unesco

Artificial Intelligence and Culture

A perspective from the Arab region

Published in 2026 by the United Nations Educational, Scientific and Cultural Organisation,7, place de Fontenoy, 75352 Paris 07 SP, France
and
UNESCO Regional Office for Egypt and Sudan/Liaison Office with The League of Arab States, First 6th of October, 3230601 Giza Governorate, Egypt

© UNESCO 2026

ISBN: 978-92-3-100901-3

DOI: https://doi.org/10.58337/DXMT5625



This publication is available in Open Access under the Attribution-ShareAlike 3.0 IGO (CC-BY-SA 3.0 IGO) license (http://creativecommons.org/licenses/by-sa/3.0/igo/). By using the content of this publication, the users accept to be bound by the terms of use of the UNESCO Open Access Repository (https://www.unesco.org/en/open-access/cc-sa).

Images marked with an asterisk (*) do not fall under the CC-BY-SA license and may not be used or reproduced without the prior permission of the copyright holders.

The designations employed and the presentation of material throughout this publication do not imply the expression of any opinion whatsoever on the part of UNESCO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

The ideas and opinions expressed in this publication are those of the authors; they are not necessarily those of UNESCO and do not commit the Organization.

Original idea, Concept, Coordination, and Supervision of the document: The UNESCO Regional Office for Egypt and Sudan / Liaison Office with the League of Arab States

Conception, Edition, and General Coordination of the Project: Paolo Fontani, Director of The UNESCO Regional Office in Beirut/Officer in Charge of The UNESCO Regional Office for Egypt and Sudan/Liaison Office for the League of Arab States

Internal Reviewers: Mr Lihui XU and Ms Yiline Zhao

External Reviewers: Dr Giovanna Di Mauro and Dr Momen M. El-Husseiny

Lead Editor: Ruoxi Wang

Technical Coordination: Jenna Khalil, Clara Epperlein, Ahmed Bayoumi and Qianzi Wang

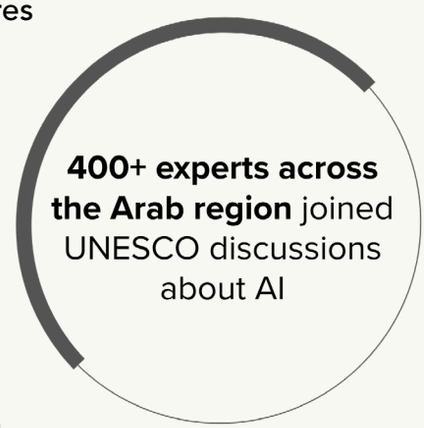
Cover Design: © Jenna Khalil

SHORT SUMMARY

Insights from Arab States on rethinking Artificial Intelligence in the cultural landscape

As Artificial Intelligence (AI) rapidly reshapes cultural production and heritage management, new questions emerge about creativity, ethics, governance and cultural rights in the digital age.This innovative tool is transforming cultural heritage and the creative industries, while exposing the ethical, legal and epistemological challenges that accompany its growing use.

With a particular focus on the Arab region, this publication explores concrete applications of AI across six cultural domains: documentary heritage, intangible cultural heritage, underwater cultural heritage, World Heritage, cultural and creative industries and culture in emergencies.



More than a purely technical tool, AI has a wide-spanning impact on authorship, data ownership, cultural diversity and institutional responsibility. The publication highlights both the opportunities offered by this transformation – such as enhanced documentation, monitoring, accessibility and innovation – and the risks of bias, cultural homogenization and the erosion of human agency if ethical safeguards are not in place.

Anchored in UNESCO's normative frameworks on culture and its Recommendation on the Ethics of Artificial Intelligence, this collective and multidisciplinary publication calls for a human-centred approach to digital transformation, in which technological innovation supports cultural diversity, creativity and memory.

unesco

"Since wars begin in the minds of men and women.it is in the minds of men and women that the defences of peace must be constructed"

Table of Contents

Foreword: Paolo Fontani, Director, UNESCO Regional Office in Beirut/ OIC, UNESCO Regional Office for Egypt and Sudan / Liaison Office with the League of Arab States

Theme 1 Artificial Intelligence (AI) and Documentary Heritage

1.1 Rethinking Documentary Heritage Digitization: An AI-Centered Economic Model, Dr. Clément Godbarge

1.2 Ancient Texts and New Technologies in the Era of Artificial Intelligence, Dr. Andrea Barucci

1.3 Combining AI, the Sciences, and the Humanities to Innovate the Study of Ancient Manuscripts, Dr. Mladen Popović

1.4 AI methods and advanced imaging techniques for augmented documentation of archaeological inscriptions: applications to ancient Egyptian hieroglyphs, Dr. Costanza Cucci

Theme 2 Artificial Intelligence (AI) and Intangible Cultural Heritage

2.1 Documenting intangible cultural heritage through Artificial Intelligence, Dr. Gabriella Giannachi

2.2 Using Artificial Intelligence in Sonic Intangible Heritage: Reflection and Recommendations, Dr. Carlos Guedes

2.3 Artificial Intelligence Translation and Cultural Preservation: A Case Study on Moroccan Malhun Poetry, Dr. Karima Bouziane

2.4 Inclusive Artificial Intelligence: Community-Driven Recommendations for Digitizing Intangible Cultural Heritage, Dr. Kasper Rodil

2.5 The Role of Artificial Intelligence in Preserving Intangible Heritage: Using an Omani Traditional Story as a Model, Dr. Fakhriya Al yahyai

Theme 3 Artificial Intelligence (AI) and Underwater Cultural Heritage

3.1 Artificial Intelligence and Cultural Heritage Preservation in Jordan: Underwater Heritage, Ms. Alaa Ababneh

3.2 Exploring AI-powered applications for mapping and monitoring Underwater Cultural Heritage: the experiences of the University of Calabria, Dr. Fabio Bruno

3.3 Underwater Cultural Heritage in the Age of AI: Reflections from Pre-AI Practices to Emerging Possibilities, Dr. Guzden Varinlioglu

3.4 Artificial Intelligence for Coastal Heritage: Responsible Detection and Monitoring, Dr. Alexandra Karamitrou

Theme 4 Artificial Intelligence (AI) and Cultural and Creative Industry

4.1 Narratives and Practice of Artificial Intelligence in the Arts: Four Recommendations, Dr. Baptiste Caramiaux

4.2 The Dual Edge: Artificial Intelligence's Impact on Cultural Production and Preservation, Dr. Katherine Elkins

4.3 Artificial Intelligence and Cultural Expressions: Regulatory Challenges in the Age of Generative Technology, Dr. Luke McDonagh and Ms. Reem A. Abbass

4.4 Ethics and Philosophy: the nature and future of Artificial Intelligence's creativity, Dr. Florent Vinchon

Theme 5 Artificial Intelligence (AI) and Protection of Cultural Properties in Emergencies

5.1 New Solutions for Old Problems: Threats and Challenges to Cultural Property in Times of Conflict and the Role of New Technologies, Dr. Amr Al Azm

5.2 The potential of Artificial Intelligence for protecting Cultural Heritage and what else is needed, Dr. Primo Zingaretti

5.3 Using Artificial Intelligence in the fight against trafficking in cultural property: Opportunities and legal risks, Dr. María-Ángeles Fuentes-Loureir

Theme 6 Artificial Intelligence (AI) and World Heritage Convention

6.1 The Evolution from 3D Digital Twin to Memory Twin in Cultural Heritage Preservation, Dr. Marinos Ioannides

6.2 Towards Collaborative Models for Artificial Intelligence for Egyptian Cultural Heritage Preservation: Innovations, Frameworks and Recommendations, Dr. Mohamed Gamal Abdelmonem

6.3 Artificial Intelligence and Remote Sensing–Driven Conservation of the Nasca Geoglyphs: Innovations and Implications for World Heritage Management, Mr. Masato Sakai

Theme 7 Artificial Intelligence (AI) and Culture in The Arab Region

7.1 From Preservation to Transformation: Artificial Intelligence, Climate Resilience, and Cultural Heritage in the Arab Region: A Contribution to MONDIACULT 2025, Dr. Abdelrahman Medhat

7.2 Using Artificial Intelligence to Detect Roman Fortified Sites in Tunisia: Reflection and Recommendations, Dr. Nabil Bachagha

7.3 Artificial Intelligence meets Culture: Innovation at the crossroads of creativity and technology, Dr. Riham Arram

7.4 Protecting Sudanese Cultural Heritage Through Innovation and Artificial Intelligence: Sudan AI Initiative, Mr. Emad Blake

7.5 Artificial Intelligence in the Arab Creative Sector: Opportunities and Challenges, Dr. Noha Mellor

7.6 Generative Pictographic Language: Rethinking Ancient Scripts through Artificial Intelligence, Dr. Haytham Nawar

7.5 Teaching the History of Islamic Art and Architecture in the time of AI: Challenges and Opportunities, Dr. Noha Abou-Khatwa

Foreword: AI and Culture

© UNESCO



Paolo Fontani

Director, UNESCO Regional Office in Beirut/ OIC UNESCO Regional Office for Egypt and Sudan/Liaison Office with The League of Arab States

AI is increasingly shaping the way societies engage with knowledge systems, creativity, and heritage—core dimensions of UNESCO's mandate to foster the identification, protection, and promotion of cultural diversity and shared heritage. At the crossroads of algorithms and artistry, the use of Artificial Intelligence (AI) demands a profound reflection on the implementation of the UNESCO Conventions in the field of culture. From chats to wearables, AI and its uncountable and expanding applications have begun to transform the cultural landscape in significant and multifaceted ways. Within the field of culture, AI technologies are being employed to digitise and safeguard documentary heritage, intervene in damaged monuments, generate and curate artistic expressions, support linguistic and cultural diversity, broaden access to cultural resources, intensify connectivity across professional communities and generations, and counter the illicit trafficking of cultural property, particularly in times of crisis and emergency.

The intersection of AI and culture thus constitutes a dynamic and inherently cross-sectoral frontier. While this transformation holds great promise for advancing innovation, inclusion, and preservation, it also raises complex ethical, legal, and epistemological challenges that call for coordinated reflection, policy coherence, and inclusive international dialogue. In response to these evolving dynamics and emerging technical and ethical imperatives, the UNESCO Regional Office for Egypt and Sudan and the Liaison Office with the League of Arab States (UNESCO Cairo Office) have developed a project entitled "Artificial Intelligence and Culture: A Global Perspective from the Arab Region".

