(Re)imag(in)ing the Past

Physical, Digital, and (Con)textual Analysis of Historical Manuscripts

International Symposium
4-6 December 2024, Gjøvik, Norway

Book of Abstracts

Organizers:
Hilda Deborah, Norwegian University of Science and Technology
Irina M. Ciortan, Norwegian University of Science and Technology
Matthew P. Monger, MF Norwegian School of Theology, Religion and Society
Sony George, Norwegian University of Science and Technology
Jon Y. Hardeberg, Norwegian University of Science and Technology

NTNU

Program

Wednesday, 4 December 2024

	12:00 – 13:00	Lunch
	13:00 – 13:30	Opening
Moderator: Irina M. Ciortan	13:30 – 14:30	Keynote Talk 1: **Keith Knox** *Recovering lost content in ancient manuscripts with multi-spectral and x-ray fluorescence imaging*
	14:30 – 15:00	Coffee break
	15:00 – 17:00	Paper session 1
		Hend Mahgoub, Patrick Layton, *et al.*, *Non-destructive dating of historical archival materials with infrared spectroscopy.* **Roxanne Radpour, Marcie Wiggins, et al.**, *Material insights and artist working methods from multi-modal imaging spectroscopy studies of Visconti-Sforza* tarocchi *playing cards.*
		15 minutes break
		Ottar A. B. Anderson, *New developments in the technical metadata framework for cultural heritage imaging*. **Eric Joakim**, *Automated multispectral imaging in multiband and narrow band and statistical analysis in one system to reveal the invisible*."
	19:00 – end	Dinner

Thursday, 5 December 2024

Moderator: Matthew P. Monger	09:30 – 10:30	Keynote Talk 2: **Hilda Deborah** *Chasing wild goats: Challenges, values, and opportunities of interdisciplinary work*
	10:30 – 11:00	Coffee break
	11:00 – 12:15	Paper session 2
		Jitka Neoralová, Andrei Kazanskii, and Petra Vávrová, *History and present of multispectral imaging in the National Library of the Czech Republic*. **Þorgeir Sigurðsson**, *Lying pens of Iceland — (Re)-imag(in)ing a pre-saga literary genre.* **Ludvik Kjeldsberg**, *From Scrolls to Screens: Crafting Online Open-Access Databases of Dead Sea Scrolls and their Reception*.
	12:15 – 13:30	Lunch

continued to the next page

Moderator: Hilda Deborah	13:30 – 14:30	Keynote Talk 3: **Maruf Dhali** *Artificial intelligence in historical manuscript analysis*
	14:30 – 15:00	Coffee break
	15:00 – 16:15	Paper session 3
		Muhammad A. Khawaja, Sony George, et al., *Reimagining manuscript analysis: Virtual RTI and algorithmic post-processing on ancient Egyptian inscriptions.* **Tabita L. Tobing and Patrick Bours**, *Building blocks approach to character-level writer authentication system of ancient manuscripts.* **Valentina Risdonne, Rachel Boyd, and Lucia Burgio**, *Non-invasive analytical study of a V&A Madonna and Child drawing.*

Friday, 6 December 2024

Moderator: Ludvik A. Kjeldsberg	09:00 – 10:00	Keynote Talk 4: **Hugo Lundhaug** *Manuscripts and literary imagination: Material philology, digital humanities, and the biblical storyworld in Coptic*
	10:00 – 10:30	Coffee break
	10:30 – 11:20	Paper session
		Estelle Guéville, *Manuscript collections and inclusivity: Making premodern female scribes' production accessible*. **Matthew P. Monger**, *(re-)Imagining a corpus of scrolls. The Dead Sea Scrolls physical and scribal features database.*
	11:20 – 12:10	Keynote Talk 5: **Årstein Justnes** *Ten Years with the Lying Pen of Scribes: What Did We Learn?*
	12:10 – end	Lunch

Keynote speakers

Årstein Justnes
University of Agder, Norway

Ten years with the Lying Pen of Scribes: What did we learn?

Hilda Deborah
Norwegian University of Science and Technology, Norway

Chasing wild goats: Challenges, values, and opportunities of interdisciplinary work

Maruf Dhali
University of Groningen, The Netherlands

Artificial intelligence in historical manuscript analysis

Hugo Lundhaug
University of Oslo, Norway

Manuscripts and literary imagination: Material philology, digital humanities, and the biblical storyworld in Coptic

Keith Knox
Early Manuscript Electronic Library (EMEL)

Recovering lost content in ancient manuscripts with multi-spectral and x-ray fluorescence imaging

List of submitted abstracts

(in the alphabetical order of first author's lastname)

Ottar A. B. Anderson, Intermunicipal Archives of Møre og Romsdal (IKAMR), Norway
New developments in the technical metadata framework for cultural heritage imaging

Estelle Guéville, Yale University, USA
Manuscript collections and inclusivity: Making premodern female scribes' production accessible

Eric Joakim, PhaseOne, Denmark
Automated multispectral imaging in multiband & narrow band and statistical analysis in one system to reveal the invisible

Ludvik A. Kjeldsberg, University of Agder, Norway
From Scrolls to Screens: Crafting Online Open-Access Databases of Dead Sea Scrolls and their Reception

Muhammad A. Khawaja, Université de Bourgogne, France; Norwegian University of Science and Technology (NTNU), Norway,
Sony George, Norwegian University of Science and Technology, Norway,
Franck Marzani, Université de Bourgogne, France,
Jon Y. Hardeberg, Norwegian University of Science and Technology, Norway, and
Alamin Mansouri, Université de Bourgogne, France
Reimagining manuscript analysis: Virtual RTI and algorithmic post-processing on ancient Egyptian inscriptions

Hend Mahgoub, University of Ljubljana, Slovenia,
Patrick Layton, Academy of Fine Arts, Austria,
Sonja Svoljsak, National and University of Library of Slovenia, Slovenia,
Jasna Malešič, National and University of Library of Slovenia, Slovenia,
Nataša Golob, University of Ljubljana, Slovenia,
Johannes Tintner-Olifiers, Academy of Fine Arts, Austria, and
Matija Strlič, University of Ljubljana, Slovenia
Non-destructive dating of historical archival materials with infrared spectroscopy

Matthew P. Monger, MF Norwegian School of Theology, Religion and Society
(re-)Imagining a corpus of scrolls. The Dead Sea Scrolls physical and scribal features database.

Jitka Neoralová, Andrei Kazanskii, and Petra Vávrová, National Library of the Czech Republic
History and present of multispectral imaging in the National Library of the Czech Republic

Roxanne Radpour, University of Delaware, USA; National Gallery of Art, USA
Marcie Wiggins, Yale University, USA
Anikó Bezur, Yale University, USA
Richard Hark, Yale University, USA
Marie-France Lemay, Yale University Library, USA
John K. Delaney, National Gallery of Art, USA
Material insights and artist working methods from multi-modal imaging spectroscopy studies of Visconti-Sforza *tarocchi* playing cards

Valentina Risdonne, Rachel Boyd, and Lucia Burgio, Victoria and Albert Museum, UK
Non-invasive analytical study of a V&A Madonna and Child drawing

Þorgeir Sigurðsson, Reykavíkur Akademían, Iceland
Lying Pens of Iceland — (Re)-imag(in)ing a pre-saga literary genre

Tabita L. Tobing and Patrick Bours, Norwegian University of Science and Technology, Norway
Building blocks approach to character-level writer authentication system of ancient manuscripts

Keynote Abstracts

KEYNOTE

Ten years with the Lying Pen of Scribes: What did we learn?

Årstein Justnes
University of Agder, Norway

Årstein Justnes is Professor of Biblical Studies at the University of Agder and project manager for the research project Lying Pen of Scribes: Manuscript Forgeries, Digital Imaging, and Critical Provenance Research (2019–2024), funded by the Research Council of Norway. Justnes specializes in the Dead Sea Scrolls. His most recent work focuses on manuscript forgeries and provenance research.

Abstract

This paper offers a playful reflection on nearly a decade of the Lying Pen project, exploring what worked, what didn't, and the surprising lessons we stumbled upon along the way. Blending nostalgia with a touch of pessimism, I'll try to navigate the project's twists and turns, share a few tales from the trenches, and confront the inevitable question: What's next?

KEYNOTE

Artificial intelligence in historical manuscript analysis

Maruf Dhali
University of Groningen, The Netherlands

Maruf Dhali is currently Assistant Professor in Artificial Intelligence at Bernoulli Institute. He received his M.Sc. degree (with distinction) in Computer Vision and Robotics from Heriot-Watt University, Edinburgh, in 2015. He joined the University of Groningen in 2016 as a PhD researcher in the multidisciplinary ERC project on analyzing the Dead Sea Scrolls. In 2021, he joined the Department of AI as a Lecturer. His research interests include computer vision, machine learning, and artificial intelligence. He appeared in numerous news outlets for his works, including BBC News, ABC Australia, Independent, and Live Science.

Abstract

The lecture will present the potential of artificial intelligence (AI) in analyzing ancient historical manuscripts, focusing on images of the Dead Sea Scrolls (DSS). The study employs several computer vision, pattern recognition, and machine learning techniques to address writer identification and dating challenges. An initial study highlights the successful application of character shape features, achieving high accuracy in identifying multiple authors within the DSS collection.

