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Digging Deeper: Automating Archaeological Feature Detection through Deep Learning

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Abstract:

Archaeological features, the non-portable components of sites (e.g. roads, structural remains, and walls,) are key elements in understanding site purpose, significance, and cultural connections. However, detecting features through traditional field survey can be challenging, particularly in forested regions with dense canopies and undergrowth. Also, investigations typically focus on defined project areas, removing features and sites outside project bounds from broader cultural landscape interpretations. This focus is necessary as site survey is time consuming and expensive. Archaeologists typically have one chance to identify and protect sites and cannot afford to miss or misinterpret features.

To improve feature identification efforts, archaeologists rely on remote sensing technologies, in particular, light detection and ranging (LiDAR). LiDAR cuts through forest canopies, revealing hidden features and providing opportunities to visualize and interpret landscapes from different perspectives. In southwest Virginia, forest archaeologists with the United States Department of Agriculture (USDA), use LiDAR data from the United States Geological Survey (USGS) 3D elevation program (3DEP) to search for surface features before conducting field work. This process has enhanced feature identification and site recordation, particularly the identification of early iron industry features such as colliers' pits. Colliers' pits are cleared areas where colliers produced charcoal to fuel Virginia's 19th century iron furnaces. Colliers' pits, difficult to detect through field observation, are subtle, circular features, with an approximate 15-meter diameter. In LiDAR-derived maps, colliers' pits have a distinct signature that helps archaeologists pinpoint features prior to field verification. This review process is reliant on specialist knowledge for data processing and feature identification.

Advances in artificial intelligence (AI) offer archaeologists novel approaches to automating object detection in datasets through custom deep learning models (Altaweel et al., 2022; Gallwey et al., 2019; Hou et al., 2024). Deep model developers annotate objects in datasets, labelling objects by class to teach (or "train") models to detect learned objects in new datasets. Incorporating deep learning models into pre-field data review workflows could improve feature identification, expediting large dataset review and removing potential human bias. Typically, successful deep learning models require high quantities of training data, which can be difficult for archaeologists to obtain. This research sought to develop and evaluate a deep learning model created with low quantities of training data aimed at automating detection of colliers' pits in large datasets.

Researchers created the model following the deep learning workflow outlined in ESRI's ArcGIS Pro. USGS 3DEP elevation data was used to create the imagery for training the model. The Mask RCNN deep learning framework was selected for training, which detects objects in data by 1) drawing a bounding box around objects and 2) creating a detailed outline of objects through instance segmentation. Researchers evaluated the model on a new dataset by assessing the model evaluation output, a polygon feature class containing potential colliers' pits. This feature class was compared with a colliers' pits feature class created through manual review of the new dataset by a USDA forest archaeologist.

Preliminary results from this research indicate that, even with low quantities of training data, custom deep learning models can detect objects in new datasets. Additionally, the model identified colliers' pits the forest archaeologist did not, suggesting incorporating AI-driven workflows could mitigate review problems related to human error. The main performance issue with the model was feature misclassification, which could be improved in future work by adding more colliers' pits, and different types of features, to grow and diversify the training schema. Even with limited training data, this research indicates that deep learning models have the potential to enhance traditional prospection techniques, offering archaeologists innovative approaches to feature identification and the important work of recording and protecting sites.

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References

Altaweel, M., Khelifi, A., Li, Z., Squitieri, A., Basmaji, T., Ghazal, M., 2022. Automated Archaeological Feature Detection Using Deep Learning on Optical UAV Imagery: Preliminary Results. Remote Sensing 14, pp. 553.

Gallwey, J., Eyre, M., Tonkins, M., Coggan, J. 2019. Bringing Lunar LiDAR Back Down to Earth: Mapping Our Industrial Heritage through Deep Transfer Learning. Remote Sensing 11, pp. 1994.

Hou, M., Huo, D., Yang, Y., Yang, S., Chen, H. 2024. Using mask R-CNN to rapidly detect the gold foil shedding of stone cultural heritage in images. Herit Sci 12, pp. 46.

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