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Unveiling the Past: Using LiDAR to Discover Lost Archaeological Features in the American Southeast

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ABSTRACT

Artificial mounds and rings are morphologically heterogeneous. While they share many compositional traits, their outlines on landscapes widely vary across geographic regions. As such, automated identification of these deposits requires the use of algorithms that are capable of evaluating a range of criteria and assessing objects that fall within acceptable ranges for each analyzed attribute. Object-based image analysis (OBIA) is one solution to this problem. Here, I develop a combined OBIA method utilizing two different approaches – multiresolution segmentation and template matching – in order to locate these features semi-automatically. The results of this study indicate the success of this method for detecting previously undocumented archaeological features in South Carolina. Remote Sensing thus increases economic and time efficiency for archaeological survey.

BACKGROUND

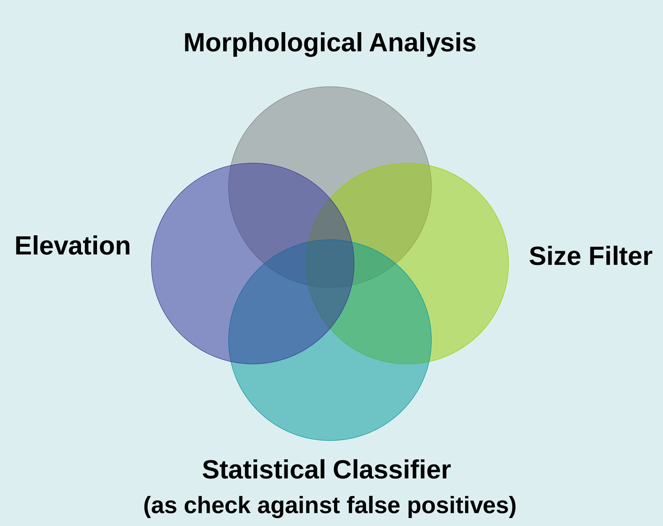
OBIA is a method of classifying remote sensing data that relies on "image objects", rather than pixels, as the primary unit of analysis. Image objects are created by dividing images into groups of pixels that correspond to changes in texture, pixel values, and shape. The most common way to create image objects is through a process known as segmentation.

Multiresolution Segmentation: OBIA method that divides images into objects based on shape, texture, and pixel values. The drawback of this approach when applied to this particular issue relates to its inability to effectively limit false positive results. Its strengths lie in its morphologically driven analysis of objects.

Template matching: OBIA method that classifies image objects using statistical correlation. Objects are compared to predefined templates to determine statistically probable matches. The drawback of this approach when applied to this study area stems from its inability to identify features that vary too much in their overall size compared to known sites. Its strength lies in its ability to eliminate false positives based on statistical classification, which results in a check against naturally occurring topographic changes.

These two methods are combined in this study in order to identify sites based on morphometric properties, elevation values (defined in the LiDAR data), size, and statistical likelihood.