After recognizing the crucial role of binarization (extracting ink traces from the background materials) for accurate writer identification, the talk will introduce BiNet, an artificial deep neural network. BiNet utilizes multispectral images and outperforms traditional models in binarizing highly degraded ancient manuscripts, facilitating improved calculation of textural and allographic features. Building upon the success of BiNet, the study identifies multiple authors for the Great Isaiah Scroll, one of the longest scrolls in the DSS collection. The quantitative findings propose a hypothesis contrary to established assumptions about the scroll's authorship.

With the success of writer identification, the work employs support vector regression and a self-organizing time map for broader time period classification. Enoch, a Bayesian regression-based model for date prediction, integrates AI with radiocarbon dating, presenting a pioneering technique for estimating manuscript dates.

The interdisciplinary fusion of AI with historical research enhances our understanding of writers' identities, the dating of ancient manuscripts, and the contextualization of historical narratives. The work advances methodologies for analyzing ancient manuscripts, contributing to improved interpretations of the past and laying the foundation for further interdisciplinary exploration in historical document analysis.

KEYNOTE

Recovering lost content in ancient manuscripts with multi-spectral and x-ray fluorescence imaging

Keith Knox
Early Manuscripts Electronic Library, USA

Keith Knox is the Chief Science Advisor for EMEL, the Early Manuscripts Electronic Library. Keith is an imaging scientist who has developed image processing algorithms to recover erased writings from palimpsests. These methods are freely available in an imaging processing software package (Hoku) that scholars can use to enhance faint writing in multi-spectral image data.

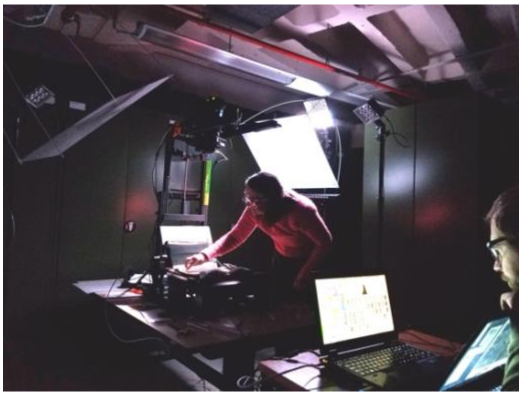
Abstract

The author has worked in the field of recovering erased text on palimpsests since the 1990s, starting with recovering obscured text on colour photographs of the Temple Scroll, one of the Dead Sea Scrolls. At the beginning of the 2000s, he worked with Roger Easton Jr. and William Christens-Barry to build a multispectral system to image the Archimedes Palimpsest. Now, the author is part of a team from EMEL that has imaged manuscripts from several libraries across Europe. EMEL uses the MegaVision spectral imaging system to capture multi-spectral images.

Since the 1990s, the author has been developing custom software to process the multi-spectral images to recover erased text. Starting in 2015, the author wrote a Java-based version of the software package (Hoku) and made it available for anyone to use to analyse their own multi-spectral data, no matter on what imaging system the data was gathered. Hoku runs on macOS, Windows, and Linux. Hoku is available at http://www.cis.rit.edu/~ktkpci/Hoku.html.

There are three steps involved in recovering erased text from a manuscript. One needs to capture the image data, extract the low contrast information, then enhance it to make the erased text visible to the eye. Each step is important. The imaging hardware needs to be able to capture the textual information. If the information is not captured, then it cannot be extracted. The software tools, used to extract the text, must be capable of finding the low-contrast text and separating it from the rest of the high-contrast noise. Lastly, to recover the erased text, it must be made visible to the eye. All three steps are needed to successfully recover the erased text.

<u>Multi-Spectral Imaging</u>

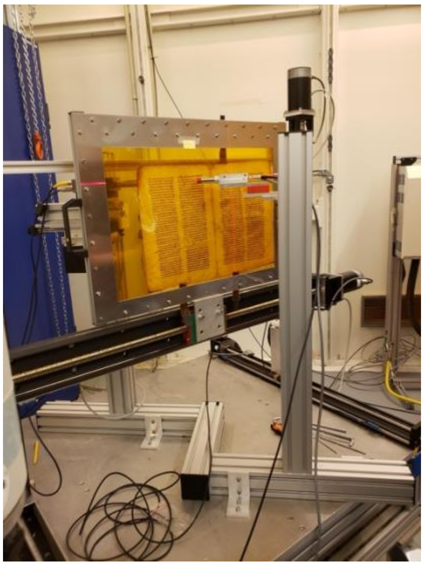


A multi-spectral imaging system is shown on the right. Two panels of LEDs, shining through diffusers, are pointed at the manuscript on the table. The camera sits directly above the table. Under computer control, individual LEDs of different wavelengths are turned on and a picture is taken. Only one wavelength (or colour) of light is turned on at any one time. If the camera and the manuscript do not move during this process, all of the individual images are in complete registration. Each pixel in the images therefore records the spectrum at its location on the manuscript.

The parchment, the ink, and the stains of the erased text, left behind behind after erasure, all respond differently to different wavelengths of light. The range of wavelengths varies from the ultraviolet, through visible light, and into the near infrared. While parchment fluoresces under ultraviolet illumination, the stains of the erased characters inhibit the fluorescence of the parchment underneath them. This contrast makes the erased characters darker against the parchment background, therefore more visible. Sometimes, the response to ultraviolet light is sufficient to reveal the erased text directly. Most of the time, it takes significant processing of all of the images together to recover the text. Processing of the multi-spectral images usually occurs after the imaging session, and may take some time to accomplish.

Besides the illumination from the LED panels above, the system also illuminates from below. A thin light sheet is placed underneath the leaf, which illuminates the leaf from below in four wavelengths, three infrared and one red. This light travels through the parchment and is captured by the camera above the leaf. This transmitted light can reveal regions where the ink of the erased text has eroded the parchment. This erosion takes place only where the ink was, leaving cavities in the parchment that are in the shape of the erased characters. Since the parchment is thinner where the cavities are located, more transmitted light can get through these cavities making those regions brighter. As a result, the eroded characters show up in transmission as characters that are brighter than the parchment. Without this transmitted illumination, these eroded characters would not be visible, since the erosion has removed the stains in the parchment that would reveal the erased characters under ultraviolet illumination.

X-ray Fluorescence Imaging



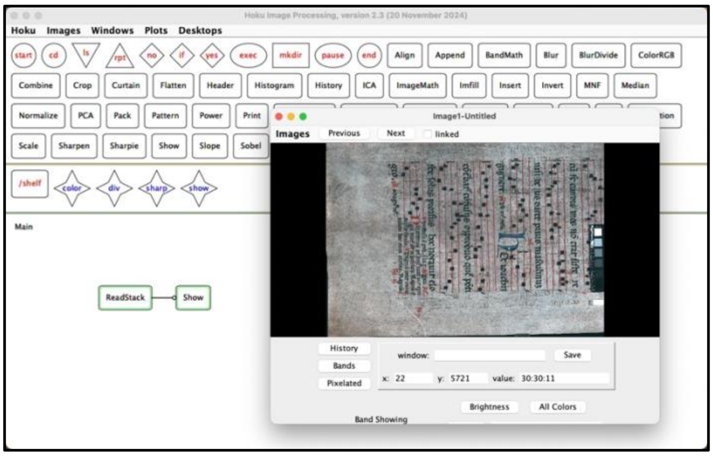
X-ray fluorescence occurs when metallic materials, such as iron, copper, or calcium, are illuminated with a high-energy X-ray beam. The material will absorb the X-rays, then re-emit other X-rays at lower energies. Each material emits X-rays of different, and very specific, energies. By recording which energies of X-ray are emitted, metallic materials in the manuscript can be detected. Since metallic materials are often used to make iron-gall inks, the X-ray images can reveal text that is not visible with multi-spectral imaging.

The figure on the right shows a manuscript folio suspended in a movable carriage that scans the leaf in front of an X-ray beam. There are two X-ray detectors, one in the front and the other in the back. The detectors point at the spot on the leaf where the X-ray beam is falling.

This experiment was done at DESY, the Deutsches Elektronen-Synchrotron in Hamburg, Germany. The advantage of imaging at a synchrotron is that the synchrotron produces very pure (single energy) X-rays. This purity of the X-ray beam improves the ability to detect different materials in the manuscript.

Imaging of a manuscript can also be done with a laboratory version of an X-ray fluorescence imaging system. This smaller X-ray source, however, does not produce as pure an X-ray beam. The result is increased noise in the detected X-ray emissions, making the detections of the metallic materials in the manuscript more difficult. Although less sensitive, a laboratory X-ray fluorescence imaging system can be useful in an initial assessment of whether it would be feasible to use X-ray fluorescence to recover erased text on a particular manuscript.

Image Processing



Whether your data is multi-spectral or X-ray fluorescence data, you will need to process the captured data to recover the erased text. Hoku is a software package that was written to accomplish this task.

In the figure on the right is the GUI for the Hoku Image Processing software. Processing jobs are created by dragging down individual modules and linking them together. Jobs can be executed right away or saved and executed later. The interface is simple enough that a non-technical person can use the software. In fact, over the last few years, the author has taught several workshops in which many scholars have learned how to process their own multi-spectral data.

There are several processing modules available for use. They range from sophisticated modules, such as Principal Components Analysis and Independent Components Analysis, to standard enhancement routines, used to adjust contrast, sharpness, or background levels. By varying the order in which separate modules link together, one can alter the appearance of the output image to improve the visibility of the erased text.

