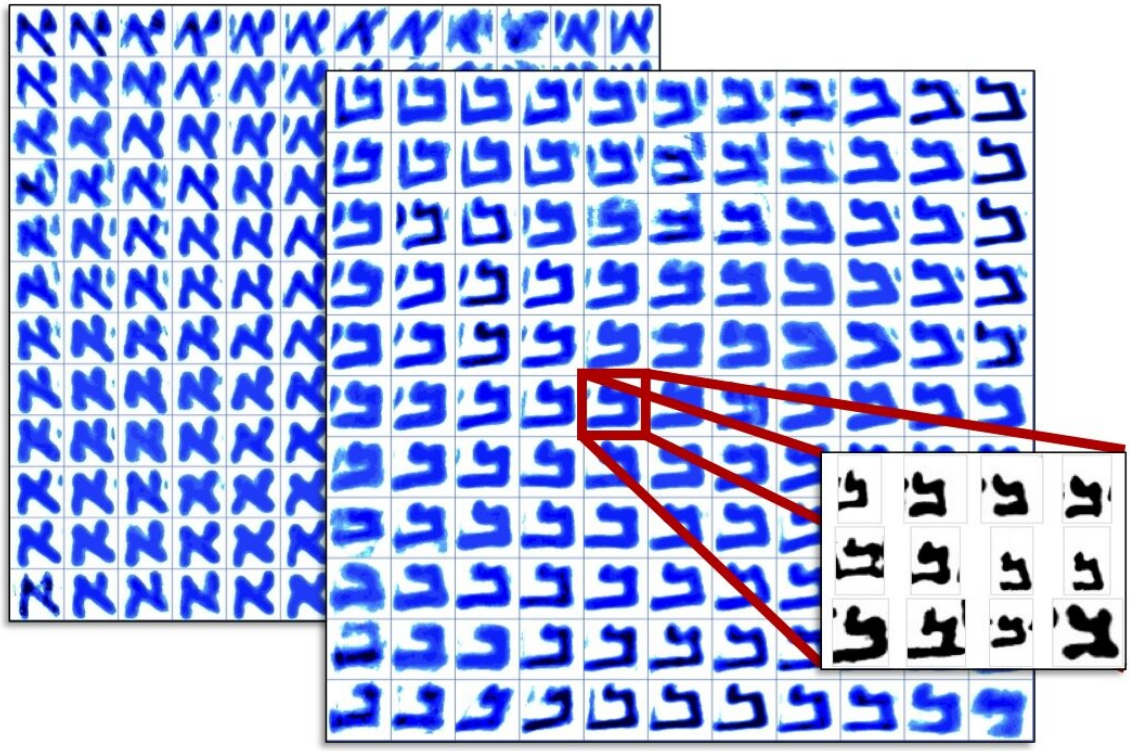
Cracking the code of the Dead Sea Scrolls

April 21 2021



Two 12x12 Kohonen maps (blue colourmaps) of full character aleph and bet from the Dead Sea Scroll collection. Each of the characters in the Kohonen maps is formed from multiple instances of similar characters (shown with a zoomed box with red lines). These maps are useful for chronological style development analysis. In the current study of writer identification, Fraglets (fragmented character shapes) were used instead of full character shapes to achieve more precise (robust) results. Credit: Maruf A. Dhali, University of Groningen

The Dead Sea Scrolls, discovered some 70 years ago, are famous for containing the oldest manuscripts of the Hebrew Bible (Old Testament) and many hitherto unknown ancient Jewish texts. But the individual people behind the scrolls have eluded scientists, because the scribes are anonymous. Now, by combining the sciences and the humanities, University of Groningen researchers have cracked the code, which enables them to discover the scribes behind the scrolls. They presented their results in the journal *PLOS ONE* on 21 April.

The scribes who created the scrolls did not sign their work. Scholars suggested some manuscripts should be attributed to a single scribe based on handwriting. "They would try to find a 'smoking gun' in the handwriting, for example, a very specific trait in a letter which would identify a scribe," explains Mladen Popović, professor of Hebrew Bible and Ancient Judaism at the Faculty of Theology and Religious Studies at the University of Groningen. He is also director of the university's Qumran Institute, dedicated to studying the Dead Sea Scrolls. However, these identifications are somewhat subjective and often hotly debated.