As a result of a multilateral reflection, this publication builds on the outcomes of a six-month webinar series on Artificial Intelligence and Culture, convened by the UNESCO Cairo Office between January and June 2025, which explored the intersections of AI across multiple cultural domains and reflected regional and global perspectives, as a contribution to MONDIACULT 2025, the world's biggest cultural policy conference, convening Member States and cultural stakeholders to shape the future of international cultural policy. The themes explored in this publication reflect both the regional dynamics of the Arab States and the evolving global discourse on the governance and application of AI in the international arena.

UNESCO's response to the ethical and societal implications of AI is anchored in its Recommendation on the Ethics of Artificial Intelligence (2021)—the first global standard-setting instrument in this domain, adopted by Member States by unanimity. This recommendation provides a normative foundation for the responsible development and application of AI systems that promote human dignity, cultural diversity, social inclusion, and environmental sustainability. Within the cultural field, these principles are further elaborated through UNESCO's suite of cultural Conventions, each of which now faces new opportunities and new challenges of implementation.

This publication explicitly links the evolving technological environment to the full range of UNESCO's normative instruments on culture, following the thematic sequence of the 2025 webinar series:

The 2015 Recommendation concerning the Preservation of, and Access to, Documentary Heritage including in Digital Form, which guides the safeguarding and accessibility of documentary heritage in an era of digital transformation:

Adopted by UNESCO in November 2015, this Recommendation sets out a normative framework for States and memory institutions (such as archives, libraries, museums, etc.) to safeguard documentary heritage — in both analogue and digital form — and ensure its enduring accessibility. It recognises that documentary heritage records human thought, history, cultures and languages, and plays a crucial role in governance, development, identity and memory.

Noting threats such as natural disasters, human conflict, or obsolescence caused by rapid technological change, the Recommendation encourages comprehensive strategies for identification, preservation, access, policy measures, and cooperation, including the development of legislation, professional capacity, and standards. Its adoption reflects UNESCO's response to the urgent need for preserving documentary materials in an era of digital transformation.[1]

1- This Recommendation is led by UNESCO's Communication and Information (CI) Sector and is included in view of its relevance to the broader UNESCO normative framework. *The 2015 Recommendation concerning the Preservation of, and Access to Documentary Heritage : https://unesdoc.unesco.org/ark:/48223/pf0000381137*

The 2003 Convention for the Safeguarding of the Intangible Cultural Heritage, which promotes the vitality and transmission of living heritage, is increasingly shaped by digital tools and online platforms:

Adopted in 2003, the Convention for the Safeguarding of the Intangible Cultural Heritage aims to ensure the continued viability of living heritage—practices, expressions, knowledge, and skills that communities recognise as part of their cultural heritage—by safeguarding it through identification, documentation, research, preservation, protection, promotion, and transmission. It highlights the role of communities and groups as primary actors in keeping this heritage alive and calls on States Parties to adopt policies, maintain inventories, raise awareness, and promote international cooperation to ensure that intangible cultural heritage contributes to cultural diversity and human creativity. [2]

The 2001 Convention on the Protection of the Underwater Cultural Heritage, which opens new avenues with AI-assisted discovery, documentation, and monitoring of submerged heritage:

The 2001 Convention on the Protection of the Underwater Cultural Heritage is a legally binding instrument that provides an international framework for safeguarding all traces of human existence of cultural, historical, or archaeological character that have been underwater for at least 100 years. Adopted in 2001 and in force since 2009, it promotes in-situ preservation as the first option, sets out rules for research and recovery, and obliges States Parties to protect underwater heritage from looting, commercial exploitation, and destruction, while encouraging scientific cooperation, capacity building, and public awareness to ensure its long-term protection. [3]

The 2005 Convention on the Protection and Promotion of the Diversity of Cultural Expressions, which addresses the evolving nature of creation, production, and dissemination of culture in light of AI-generated content and algorithmic curation:

The 2005 Convention on the Protection and Promotion of the Diversity of Cultural Expressions is a legally binding UNESCO framework that recognises cultural goods, services, and activities not only as economic commodities but fundamentally as expressions of identity, values,

---

2- UNESCO 2003 Convention for the safeguarding of Intangible Cultural Heritage
https://ich.unesco.org/doc/src/2003_Convention_Basic_Texts_2024_version_EN.pdf

3- UNESCO Convention on the Protection of Underwater Cultural Heritage
https://unesdoc.unesco.org/ark:/48223/pf0000126065.locale=en

4- UNESCO 2005 Convention on the Protection, Promotion, and Diversity of Cultural Expressions
https://unesdoc.unesco.org/ark:/48223/pf0000246264.locale=en

and creativity. It commits States Parties to adopt policies and measures that support the creation, production, dissemination, distribution, and access to diverse cultural expressions, fostering interaction among cultures in a spirit of openness, equity and mutual respect. The Convention also enshrines artists' rights, encourages civil society participation, supports cultural and creative industries, and gives particular attention to developing countries and to situations where cultural expressions are under threat. [4]

The 1954 Hague Convention for the Protection of Cultural Property in the Event of Armed Conflict and its Protocols, which calls for enhanced digital inventories and risk-mapping, where AI technologies are proving to be essential tools:

The 1954 Hague Convention for the Protection of Cultural Property in the Event of Armed Conflict (and its Protocols) is the first major international treaty dedicated to safeguarding cultural property—monuments, works of art, manuscripts, museums, archaeological sites and archives—both in peacetime and armed conflict. It requires States Parties to take preventive measures such as compiling inventories, planning emergency responses, designating authorities responsible for protection, and establishing legal sanctions for damage or misuse. The Convention's Protocols strengthen its provisions, including the regime for "enhanced protection" of particularly important cultural properties under the Second Protocol, and reinforce obligations against attacks or misuse even in times of war. [5]

The 1970 Convention on the Means of Prohibiting and Preventing the Illicit Import, Export and Transfer of Ownership of Cultural Property, which increasingly relies on AI-powered image recognition, provenance tracking, and blockchain documentation to prevent illicit trafficking and improve restitution mechanisms:

The 1970 UNESCO Convention on the Means of Prohibiting and Preventing the Illicit Import, Export and Transfer of Ownership of Cultural Property obliges its States Parties to take concrete preventive and cooperative measures to combat illicit trafficking of cultural property. It requires the establishment of national legislation, regular cultural-property inventories, export certificates, sanctions against illicit activities, and education or awareness campaigns. It also provides for restitution of stolen or illicitly exported items, with States cooperating to recover and return cultural property, and encourages bilateral or multilateral cooperation to that end. [6]

5- UNESCO 1954 Hague Convention

https://unesdoc.unesco.org/ark:/48223/pf0000082464.locale=en

6- UNNESCO 1970 Convention on the Means of Prohibiting and Preventing the Illicit Import, Export, and and Transfer of Ownership of Cultural Property

https://unesdoc.unesco.org/ark:/48223/pf0000133378.locale=en

The 1972 Convention concerning the Protection of the World Cultural and Natural Heritage, which increasingly relies on AI-driven spatial analysis, predictive modelling, and environmental monitoring for the preservation of heritage sites:

The 1972 UNESCO Convention concerning the Protection of the World Cultural and Natural Heritage establishes a global legal framework by which States Parties commit to identifying, protecting, conserving, presenting and passing on to future generations cultural and natural heritage of "outstanding universal value." It defines what counts as cultural heritage (monuments, architectural works, groups of buildings, sites) and natural heritage (natural features, geological formations, habitats of threatened species) and places on States the primary responsibility for safeguarding these, including by legal, scientific, technical, administrative and financial means; it also requires international cooperation and assistance to help those States that need support. [7]

Also intersected with the 1980 Recommendation concerning the Status of the Artist, which calls to address authorship, intellectual property rights, algorithmic creativity, and the economic impact of generative AI tools on the livelihoods of cultural professionals:

The 1980 UNESCO Recommendation concerning the Status of the Artist urges Member States to enhance the professional, social, and economic status of artists by putting in place policies and measures addressing training, fair remuneration, social security, employment and tax conditions, mobility, and freedom of expression. It also affirms artists' rights to organise into professional bodies or unions to defend their interests.

UNESCO recognises that while the Recommendation predates many of today's technological developments, its provisions—particularly those on artists' income, economic rights, and creative freedom—remain especially relevant in contexts shaped by digital technologies and the Internet, where challenges such as online distribution, copyright, and protection of artists' material and moral interests have become more complex. [8]

Each of these normative instruments is encountering new interpretations, practices, and technical scenarios in the context of AI adoption. While the innovation potential is considerable, the associated risks must be addressed with vigilance and foresight. Among these: algorithmic biases that can misrepresent cultural identities, questions surrounding

---

2- UNESCO 1972 Convention for the Protection of the World Cultural and Natural Heritage

https://whc.unesco.org/archive/convention-en.pdf

4- UNESCO 1980 Recommendation concerning the Status of the Artist

https://unesdoc.unesco.org/ark:/48223/pf0000111428.locale=en

data ownership and consent, concerns over the authenticity of digital representations, and the risk of cultural homogenisation through automated systems open new interrogations. Addressing these issues requires interdisciplinary collaboration, participatory governance, and an adaptive policy environment.

Against this backdrop, the UNESCO Cairo Office initiated the AI and Culture Webinar Series to foster dialogue, promote knowledge exchange, and generate grounded reflections on the ethical and operational dimensions of AI in the cultural domain. Each session was structured to align with one of UNESCO's cultural Conventions or priority areas, collectively forming a comprehensive inquiry into the applications of AI across six cultural domains, and the ethical, legal, and policy considerations that accompany their implementation.

The seven thematic sessions were as follows:

- AI and Documentary Heritage – 21 January 2025
- AI and Intangible Cultural Heritage – 21 February 2025
- AI and Underwater Cultural Heritage – 27 March 2025
- AI and Cultural and Creative Industries – 29 April 2025
- AI and the Protection of Cultural Property in Emergencies – 27 May 2025
- AI and World Heritage Sites – 19 June 2025
- AI and Culture in the Arab Region: Regional Vision from Cairo – 25 June 2025

Through these events, we have invited over 40 global and regional leading experts as speakers and discussants, reflecting a wide array of academic, institutional, technical, and community-based perspectives across different geographical contexts. The webinar series has engaged more than 400 participants cumulatively across the Arab region and beyond, including stakeholders from Ministries of Culture, Tourism and Antiquities, Communications and Information technology, Academia, representatives of UNESCO National Commissions, members of ICOM, and ICOMOS, and representatives of cooperation development agencies in the Arab region and NGOs.