Hoku can create individual processing tasks, which are done only once, or create tasks which are applied to a whole series of images. The latter is done by constructing a flowchart, using the modules in red in the upper left corner of the GUI. With a flowchart, one can loop over directories within directories, applying the same task to every image directory within the loop. The processed results can then be written out to arbitrary locations to keep the results separate.

Hoku is not associated with any particular spectral imaging system. The software can process multi-spectral images from any imaging system. To date, Hoku has been used to recover text from several imaging systems, such as MegaVision, Phase One, Lumiere Technology, and Misha. Besides multi-spectral data, Hoku can process the image data taken with X-ray fluorescence imaging systems. In fact, Hoku is versatile enough to be used to manipulate screen shots from a computer, or even your family photos. Hoku is available for public use, free of charge.

References

[1] Knox, Keith T. (2008): Enhancement of overwritten text in the Archimedes Palimpsest, in *Proceedings of SPIE: Computer Image Analysis in the Study of Art* 6810, 32–42.

[2] Bergmann, Uwe, and Keith T. Knox (2009): Pseudo-color enhanced x-ray fluorescence imaging of the Archimedes Palimpsest, in *Document Recognition and Retrieval XVI*. Vol. 7247, p. 7247-02.

[3] Houghton, Hugh A.G. & Parker, David C. (eds.) (2020): *Codex Zacynthius: Catena, Palimpsest, Lectionary*. Piscataway, NJ: Gorgias Press (Texts and Studies [Third Series] 21).

[4] Knox, K. T. (2022): Hoku—A Multispectral Software Tool to Recover Erased Writing on Palimpsests. *The Vatican Library Review*, *1*(2), 205-214.

Submitted Abstracts

New developments in the technical metadata framework for cultural heritage imaging

Ottar A. B. Anderson
Intermunicipal Archives of Møre og Romsdal (IKAMR), Norway

Abstract

The International Council on Archives (ICA) code of ethics states: *"Archivists should protect the authenticity of documentation during archival processing, preserving and use"*. A robust and up to date technical metadata framework can be one of the key components for detecting trustworthy, and tracking authenticity and provenance in all kinds of digital media content. The Content Authenticity Initiative (CAI) and the Coalition for Content Provenance and Authenticity (C2PA) are providing one key component for such a technical metadata framework. CAI/C2PA brings the open industry standard for provenance metadata, also known as Content Credentials, an open-source tool to address the prevalence of misleading information and to identify altered media content. Will this relative new initiative be the entrance for the cultural heritage community, also referred to as GLAM (Galleries, Libraries, Archives and Museums) community, to a new era in trustworthy and authenticity for their digital collections?

Challenge. So, is the digital content the same at the physical content, 1:1? In the meaning, that the collections, if not digital born, has undertaken a transformation from its physical original form to its digital form. What about the process, how is the process outcome results of this transformation monitored? Did we lose something on the way? And how about the description of the physical nature of the original content? This is equal as important in the matter of provenance and authenticity, right? We are transforming physical content and separating its nature and original form totally.

Approach. In 2017 the ISO 19264-1 standard was published, this standard describes the method of analysing imaging systems quality in cultural heritage imaging of reflective originals. The method describes analyses of multiple imaging systems quality characteristics, from a single image of a specified test target. The specification states which characteristics are measured, how they are measured, and how the results of the analysis need to be presented. By using the standard, we can determine and know how the transformation outcome results are, and how the imaging systems performance stability is. By embedding this process based technical metadata from imaging quality analyses, the to the digital collection file itself, we ensure that the information can be used as another key component in the new technical metadata framework. A proof of concept on this approach, was conducted in the independent quality control management project of the Digital Archives platform for The National Archives of Norway in 2022. By using The International Press Telecommunications Councils (IPTC) Photo Metadata Standard, we can provide several material specific metadata fields to bring information regarding the physical description, the provenance, and the origin of the of the content. To secure or regulate if, or how the digital collections can be data mined, the data mining field is used.

Conclusion. We believe that by implementing the image quality process metadata, as a new feature in the IPTC Photo Metadata standard, in conjunction with the use of material specific metadata fields, the possibilities within CAI/C2PA will be much stronger as today. These technical metadata fields can be used as a new framework for fulfilling the entrance of a new era in trustworthy and authenticity for our digital collections. Bringing the respect of the origin and nature of our physical collections, and by this also fulfilling The International Council on Archives

(ICA) code of ethics: *"Archivists should protect the authenticity of documentation during archival processing, preserving and use".*

Figure 1. IPTC Photo Metadata Standard, **Digital Source Type**: Digitized from a print on non-transparent medium. **Data Mining**: Prohibited **Artwork or Object**, **Physical Description** (Free-text based field) Figure presenting Ørskog intermunicipal Chairmanship protocol 1858-1881, additional screen shots from Photo Mechanic software (build 7765) IPTC Metadata Template. Photo credit: Piotr Cabaj / IKAMR

References

[1] https://contentauthenticity.org/how-it-works
[2] https://c2pa.org/
[3] https://www.iso.org/obp/ui/en/#iso:std:iso:19264:-1:ed-1:v1:en
[4] https://ntnuopen.ntnu.no/ntnu-xmlui/handle/11250/3002862
[5] https://library.imaging.org/archiving/articles/20/1/16
[6] https://iptc.org/standards/photo-metadata/iptc-standard/

Manuscript Collections and Inclusivity:
Making Premodern Female Scribes' Production Accessible

Estelle Guéville
Yale University, USA

Abstract

The mass digitization of sources has significantly altered historical research practices. As Putnam [1] noted, this shift has "made transnational research easier, at the expense of familiarity with specific places." While online catalogues and digital surrogates have increased the availability of some data, they do not inherently ensure the accessibility of all data. The discoverability of dispersed manuscripts remains a question as many collections continue to be partially or entirely unknown, inaccessible due to both conscious and unconscious decisions made during cataloguing and digitization processes. Digitization projects and cataloguing practices often reflect what is deemed important, interesting to the public, or straightforward to digitize. These priorities are frequently aligned with the national European and North American collections established in the nineteenth century, which support traditional research fields such as literary studies and questions of authorship or provenance. As Thylstrup [2] argues, mass digitisation is a political act and it reproduces "established gendered and racialized infrastructures already present in both cultural institutions and the tech industry." Thus, such projects may overlook underrepresented or understudied collections and other methodological approaches. Fragments and non-European collections are usually more difficult to discover due to varying cataloguing standards and geographical disparities: European and North American institutions tend to be more advanced in cataloguing their collections, thus increasing existing inequalities in cultural access rather than diminishing them. These decisions shape the direction of research by providing some materials that are, comparatively, easier to access, while vast quantities of historical sources remain undiscoverable and inaccessible.

Despite these issues, there have been several initiatives to centralise manuscript data from multiple institutions, to be "able to search in all repositories everywhere at the same time."[3] The MASTER project, initiated in 1999, represented an early attempt to create interoperable union catalogues of European medieval manuscripts, which was followed by many others. The most recent and arguably the most advanced of these is Biblissima. It is important to emphasize that the success of these efforts has largely relied on the deliberate use of established standards and protocols, as the ability to query multiple databases simultaneously depends on the quality and interoperability of the metadata. But tensions about understudied production extend to the biases that exist in how collections are curated, catalogued, and made discoverable. Existing catalogue descriptions often fail to account for research areas such as gender or race, which means that cataloguing practices and digitization can influence what historians study, shaping how history is written.

The creation of new large-scale historical datasets from older catalogues has the potential to further marginalize understudied communities and culturally disadvantaged groups. For instance, medieval female literacy and production has been ignored by scholars and curators alike for a long time. Yet, we know that women wrote and copied manuscripts, and some of them were even depicted in illuminations (fig. 1). To transform the practice of history and ensure inclusivity, we must develop tools and platforms that are themselves inclusive. This is the objective of "Unknown Hands", a web-based platform currently being developed that aims to provide the most comprehensive open-source database about female scribes to date. Practically, "Unknown Hands" seeks to address the issues of accessibility and usability of the

data (or “capta”, the information actively “taken”[4]) regarding female scribes. It questions the ways in which we can design a database and platform to offer new ways of organizing, searching, and visualizing codicological, palaeographical, chronological, geographical and prosopographical data about the book production of medieval women up to 1600 while offering its dataset as an open-source resource, freely searchable and downloadable.

Manuscripts currently included in the dataset are dispersed across more than 160 institutions in 20 countries, leading to inconsistencies in how their metadata has been recorded in catalogues. On top of identifying this unfamiliar production, standardizing the fields, cleaning and curating the metadata on a case-by-case basis is one of the main objectives of this project. The goal is to (re)catalogue these overlooked materials with a focus on discoverability, accessibility, and reuse. By consolidating this dispersed and often difficult-to-access information into a publicly available and searchable digital repository, the project offers a new understanding of women’s literacy and scribal production and will serve as a valuable resource for researchers and scholars.

Figure 1. The copyist Guta de Schwarzenthann and the illuminator Sintram depicted on f.4r of Strasbourg, Bibliothèque du Grand Séminaire. Bibliothèque Virtuelle des Manuscrits Médiévaux (BVMM) – IRHT-CNRS.

References

[1] Putnam, Lara. ‘The Transnational and the Text-Searchable: Digitized Sources and the Shadows They Cast’. The American Historical Review 121, no. 2 (April 2016): 377–402.