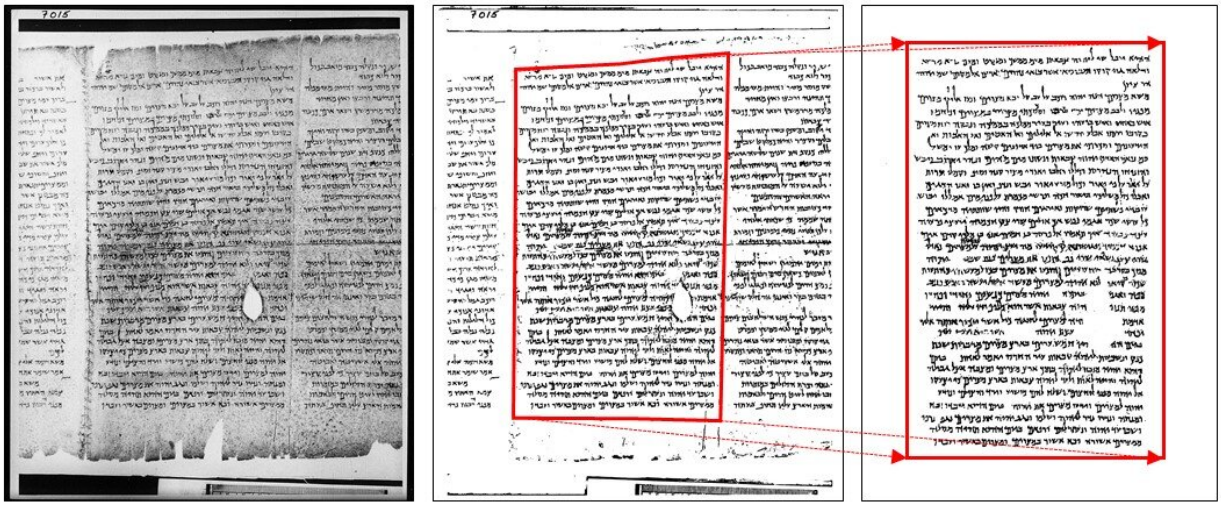
Scribes

Popović, in his project "The Hands that Wrote the Bible," teamed up with his colleague Lambert Schomaker, professor of Computer Science and Artificial Intelligence at the Faculty of Science and Engineering. Schomaker has long worked on techniques to allow computers to read handwriting, often from historical materials. He also performed studies to investigate how biomechanical traits, like the way in which someone holds a pen or stylus, would affect handwriting.

In this study, together with Ph.D. candidate Maruf Dhali, they focused on one scroll in particular: the famous Great Isaiah Scroll (1QIsa^{a}) from Qumran Cave 1. The handwriting in this scroll seems near-uniform, yet it has been suggested it was made by two scribes sharing a similar

writing style. So how could this be decided?

Schomaker says, "This scroll contains the letter aleph, or "A," at least 5,000 times. It is impossible to compare them all just by eye." Computers are well suited to analyze large datasets, like 5,000 handwritten A's. Digital imaging makes all sorts of computer calculations possible, at the microlevel of characters, such as measuring curvature (called textural), as well as whole characters (called allographic).



(from left to right) Greyscale image of column 15 of the Great Isaiah Scroll, the corresponding binarized image using BiNet, and the cleaned-corrected image. From the red boxes of the last two images, one can see how the rotation and the geometric transformation is corrected to yield a better image for further processing. Credit: Reprinted from Lim TH, Alexander PS. Volume 1. In: The Dead Sea Scrolls Electronic Library. Brill; 1995 under a CC BY license, with permission from Brill Publishers, original copyright 1995.

