Peer Community In Archaeology

A valuable contribution to automated analysis of palaeolithic artefacts

Sebastian Hageneuer *based on peer reviews by* ***Lutz Schubert*** *and 1 anonymous reviewer*

Florian Linsel, Jan Philipp Bullenkamp & Hubert Mara (2024) Linking Scars: Topology-based Scar Detection and Graph Modeling of Paleolithic Artifacts in 3D. Zenodo, ver. 3, peer-reviewed and recommended by Peer Community in Archaeology.
https://doi.org/10.5281/zenodo.8296269

Submitted: 02 September 2023, Recommended: 10 January 2024

Cite this recommendation as:
Hageneuer, S. (2023) A valuable contribution to automated analysis of palaeolithic artefacts. *Peer Community in Archaeology*, 100413. 10.24072/pci.archaeo.100413

Published: 10 January 2024

In this paper (Linsel/Bullenkamp/Mara 2024), the authors propose an automatic system for scar-ridge-pattern detection on palaeolithic artefacts based on Morse Theory. Scare-Ridge pattern recognition is a process that is usually done manually while creating a drawing of the object itself. Automatic systems to detect scars or ridges exist, but only a small amount of them is utilizing 3D data. In addition to the scar-ridges detection, the authors also experiment in automatically detecting the operational sequence, the temporal relation between scars and ridges. As a result, they can export a traditional drawing as well as graph models displaying the relationships between the scars and ridges.

After an introduction to the project and the practice of documenting palaeolithic artefacts, the authors explain their procedure in automatising the analysis of scars and ridges as well as their temporal relation to each other on these artefacts. To illustrate the process, an open dataset of lithic artefacts from the Grotta di Fumane, Italy, was used and 62 artefacts selected. To establish a Ground Truth, the artefacts were first annotated manually. The authors then continue to explain in detail each step of the automated process that follows and the results obtained.

In the second part of the paper, the results are presented. First the results of the segmentation process shows that the average percentage of correctly labelled vertices is over 91%, which is a remarkable result. The graph modelling however shows some more difficulties, which the authors are aware of. To enhance the process, the authors rightfully aim to include datasets of experimental archaeology in the future. They also aim to develop a way of detecting the operational sequence automatically and precisely.

This paper has great potential as it showcases exactly what Digital and Computational Archaeology is about: The development of new digital methods to enhance the analysis of archaeological data. While this procedure

is still in development, the authors were able to present a valuable contribution to the automatization of analytical archaeology. By creating a step towards the machine-readability of this data, they also open up the way to further steps in machine learning within Archaeology. Bibliography

Linsel, F., Bullenkamp, J. P., and Mara, H. (2024). Linking Scars: Topology-based Scar Detection and Graph Modeling of Paleolithic Artifacts in 3D, Zenodo, 8296269, ver. 3 peer-reviewed and recommended by Peer Community in Archaeology. https://doi.org/10.5281/zenodo.8296269

Reviews

Evaluation round #1

DOI or URL of the preprint: https://doi.org/10.5281/zenodo.8296269
Version of the preprint: 1

Authors' reply, 18 December 2023

Reviewed by anonymous reviewer, 27 Sep 2023 14:48

The paper presents a scar segmentation approach for stone tools.

The authors use many abbreviations that make the reading of the paper complex.

* Avoid the abbreviations as much as possible and introduce them after the first time they appear in the paper.

Deleted abbreviation:

- GMM: Geometric Morphometric Method
- CC: connected components
- DMT: Discrete Morse Theory

—

* The "Scar Segmentation using Morse Theory "section is unclear to me. For example, the authors say, "There is a topologically consistent method of simplifying the skeleton using persistence, a measure of the importance of critical points", but I do not understand what this measure of persistence is.

Then, in the section, explaining all the processing steps with figures is better to highlight their contributions better.

- added figure to show pipeline
- changed text: removed some technical, but not so relevant part and extended the subchapters with the required parts

—

* Then, I need clarification about the contribution of the graph-based representation of the scar-ridge patterns. What is its final purpose?

For more clarity, we added a new subchapters for the work of OS and graph models in the current archaeological practise (73 - 91) and in "Relative Chronology of Scars (OS)" more details of how to use the graph based representation in the future (352 - 364).

—

* In the references, the following paper is missing:

Visualization and Extraction of Carvings for Heritage Conservation, DOI 10.1109/TVCG.2016.2598603

- We are not sure, why we should add the article. The topic is interesting and can possibly be considered in a paper, which is solely focused on the visualization of engravings, but is not applicable to lithic artifacts.

Reviewed by Lutz Schubert, 03 Oct 2023 06:54

Overall, the paper is very well elaborated and scientifically sound. There are some explanatory gaps though which may be worth addressing:

* The ”ground truth” is not basing on an objective measurement - this is not the fault of the author, but simply how the chaine operatoire is reconstructed. However, this means that there is more than one interpretation of the ”correct” order that affects the interpretation of the accuracy of the method. The author uses his own ground truth for comparison, which is ok, but the implication should be discussed in the methodology and discussion of the results.

- Thank you for the remark! The GT data we are using is by no means the sole interpretation. Hence, we added in the lines (107 - 115) explanations of, how to interpret our results. In future projects, we are also using experimental datasets, where we can define a direct relationship between positive and negative scars (347 - 351).