[2] Thylstrup, Nanna Bonde. The Politics of Mass Digitization. The MIT Press, 2019.

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Automated Multispectral Imaging in Multiband & Narrowband and statistical analysis in one system to reveal the invisible

Eric Joakim
PhaseOne, Denmark

Abstract

The potential and relevance of electromagnetic radiation in non-invasive analyses is growing more and more. It will be presented Multispectral Imaging methods, including both Multiband and Narrowband, in one solution. The various wavebands and light-/filter combinations allow precise evaluation of image data to recreate readability in text and scenes and to provide spectral readout data for scientific analysis and research. We will present an automated and standardized modular workflow using high level colorimetry and high-resolution data delivery based on a 16-bit 151 MP medium format CMOS BSI (back side illuminated) sensor.

For Multiband imaging, we follow the calibration standards developed by a pan-European group of partner institutions led by the British Museum, CHARISMA. For Narrowband imaging, normalization is based on specific reflectance materials, showing nearly identical reflectance values through the whole range of imaged wavelengths from ca. 350nm to ca. 1100nm using a specialized Teflon target. This produces scientifically valuable results. In one modular and mobile solution, including hardware & software, image stacks can be created with perfect pixel alignment and image data can be used for calculation of statistical analysis, thus delivering both qualitative and quantitative data. The automated system is based on a predefined workflow that can be used by everyone, so even non-experts can produce perfect image stacks. The very important processes like refocusing in each wavelength, illumination homogeneity, filter-/light combination changes, exposure compensation and White Balance for each image as well as resizing and de-skewing for perfect pixel alignment are all handled automatically during capturing process. Imaging becomes more precise and repeatable in research, conservation and restoration processes in less time and without need of post processing on image calibration.

Covering all relevant parameters, the results, based on reflectance and photo-induced luminescence images, can be analyzed immediately after capture in the same software for statistical analysis like PCA (principal component analysis), ICA (independent component analysis) and K-Means Clustering. A spectral readout on 16 wavelength per pixel delivers accurate spectral information, useful for example distribution and/or identification of materials like inks, pigments, binders etc.

The system can cover an area up to A0, with a resolution at A0 of 300ppi (smaller sizes can be imaged at higher resolution). Results are available for analysis immediately after capture, covering documents, manuscripts, maps, books, paintings, artworks and 3D objects. With Multiband and Narrowband imaging, both qualitative and quantitative data are delivered, connecting image data delivery to scientific analysis and measurement. Once identified, the distribution of different materials on the surface of the object can be observed. Study cases will be presented to show the potential of technical features and its benefit to art historians, conservators, restorers, scientists and researchers - therefore to the complete interdisciplinary community.

We will demonstrate the delivered image stacks, ready for subsequent analysis, whether in the studio or on location, and their potential as scientifically valid data for research and investigation will be pointed out. We will be focus on results on documents and readability as well as on material research and material distribution in monochrome and polychrome objects.

The system has an optional inks and pigments reference chart that helps to get the system up and running as efficiently as possible and helps with the visual analysis of Multiband results. The potential of future development on a modular system will also be presented.

The system is a modular instrument that can also be used for mass digitization of visible images, making it extremely useful, due to this modularity, in museums, archives and libraries, institutes, and universities, delivering a greater return on investment when compared to standalone multispectral imaging systems. Colorimetry and color accurate images produced in the software from the eleven channels in the visible range will be shown, along with the potential to monitor changes in objects over time.

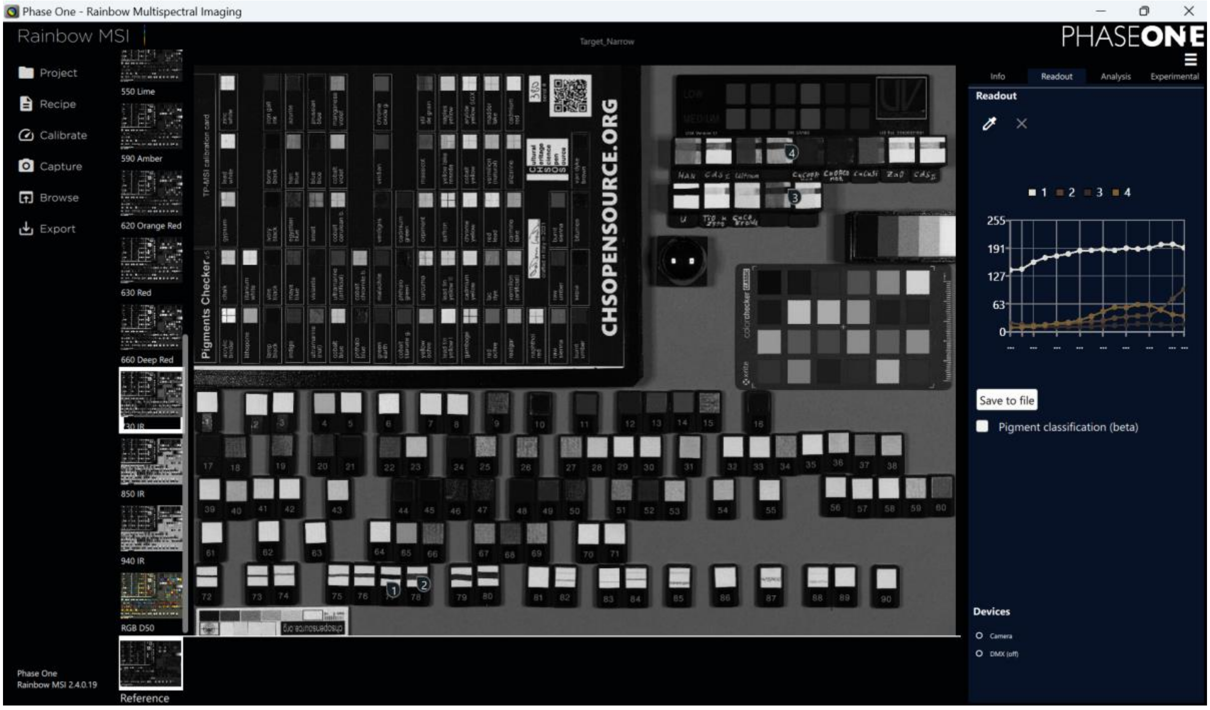

Figure 1. Phase One - Rainbow Multispectral Imaging.

Reimagining manuscript analysis: Virtual RTI and algorithmic post-processing on ancient Egyptian inscriptions

Muhammad Arsalan Khawaja[1,2], Sony George[2], Franck Marzani[1], Jon Yngve Hardeberg[2], and Alamin Mansouri[1]

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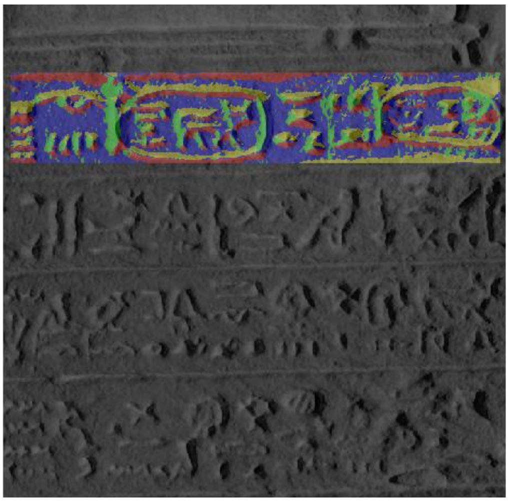
Abstract

Writing was first invented in southern Mesopotamia (modern-day Iraq) in the middle of the fourth millennium B.C [4]. These writings were inscribed first on clay and later stones [4]. However, understanding and analyzing these inscriptions is challenging because of the lack of understanding of ancient writing systems, accessibility, physical degradation, and missing pieces. We provide a framework to analyze these inscriptions using virtual Reflectance Transformation Imaging (RTI). RTI data can be used for analysis and as an important tool for understanding the inscriptions.

In this work, the 3D models were obtained from SketchFab [2] and virtual RTI was simulated using Blender software [1]. The first object is Commodus Stela (W946) which is also known as Sacred Cow Stela and the second object is Scribal palette (EC2018). The illumination variation data of RTI (27 light directions) was used to classify the surfaces according to their reflectance response using Self organizing map (SOM). SOMs are unsupervised neural networks used for dimensionality reduction and clustering tasks [3]. The normal map further gives us a better understanding of the inscriptions. Figure 1 shows some initial results son Commodus Stela and Scribal Palette.

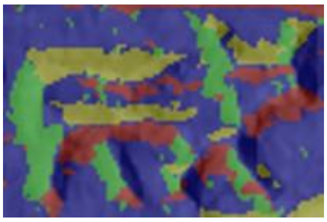
The framework we proposed offers several significant advantages. It allows for detailed analysis without requiring physical access to the artifacts, which is often a limitation. We aim to demonstrate the potential of RTI by developing post processing algorithms which can analyze the RTI data for better understanding of inscriptions.

3D models provide significantly complete spatial representation of the object. However, RTI is 2.5D focused on accurate surface visualization details. RTI provides the opportunity for detailed examination of surface details under varying illumination conditions which might not be feasible in static 3D model visualization. Therefore, it is more useful for researchers and archeologist for inspecting inscriptions without requiring computationally expensive 3D rendering systems.