The purpose of this publication is threefold. First, it aims to consolidate the insights and findings generated through the webinar series, offering a multi-perspective overview of the current uses and debates around AI as case studies. Second, it seeks to document and disseminate emerging promising practices in the responsible application of AI technologies across six core cultural domains. Third, it is designed to strengthen regional and international dialogue on the role of AI in cultural policy, with particular emphasis on capacity-building, ethical guidance, and institutional preparedness in Member States.

In doing so, this publication contributes to UNESCO's broader strategic objectives related to digital transformation and cultural governance. It offers a resource for policymakers, cultural institutions, researchers, and civil society actors seeking to understand the implications of AI technologies and to engage with them constructively, in a manner that upholds the principles of cultural rights and diversity.

For more than a decade, we have been eagerly following experimentation with generative AI, and in recent years, we have learned about its uses and understood its limitations. We are aware of the environmental debt derived from its high energy cost. We read with concern about the technical and commercial disputes between technology gurus over applied research into future developments based on linguistic, visual or spatial recognition models. However, it seems that we have not yet given sufficient thought to the consequences of equipping algorithms with the ability to learn and make decisions autonomously, nor to the possibilities of providing more computing power to deep learning models. Meanwhile, academia and industry, in a reassuring attempt, keep us informed about the development of more intelligent algorithms while trying to persuade entrepreneurs by promoting more efficient research practices. In addition, the latest discoveries and challenges in neuroscience are creating a new frontier. We still do not know how our brain works, nor how our neural networks function, but we trust that algorithms will be able to increase the available human intelligence.

UNESCO's cultural conventions, initially designed for more analogue worlds, probably need to adapt their standards to virtual realities. Augmented realities and terabytes of data attempt to convey the visual, olfactory and tactile sensations of the Outstanding Universal Values by which a site is inscribed on the World Heritage List, while the authenticity of a musical performance understood as intangible heritage can be recorded in dozens of languages and translated immediately, and while the creative industry of audiovisual documentaries will be able to create visual certainties with fictional images, in short, credible but not true virtual realities. In view of this, the concepts of authorship, transmission, identity and cultural rights will require not only new epistemologies, but also a new multilateral ethic.

During our discussions, questions have arisen, such as: when is a work of art or literature considered finished? Who is the author of a melody generated with Chat tools? How should we report on non-real images and facilitate their publication in institutional editions? How will industries, including creative industries, be able to generate viable, low-cost business models? How can we guarantee more equitable access to culture for growing, million-strong virtual audiences? How can culture sustain critical awareness of new technological arenas? Are cultural conventions currently the regulatory frameworks that provide legal certainty for the implementation of generative AI in the field of culture? How can cultural Conventions

ensure that culture is a public good? Will there be more efficient forms of co-creation with robots? Do cultural industries have specific processing requirements? How can we ensure the longest and most fruitful future for our sound, oral, textual and olfactory heritage? How can we accelerate our capacity to document in the face of the imminent deliberate or forced disappearance of millennial collections and landscapes? How can we respond urgently to the need for data storage, ensuring the transmission of heritage over the long term, without being stranded by planetary blackouts?

The areas of application of AI cover a wide range of functions, from prediction and modelling to decision-making, with varying levels of autonomy and adaptability. In the field of culture, the possibility of increasing our creative intelligence, improving contemplation, mediation, creation, interpretation, observation and documentation are areas of experience that are already part of the AI landscape, and UNESCO's cultural conventions establish a fundamental framework for reflection on new ways of experiencing and consuming cultural diversity.

We have always been technological; what we need to ensure now is the preservation of humanity in digital use. We need to define, in record time, what human cultural heritage and the preservation of cultural legacies mean, without algorithms subordinating our capacities and our freedom of thought and expression. AI forces us to reflect on what it means to be human and on the role of the humanities in generating an epistemology for a new social/cultural contract. In the debate over the limits of humanity (the human condition), culture must help us ensure human control over the capabilities and skills of deep artificial intelligence. That must be the role of cultural capital: to act as a driving force for ongoing reflection that creates sufficient antibodies to anything that threatens our creative freedom. AI forces us to devise curricula for new cultural professions and to safeguard the role of art as the most unique space where what is truly human dwells, and to enhance our creative intelligence and our forms of transcendence.

The contributions presented here echo the need to propose new forms of dialogue with the industry. This working document serves as an observatory of professional practices, helping to establish a field of analysis and experimentation on what we cannot yet answer. These pages allow us to understand how culture can help us navigate the fragmentation of audiences, the volatility of networks, and textual worlds built on opinions, while taking us out of our virtual comfort zone.

Culture cannot lose its ability to guide our self-knowledge and ensure the role of social intelligence in decision-making. Culture must help combat the loss of our human skills and the pressure to consume culture only digitally, promoting understanding of the importance of accumulated knowledge and its forms of memory.

Foreword

We still need to visit museums where a QR code not only/mainly directs interaction; we need museums where photos are avoided so that we can enjoy personal and shared contemplation, where screens cannot exclude the third dimension or the spirit of the place, where tourists dressed up in costumes do not intimidate those who do not want to publicise their visit to a heritage site on social media, thus contributing to further reducing our deficit of reality.

Culture is also a process of self-knowledge, and we now need to trigger that function so as not to entrust our cultural decisions to thinking technologies, because that would mean placing limits on what it means to be human. We cannot allow ourselves to stray from our evolution. The culture that has made us human must be our rudder. We need culture to delve into complexities and foster innovative responses.

In contexts where criticism is increasingly rare, but more cultural studies are published, culture should act as a filter against information overload, as a sieve to select and confront the dehumanisation of decision-making processes. Culture has proven its ability to face uncertain horizons over millions of years, charting a course into the unknown and manifesting itself as a form of rebellion against the imposed. Culture shakes up the entry into another phase of our technological evolution and can re-signify our experience. The reserve of humanity is found in the reservoir of culture. Culture is the repository that gives meaning to our practice. May it continue to be so, and may technologies contribute to this human endeavour.

As we look ahead, it is evident that the responsible governance and application of AI in cultural fields will require sustained dialogue, inclusive policymaking, and targeted capacity-building. The UNESCO Cairo Office remains fully committed to advancing this agenda in close cooperation with Member States, regional partners, and global stakeholders. We hope that this publication will serve as a reference point for future cooperation and inspire new forms of innovation and solidarity in the use of AI for cultural development.

Paolo Fontani
Director,
UNESCO Regional Office in Beirut
OIC UNESCO Regional Office for Egypt and Sudan
/ Liaison Office with the League of Arab States

Acknowledgements

The work has greatly benefited from the contributions of a wide range of individuals and institutions. We express our sincere appreciation to the following authors for their original scholarly written contributions: Dr. Clément Godbarge, Dr. Andrea Barucci, Dr. Mladen Popović, Dr. Costanza Cucci, Dr. Gabriella Giannachi, Dr. Carlos Guedes, Dr. Karima Bouziane, Dr. Kasper Rodil, Dr. Fakhriya Al-Yahyai, Dr. Alaa Ababneh, Dr. Fabio Bruno, Dr. Guzden Varinlioglu, Dr. Alexandra Karamitrou, Dr. Baptiste Caramiaux, Dr. Katherine Elkins, Dr. Luke McDonagh, Dr. Florent Vinchon, Dr Amr Al-Azm, Dr. Primo Zingaretti, Dr. María-Ángeles Fuentes-Loureiro, Dr. Marinos Ioannides, Dr. Mohamed Gamal Abdelmonem, Dr. Sakai Masato, Dr. AbdelRahman Medhat, Dr. Nabil Bachagha, Dr. Riham Arram, Mr. Emad Blake, Dr. Noha Mellor, Dr. Haytham Nawar and Dr Noha Abou-Khatwa.

We also wish to thank the following speakers and discussants for their valued contributions to the webinars' presentations: Mr. Youssef Nader, Dr. Ahmed Mansour, Dr. Danilo Gigitto, Dr. Crystal El Safadi, Dr. Momen El-Husseiny, Dr. Amr Al-Azm, Dr. Marina Paolanti, Dr. Asmaa Mehdioui, Dr. Daniele Burisch, Dr. Giorgia Cafici, Dr. Fekri Hassan, Dr. Mahrous Elsanadidy, Dr. Noha Abou-Khatwa, and Dr. Rasha Metawi.

Dr Nuria Sanz, Akatsuki Takahashi, Ruoxi Wang, Jenna Khalil, Clara Epperlein, Ahmed Bayoumi, Amal Gad, Youssef Suleiman, Qianzi Wang and Lamees Amin Khalil at the UNESCO Cairo Office have supported the conception, organisation and edition of the results of the webinar series.

CHAPTER I

AI and Documentary Heritage


45 82 59 74 61 56 45 82 82 56
62 65 32 53 80 31 62 65 65 31
63 85 30 17 51 61 63 85 85 61
21 58 34 44 23 17 21 58 58 17
71 75 74 86 46 31 71 75 4

AI & Culture

Chapter 1

Artificial Intelligence and Documentary Heritage

Documentary heritage includes a diverse array of recorded knowledge—such as manuscripts, archives, rare books, inscriptions, audiovisual materials, and digital records—that collectively preserve humanity's memory. Under UNESCO, this heritage is primarily protected through initiatives like the Memory of the World Programme, which fosters the preservation, access, and awareness of globally significant documentary collections. The 2015 Recommendation on Documentary Heritage emphasizes the importance of safeguarding these materials. These efforts are further supported by broader frameworks, including the 1972 World Heritage Convention and the 2003 Convention for the Safeguarding of Intangible Cultural Heritage, highlighting the connections between documentary, tangible, and living heritage.

The rapid growth of artificial intelligence (AI) offers both exciting opportunities and significant challenges in this field. AI facilitates large-scale digitization, automated transcription, metadata creation, and improved access to fragile or dispersed archives. However, it also raises concerns about data bias, authenticity, intellectual property, and the ethical use of digitized cultural materials. These issues increasingly demand governance in line with UNESCO's normative role, particularly highlighted by the 2021 Recommendation on the Ethics of Artificial Intelligence.

