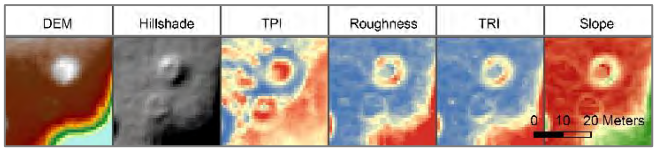
Machine learning methodologies for identifying Native American burial mounds from high-resolution LiDAR data sets, Minnesota, USA

The identification and preservation of prehistoric burial mounds and earthworks is of the utmost importance to a better understanding of the cultural and historical record of Native American peoples, as these features play an important role in their belief systems. Geoarchaeologists must be able to efficiently identify, study and protect these features from destructive land-use practices and erosional processes if they are to construct a holistic picture of Native American histories and the pre-settlement environmental contexts in which they lived.

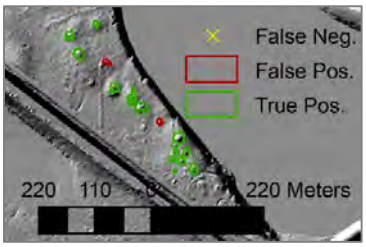
T.H. Lewis surveyed thousands of Minnesota's mounds in the late 1800's, but many more unidentified mounds and earthworks have since been recognized throughout the state. Efficiently identifying mounds across broad spatial extents has proven difficult. Modern landscape alterations due to agriculture and urbanization, mound locations in densely vegetated areas, and the presence of morphologically similar geomorphic features make it difficult to identify them without being in close proximity to the mounds. The advent of aerial photography and other remotely sensed geospatial data, like high-resolution LiDAR-derived DEMs, provide a unique and efficient opportunity to assist in locating unrecorded mounds and earthworks across broad spatial extents.

Due to the canopy coverage, remote sensing data that focus on height differences and are insensitive to vegetation are very valuable data sources for geoarchaeological surveys, because archaeological sites are often covered by vegetation. Therefore, different data layers are used as inputs to determine their efficiency to identify and locate mounds: DEM, hillshade, Topographic Position Index (TPI), roughness index, Terrain Ruggedness Index (TRI) and slope. Several input layers are important for the machine learning approaches so that different information about the appearance of the target feature can be derived.



Input layers

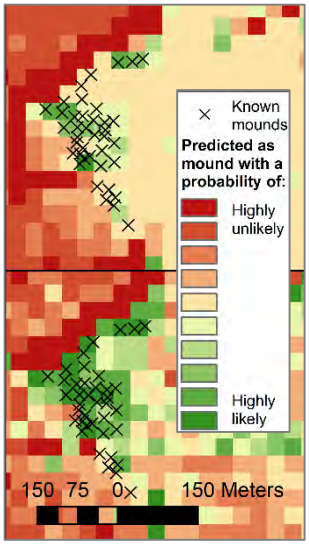
Based on training and testing data sets, two machine learning techniques create models to predict the presence and map the location of mounds in LiDAR-derived imagery. Feature Analyst is a automated feature extraction (AFE) software that addresses the goal of extracting, recognizing and visualizing features. By doing so, the software interprets the image with regard to attributes such as shape, size, texture, pattern, color, and pixel values. Moreover, the supervised learning process allows removing clutter and adding missed features to improve the output. Feature Analyst is restricted to - but at the same time also specialized on - geospatial analyses and suitable when working with high-resolution imagery and not extensive data sets.



Predicted mounds by Feature Analyst

TensorFlow is a type of artificial intelligence of computer vision and was developed by Google. It requires a once developed, complex script based on a Convolutional Neural Network that is fed with abundant training examples of the targeted feature.

Just as human eyes sometimes struggle with distinguishing ancient mounds and other natural mounds, both object recognition approaches have difficulties with differentiating the morphological reasons why a mound exists.



Predicted mounds by TensorFlow

TensorFlow offers more sustainable opportunities for future adaptions of the script and various fields of application for automated feature extraction. The results of this work point to broader implications for efficient identification and preservation of Native American cultural sites elsewhere and for expansion of this method into other geospatially-oriented fields.

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