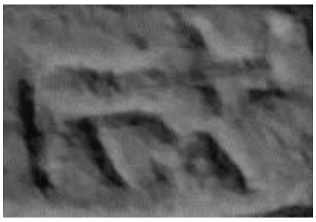


(a) SOM Classification of a ROI of Commodus Stela. The surface with similar reflectance profiles are clustered together.

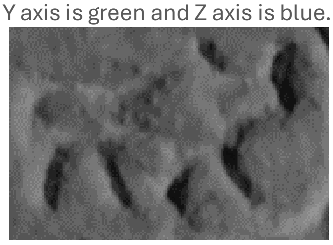
(b) Normal Map obtained using photometric stereo. The normal map shows where each normal vector points towards. X axis is red, Y axis is green and Z axis is blue.



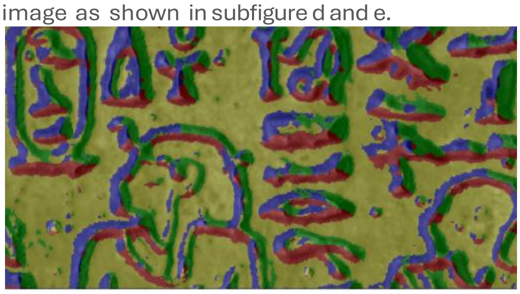
(c) Classification mask zoomed in from subfigure a to give better perspective of hieroglyphic alphabet than single light image as shown in subfigure d and e.



(d) Single light image 1



(e) Single light image 2



(f) Surface Classification of scribal palette using SOM. Similar reflectance responses are clustered together.

(g) Egyptian scribal palette Image from RTI dataset.

Figure 1. Analysis of ancient Egyptian inscriptions. (a), (b), (c), (d) and (e) shows Commodus Stela analysis and (f) and (g) show Scribal Palette analysis.

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From Scrolls to Screens: Crafting Online Open-Access Databases of Dead Sea Scrolls and their Reception

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Abstract

Since the announcement of their discovery in 1948,[1] the Dead Sea Scrolls have generated significant excitement and sparked controversy within both the academic community and popular culture. They have been enveloped in intrigue and mystery, sparking public interest and creating an impact that extends far beyond the academic world—thereby securing a lasting presence in our imagination. Many aspects of this modern reception history of the scrolls are, however, yet to be examined.[2]

To further enhance research on this aspect of the scrolls' history, equipping scholars with effective tools is essential. Databases are a crucial part of these tools.[3] Existing websites, such as the Leon Levy Dead Sea Scrolls Digital Library and Scripta Qumranica Electronica,[4] provide excellent tools for studying the physical features of the different manuscripts in the Dead Sea Scrolls collection. Particularly when they are complemented by bibliographical databases like the one from the Orion Center for the Study of the Dead Sea Scrolls.[5] However, databases focusing mainly on the scrolls' reception history are lacking. The Lying Pen of Scribes' Dead Sea Scrolls Lab project aims to change this.

I have, together with colleagues, created a database on the so-called Post-2002 Dead Sea Scrolls-like Fragments forgeries, and a database on the exhibitions of scrolls is underway. Both are built with an open-source Python framework entitled Streamlit.[6] The first-mentioned is also published in the Journal of Open Humanities Data.[7] These two databases both deal with the modern reception history of the scrolls, id est how the scrolls have been received, interpreted, and understood over time across different cultures, contexts, and communities.[8] Key features that enhance their utility for researchers include their accessibility, searchability, and interconnectivity. These elements are central to my discussion on the design and construction of these databases.

In general, digital databases play a crucial role in preserving historical manuscripts by ensuring their longevity (and safeguarding them against physical deterioration). For instance, the use of multispectral photographs allows for detailed examination without the need to physically handle the manuscripts.[9] However, these images can also present challenges, particularly concerning copyright issues. While copyright for these pictures can sometimes be purchased, it remains a complex and challenging endeavour. This is highly true for the scrolls, where access to high-quality photographs is controlled by a few institutions. Except for occasional links, pictures are excluded from both databases.

On the other side, excluding copyrighted items made it possible to make the database contents accessible to a global audience, overcoming the geographical barriers that may especially limit physical archives. Scholars, researchers, and the public can access the database resources from anywhere in the world, thus the knowledge is democratised, fostering greater collaboration, and innovation within the academic community.[10]

Both the database of post-2002 Dead Sea Scrolls-like fragments and the scrolls exhibitions incorporate advanced search functionalities, comprehensive metadata, and interlinked resources. Given a query, the un-biased advanced search functionalities significantly simplify the process of locating specific manuscripts, passages, or topics within extensive collections. It

allows users to narrow down their results by various criteria such as date, location, or collector/exhibitor. This feature provides a robust framework for scholars to engage with the materials in a more meaningful and organised manner.

Using Structured Query Language (SQL), it is possible to connect data within datasets to a variety of other digital resources and databases, thereby creating a vast and interconnected network of information. The Lying Pen of Scribes Dead Sea Scrolls Lab project gathers several databases under the same umbrella. Built with SQL, they enhance the ability to cross-reference data, enabling researchers to draw from a wider array of sources for more robust and comprehensive studies. The enhanced interconnectivity fosters a dynamic and collaborative research environment. It also accelerates the discovery process, leading to deeper insights and more innovative outcomes.

In my presentation, I further explore the advancements made in the development of these databases to enhance the accessibility and comprehensiveness of reception history data concerning the Dead Sea Scrolls. Moreover, I place the databases in a broader discussion of the potential future directions for digital humanities and database projects.[11]

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Non-Destructive Dating of Historical Archival Materials with Infrared Spectroscopy

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Abstract

Dating archival materials is crucial for understanding the historical context, authenticity, and cultural significance. Traditional methods, such as watermark analysis, codicology, and dendrochronology, along with historical evidence have long been used but often require extensive research, time and expert interpretation, which can introduce challenges and limitations. In this context, non-destructive infrared (IR) spectroscopic techniques have emerged as invaluable complementary tools for the non-invasive characterization and dating of various cultural heritage materials such as paper [1, 2] and parchment [3]. By analysing the chemical compositions and aging processes, IR spectroscopy offers a means of dating archival objects without damaging them. When combined with multivariate data analysis and machine learning, IR spectroscopy can construct accurate dating models by correlating spectral data with specific production dates [4]. These techniques are vital for scholars, historians, and forensic specialists in verifying the authenticity and true age of artifacts, thereby impacting their cultural and monetary value [5]. Additionally, the same methodology can be applied to hyperspectral imaging (HSI) to address material heterogeneity, offering the advantage of creating chemical maps. These maps provide essential tools for evidence-based conservation decisions [6]. Non-invasive methods like IR spectroscopy are particularly beneficial for large-scale surveys, offering rapid and reliable results without requiring material samples, as direct methods such as radiocarbon dating (C14) would. This approach preserves the integrity of historical artifacts while providing critical insights into their material history, enhancing both scholarly research and the preservation of cultural heritage for future generations.

The general approach for developing a dating model using spectroscopic techniques involves several key steps. First, a representative, well-dated calibration set from the target material (e.g., paper) is selected. Next, spectral dataset is collected and paired with samples' known dates. This data is then processed using machine learning methods for preprocessing and modelling with the aim of achieving the highest possible accuracy, closely aligning with the actual dates. Once the dating model is developed, it can be applied to spectral data from samples with unknown dates within the range covered by the calibration set. The spectral information obtained reflects the age of the sample by capturing the chemical identity and changes influenced by factors such as material composition, manufacturing techniques, and environmental conditions during storage thereby enabling accurate dating.

As a practical case study, IR spectroscopic techniques—specifically near-infrared (NIR, 350-2500 nm) and Fourier Transform Infrared (FTIR, 4000-400 cm^{-1}) using Attenuated Total Reflectance (ATR) and External Reflectance (ER) modules—were conducted to develop a dating methodology for historical European papers from the Medieval era. The study analysed around 100 well-dated books from the National and University Library (NUL) in Slovenia, which includes manuscripts and printed documents. Each IR spectroscopic method has distinct advantages and limitations regarding sample contact, spectral resolution and penetration depth. To assess

prediction accuracy, various regression models were developed and compared using metrics such as root mean square error of prediction and correlation coefficient. Concurrently, historical and codicological information for the same dataset are gathered and analysed to validate, and complement the predictions made by the dating models.

Thousands of spectra were collected from 100 well-dated archival paper objects, spanning the 15th to mid-19th centuries, to ensure comprehensive dataset representation. For NIR, 650 pages were scanned with five locations per page, while 400 pages were scanned for both FTIR modes with three locations per page. A custom R code was developed to manage spectral files, prepare datasets, perform spectral pretreatments, apply regression models, handle testing and validation, and format outputs. Preliminary results from the three models revealed varying accuracies and dependencies on specific spectral bands. The NIR model had the highest accuracy, followed by the FTIR-ER, while FTIR-ATR showed the lowest. Despite this, all models demonstrated a strong correlation (R^2) between predicted and known dates, affirming the dataset's quality. In the next phase, the methodology will be refined through additional spectral treatments, advanced machine learning for variable selection, in addition to cross-institutional validation, and assessment of environmental influences on model accuracy.