Neural network

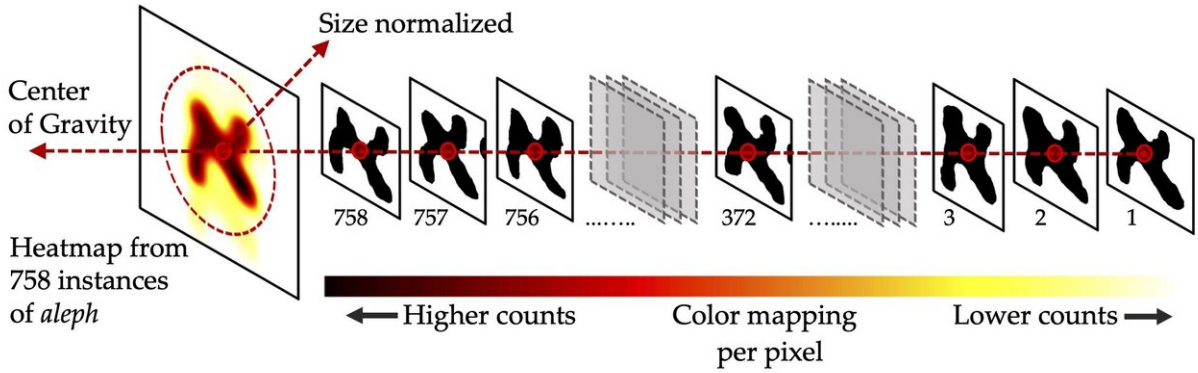
"The human eye is amazing and presumably takes these levels into account too. This allows experts to see the hands of different authors, but that decision is often not reached by a transparent process," Popović says. "Furthermore, it is virtually impossible for these experts to process the large amounts of data the scrolls provide." That is why their results are often not conclusive.

The first hurdle was to train an algorithm to separate the text (ink) from its background (the leather or the papyrus). For this separation, or "binarization," Dhali developed a state-of-the-art artificial neural network that can be trained using deep learning. This neural network keeps the original ink traces made by the scribe more than 2,000 years ago intact as they appear on the digital images. "This is important because the ancient ink traces relate directly to a person's muscle movement and are person-specific," Schomaker explains.

Similarities

Dhali performed the first analytical test of this study. His analysis of textural and allographic features showed that the 54 columns of text in the Great Isaiah Scroll fell into two different groups that were not distributed randomly through the scroll, but were clustered, with a transition around the halfway mark.

With the observation that there might be more than one writer, Dhali then handed the data to Schomaker, who then recomputed the similarities between the columns, now using the patterns of letter fragments. This second analytical step confirmed the presence of two different. Several further checks and controls were performed. Schomaker: "When we added extra noise to the data, the result didn't change. We also succeeded in demonstrating that the second scribe shows more variation within his writing than the first, although their writing is very similar."



An illustration of how heatmaps of normalized average character shapes are generated for individual letters (in this example: aleph). Credit: Maruf A. Dhali, University of Groningen