Scholarly work in this chapter illustrates how AI is transforming both the value and methods of preserving documentary heritage. Dr. Godbarge argues that digitization should be seen not just as a cultural preservation effort but also as an economic necessity, given the rising demand for high-quality training datasets for AI systems.

This perspective positions documentary heritage as a strategic asset in the global data economy. Meanwhile, Dr. Barucci discusses AI's significant impact on Egyptology, especially in deciphering complex scripts like Hieratic. Collaborating with experts, annotated datasets and machine learning models are providing deeper insights into ancient Egyptian administrative and cultural systems.

Dr. Popović shows how pattern recognition and AI techniques applied to multispectral imaging can solve longstanding palaeographic issues, such as identifying anonymous scribes and dating manuscripts through stylistic analysis. Additionally, Dr. Cucci highlights the capabilities of advanced imaging technologies like hyperspectral imaging, which create rich datasets that far exceed traditional RGB photography. These datasets help recover faded or invisible text features, greatly improving the readability and understanding of damaged inscriptions and manuscripts.

Collectively, these contributions signify a shift in the documentary heritage field, where AI serves not only as a preservation tool but also as a catalyst for new knowledge and interdisciplinary collaboration. From deciphering undeciphered scripts to reconstructing lost texts and redefining heritage as a valuable data resource, AI enhances the scope and impact of documentary heritage work.

However, these advancements underscore the importance of balanced approaches that integrate technological innovation with ethical safeguards, capacity building, and international cooperation. As UNESCO and its partners continue to be a hub for ideas, setting standards, and fostering collaboration, integrating AI into documentary heritage presents a promising avenue for preserving the past and shaping the future of shared human knowledge.

Rethinking Documentary Heritage Digitisation: An AI-Centred Economic Model

© Clément Godbarge



Dr. Clément Godbarge

Lecturer in Digital Humanities, School of Modern Languages, University of St Andrews, United Kingdom.

Abstract

The paper proposes a strategic shift in how we approach documentary heritage digitisation, framing it as an economic imperative driven by AI technology's growing need for high-quality training data. Current AI language models, whilst powerful, rely heavily on web-scraped content that represents only a fraction of human knowledge. This limitation presents an opportunity to reimagine heritage digitisation not merely as preservation but as a strategic investment in our digital future. Through AI-powered tools and workflows, digitization can become more cost-effective and scalable; yet, the humanities sector needs to fundamentally restructure its approach.

The paper critically examines current academic practices that favour expensive, grant-funded flagship projects over sustainable, replicable workflows. To achieve meaningful scale in heritage digitisation, we need practical reforms in academia, including revised tenure criteria, micro-grant programmes, and stronger data-sharing practices. By learning from the life sciences and computer science sectors, humanities departments can develop more efficient approaches that balance scholarly rigour with practical scalability. This new economic model for digitisation promises to unlock the vast potential of our documentary heritage whilst fostering innovation and reducing technological monopolies in the AI sector.

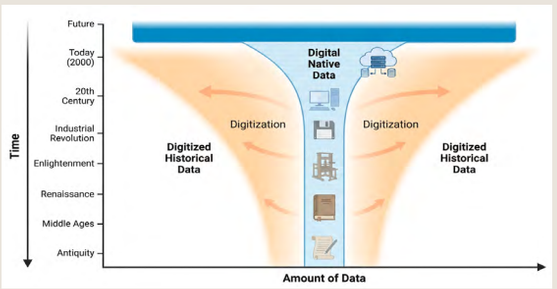


Figure 1: The Effects of Large Scale Historical Digitisation. Conceptual model after Frédéric Kaplan (2013). © Clément Godbarge

I

Digitising our written heritage has never been so important—not just for preservation, but as a strategic investment in our economies. Research suggests that high-quality text data is growing increasingly scarce, as humanity struggles to produce enough digital material to meet the demands of technology companies for training, fine-tuning, and evaluating their frontier Large Language Models (LLMs).[1]

Whether this "data scarcity" will truly hinder progress remains a matter of debate. Experts, such as Yann LeCun, argue that future advances will hinge less on ever-growing datasets and more on shifts in AI architecture.[2] Yet discussion about data shortages is often misguided by a flawed commonplace—namely that the vast pools of web-scraped data training LLMs represent "the sum of human knowledge."[3] As a consequence, AI experts and industry leaders tend to focus their attention on artificial data or algorithmic innovation, while neglecting the vast resources that our heritage could provide.

That LLMs embody humanity's collected wisdom is wishful thinking. Even a cursory glance at our book collections and archives reveals how far today's models stand from the lofty ideals of a universal library. They merely scratch the surface of human culture, lacking in historical depth and linguistic diversity. Their grasp of the past relies on a narrow and fragmentary collection of secondary-source literature, predominantly written in English. For a technology that is increasingly central in multimedia content creation, this imbalance raises pressing concerns about accuracy and inclusiveness.

To address these shortcomings, a comprehensive, systematic digitisation of our shared cultural heritage should be a priority, particularly for regions where cultural artefacts risk destruction from war, climate change, or neglect. Such efforts are more than mere preservation initiatives. They represent strategic investments with multiplicative benefits. By creating public repositories of heritage data, we can stimulate AI-driven innovation, foster market competition, and reduce technological monopolies.[4]

Crucially, artificial intelligence itself is now helping to make this process more scalable and cost-effective. Advances in machine learning are cutting digitisation expenses by streamlining labour-intensive tasks. Printed and handwritten text recognition, as well as LLM-based coding assistants, are transforming editorial work, making it possible to transcribe and encode vast collections efficiently. These tools are not simply accelerating existing workflows; they are reshaping the very economics of digitisation, allowing scholars to produce high-quality datasets at a scale previously unimaginable.

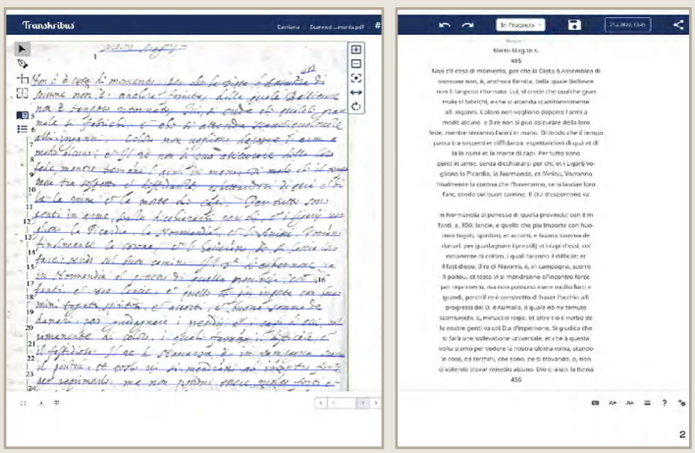


Figure 2: Transkribus Digital Text Recognition Application © Clément Godbarge

Platforms such as Transkribus demonstrate how these technologies have become integral to academic work: scholars with limited technical expertise can now train and share neural network models to digitise ever-larger collections of written heritage.

Discourses on productivity and economic performance are uncommon in the humanities. Yet, a frank conversation on the topic is necessary if we want to increase the scale and impact of digitisation.

A robust economic model for digitisation workflows is crucial, and although AI can make significant contributions, we cannot rely solely on technological innovation. Recalibrating scholarly values and funding strategies is equally important.

Indeed, by viewing digitisation projects primarily as vehicles for securing grants, humanities departments tend to neglect the development of economically sustainable practices. While flagship digital humanities projects have produced exemplary scholarly editions, their costs can often exceed $1 million for relatively small collections.

Their workflows, which rely heavily on specialized researchers performing manual work, are neither scalable nor replicable without substantial institutional support.

Secrets of Craft and Nature, a digital edition to which I contributed, is a notable example.[5] Praised for its findings and innovations, this award-winning project took no fewer than five years to complete, relying on major funding from private foundations and public institutions. Despite its scholarly achievements, such a resource-intensive approach cannot be scaled globally.

To truly think big, we must also think small. While pursuing ambitious projects like *Secrets of Craft and Nature,* we also need to develop efficient, replicable workflows that can be widely adopted.

1. Pablo Villalobos, Anson Ho, Jaime Sevilla, Tamay Besiroglu, Lennart Heim, and Marius Hobbhahn, "Will We Run out of Data? Limits of LLM Scaling Based on Human-Generated Data," arXiv, 2022, https://doi.org/10.48550/ARXIV.2211.04325.

2. Yann LeCun (@ylecun), "Using more data (synthetic or not) is a temporary stopgap made necessary by the limitations of our current approaches," X (formerly Twitter), 23 November 2023, https://x.com/ylecun/status/1727575133143875919.

3. The Guardian, "Elon Musk Warns of Data Shortages for AI Training," The Guardian, 9 January 2025, https://www.theguardian.com/technology/2025/jan/09/elon-musk-data-ai-training-artificial-intelligence.

4. OECD, Enhancing Access to and Sharing of Data: Reconciling Risks and Benefits for Data Re-use across Societies (Paris: OECD Publishing, 2019), https://doi.org/10.1787/276aaca8-en.

5. Making and Knowing Project, Pamela H. Smith, Naomi Rosenkranz, Tianna Helena Uchacz, Tillmann Taape, Clément Godbarge, Sophie Pitman, Jenny Boulboullé, Joel Klein, Donna Bilak, Marc Smith, and Terry Catapano, eds., Secrets of Craft and Nature in Renaissance France. A Digital Critical Edition and English Translation of BnF Ms. Fr. 640 (New York: Making and Knowing Project, 2020), https://doi.org/10.7916/78yt-2v41.

This transformation requires a shift in academic culture, particularly in humanities departments, where theoretical and interpretive scholarship often overshadow empirical research and textual editing. High-level analysis is vital, but neglecting efforts to edit text in robust, sustainable digital formats undermines the broader potential of the humanities, particularly when technology can so powerfully amplify that potential.

Practical steps include revising tenure criteria to value digital editions, creating accessible micro-grant programmes that encourage cost-effective approaches, and fostering stronger data-sharing practices. The humanities can learn from the life sciences and computer science, where open data sharing has created thriving commercial ecosystems despite intellectual property considerations.

Ironically, while these fields generate considerable proprietary content, they have made better use of public data for economic growth than humanities scholars working with cultural heritage.