Requirements for Mound Identification

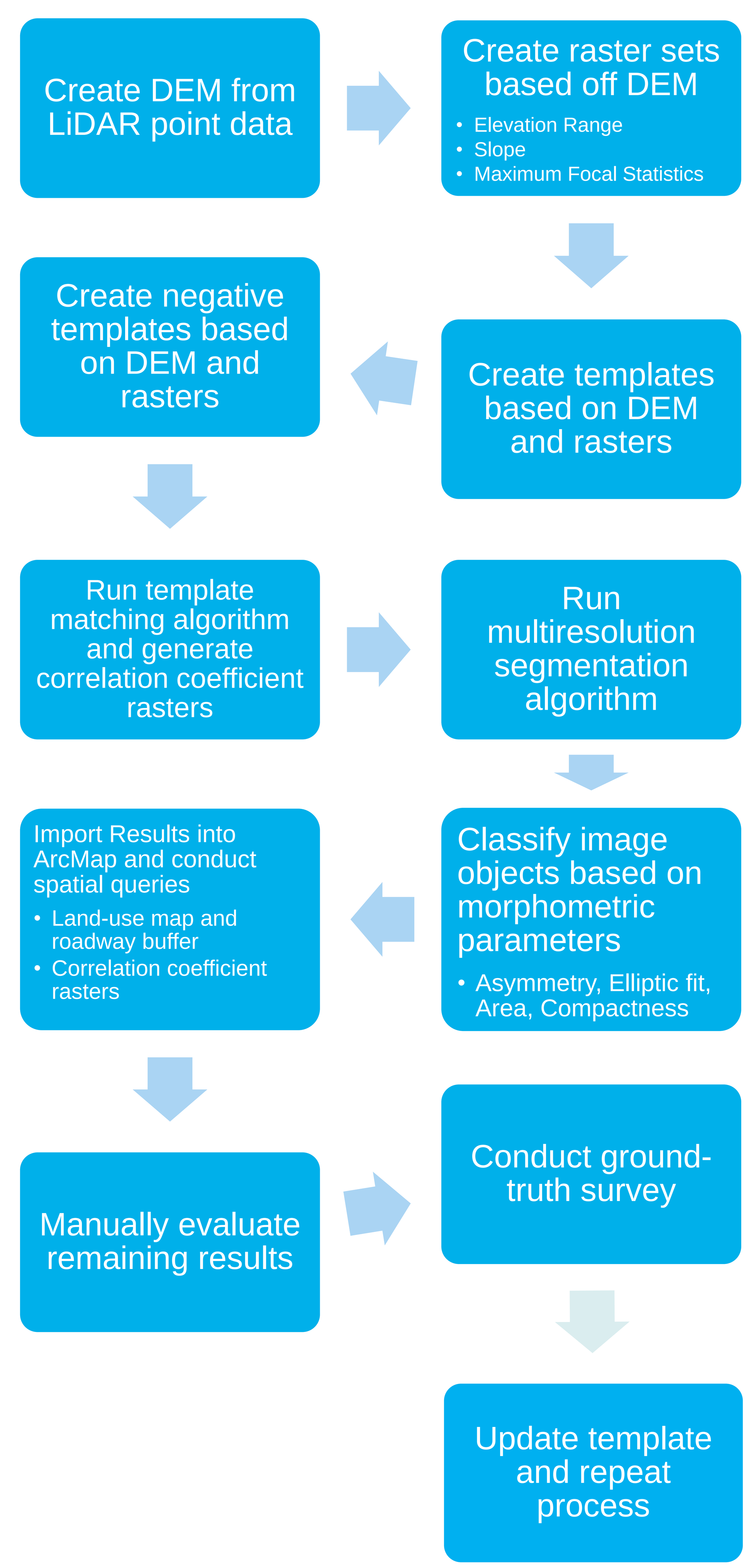


OBJECTIVE

Develop a semi-automatic algorithm that can accurately identify artificial topographic anomalies in the American Southeast. The primary focus is the identification of prehistoric features including: earthen and shell mounds and shell rings.