Handwriting

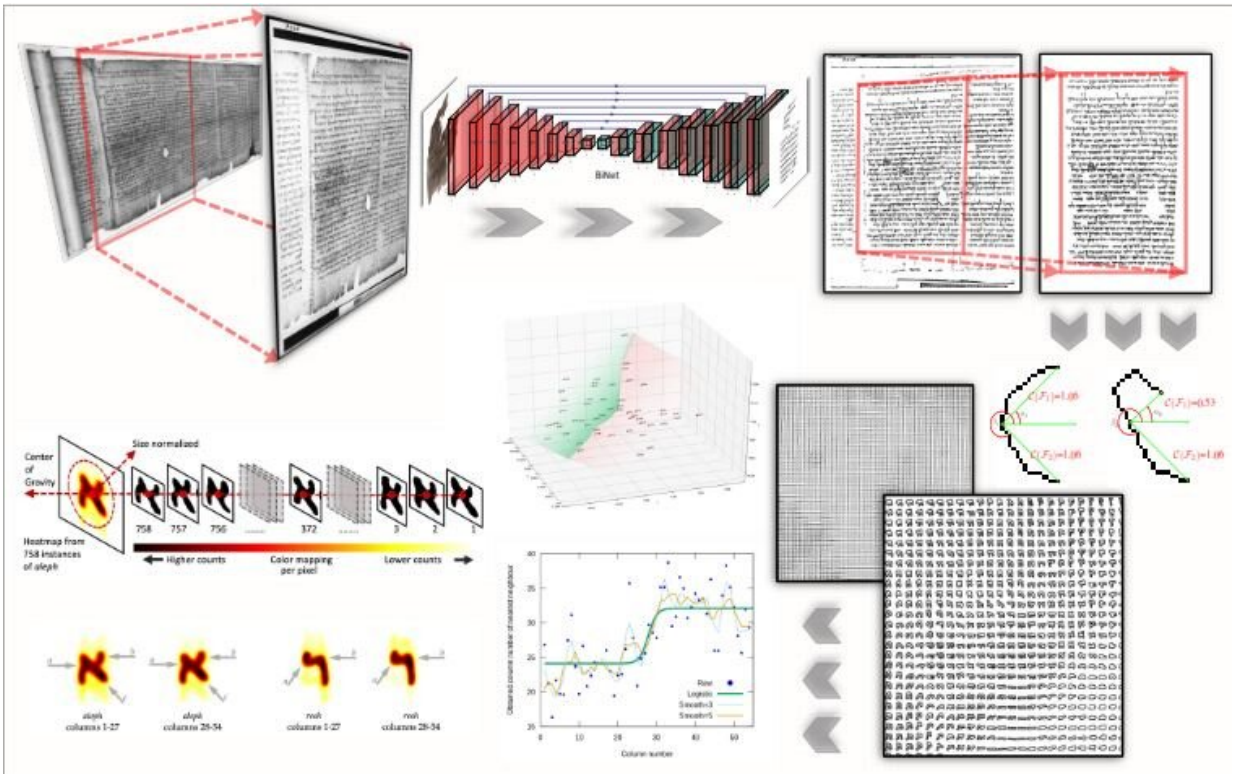
In the third step, Popović, Dhali, and Schomaker have produced a visual analysis. They created heat maps that incorporate all the variants of a character across the scroll. Then they produced an averaged version of this character for the first 27 columns and the last 27 columns. Comparing these two average letters by eye shows that they are different. This links the computerized and statistical analysis to human interpretation of the data by approximation, because the heatmaps are neither dependent nor produced from the primary and secondary analyses.

Certain aspects of the scroll and the positioning of the text had led some scholars to suggest that after column 27 a new scribe had started, but this was not generally accepted. Popović: "Now, we can confirm this with a quantitative analysis of the handwriting as well as with robust statistical analyses. Instead of basing judgment on more-or-less impressionistic

evidence, with the intelligent assistance of the computer, we can demonstrate that the separation is statistically significant."

In addition to transforming the palaeography of the scrolls—and potentially other ancient manuscript corpora—this study of the Great Isaiah Scroll opens up a totally new way to analyze the Qumran texts based on physical characteristics. Now, researchers can access the microlevel of individual scribes and carefully observe how they worked on these manuscripts.

Popović: "This is very exciting, because this opens a new window on the ancient world that can reveal much more intricate connections between the scribes that produced the scrolls. In this study, we found evidence for a very similar writing style shared by the two Great Isaiah Scroll scribes, which suggests a common training or origin. Our next step is to investigate other scrolls, where we may find different origins or training for the scribes."



Dead sea scroll text analysis collage. Credit: Mladen Popovic

In this way, it will be possible to learn more about the communities that produced the Dead Sea Scrolls. "We are now able to identify different scribes," Popović concludes. "We will never know their names. But after seventy years of study, this feels as if we can finally shake hands with them through their handwriting."

More information: Artificial intelligence based writer identification generates new evidence for the unknown scribes of the Dead Sea Scrolls exemplified by the Great Isaiah Scroll (1QIsaa), *PLOS ONE* (2021). journals.plos.org/plosone/arti … journal.pone.0249769

Provided by University of Groningen

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