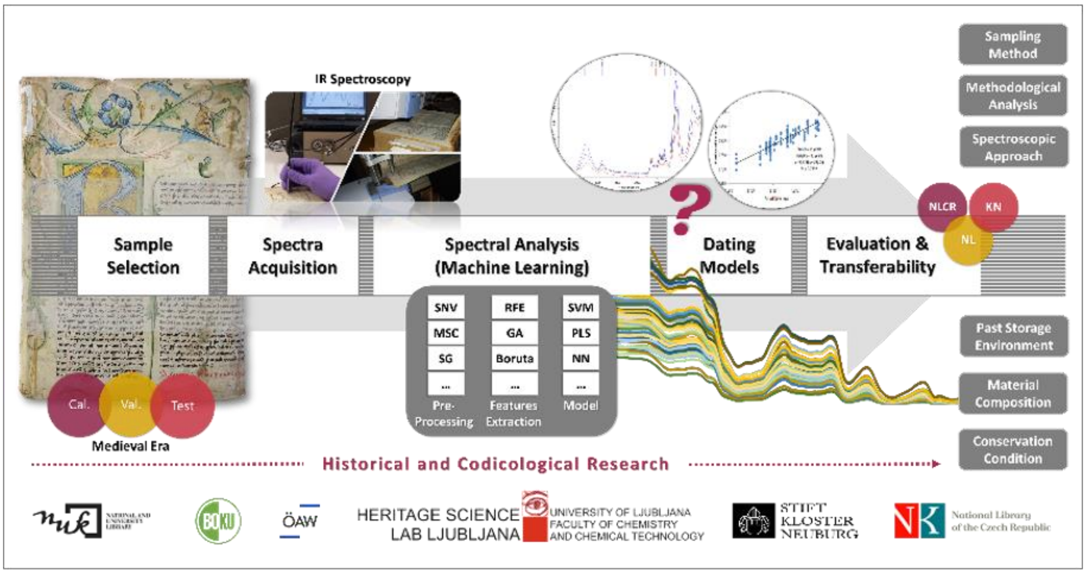

Figure 1. Research scheme outlines the approach used to develop and test the robustness of a dating methodology for historical European paper samples from the 15th to 19th centuries, utilizing NIR and FTIR spectroscopic techniques and machine learning methods, alongside historical and codicological analysis.

This research is part of the Austrian/Slovenian project Ancient Book Craft (ABC, 2022-2025, N1-0271) [7], which aims to systematically explore the potential of non-destructive IR spectroscopic methods for dating library materials. The project involves collaboration between BOKU (University of Natural Resources and Life Sciences, Austria), ÖAW (Institute of Medieval Research, Austria), NUL (National and University Library, Slovenia), and UL (University of Ljubljana, Slovenia). It also includes partnerships with the NLCR (National Library of the Czech Republic) and KN (Abbey Library and Archives of Klosterneuburg).

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(re-)Imagining a Corpus of Scrolls:
The Dead Sea Scrolls Physical and Scribal Features Database

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Abstract

Since the initial discovery of the DSS in the 1940s and 50s, scholars and non-scholars alike have tried to imagine what the fragmentary manuscripts may once have been—and what the collection of scrolls represents. The DSS were initially edited and published in different contexts, but the primary publication channel for the scrolls was the *Discoveries in the Judaean Desert* series, which included editions, translations, and discussions of the scrolls and fragments of scrolls found at Qumran and several other locations along the West bank of the Dead Sea.[1] This massive publication effort, spanning over 50 years was undertaken by many different scholars and editors and while it included expansive indices,[2] the physical and scribal features of the manuscripts are not systematically described or collated in the series.

The work to collect and analyze the physical and scribal features of the DSS has been carried out by the general editor Emanuel Tov in a book entitled *Scribal Practices and Approaches Reflected in the Texts Found in the Judean Desert*.[3] Tov's publication provides detailed information about many manuscripts, for the most part culled from the countless editions in the DJD series. In this paper, I will look at the way big(ish) data collected in the form of a database can contribute to the (re-)imagination of the corpus of the Dead Sea Scrolls. Further, I will discuss two aspects of working with this specific material as they relate to digital humanities: 1) The DSS represent a closed and comparatively limited corpus which restricts the usefulness of many digital humanities tools which rely on big data to secure accuracy; and 2) Small, detailed analyses of the DSS will almost always be required to produce the data necessary to driver big(ish) data projects.

To illustrate this, I will give examples of editions in the DJD series, notes from Tov's Scribal practices, and introduce the Dead Sea Scrolls Physical and Digital Features Database [4] which collects and systematizes data about the DSS, making it possible to analyze the data at a deeper level than previously.

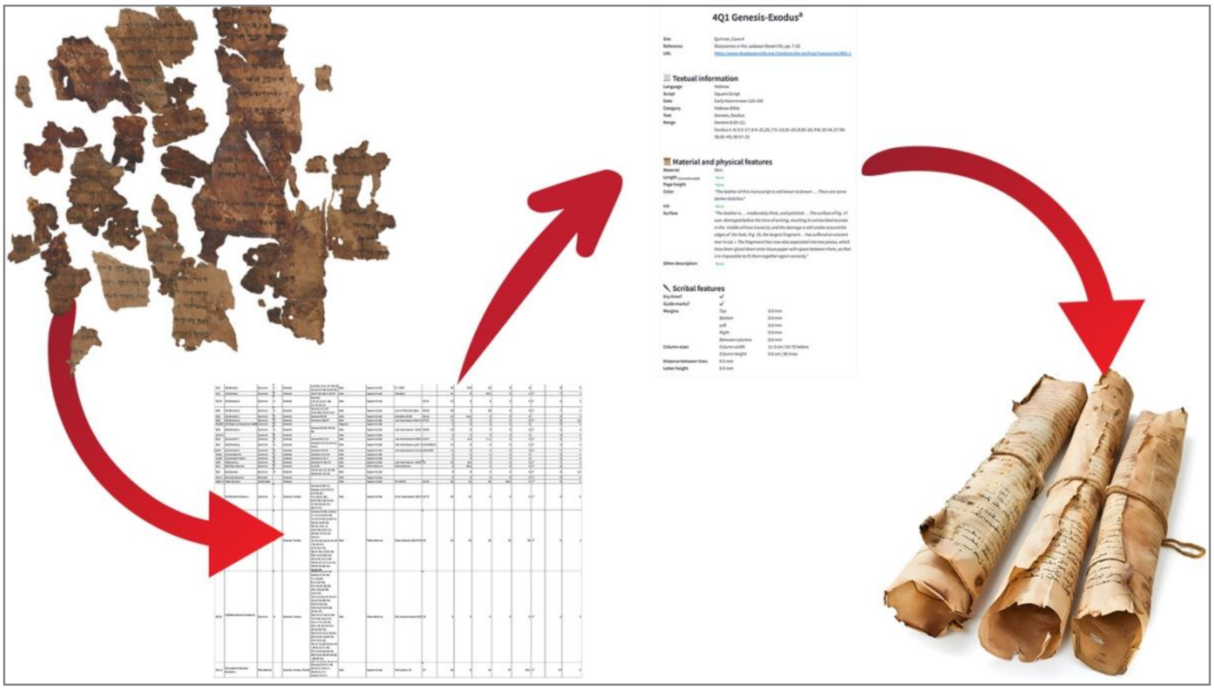

Figure 1. Dead Sea Scrolls Fragments; an Excel spreadsheet; an entry in the Database; AI reconstructed scrolls.

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History and present of multispectral imaging in the National Library of the Czech Republic

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Abstract

The use of multispectral methods for the analysis of illuminations, written texts, or previously invisible drawings and inscriptions has a long tradition in the National Library of the Czech Republic. The principle of multispectral imaging is based on the ability to observe historical documents across a wide spectrum of wavelengths, particularly in the UV, visible light, and near-infrared regions. By photographing documents under various wavelengths, multiple images are obtained, in which the sought-after elements appear differently, facilitating their interpretation. These images are then compared and processed using specialized image analysis software that allows for a range of operations and combinations, such as image segmentation, thresholding, and the addition or subtraction of individual images. This approach enables the extraction of the maximum amount of information, often yielding significantly better results, such as rendering unreadable text legible once again. This publication focused on developing and applying non-invasive imaging techniques to analyze historical library documents. The primary objective was to uncover and document hidden information not only within the text itself but also in the book bindings, materials, and other elements that are typically inaccessible through traditional methods. The publication thoroughly explores the research and testing of several key imaging techniques, including multispectral analysis using a video spectral comparator and radiography using an X-ray cabin. Multispectral analysis which captures documents in various wavelengths from ultraviolet to infrared, has proven highly effective at revealing previously obscured text and images, which may have been damaged, overwritten, or altered over time. Radiography, on the other hand, allows for the examination of a book's internal structure, making it valuable for analyzing book bindings, identifying metal components, and detecting biological damage or material defects.

The publication is enriched with an extensive array of images that visually document the results of the various imaging techniques. Readers are provided with not only the theoretical background but also concrete evidence of the efficacy of these methods. This work serves as an invaluable resource for experts in librarianship, conservation, and restoration, while also offering insights to the broader scientific community involved in the study of historical documents. By advancing non-invasive imaging techniques, this research significantly enhances traditional methods for studying and preserving valuable cultural heritage.

Acknowledgment

This article was created with the institutional support of The National library of the Czech Republic for the long-term conceptual development of a research organisation provided by the Ministry of Culture of the Czech Republic.