METHODS

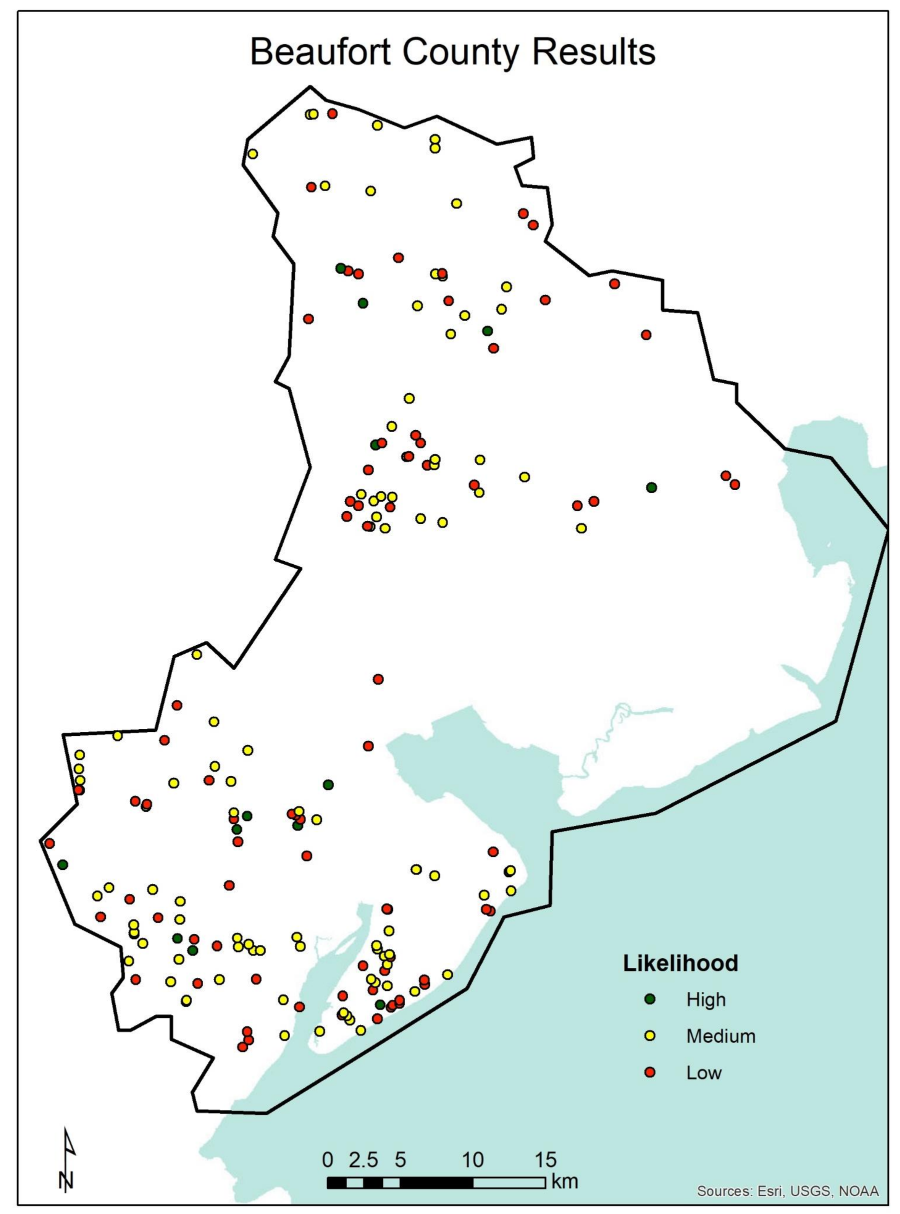
- LiDAR data (collected by NOAA, USGS, and DNR) forms the basis for the analysis. DEM's are processed in ArcGIS 10.5.1 and have a spatial resolution of 1.2 meters
- OBIA processes are conducted in eCognition 9.2.
- SAGA is used to create Red Relief Image Maps (RRIMs), which are used for visual interpretation of results.
  - In brief, RRIM is a shade-free 3D image that allows for small topographic changes to be visualized on a landscape[1]
- Land-use maps from USGS and transportation shapefiles from DOT are incorporated to eliminate false positives on the basis of proximity to modern development

