New algorithm for the automated detection and classification of multi-cell phytoliths using AI

A new study shows that it is possible to automate the detection and classification of phytoliths with a high-level of accuracy, up to a species level.

This method has the potential to allow the development of much larger analytical datasets in a fraction of the time than was previously feasible, as well as to assure consistency in phytolith identification and increase the validity of sample analysis.

The incorporation of Machine Learning-based workflows in archaeology, while still little explored beyond site detection studies (Berganzo-Besga *et al.*, 2021; Orengo *et al.*, 2021), presents significant potential within archaeological research.

The doctoral researcher Iban Berganzo-Besga (GIAP research group at the ICAC) led by Dr. Hèctor A. Orengo (ICAC) and Dr Felipe Lumbreras (Computer Vision Center, UAB), in collaboration with Dr Monica N. Ramsey (University of Toronto Mississauga; McDonald Institute for Archaeological Research, University of Cambridge) and Paloma Aliende (ICAC), has developed a Deep Learning (DL) algorithm for the automated detection and classification of multi-cell phytoliths.

Automated detection and classification of multi-cell Phytoliths using Deep Learning-Based Algorithms. Iban Berganzo-Besga, Hèctor A. Orengo, Felipe Lumbrera, Paloma Aliende, Monica N.Ramsey. *Journal of Archaeological Science*, 2022, 105654, ISSN 0305-4403, https://doi.org/10.1016/j.jas.2022.105654.

The use of DL algorithms has the potential to provide tools for the automated identification of phytoliths.

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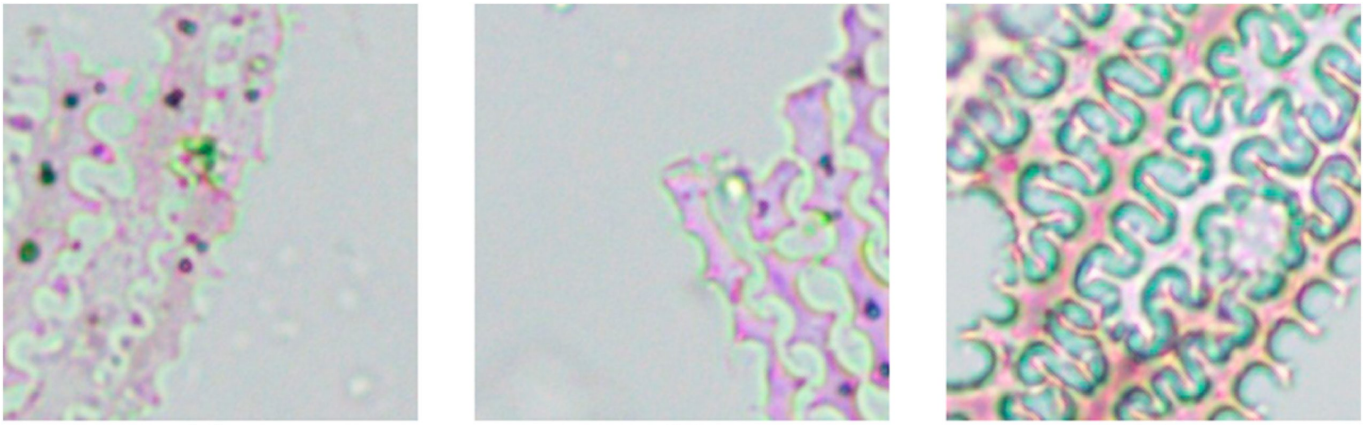
Multi-cell phytoliths, particularly grass husks, provide more specific genera level identifications and are therefore critical to the archaeological application of phytolith analysis (Rosen, 1992). Also, given the complexity of forms that multi-cells present, and the similarity between these forms, these identifications can be time consuming and challenging even for experienced phytolith analysts. The use of DL algorithms has the potential to provide tools for the automated identification of phytoliths. This approach has been tested using three key phytolith genera for the study of agricultural origins in Near Eastern archaeology: *Avena*, *Hordeum* and *Triticum*.



"Avena" (a), "Hordeum" (b) and "Triticum" (c) phytoliths. @ Authors of the paper.

The method and algorithm published in the *Journal of Archaeological Science*, has been able to identify and classify the three genera with more than 93% overall confidence and two species (*Triticum boeoticum Acc*. and *Triticum dicoccoides Acc*.) with a 100% confidence.

Complex digital microscopes can incorporate DL algorithms, allowing **near-instantaneous automatic phytolith-type counts**, a radical improvement on the current analysis speeds. Beside this, the algorithm is designed to be employed by other interested parties using freely available computational resources such as Google

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Colaboratory.

The published paper can provide an important methodological tool for researchers using phytoliths in vegetation history, archaeobotany, palaeoecology, human environmental-interactions and the origins of agriculture.

This method has the potential to revolutionise all these fields by allowing not just the development of much larger analytical datasets in a fraction of the time than was previously feasible but also by **allowing the incorporation of new measurements and analysis methods** (such as fragmentation patterns, phytolith size, etc.), ensuring consistency in phytolith identification, and **increasing the validity of sample analysis by moving from statistical estimations to total phytolith counts**.

The incorporation of new methods and automated detection and classification algorithms should ultimately allow archaeologists to concentrate their efforts into the historical and sociocultural interpretations that make archaeological insight unique and necessary.

Contributions by authors

- **Iban Berganzo-Besga**: formal analysis, investigation, methodology, validation, software, data curation, writing of the original draft, visualisation.
- Felipe Lumbreras: methodology, resources, writing, review and editing, supervision.
- Monica N. Ramsey: conceptualisation, data curation, writing of the original draft, project administration, funding acquisition.
- Hèctor A. Orengo: conceptualisation, methodology, re- sources, writing, review and editing, supervision, project administration, funding acquisition.
- Paloma Aliende: data curation.

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