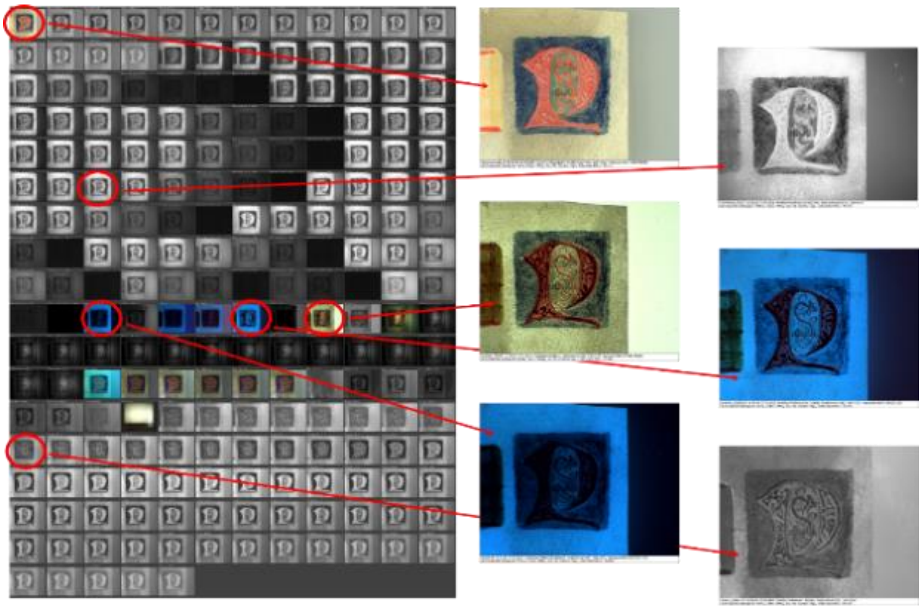

Figure 1. Multispectral analysis using a video spectral comparator.

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Material insights and artist working methods from multi-modal imaging spectroscopy studies of Visconti-Sforza *tarocchi* playing cards

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Abstract

Technical art history and conservation science studies conducted through close collaboration between curators, conservators, and conservation scientists have produced impactful art historical knowledge of cultural heritage materials. Manuscript analyses have benefitted from such collaboration – one example is the ongoing research project on the analysis of the Visconti-Sforza playing card decks – three collections of illuminated 15th-century *tarocchi* (an Italian trick-taking card game) cards. During a conversation regarding their respective *tarocchi* decks at a 2016 exhibition on European playing cards, conservators from the Yale University Library and the Morgan Library and Museum realized that very little information was known about these decks' construction or material nature. This meant there was a persistent knowledge gap in the artists' working methods behind these painted miniatures that represented not only conventional manuscript illumination techniques and materials but artistic inspiration from fresco and panel painting as well. Thus, starting in 2018, the technical analysis of *tarocchi* playing cards has been advanced to close the knowledge gap, which includes an impressive array of non-invasive, non-destructive analyses as well as minimally-invasive microanalytical investigations undertaken by a team of professionals comprising conservation scientists, conservators, and art historians from multiple institutions around the world [1]. The results presented here will showcase the material insights gained on the analysis of *tarocchi* cards in the Cary Collection of Playing Cards at Yale University's Beinecke Rare Books and Manuscripts Library using complementary imaging spectroscopy approaches, including visible-to-near-infrared (400-1000 nm) reflectance imaging spectroscopy, short-wave infrared (1000-2500 nm) reflectance imaging spectroscopy, and scanning micro X-ray fluorescence spectroscopy. The data-rich three-dimensional (2-D spatial, 1-D spectral) image cubes produced by these chemical imaging modalities provide molecular and elemental composition maps that together give a comprehensive look at the types of pigments and preparatory materials used, as well as the symbolic material choices by the artists in the technical execution of these miniature paintings. The research presented will highlight both the data collection and analysis process (image cube acquisition and data processing approaches) and the knowledge gained on the pigment palette and painting techniques (pure applications, combinations and layering of pigments), demonstrated by a case study on the Cavalier of Swords (female) (Playing Cards GEN 965), from the Visconti-Sforza deck in the Cary Collection of Playing Cards at Yale University.

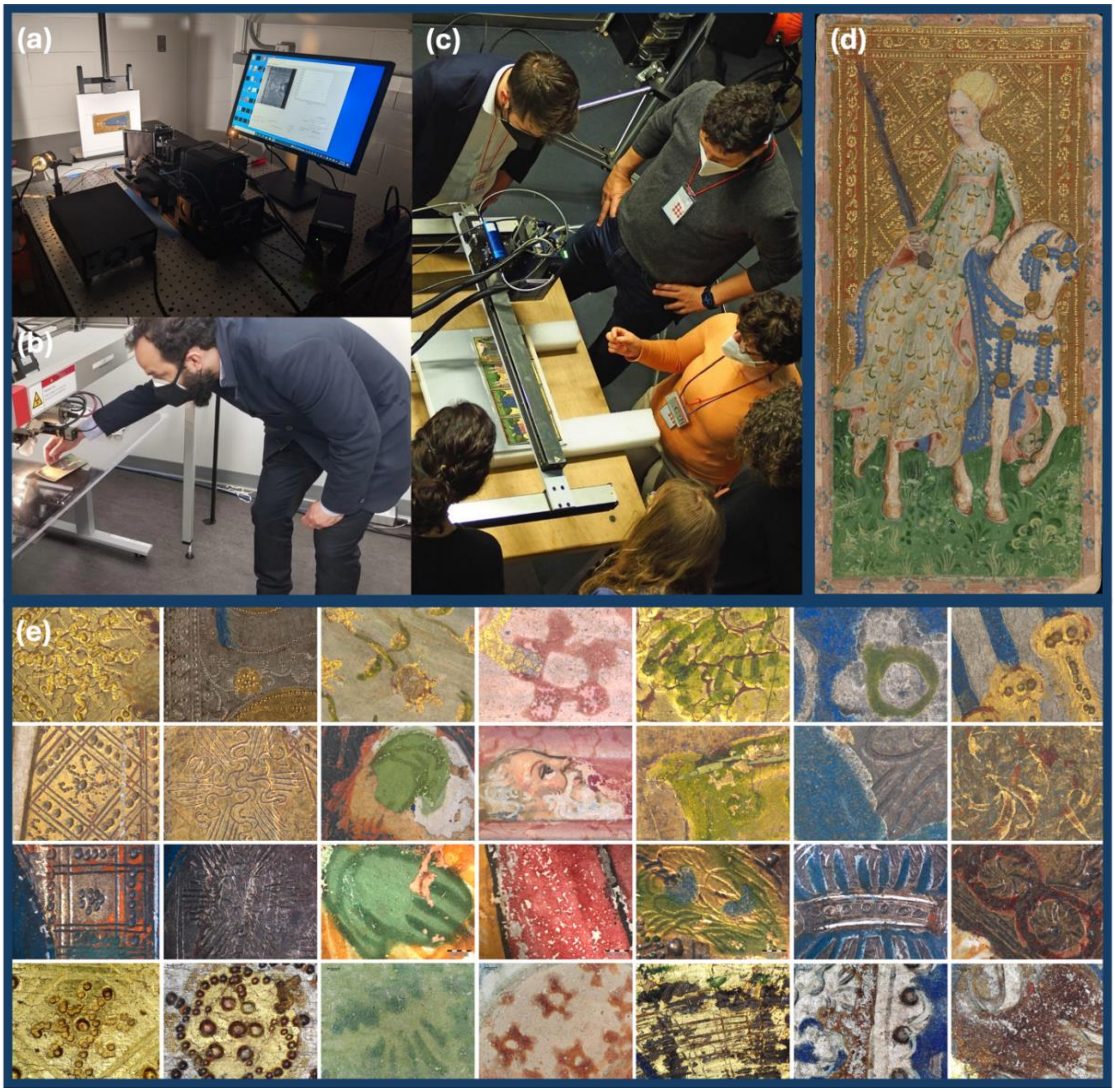

Figure 1. (a)-(c) represent different chemical imaging modalities applied to *tarocchi* cards in the three Visconti-Sforza decks: visible-to-near infrared (VNIR) reflectance imaging spectroscopy (RIS), scanning X-ray fluorescence (XRF), and an integrated RIS-XRF scanner, respectively. (d) Cavalier of Swords (female) (Playing Cards GEN 965, Beinecke Rare Books and Manuscripts Library, Yale University). (e) A detailed look at the metalwork and painting applications of various *tarocchi* cards across the three decks [1].

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Non-invasive Analytical Study of a V&A Madonna and Child Drawing

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Abstract

This study investigates the 'Virgin and Child' drawing (E.603-1936, Figure 1a), attributed to Baccio Bandinelli or his workshop, using non-invasive analytical techniques to explore its materials, history, and connection to the controversial marble sculpture, the Dudley Madonna (A.84-1927, Figure 1b). This sculpture, displayed with an attribution to Desiderio da Settignano (circa 1450-1460), has been a focal point of debate, with some scholars considering it a Renaissance masterpiece by Donatello, and others suspecting it may be a 19th-century forgery. The drawing's composition mirrors that of the sculpture, making it a crucial artifact for understanding the sculpture's history and iconography.

The primary objectives of this study include identifying any watermark on the drawing, examining the verso for inscriptions or drawings, mapping the distribution of different artist materials, and conducting a microscopic analysis of iconographically significant details. To achieve these goals, Scanning X-ray Fluorescence (XRF), Infrared Reflectography (IRR), and High-Resolution Digital Microscopy were employed to study the drawing's material composition and condition.