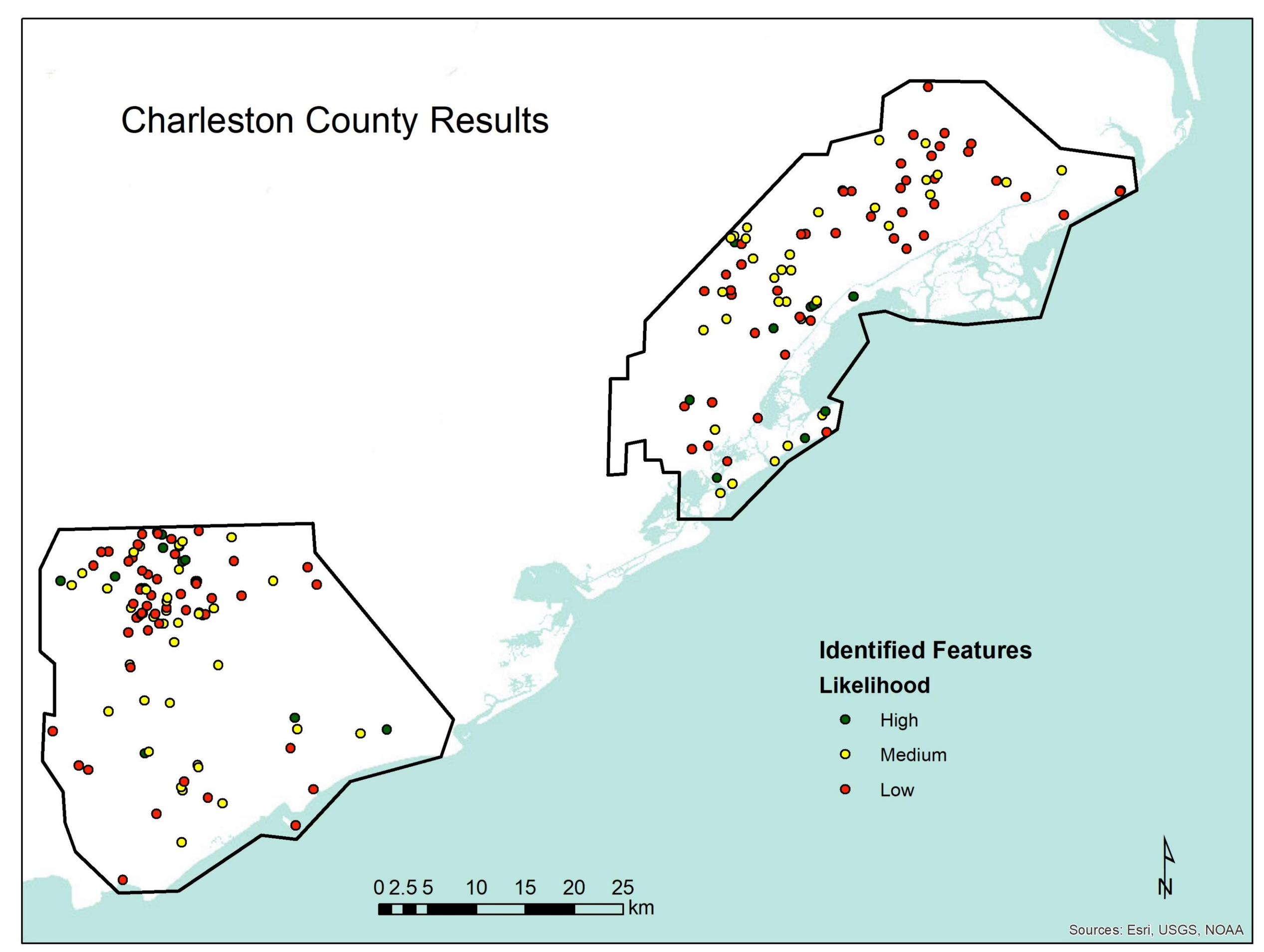


1. Chiba, T., Kaneta, S., & Suzuki, Y. (2008). Red relief image map: new visualization method for three dimensional data. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, *37*(B2), 1071–1076.