Many remain unconvinced of the value in openly sharing research data. Overcoming this hesitation will require clearer institutional incentives, a re-evaluation of academic priorities, and a renewed focus on collaboration—steps essential for achieving the scale of digitisation our collective heritage deserves.

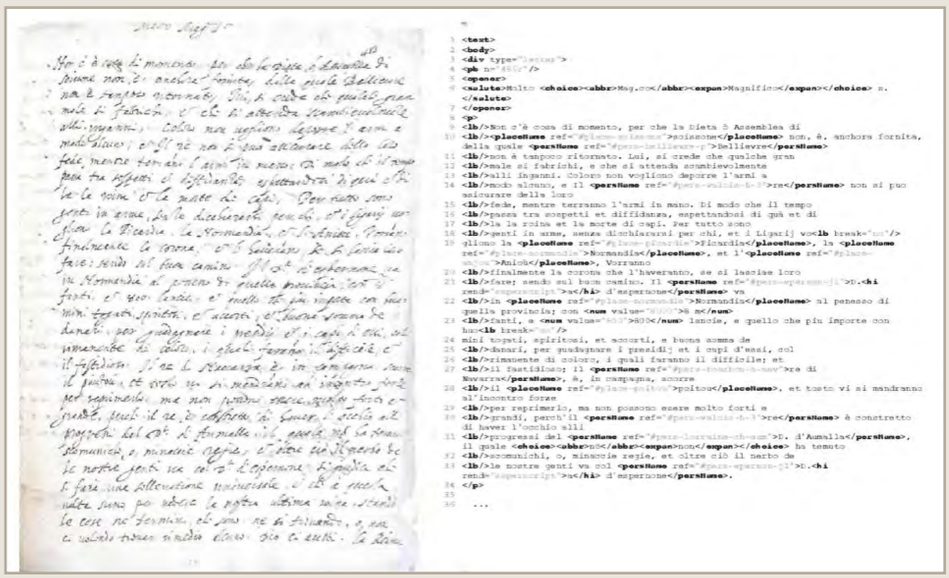


Figure 3: Digital Text Recognition © Clément Godbarge

Recommendations for Enhancing Cultural Heritage Digitisation

1. Promote Scalable, Cost-Effective Workflows: Universities, libraries, and cultural institutions should collaborate on open-source tools and shared protocols for digitisation. Leveraging AI-driven text recognition, automated metadata generation, and cloud-based repositories can reduce costs and standardise processes. This approach enables smaller collections to be digitised effectively by a greater number of people.

2. Make Cultural Heritage Digitisation Attractive: UNESCO should advocate for tech companies and governments to invest massively in the digitisation of cultural heritage, highlighting the mutual benefits for economic growth, heritage preservation, and cultural diversity. By supporting these efforts, tech companies can enhance AI training data, promote corporate social responsibility, foster innovation, and support global knowledge sharing.

3. Update Funding Strategies: Cultural and academic institutions should diversify funding strategies beyond traditional grant models. This includes promoting micro-grant programmes to help scholars complement research with digital editions of primary source documents.

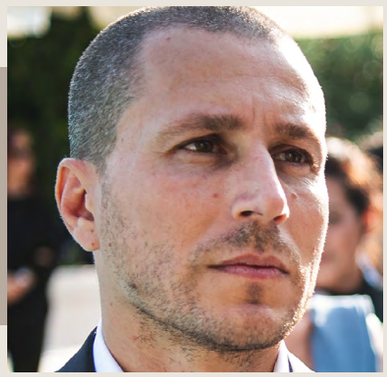
4. Incentivise Academic Culture Change: Universities and research institutions must recognise and reward the labour involved in creating digital editions, just as they do for traditional academic publications. Revising tenure and promotion criteria to value data curation and editorial work will motivate researchers to engage with digitisation.

5. Champion Open Data Sharing: Drawing lessons from fields such as computer science and the life sciences, humanities scholars should adopt open data principles. By making digitised collections accessible as public goods, institutions create a fertile environment for academic research, commercial partnerships, and creative reuse. This openness also supports competition in AI, fostering both technical and economic dynamism.

6. Promote Cross-Disciplinary Collaboration: Bringing together expertise from the humanities, computer science, economics, and library sciences can produce more robust and user-friendly digitization initiatives. Joint projects foster innovation, pool resources, and create a shared sense of ownership, ultimately multiplying impact and reach.

Ancient Texts and New Technologies in the Era of Artificial Intelligence

© Andrea Barucci



Dr. Andrea Barucci

Institute of Applied Physics "Nello Carrara" (IFAC), National Research Council, Italy

Abstract

Artificial Intelligence (AI) is revolutionizing the preservation of cultural heritage by enhancing the accessibility, documentation, and understanding of ancient artifacts. Our team has been focusing on Egyptian hieroglyphs and the Hieratic writing system. This work involves applying artificial intelligence techniques to analyze and interpret ancient scripts. For instance, deep learning models have been developed to classify Egyptian hieroglyphs with high accuracy automatically. Through deep learning models, we have developed workflows capable of accurately segmenting and classifying hieroglyphic symbols.

Collaborations with Egyptologists have further highlighted AI's potential in deciphering complex scripts, such as Hieratic, leading to the creation of annotated datasets and AI models that facilitate the exploration of ancient Egyptian administrative and cultural history.

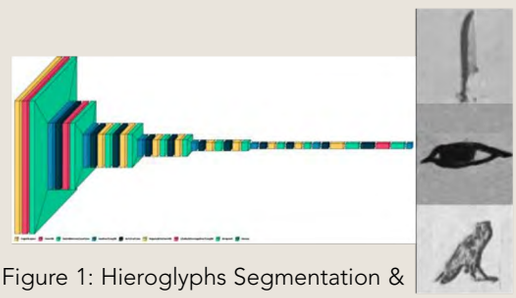


Figure 1: Hieroglyphs Segmentation & Classification © Andrea Barucci

This synergy between AI and cultural heritage not only uncovers previously inaccessible details of artifacts but also promotes ethical preservation by minimizing physical intervention. The ultimate goal is to inspire international collaboration and innovation, integrating AI into a cohesive framework that ensures sustainability and fosters a deeper understanding of the diverse narratives encapsulated in ancient writings.

I

Exploring Cultural Heritage through Artificial Intelligence

The preservation of cultural heritage is undergoing a significant transformation with the advent of Artificial Intelligence. These tools are bridging the gap between traditional methodologies and modern technology, offering new avenues for the study and conservation of ancient artifacts. A prime example of this interdisciplinary effort is the application of AI in analyzing Egyptian hieroglyphs and the Hieratic writing system.

Deep learning models, such as Glyphnet and Detectron2, have been instrumental in developing workflows that can segment and classify hieroglyphic symbols with remarkable precision[1,2,3]. Glyphnet, for instance, achieves an impressive 97% accuracy in classifying single hieroglyph images, while Detectron2 excels in handling complex images containing multiple glyphs.

This approach not only supports archaeologists in their transliteration efforts but also lays the groundwork for building digital archives that preserve these symbols for future generations.

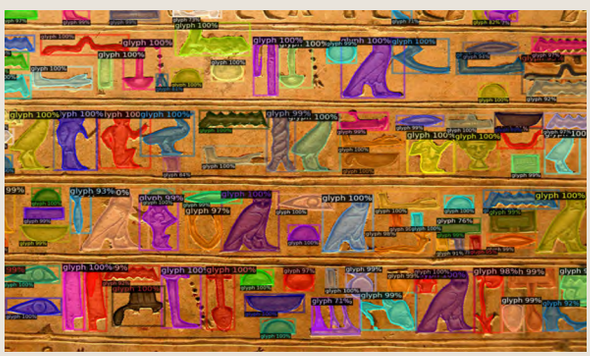


Figure 2: Our results on Egyptian hieroglyphs segmentation © Guidi2023; Barucci2023.



Figure 3: An example of hieroglyphs segmentation using the Detectron2 framework as reported in © Guidi2023; Barucci2023.

In our work, we started with ancient Egyptian hieroglyphs. Still, collaborations with Egyptologists have highlighted the limited focus of transliteration efforts on hieroglyphs, prompting a shift towards the more complex Hieratic writing system.

Used in administrative and religious texts, Hieratic presents unique challenges for AI due to its fluid and non-standardized forms. To address this, we have developed workflows that start from high-resolution image acquisition (already available thanks to our collaboration with the Egyptian Museum of Turin in Italy), semi-automatic segmentation, and the use of computer vision tools to curate and annotate datasets.

To date, this effort has produced a dataset with about one thousand annotations across more than 130 distinct classes, demonstrating excellent segmentation results and promising classification accuracy of up to 85%. This work offers a new perspective for exploring and interpreting the rich environment of ancient Egyptian administrative and cultural history.[4]

However, the transformative role of AI in cultural heritage extends beyond the analysis of writing systems. By employing machine learning, researchers can uncover details of ancient artifacts that were previously inaccessible, such as hidden inscriptions, layered texts, and degraded materials.

Workflow Development



Figure 4: Workflow © Guidi2023; Barucci2023.

This capability not only contributes to digital preservation but also supports ethical considerations by minimizing physical intervention in fragile artifacts[5]. These efforts aim to inspire international collaboration and innovation in heritage preservation. The ultimate goal is to integrate AI into a cohesive framework that promotes accessibility, ensures sustainability, and fosters a deeper understanding of the diverse narratives encapsulated in ancient writings.

Initiatives like the UNESCO webinar serve as critical platforms for sharing these insights, discussing policy trends, and identifying priorities for the future of cultural heritage preservation.

By addressing challenges such as data annotation, computational complexity, and explainability, the interdisciplinary use of AI in cultural heritage is paving the way for more sophisticated tools and techniques. These advancements promise to revolutionize the preservation and interpretation of ancient texts, enabling us to "boldly go where no algorithm has gone before."

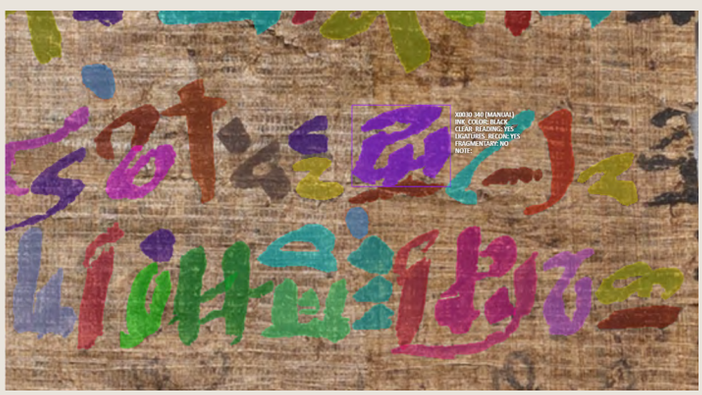


Figure 5: Our results on Egyptian Hieratic, as presented in Turin (2024) © Guidi2023; Barucci2023.