The results of the XRF analysis reveal no visible watermark on the folio, despite its thin lining. It is likely that the watermark was in another section of the larger sheet from which the drawing was cut. The verso of the folio shows no drawings, but three inscriptions were observed: "T" and "Baccio ... nd ... ll ...," which are located under the lining, and "J.P.H." on top. The materials used in the drawing include four types of paper, with the original paper containing calcium, and three different types used in later repairs. These repairs do not necessarily indicate separate restoration campaigns. Iron gall ink, which has significantly corroded, was used extensively in the drawing. Red chalk is found in the lower-right corner, and a dark carbon-based material, visible both to the naked eye and through IRR, is present in other areas of the drawing.

A significant area of focus is the Virgin's left foot, which rests on a spherical object framed by drapery and leaning on a rectangular object. This detail has worn away substantially but remains important for interpreting the drawing's iconography. Microscopic photography of this region helped clarify the object's form, contributing to the ongoing debate about the drawing's connection to the Dudley Madonna. Additionally, the child's right hand, partially obscured by shadowing and ink corrosion, was further examined under magnification, revealing the extent of material deterioration.

The analysis also maps the materials used in the drawing. The XRF results show areas with high calcium intensity, particularly on the Virgin's cheek and the baby's forehead, likely due to the use of calcium-containing materials such as chalk or gypsum. The paper used in the top corners for repairs contains iron, with traces of lead and cobalt, while the bottom left section is primarily repaired with zinc-containing paper. The presence of gold at the edges suggests that the original folio may have had gilded or gauffered edges, though much of the gold has been abraded over time.

Through this technical analysis, key questions surrounding the materials, composition, and possible alterations of the 'Virgin and Child' drawing are addressed. The results offer new insights into the drawing's creation process, its relationship with the Dudley Madonna, and the historical context in which it was produced and later restored. Although no definitive conclusion can be

drawn regarding the drawing’s use as a preparatory sketch or a copy, the findings enhance our understanding of the drawing's materiality and iconographic significance.

This study demonstrates the value of combining advanced imaging techniques such as XRF, IRR, and digital microscopy for the non-invasive examination of delicate historical artworks. These methods not only provide vital information about the physical and chemical composition of the drawing but also offer new perspectives on the artwork’s historical and artistic context. Further investigations, such as Raman spectroscopy and additional microscopic analysis, could deepen our understanding of the drawing's original intent and its relationship to other Renaissance artworks, which are currently being investigated by curators.

(a) (b)

Figure 1. (a) the ‘Virgin and Child’ drawing (E.603-1936) and (b) the ‘Dudley Madonna’ relief (A.84-1937).

Lying pens of Iceland — (Re)-imag(in)ing a pre-saga literary genre

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Abstract

This study demonstrates the usefulness of infrared (IR) imaging for recovering a text obscured by soot written in iron gall ink. Our text is in AM 445 b 4to. It has genealogical tables preceding a fragment version of *Landnáma* 'The book of settlements in Iceland'. Many Icelandic medievalists maintain that saga-authors fabricated historical accounts, but made them believable by various means, creating an 'illusion of reality' *raunveruleikablekking*. Some doubt the veracity of *Landnáma* [1], which has traditionally been thought to be historically reliable, primarily mapping Iceland with old genealogies to give an account of its settlement around year 900. In the First Grammatical Treatise, from the middle of the 12th century, genealogies (*áttvísi*) in writing are said to exist. The sagas were, however, not composed until in the middle of the 13th century and later. The veracity of *Landnáma* would be supported if genealogical tables older than the sagas existed today. They do not exist, not even in younger copies, except for genealogical tables of the earliest Icelandic bishops [2]. Additionally, our manuscript contains genealogical tables of secular leaders in the early 13th century, before they battled unsuccessfully for domination of Iceland, finally surrendering it to the Norwegian King Hákon Hákonarson. These tables are, however, mostly unreadable.

Figure 1. AM 455 b 4to a. Part of a Landnáma manuscript in Reykjavík. IR image on right.

Infrared (IR) imaging of manuscripts requires no special lighting and causes minimal harm. Ordinary cameras can be used with minor modifications. If the ink is of carbon type, the ink appears black because the carbon does not reflect IR radiation. Nordic medieval documents use iron gall ink. This ink has some interesting properties: It impresses itself into the writing medium and it is invisible in IR light. IR photographs of most manuscripts reveal empty pages with no writing. There is an important exception: Outer pages of manuscripts are often dark and illegible due to soot (carbon), which they probably accumulated in buildings lit and heated by open fire. The iron gall ink protects the parchment and when the outer pages are viewed in IR, the script appears inverted (see Fig. 1 and references 3 and 4)). The manuscript AM 445 b 4to has an outer page that is mostly illegible. Most of it was, however, read and transcribed in the 19th century by Jón Sigurðsson, possibly, by pouring acid solutions on it, which made the script temporarily more legible. Because his transcript doesn't retain the spelling and is unverifiable, the genealogical tables have not been properly published. However, the present study reveals that most of the text can be verified, and improvements can be made with IR imaging. A planned publication will add important details to old Icelandic genealogies and strengthen the case for the veracity of *Landnáma*.

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Building Blocks Approach to Character-Level Writer Authentication System of Ancient Manuscripts

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Abstract

Introduction. The preservation and analysis of ancient manuscripts pose significant challenges due to their physical degradation over time. However, advances in document imaging technologies have enabled the digital archiving of these historical texts, greatly facilitating their accessibility for research across various disciplines. Paleography, an important auxiliary science of history, involves analyzing ancient manuscripts to understand script types, stylistic features, and historical writing practices. While it often includes determining if manuscripts were produced by the same hand, its broader aim is to elucidate the development and variations of writing styles across different periods and regions [1]. This analysis bears similarity to modern writer identification tasks in computer science, which use pattern recognition and machine learning techniques. This study proposes using the n-level building blocks approach to leverage these computer-aided methods as an additional tool to complement traditional paleographic analysis. By incorporating detailed data from computer-aided techniques, the study aims to enhance the accuracy of writer authentication for the Great Isaiah Scrolls, offering a more comprehensive understanding of the manuscripts.

Related Works. Paleography traditionally focuses on identifying the characteristic features of handwriting to understand historical contexts and trace the evolution of writing practices. This analysis includes examining aspects such as handwriting size, error frequency, and correction procedures, which are essential for contextualizing documents within specific historical periods [3]. However, this approach is often script-specific, and in the writer identification task, it may be limited in its applicability across different scripts or writing systems. In contrast, computer-aided writer identification has been extensively researched for both modern and historical documents [2]. These techniques use machine learning frameworks to analyze handwriting at various token levels, including characters, words, and pages, employing feature extraction methods and classifiers. While these methods demonstrate the capability of machine learning to handle diverse scripts, there is a gap in systematically integrating decision scores across different token levels of textual content, which this study aims to address.

Method. This study proposes the n-level building blocks approach, integrating a layered decision strategy with a machine-learning-based writer authentication system. The approach allows for detailed analysis across multiple levels of tokens, from individual characters to sentences. The system is validated using the Great Isaiah Scrolls, specifically examining the distinct writing styles of two hypothesized scribes: Scribe A, who wrote Columns I–XXVII, and Scribe B, who wrote Columns XXVIII–LIV. The framework utilizes Edge-directional feature extraction combined with a Support Vector Machine (SVM) classifier, known for its robustness with high-dimensional and non-linearly separable datasets. For training and validation, the set referring to Scribe A includes single characters extracted from Columns I–XXVI, while the set for Scribe B includes characters from Columns XXVIII–LIII. The test set comprises one sentence from Column XXVII (attributed to Scribe A) and one from Column LIV (attributed to Scribe B). The decision strategy is further refined using soft voting and majority voting systems to enhance the accuracy of writer authentication at higher token levels.

Results. The proposed character-specific classification model reveals that certain Hebrew letters, such as 'tav,' are more effective at distinguishing between the handwriting of different scribes. The n-level building blocks approach, particularly when integrated with the soft voting system, significantly improves the accuracy of writer authentication on a sentence level, achieving 69.2% for Scribe A and 66.7% for Scribe B (see Table). Figures 1a and b further illustrate the probability scores of character-level writer authentication for Scribe A and Scribe B, respectively. These figures highlight the variability in classification confidence across different characters, underscoring the model's sensitivity to specific letter forms. The results also demonstrate the limitations of majority voting, which is more prone to 'ignored' measures, thus reducing its statistical power.

Conclusion. This study highlights the potential of integrating paleographic knowledge with advanced machine learning techniques for authenticating ancient manuscripts. The proposed n-level building blocks approach offers a detailed investigation at the character level, demonstrating that character-specific models when combined with a soft voting system, can enhance the accuracy of writer authentication. Although the accuracy scores achieved are relatively modest, the flexibility of the framework allows for its application across various types of documents, both historical and modern. While the research primarily focuses on Hebrew texts, the methodology has broader implications for improving writer authentication in diverse contexts. Future work will explore the impact of different feature extraction and classification techniques on the accuracy of this writer authentication system, aiming to further refine and extend its applicability.

Figure 1. Probability scores of a token predicted as being written by (a) Scribe A and (b) Scribe B on character level.

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