Newcastle University

Open Research Case Study

Automated Archaeological Change Detection

Louise Rayne

Newcastle University Academic Track Fellow, School of History, Classics and Archaeology

Introduction and research context

Archaeological sites across the Middle East and North Africa are at risk of damage from conflict and modern development. The fast pace of change and pressures on resources makes it impossible for archaeologists to manually record the condition of all known sites in national databases. Therefore, we produced an open-source tool using free satellite images to automatically detect changes threatening sites.

Satellite remote sensing allows rapid recording via a bird's eye perspective. Commercial high-resolution imagery has allowed detailed recording of cultural heritage but it is very expensive, has limited spatial and temporal coverage and embargos restrict use in the Middle East and North Africa. Because of this we used Sentinel-2, which provides open-source and regularly repeated (c.12 days) optical satellite imagery with a resolution of up to 10 m across 13 spectral bands.

Our tool comprises JavaScript code to run within the open-source interface Google Earth Engine because it supplies regularly updated free satellite imagery and high-performance computing [1]. Users upload the sites they want to monitor and define dates, an area of interest, and the size of a buffer area for analysis around each site. Sentinel-2 satellite imagery is divided into two collections according to the date function (earlier and later). The collections are filtered according to the area of interest the user defined and to limit cloud percentage to less than 10%. Composites are made by calculating the median values of each pixel in the collections. A per-pixel, layer arithmetic change detection algorithm then computes the amount of difference in reflectance values between the composites. The algorithm thresholds the resulting change product and appends an indication of change to the buffered area around each site which can be visualised and downloaded by users.

In a published article [2] and blog post [3], we tested the script on point data of site locations for two case studies, the Aswan and Kom-Ombo area in Egypt and the Jufra oases in Libya. The algorithm performed with an overall accuracy of 85-91% [2]. In our recent blog, we updated the code to also provide a measure of change in different land cover types using the Dynamic World layer [4], which performed with an accuracy of 73% [3]

Open practices

The automated change detection script is available via a Creative Commons Attribution-ShareAlike 4.0 International License in an open-access repository (https://github.com/LouiseRayne/change_detection) and linked to in a recent blog post as part of the Newcastle University Spatial Humanities initiative [3]. An older version of the code is attached as supplementary material to an open-access paper (Creative Common CC BY License) which gives the methods and accuracy assessment in detail [2]. We .demonstrated the code to heritage professionals based in the Middle East and North Africa at training courses focused on geospatial analysis (2017-2021), and most recently at a collaborative event between academics from Newcastle and Iraq (February 2023)..

Challenges and benefits

Embargos and the need for expensive software licenses, high-performance computers and specialist skills limit the update of satellite remote sensing amongst heritage professionals. We chose to use a relatively simple and unsupervised per-pixel comparison approach because it is fast to use and to understand for a variety of stakeholders, enabling them to modify the code to meet their needs. The locations of archaeological sites themselves can generally not be made completely open source due to the risk of looting, however, because our code is entirely open-source, heritage professionals can access it and run it with their own databases without needing to make these publicly available (e.g. see citations of our article [2]).

Conclusion and lessons

The impacts of mundane land use activities were found to be significant on heritage in the case study areas. Agricultural and urban expansion were found to be destroying sites, as expected. In particular, the construction of 'New Aswan' is rapidly destroying cultural heritage. In addition, the algorithm revealed other issues which we had not predicted including damage from burning and flooding.

Our tool allows threats to archaeological sites to be automatically, rapidly and regularly monitored, without the need for laborious manual examination of satellite images or time-consuming site visits. The code and the datasets used are open-source, so our methods are replicable and there are no limitations imposed by embargos or financial restrictions.

References

1. Gorelick, N., et al., Google Earth Engine: Planetary-scale geospatial analysis for everyone. Remote sensing of Environment, 2017. 202: p. 18-27.

2. Rayne, L., et al., Detecting change at archaeological sites in North Africa using open-source satellite imagery. Remote Sensing, 2020. 12(22): p. 3694.

3. Rayne L., et al Dynamic World for monitoring heritage destruction using Google Earth Engine. 2022; Available from: https://blogs.ncl.ac.uk/nush/2022/08/23/dynamic-world-for-monitoring-heritage-destruction-using-google-earth-engine/.

4. Brown, C.F., et al., Dynamic World, Near real-time global 10 m land use land cover mapping. Scientific Data, 2022. 9(1): p. 251.