RESULTS

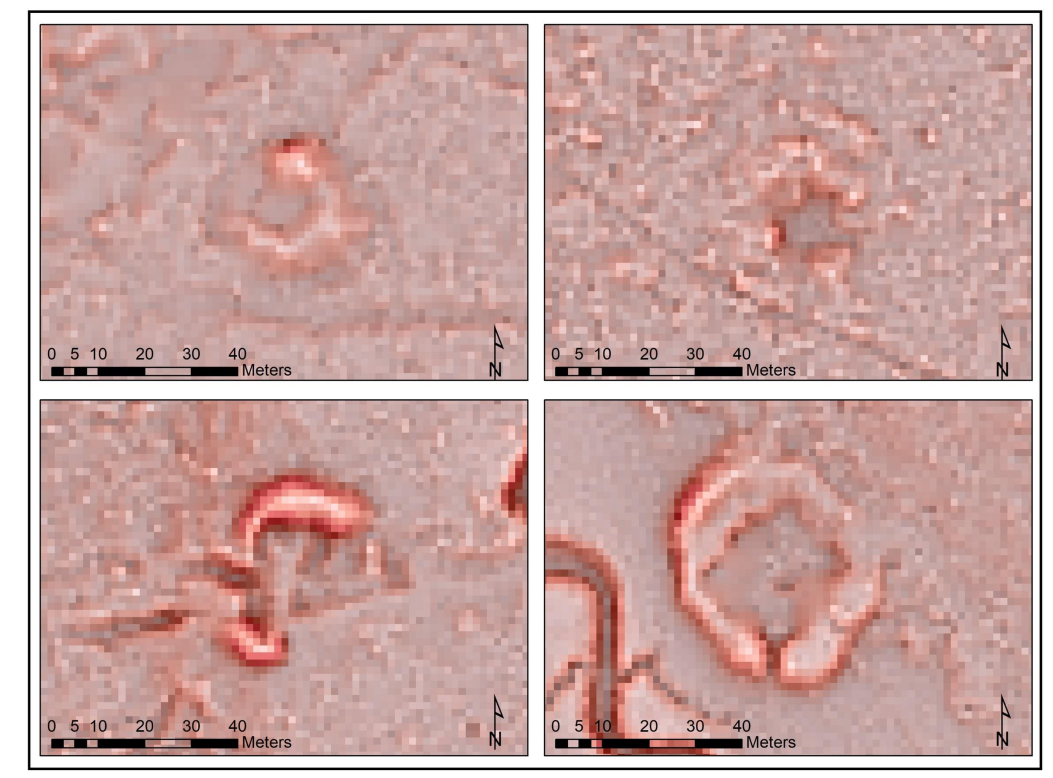
- A total of 373 features are identified (77 are rings and 296 are mounds)
- Each result is given a qualitative likelihood value based on size, relative location (i.e., is its immediate area disturbed by modern development), and elevation profile.
- 35 of these results are ranked as high likelihood
- Ground-testing was conducted on 5 locations identified in Beaufort County
  - Represents a 33% sample of high likelihood identifications in this county (n=15)
- 3 of 5 are previously identified archaeological features, while 2 represent new discoveries





RESULTS

- The automated portion of the algorithm requires approximately 20-30 hours of processing time (depending upon the size of the area being surveyed)
- Manual processing for Beaufort and Charleston required an additional 35 hours
- The total processing time was approximately 65 total hours, which was spread over the course of about 3 weeks
- This is a significant improvement in archaeological survey time, and has the advantage of surveying entire landscapes without obstruction due to inaccessibility



High Likelihood ring-features identified. The site on the top right was visited during ground-truth surveys and is a shell-ring feature.

Likelihood	Mound	Ring	Total
Low	138	29	167
Medium	130	41	171
High	**28**	**7**	**35**
Total	296	77	373

CONCLUSIONS

This semi-automatic OBIA method successfully surveyed the entirety of Beaufort County (2,391 km²) and Charleston County (2,256 km²) in the span of 3 weeks. Despite its small sample size, this method proved highly successful in ground-truth surveys. The primary takeaway from this study is that a multifaceted approach must be taken when utilizing remote sensing technologies for archaeological purposes. In this instance, two alternative OBIA methods were combined (segmentation and template matching) to incorporate the benefits of each method while countering each method's drawbacks. Future work will expand this algorithm to additional areas along the coast of the American Southeast.

ACKNOWLEDGEMENTS

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