---

* The paper is introduced as talking about the operation sequence / chaine operatoire, but this context is frequently lost. In particular the graph model analysis is not put into this context sufficiently, though the impact and relevance for it is immediately clear. It would be good to spend a paragraph or two on introducing the relevance of the graph model for OS analysis and to take that up in the results discussion (see also below).

We added multiple paragraphs to adress this point: one new subchapters ”OS and graph models in the current archaeological practise” (73 - 91), a paragraph in the results (327 - 337) and in ”Relative Chronology of Scars (OS)” more details of how to use the graph based representation in the future (352 - 364).

---

* Along similar lines, the impact of shape on the graph model is not sufficently discussed. A quick introduction to how the operational sequence impacts on the graph direction and which parameters could be used to affect the graph accordingly. For example, how shapes of ridges would affect the direction in the neighbourhood graph. This does not have to be complete, since it is work in progress and early in the research, but it should make clear that these aspects have to be considered in the long run. The authors builds up on his own assumptions, which is perfectly fine, but these should be clear to the reader.

- This is part of an ongoing investigation. This paper should be considered as an introduction of a scar-ridge graph model and its visualisation. We explained that we are currently working on two methods derived from Pastoors et al. (2015) of determining the temporal relation between neighboring scars (352 - 364).

---

* It would be good if the result discussion spends some more time on how the work will proceed and which gaps are still apparent. In particular in light of the chaine operatorie, aspects such as shape of the area, ridge patterns etc. are relevant for sequencing the operations. This will impact on the graph model and will allow for wider discussion on different OS. This is a major contribution of the paper / approach presented and should therefore not be omitted. The conclusion should therefore discuss which difficulties arise with the current interpretation of the OS from the graph model, which aspects still need to be considered and how this could be approached. This does not have to be a long text, but be sufficient to guide future research and uptake of the approach.

- We addressed this point in the lines 327 - 337 and 352 - 364.

Download tracked changes file

Decision by Sebastian Hageneuer, posted 19 October 2023, validated 19 October 2023

Minor revisions based on the comments of the reviewers

The paper ”Linking Scars: Topology-based Scar Detection and Graph Modeling of Paleolithic Artifacts in 3D” is a well-written and a highly intersting paper on the ”lost voice of three-dimensionality” in documenting paleolithic artefacts. Although the paper in general is of great quality, some minor clarifications and corrections mentioned by the reviewers should be implemented.

I hereby ask the authors to take the constructive criticism of the two reviewers and implement it in their paper. I also ask the authors to provide a documentation of the changes made to the paper and upload it here on PCI Archaeology as a response.

We are looking forward to your updated version!

Reviewed by anonymous reviewer 1, 27 September 2023

The paper presents a scar segmentation approach for stone tools.
The authors use many abbreviations that make the reading of the paper complex. Avoid the abbreviations as much as possible and introduce them after the first time they appear in the paper.
The ”Scar Segmentation using Morse Theory”section is unclear to me. For example, the authors say, ”There is a topologically consistent method of simplifying the skeleton using persistence, a measure of the importance of critical points”, but I do not understand what this measure of persistence is. Then, in the section, explaining all the processing steps with figures is better to highlight their contributions better.
Then, I need clarification about the contribution of the graph-based representation of the scar-ridge patterns. What is its final purpose?
In the references, the following paper is missing:
- Visualization and Extraction of Carvings for Heritage Conservation, DOI 10.1109/TVCG.2016.2598603

Reviewed by Lutz Schubert, 03 October 2023

Overall, the paper is very well elaborated and scientifically sound. There are some explanatory gaps though which may be worth addressing:

* The ”ground truth” is not basing on an objective measurement - this is not the fault of the author, but simply how the chaine operatoire is reconstructed. However, this means that there is more than one interpretation of the ”correct” order that affects the interpretation of the accuracy of the method. The author uses his own ground truth for comparison, which is ok, but the implication should be discussed in the methodology and discussion of the results

* The paper is introduced as talking about the operation sequence / chaine operatoire, but this context is frequently lost. In particular the graph model analysis is not put into this context sufficiently, though the impact and relevance for it is immediately clear. It would be good to spend a paragraph or two on introducing the relevance of the graph model for OS analysis and to take that up in the results discussion (see also below).

* Along similar lines, the impact of shape on the graph model is not sufficently discussed. A quick introduction to how the operational sequence impacts on the graph direction and which parameters could be used to affect the graph accordingly. For example, how shapes of ridges would affect the direction in the neighbourhood graph. This does not have to be complete, since it is work in progress and early in the research, but it should make clear that these aspects have to be considered in the long run. The authors builds up on his own assumptions, which is perfectly fine, but these should be clear to the reader.

* It would be good if the result discussion spends some more time on how the work will proceed and which gaps are still apparent. In particular in light of the chaine operatorie, aspects such as shape of the area, ridge patterns etc. are relevant for sequencing the operations. This will impact on the graph model and will allow for

wider discussion on different OS. This is a major contribution of the paper / approach presented and should therefore not be omitted. The conclusion should therefore discuss which difficulties arise with the current interpretation of the OS from the graph model, which aspects still need to be considered and how this could be approached. This does not have to be a long text, but be sufficient to guide future research and uptake of the approach.

Again, this should be just minor additions and explanations, not a major change in the text.