An experimental study for the detection of surface ceramics through Unmanned Aerial Vehicles (UAV)

EARSeL Cyprus 2022
Abstract
Corresponding Author:
ac.argyrou@edu.cut.ac.cy

Argyro Argyrou[1*], Vasiliki Lysandrou[1], Michalis Christoforou[1], Athos Agapiou[1]

[1] Earth Observation Cultural Heritage Research Lab, Department of Civil Engineering and Geomatics, Faculty of Engineering and Technology, Cyprus University of Technology, Lemesos 3036, Cyprus

Keywords: Remote Sensing Archaeology, Machine Learning (ML), Potsherds, Classification, Unmanned Aerial Vehicles (UAV)

The challenge

One of the most popular techniques for detecting archaeological sites and characterization of archaeological landscapes is the archaeological pedestrian survey, with fieldwalking being the most common type of survey (Orengo H.A., Garcia-Molsosa A. 2019). Further important findings, together with those published by Agapiou et al. (2021), followed the work of Orengo and Garcia-Molsosa (2019), show that low-altitude remote sensing sensors (e.g., Unmanned Aerial Vehicles, UAVs) can provide significant outcomes. This study is designed, under the newly established research project "Innovative survey techniques for detection of surface and sub-surface archaeological remains", in short ENSURE, along with the scientific objectives of the PhD of the first author oriented on the same topic.

The overall objective of the study is to present the methodology of a simulation study towards the semi-automatic detection of surface ceramics through low altitude multispectral and RGB cameras. Surface ceramics detection will be carried out through machine learning (ML) methods and image post-processing techniques. The results show the potential of this technique, under appropriate field circumstances, to produce accurate distribution maps of surface ceramics.

Methodology

The aim of our pilot study is to investigate whether a semi-automated methodology for recording potsherds could be developed and to answer research questions for a more efficient approach in terms of time and accuracy compared to traditional fieldwalking archaeological surveys. In this study, we have implemented an artificial intelligence image processing methods over o plot approximately 20m x 20m (Area 1) in an area of interest near the village of Alambra, in Lefkosia District of the Republic of Cyprus.

The workflow followed includes a drone-based image acquisition. In spring 2022, a campaign over Area 1 was performed, using the DJI P4 Multispectral system with the following spectral bands: Blue (B): 450 nm ± 16 nm; Green (G): 560 nm ± 16 nm; Red (R): 650 nm ± 16 nm; Red edge (RE): 730 nm ± 16 nm and Near-infrared (NIR): 840 nm ± 26 nm. Flight height was set to approximately 20m above ground level (AGL), providing orthophotos with a spatial resolution of a few centimetres, and sufficient to clearly identify ceramics on Area 1.

As a second step, was the ground truth data collection (simulating thus the traditional pedestrian survey). We divided Area 1, in a 5×5 m grid and the field-walkers identified and counted 300 ceramics. The largest width of the identified surface ceramic fragments ranges from 3 cm to 6 cm (Figure 1), while the colour of their surface also varies, depending on firing, from reddish orange to brown.

Next process included standard photogrammetric processing to combine all these photographs into a single orthophoto-mosaic. Finally, two steps included computational processing (ML techniques) and geospatial analyses (GIS software) to identify and isolate ceramic fragments.

Results

Various ML algorithms such as the Support Vector Machine (SVM) and the Random Forest (RF) classifiers have been implemented and compared along with the results from foot surveys. This is also demonstrated through numerous articles highlighting decision-making and the analysis of scientific models using ML techniques with minimal human interaction. Utilizing workflow of Orengo and Garcia-Molsosa (2019), in our study, the overall accuracy and relative accuracy were estimated. The results were compared with the archaeological surface-survey records showing that semi-automatic detections methods using low-altitude remote sensing sensors can be used as a first proxy indicator for the detection of surface archaeological ceramics.

These results and accuracy can vary, depending on variety of factors like, the type of soil, the conditions of the plot, the period of flight, the visibility and quantity of the material culture but also the number and experience of the inspectors.

Outlook for the future

The aim of this study was to investigate the potential of low-altitude remote sensing sensors that use high-resolution UAV multispectral sensors to detect fragmented ceramics at archaeological sites. The overall findings, show that low-altitude remote sensing sensors can be innovative in the field of archaeological field research. Future archaeological projects may rely on such methodologies to be cost-effective, especially in cases where there is an urgent need to record rapidly disappearing archaeological sites or even when the research schedule is limited. In addition, it is especially important both before the flight operations with the UAV sensors, and during the image analysis for ceramic detection to make critical preparations such as spectral analysis of the camera, spatial analysis, etc.

In the future further improvements are expected, while more sophisticated remote sensing algorithms will be tested to cover even larger areas with a higher success rate.

Figure1. Example of unwashed surface potsherds and washed surface potsherds (Photos: A. Argyrou, Earth Observation Cultural Heritage Research Lab©).

References

Agapiou A., Vionis A. and Papantoniou G. (2021). Detection of Archaeological Surface Ceramics Using Deep Learning Image-Based Methods and Very High-Resolution UAV Imageries. https://doi.org/10.3390/land10121365 Land 2021, 10,1365.

Orengo H.A, Garcia-Molsosa A. (2019). A brave new world for archaeological survey: Automated machine learning based potsherd detection using high-resolution drone imagery. Journal of Archaeological Science 112, 105013

Acknowledgments

The authors would like to acknowledge the ENSURE project (Innovative survey techniques for detection of surface and sub-surface archaeological remains, CUT internal funding. This paper is a part of the PhD of the first author in the same topic.