1.Barucci, Andrea, Costanza Cucci, Massimiliano Franci, Marco Loschiavo, and Fabrizio Argenti. "A deep learning approach to ancient egyptian hieroglyphs classification." Ieee Access 9 (2021): 123438-123447, doi: 10.1109/ACCESS.2021.3110082.

2. Guidi, Tommaso, Lorenzo Python, Matteo Forasassi, Costanza Cucci, Massimiliano Franci, Fabrizio Argenti, and Andrea Barucci. "Egyptian hieroglyphs segmentation with convolutional neural networks." Algorithms 16, no. 2 (2023): 79. https://doi.org/10.3390/a16020079

3. Barucci, Andrea, Michela Amendola, Fabrizio Argenti, Chiara Canfailla, Costanza Cucci, Massimiliano Franci, Tommaso Guidi, and Lorenzo Python. Discovering the Ancient Egyptian Hieroglyphs with Deep Learning. Consiglio Nazionale delle Richerche (CNR), 2023., 2023 Consiglio Nazionale delle Ricerche (CNR), Roma, Italia; ISBN: 978-88-947081-1-0; DOI: 10.5281/zenodo.11443010; http://eprints.bice.rm.cnr.it/22377/; Biblioteca Museo Egizio di Torino: Inv. 16126; Collocazione: F-III-114; https://biblioteca.museoegizio.it/ricerca/dettaglio/discovering-the-ancient-egyptian-hieroglyphs-with-deep-learning/13888

4. Invited presentation to the International Symposium "Memory is our Future, Museo Egizio in Turin, 16 - 18 December 2024. This event is part of the Bicentenary celebrations of the Museo Egizio. Panel "Ancient and new technologies"

5. Cucci, Costanza, Tommaso Guidi, Marcello Picollo, Lorenzo Stefani, Lorenzo Python, Fabrizio Argenti, and Andrea Barucci. "Hyperspectral imaging and convolutional neural networks for augmented documentation of ancient Egyptian artefacts." Heritage Science 12, no. 1 (2024): 75. https://doi.org/10.1186/s40494-024-01182-9

Recommendations for Integrating AI into Cultural Heritage Preservation

1. **Foster Interdisciplinary Collaboration:** Encourage partnerships between technologists, historians, archaeologists, and conservators to ensure that AI applications are informed by domain-specific knowledge and address the nuanced needs of cultural heritage preservation.

2. **Develop Comprehensive Datasets:** Invest in the creation and curation of extensive, annotated datasets that represent the diversity of artifacts and scripts. High-quality data is essential for training effective AI models that can perform accurate analysis and interpretation.

3. **Prioritize Ethical Considerations:** Establish ethical guidelines that govern the use of AI in cultural heritage, emphasizing the minimization of physical intervention in artifacts, respect for cultural sensitivities, and the importance of data sovereignty, especially concerning indigenous and local communities.

4. **Enhance Accessibility and Public Engagement:** Utilize AI to create interactive and educational tools that make cultural heritage more accessible to the public. Virtual reconstructions, digital archives, and AI-driven educational platforms can engage a broader audience and promote appreciation for cultural heritage.

5. **Invest in Capacity Building:** Provide training and resources for heritage professionals to develop AI literacy. Equipping conservators and researchers with the skills to leverage AI tools will facilitate their integration into preservation practices and encourage innovation.

6. **Ensure Transparency and Explainability:** Develop AI models that are transparent and provide explanations for their outputs. This approach fosters trust among heritage professionals and enables the validation and interpretation of AI-generated insights.

7. **Promote Open Access and Data Sharing:** Encourage the sharing of data, methodologies, and AI models within the cultural heritage community. Open access fosters collaboration, accelerates innovation, and ensures that advancements benefit a wide range of institutions and stakeholders.

8. **Address Technical Challenges:** Focus research efforts on overcoming technical hurdles such as computational complexity, data variability, and the need for models that can generalize across different types of artifacts and scripts.

9. **Monitor and Evaluate Impact:** Implement mechanisms to continually assess the effectiveness of AI applications in preservation efforts. Regular evaluation ensures that AI tools are meeting their intended goals and allows for iterative improvements based on feedback.

10. **Advocate for Policy Support:** Engage with policymakers to develop supportive frameworks that facilitate the integration of AI into cultural heritage preservation. Policies should address funding, ethical standards, and the promotion of interdisciplinary research.

By following these recommendations, stakeholders can harness the transformative potential of AI to preserve and enrich our shared cultural heritage for future generations.

Combining AI, the Sciences, and the Humanities to Innovate the Study of Ancient Manuscripts

© Mladen Popović



Dr. Mladen Popović

Professor of Hebrew Bible and Ancient Judaism, University of Groningen, Netherlands

Abstract

This article describes the application of pattern recognition and AI techniques on digitized multispectral images of ancient handwritten manuscripts to solve two fundamental problems in the palaeography—the study of ancient handwriting—of the Dead Sea Scrolls: firstly, to identify the anonymous scribes; secondly, to date manuscripts based on their writing style, as none carries a calendar date. The images are binarized by using an in-house developed deep neural network for the detection of handwritten ink-trace patterns, BiNet.

This allows for geometric shape-based analysis at textural and allographic levels, providing explainability (interpretability) and preventing the presence of a black box in our algorithm. This empirical evidence combined with statistical evidence allows for robust writer identification. For dating purposes, AI techniques and methods are combined with 14C dating, because radiocarbon dates give an objective date for the writing styles in the tested manuscripts, which can be used to train the date-prediction model called Enoch. The corresponding handwritten style featured in the tested manuscript images can then be used to estimate the date of undated manuscripts. The methods underpinning Enoch can also be used for date prediction in other partially dated manuscript collections.

I

The ERC project The Hands That Wrote the Bible is at the intersection of historical research into manuscripts from antiquity and the most modern techniques of Artificial Intelligence (AI) and machine learning. A major challenge of historical research, especially when going far back in time, is the scarcity of available source material. The emerging field of AI is known for being able to make great strides with big data.

However, the challenge for AI is to be able to work reliably with a very limited amount of data and to be able to perform a thorough analysis. We have succeeded in setting up a complete computational processing line for the application of AI techniques to the Dead Sea Scrolls that yields new empirical, quantitative results, with which historians and manuscript experts can unlock new insights into the past. The techniques we developed are applicable not only to the Dead Sea Scrolls but also to other historical corpora.

The project was set up to tackle two fundamental problems in the palaeography—the study of ancient handwriting—of the Dead Sea Scrolls: to identify anonymous scribes and to date manuscripts based on their writing style, as none carries a calendar date. These issues are not only problems with palaeography. Solving these problems has important implications for our ability to better understand the Dead Sea Scrolls as a collection of writings of diverse origins and genres, and also to better understand text production, consumption, and collection practices in ancient Judaea, which means that we will be in a better position to understand ancient textual and reading cultures—ultimately, cultures of hands that wrote the Bible before the Bible was more or less finalized.

The problem with writer identification in the Dead Sea Scrolls is that there is no robust method in palaeography for how to determine and verify writer identity. On the one hand, scribes may show a range in a variety of forms of individual letters in one or more manuscripts. On the other hand, different scribes might be written in almost the same way, making it a challenge to identify the individual scribe beyond general stylistic similarities. The problem with knowing which differences are likely to be idiographic, and thus significant, is that, in the end, this involves using implicit criteria that are experience-based.

The problem with dating manuscripts by style/typological development is that the finer typological distinctions and chronological estimations of the scripts in the third century BCE until the first century CE lack a sound empirical basis, which is why palaeographers sometimes gave very different dates for individual manuscripts.

The basic idea of the project is to use the physical evidence of the manuscripts and, more precisely, the handwriting on the manuscripts as a new entry point to access this ancient scribal culture and also to pioneer the microlevel of individual scribes.

The big pay-off is the ability to quantify the data and to stimulate palaeographers to explain their reasoning. The combination of disciplines provides a new and much-needed empirical and quantitative basis for the typological estimations of traditional palaeography.

In order to get there, we apply pattern recognition and artificial intelligence techniques on digital images that were kindly provided for us by Brill Publishers as well as on digitized multispectral images from the Leon Levy Dead Sea Scrolls Digital Library of the Israel Antiquities Authority. The assumption is that the ink traces can be analysed at the pixel level as the effects of an ancient scribe's muscle movement and as such can be quantified (geometric character-shape-based analysis). Furthermore, we performed radiocarbon testing on samples kindly provided for us by the Israel Antiquities Authority so as to have ground truths based on physical evidence for dating the manuscripts. New tests were necessary because of castor oil contamination issues with most of the samples that were tested in the 1990s in Zürich, Oxford, and Tucson, Arizona.

In the case of ancient manuscripts such as the Dead Sea Scrolls, which are often heavily damaged and fragmented, it is crucial to provide the data (the ink traces were written by scribes more than 2000 years ago) as cleanly as possible for further analysis.

To do this, it is necessary to distinguish the foreground (the writing) from the background (the leather or papyrus of the manuscript, shadows and frayed edges visible on the digital images, color codes, etc.). This process of distinguishing is called binarization. Binarization is relatively easy for modern texts, especially when they are typed. For historical handwritten texts, it is a challenge. For the Dead Sea Scrolls, it is not possible to do this well with existing techniques such as Otsu, Niblack or Sauvola. Maruf Dhali, who worked as a PhD on the project The Hands that Wrote Bible, developed a new optimized binarization process, called BiNet, based on deep learning and novel image fusion techniques that also outperforms current state-of-the-art machine learning-based models such as CGAN.[1] This is crucial for the extraction of the ink traces on digital images, which can then be geometrically analyzed at the pixel level.

Handwritten texts are the result of muscle power and the speed with which the ink is written down. Therefore, it is important to be able to extract only the ink traces and separate them from the background texture, because this allows the individual hand of the writer to be analyzed.

