines  
                | Dist. to water  
                | Soil type |
| Wetland        | • Wetland neighbor cells  
                | • **Dist. to primary road**  
                | • Soil type  
                | Water neighbor cells  
                | Wetland neighbor cells  
                | Dist. to water |
Analyzing Transitional Rules

- Most frequently referred variables (2001-2006):

<table>
<thead>
<tr>
<th>Region</th>
<th>North</th>
<th>South</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change to</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>• Dist. to urban&lt;br&gt;• Urban neighbor cells&lt;br&gt;• <strong>Elevation</strong></td>
<td>Dist. to urban&lt;br&gt;<strong>Dist. to primary road</strong>&lt;br&gt;Urban neighbor cell</td>
</tr>
<tr>
<td>Agriculture</td>
<td>• <strong>Elevation</strong>&lt;br&gt;• Dist. to pipelines&lt;br&gt;• <strong>Dist. to primary road</strong></td>
<td><strong>Dist. to primary road</strong>&lt;br&gt;Dist. To secondary road&lt;br&gt;<strong>Dist. to pipelines</strong></td>
</tr>
<tr>
<td>Grassland/Shrub</td>
<td>• Dist. to water&lt;br&gt;• <strong>Dist. to primary road</strong>&lt;br&gt;• Soil type</td>
<td>Dist. To secondary road&lt;br&gt;Water neighbor cells&lt;br&gt;<strong>Dist. to pipelines</strong></td>
</tr>
<tr>
<td>Forest</td>
<td>• <strong>Elevation</strong>&lt;br&gt;• <strong>Dist. To primary road</strong>&lt;br&gt;• Soil type</td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>• Dist. to water&lt;br&gt;• <strong>Elevation</strong>&lt;br&gt;• Dist. to urban</td>
<td><strong>Dist. to pipelines</strong>&lt;br&gt;Dist to water&lt;br&gt;Soil type</td>
</tr>
<tr>
<td>Wetland</td>
<td>• <strong>Elevation</strong>&lt;br&gt;• <strong>Dist. to primary road</strong>&lt;br&gt;• Dist. to urban</td>
<td><strong>Dist. to primary road</strong>&lt;br&gt;Dist to water&lt;br&gt;Soil type</td>
</tr>
</tbody>
</table>
Frequency of changing to urban by elevation

Frequency of changing to urban by distance to primary roads

Legend:
- north
- south
Current conclusions

• The south and the north part of the study area are undergoing different LULC processes

• The LULC changes in the south and north have different transitional rules and related to different factors.

• Data mining is an effective approach to model and analyze LULC changes.
Next steps

• Simulation
  – Given the transitional rules/functions in a time interval, predict the scenario in the next time stamp.
  – Compare the future scenario between the south and north
  – Compare the performances between rule sets mining and ANN.

• Coupling with other project components
  – Community resilience
  – Biomass and vegetation
  – Land pricing and population change
Thanks for your attention!

Questions?