Since the 1950s, scholars have disagreed about whether the Great Isaiah Scroll was written by one or two scribes. The handwriting in the Great Isaiah Scroll seems near uniform, which is why it seems that most scholars think that the entire manuscript was written by one scribe, but no one has been able to provide a conclusive palaeographic substantiation for either possibility.[2]

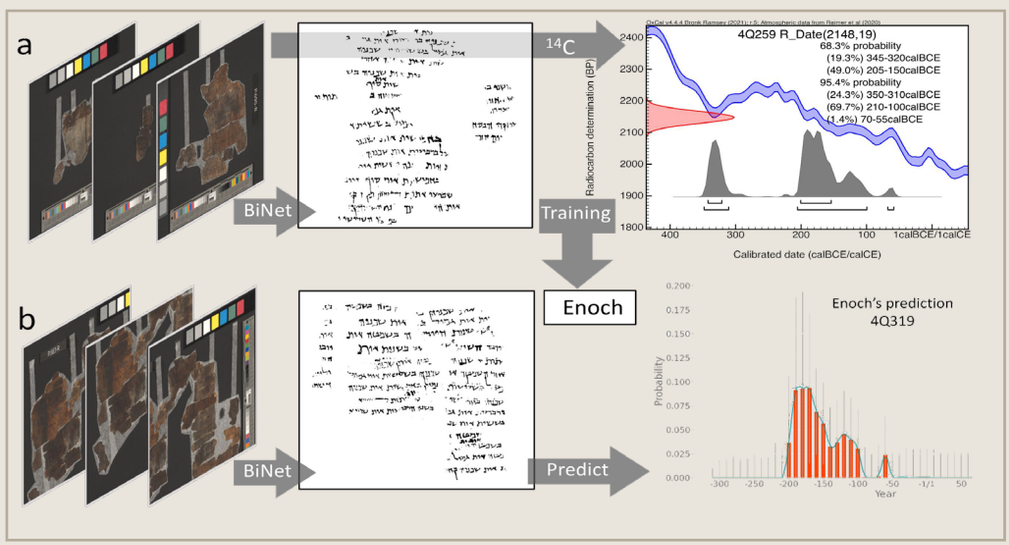


Figure 1: The Enoch Dating Process© Mladen Popović/ Maruf Dhali

Palaeography involves comparing the handwriting styles of various manuscripts to identify potential scribes. This method relies heavily on the skill and expertise of the palaeographer, who must examine the specific characteristics of letterforms, spacing, and other writing conventions. However, palaeography has its limitations. One of the limitations is the difficulty of distinguishing the variability of handwriting of one writer from that of another writer who writes in a similar style. Another limitation is the processing of large amounts of data. The Great Isaiah Scroll contains 54 columns of Hebrew text. The number of instances of a specific letter may run in the thousands. For example, the letter aleph occurs at least five thousand times. It is impossible to compare them all just by eye.

Computers are well suited to analyse large datasets, for instance, 5,000 handwritten alephs. Digital imaging makes all sorts of computer calculations possible, at the micro-level of characters, such as measuring curvature (called textural), as well as at the macro-level of whole characters (called allographic).

In the first step, our 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. This coincides with a codicological break between columns 27 and 28 in the form of a three-line lacuna at the bottom of column 27, and there is also a change of sheet between columns 27 and 28, i.e., two sheets are sewn together at this point.

In a second step we then recomputed the similarities between the columns, now using the patterns of letter fragments, and applied several statistical tests. This second analytical step confirmed the presence of two different signal sources. Several further checks and controls were performed, such as adding extra noise to the data, but the result did not change.

The most likely explanation for the two different signal sources in the data is that two scribes were responsible for the copying of the Great Isaiah Scroll, not that there was a change of pen by one scribe or that the writing conditions of one scribe changed dramatically between the two halves of the manuscript, for example, due to writing fatigue or a significant age difference.

We also succeeded in demonstrating that the second scribe shows more variability within his writing than the first, although their writings were very similar.

In the third step of visual analysis, we presented heatmaps, for example, showing one possibility for how to get from computerized and statistical analysis to human interpretation of the data. These heatmaps show minute but significant differences between characters from the two halves of the Great Isaiah Scroll, because a heatmap represents all particular instances of a character.

The significant breakthrough of this study is the use of empirical evidence (character-shape-based analysis from geometry) combined with statistical evidence that provides a degree of quantified objectivity to palaeography that had never been provided in the field, thereby reducing palaeographic subjectivity and the role of implicit expert knowledge.

This study of the Great Isaiah Scroll opens up a new way to analyse ancient texts based on physical characteristics. Now, researchers can, as it were, shake hands with individual scribes through their handwriting, and carefully observe how they worked on these manuscripts. This is 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. While our ongoing research on other scrolls may suggest different origins or training for their scribes,[3] the evidence we found for a very similar writing style shared by the two Great Isaiah Scroll scribes suggests a common training or origin in this case.

1. Maruf A. Dhali, Jan Willem de Wit, and Lambert Schomaker, "BiNet: Degraded-manuscript binarization in diverse document textures and layouts using deep encoder-decoder networks," arXiv preprint (2019), https://arxiv.org/abs/1911.07930.

2. Mladen Popović, Maruf A. Dhali, and Lambert Schomaker, "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 16/4 (2021): 1–28, doi.org/10.1371/journal.pone.0249769.

3. Gemma Hayes, "Searching for Dead Sea Scribes: A Study on Using Artificial Intelligence and Palaeography for Writer Identification in Correlation with Spelling and Scribal Practices, Codicology, Handwriting Quality, and Literary Classification Systems for the Dead Sea Scrolls," PhD diss. University of Groningen, 2023, 10.33612/diss.563365951; Mladen Popović, "Book Production and Circulation in Ancient Judaea as Evidenced by Writing Quality and Skills in the Dead Sea Scrolls Isaiah and Serekh Manuscripts," in The Dead Sea Scrolls in Ancient Media Culture, ed. Travis B. Williams, Chris Keith, and Loren T. Stuckenbruck, STDJ 144 (Leiden: Brill, 2023), 199–265.

4. Mladen Popović, Maruf A. Dhali, Lambert Schomaker, Johannes van der Plicht, Kaare Lund Rasmussen, Jacopo La Nasa, Ilaria Degano, Maria Perla Colombini, Eibert Tigchelaar, "Dating ancient manuscripts using radiocarbon and AI-based writing style analysis," PLoS One 20/4 (2025): https://doi.org/10.1371/journal.pone.0323185.

AI-supported writer identification offers unprecedented opportunities for historical research into the social circumstances of manuscript and text production in antiquity at the micro level of individual scribes. In the case of the Great Isaiah Scroll, for example, this concerns new insights into the writing skills and qualities of scribes, such as the meticulous imitation of each other's handwriting or the fact that one scribe wrote slightly less neatly than the other scribe, which is not clearly visible to the naked eye but can be unlocked thanks to AI techniques.

We also developed a model, called Enoch, named after the ancient Jewish science hero, to provide an empirical basis for the manuscript dating of the Dead Sea Scrolls.4 For this purpose, we combined AI techniques and methods with 14C dating. Until then, the dating of individual manuscripts was based on palaeography alone, but this lacked a solid foundation. The radiocarbon dates provide an objective date for the writing styles in the tested manuscripts, which can be used to train the AI model. The corresponding handwritten style features in the tested manuscript images can then be used to estimate the date of the undated manuscripts.

We pursue a probability-based strategy, applying a Bayesian regression method and using the full probability distribution of radiocarbon dating to ensure transparency and interoperability. In doing so, we provide a powerful new tool that paleographers and historians can use to support, refine, or modify their own subjective estimations for specific manuscripts, often to an accuracy of only 50 years for manuscripts over 2,000 years old. The combination of empirical evidence (14C from physics and character-form-based analyses from geometry) brings a degree of quantified objectivity to paleography that had never before been achieved in the field.

To be clear, human experts are in control. The AI model is a tool, like the microscope for a biologist. It helps us to look better at the evidence, explicate and clarify our own reasoning. The model helps to generate data from texts that we otherwise would not be able to know, such as identifying scribes and dating manuscripts more securely. This enables new ways of researching ancient manuscripts, combining material studies with content-driven research and providing new insights into the ancient world.

And for the Dead Sea Scrolls in particular, the combination of AI and radiocarbon dating is leading to new and often older dates for individual manuscripts, allowing new insights to be developed about literacy in ancient Judaea in relation to historical, political, and cultural developments such as urbanization, the rise of the Hasmonaean dynasty, and the rise and development of religious groups such as those behind the Dead Sea Scrolls and the early Christians.

Recommendations on future actions:

- As the guardian of world heritage, UNESCO can play a key role in connecting researchers and conservators of documentary heritage in order to facilitate the exchange of good practices on AI and documentary heritage across very diverse corpora.

- With regard to custodianship of world memory, UNESCO can advocate with national governments for the crucial importance of investing in the digitization, also by means of AI, and of a democratic approach to unlocking the treasures of documentary heritage.

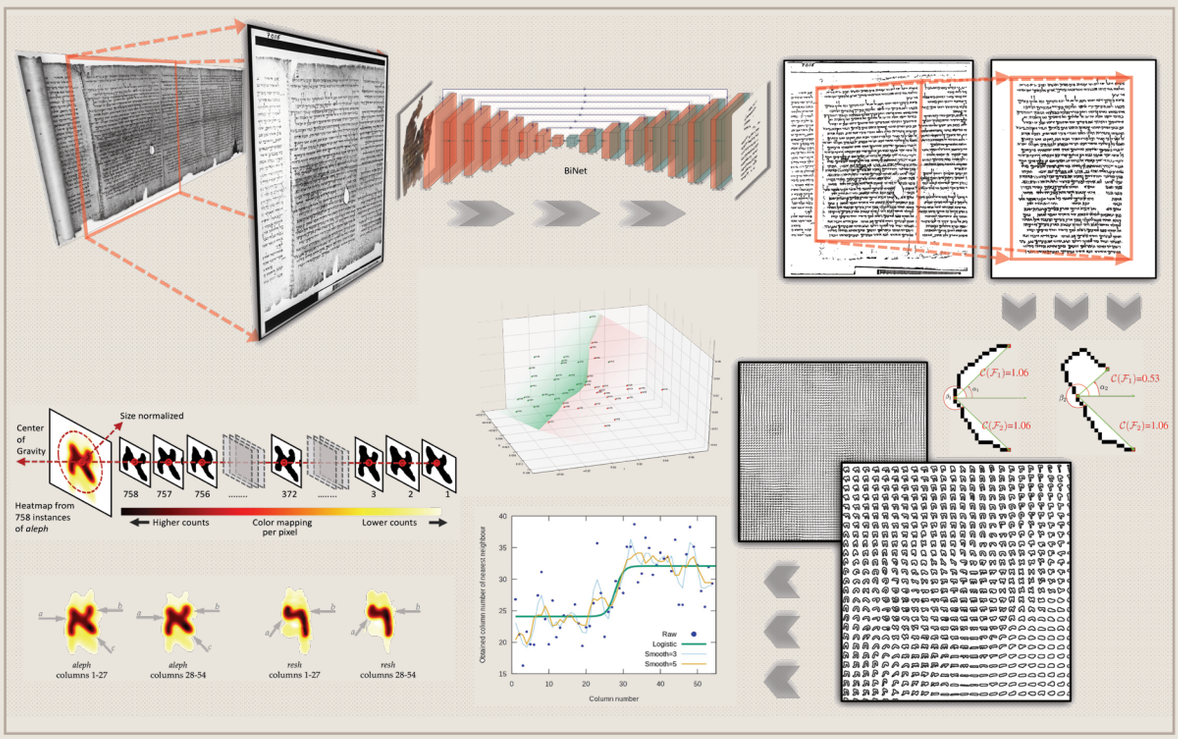


Figure 2: The Writer Identification Process © Mladen Popović/ Maruf Dhali

AI methods and Advanced Imaging Techniques for Augmented Documentation of Archaeological Inscriptions: Applications to Ancient Egyptian Hieroglyphs

© Costanza Cucci



Dr. Costanza Cucci

Institute of Applied Physics "Nello Carrara" (IFAC), National Research Council, Italy.

Abstract

Several recent applications in documentary heritage have demonstrated that advanced imaging techniques, such as hyperspectral imaging (HSI), can produce data usable for extracting augmented images of a scene. Such image datasets are far richer than those of typical RGB photographs. They can be used to retrieve faded traits and enhance the readability of corrupted characters in archaeological inscriptions or ancient textual sources. This characteristic of HSI has been exploited in the context of ancient Egyptian hieroglyphic segmentation, in combination with Deep Convolutional Neural Networks (DCNN), to address tasks related to automated hieroglyph recognition. The contribution illustrates the basics of an ongoing research aimed at investigating the possibility of automatically identifying ancient hieroglyphs in real contexts, that is, when inscriptions are degraded and the symbols are corrupted, by leveraging the combination of deep learning techniques and Hyperspectral Imaging acquisition.

Foreword

Ancient manuscripts and handwritten documents, archaeological inscriptions on different supports, and several other types of textual and iconographic sources are just a few examples of the records that trace the knowledge(s) evolution through history and places. All these documentary sources indirectly report on the growth of cultures and the thoughts of civilizations, and their preservation is a critical endeavor to safeguard humanity's collective memory.

I

Thus, in the domain of Documentary Heritage, a significant portion is represented by archaeological items, featuring inscriptions, texts, and ideograms, as well as decorated and painted surfaces. In addition to serving as vehicles of intangible heritage content, these textual and visual sources are themselves valuable historical objects, requiring care and protection. Depending on the nature of their constituent materials, these items can be highly prone to deterioration and aging, which cause various effects, such as fragility of supports, fading of inks, losses, and discoloration of pigments. These degradation phenomena not only threaten the physical integrity of the objects but can also seriously compromise access to textual contents, ultimately limiting the true fruition of a significant part of the documentary heritage.

For these reasons, over the last few decades, increasing efforts have been devoted to proposing innovative methods for the augmented documentation of ancient texts, manuscripts, and archaeological artifacts, with special attention to technologies that enable the retrieval of lost content, the virtual reconstruction of missing texts, and the enhancement of faded inscriptions. To mention a few, yet not exhaustive, examples: advanced imaging methods such as multi-band, multi-spectral, and hyperspectral imaging, UV-induced fluorescence imaging, or X-ray-based methods have proven their effectiveness for enhancing the readability of ancient manuscripts and archaeological inscriptions (Toth et al. 2020, Powers et al. 2009, Cucci et al. 2020).[1,2,3] Specifically, in recent years, the use of Hyperspectral Imaging (HSI) technique, which has been underutilized for applications in documentary heritage, is gradually increasing due to its significant potential for virtual restoration, material analysis, and digital archiving. Thanks to the recent commercialization of compact and affordable cameras, HSI can be easily implemented in situ to investigate various items (manuscripts, scrolls, inscriptions on different supports, etc.) in different contexts (archaeological sites, museums, libraries, etc.).[4,5]

Hyperspectral imaging methodology is based on capturing a sequence of spectral images across a wide range of wavelengths, spanning from the Visible to the InfraRed regions, thus enabling the visualization of details not visible to the naked eye. The HSI data can be elaborated with different algorithms, including statistical methods, machine learning, and deep learning, yielding multiple outcomes (e.g., RGB color images, IR reflectography, false colour pictures, classification maps, etc.) that can be used to meet, at once, various tasks such as: digitization, augmented imaging (e.g., visualization of enhanced text, retrieval of faded characters, etc.), identification of selected constitutive materials (e.g. inks, pigments) (Cucci and Casini 2019).[4]

Along with the aforementioned physical methods, Artificial Intelligence has made significant inroads into the field of documentary heritage over the last decade, revolutionizing research methodologies and opening up unprecedented perspectives on several long-standing problems, such as deciphering ancient languages, automated encryption, and text reconstruction.[5] In this articulated scenario, one of the latest research fronts in the study of extinct languages explores the combination of AI with technologies for augmented documentation.



Figure 1a: A view of the hyperspectral Imaging Measurements campaign on XXVth. Century manuscript (Corale 43) from the Biblioteca Medicea Laurenziana Florence © CNR-IFAC



Figure 1b: Multi-band and Multi-Spectral imaging techniques are used for retrieving readability of degraded ancient manuscripts. An example of application of multiband imaging (RGB Visible and UV-fluorescence photography) on the manuscript Psalter of Saint Romuald (Psalterium Gallicanum) (9th Century), belonging to the Library of the Sacred Hermitage of Camaldoli Arezzo (IT). Measurements campaign by IFAC-CNR within a collaborative project with the Restoration Laboratory of the Biblioteca Nazionale Centrale di Firenze, Italia Link: https://xp9.ifac.cnr.it/webshare/salterio © CNR-IFAC

Specifically, a recent segment of this research focused on the problem of classifying and semi-automating the recognition of ancient Egyptian hieroglyphs through the combined use of readapted Convolutional Neural Network architectures and hyperspectral imaging (Cucci et al., 2024 [6]). The outcomes of this study are summarized briefly below.

Hyperspectral imaging and CNNs for automated segmentation of ancient Egyptian hieroglyphs: a promising pilot study.

As a preliminary step towards solving the broader problem of semi-automated and extensive deciphering of ancient Egyptian writing, the use of well-established CNN architectures, specifically retrained for the tasks of segmenting and classifying Egyptian hieroglyphs, was proposed in (Guidi et al. 2019)[7] and (Barucci et al. 2021, 2022[8,9]). These retrained CNN architectures have proven to be highly promising on trial datasets comprising clear and sharp images of glyphs from various sources. However, when dealing with real-world applications, the presence of corrupt, overwritten, or deleted signs on the aged surfaces of archaeological objects can seriously impair CNN performance in glyph identification. To address this issue and enhance the capabilities of CNN in the presence of corrupted inscriptions, the use of HSI augmented images was proposed as input instead of standard RGB images to feed the CNNs and improve their performance. A promising pilot study was conducted on a degraded hieroglyphic inscription from an ancient Egyptian coffin from the XXV Dynasty. Specifically, a non-invasive measurement campaign performed in situ with an HSI portable camera provided the HSI data sets, which were utilized in various pipelines to enhance the segmentation of CNN workflow. The complete details of the study are reported in (Cucci et al. 2024[10]).

1. M. Toth et al., "Integrating Advanced Imaging of Ancient Manuscripts," Archiving Conference 17 (2020): 33–38.

2. J. Powers et al., "X-Ray Fluorescence Imaging Analysis of Inscription Provenance," Journal of Archaeological Science36, no. 2 (2009): 343–50.

3. C. Cucci et al., "Remote-Sensing Hyperspectral Imaging for Applications in Archaeological Areas: Non-Invasive Investigation on Wall Paintings and on Mural Inscriptions in the Pompeii Site," Microchemical Journal 158 (2020): 105082.

4. C. Cucci and A. Casini, "Hyperspectral Imaging for Artworks Investigation," in Data Handling in Science and Technology, ed. D. Saunders (Amsterdam: Elsevier, 2019), 583–604, https://doi.org/10.1016/b978-0-444-63977-6.00023-7.

5. T. Sommerschield et al., "Machine Learning for Ancient Languages: A Survey," Computational Linguistics 49, no. 3 (2023): 703–47.

6. C. Cucci et al., "Hyperspectral Imaging and Convolutional Neural Networks for Augmented Documentation of Ancient Egyptian Artefacts," Heritage Science 12, no. 1 (2024): 75.

7. T. Guidi et al., "A Deep Learning Approach to Ancient Egyptian Hieroglyphs Classification," IEEE Access 9 (2019): 123438–44.

8. A. Barucci et al., "EA Deep Learning Approach to Ancient Egyptian Hieroglyphs Classification," IEEE Access 9 (2021): 123438–44.

9. A. Barucci et al., "Ancient Egyptian Hieroglyphs Segmentation and Classification with Convolutional Neural Networks," in International Conference Florence HeriTech: The Future of Heritage Science and Technologies (Cham: Springer, 2022), 126–39.

10. Cucci, C., T. Guidi, M. Picollo, L. Stefani, L. Python, F. Argenti, and A. Barucci. 2024. "Hyperspectral Imaging and Convolutional Neural Networks for Augmented Documentation of Ancient Egyptian Artefacts." Heritage Science 12 (1): 75.



Figure 2: A view of Hyperspectral Imaging (HSI) measurements campaign performed in-situ by IFAC-CNR on an Egyptian Coffin (XXV Dinasty) Franciscan Ethnographic Museum, Fiesole (Florence) Italy, Image source: (Cucci-et al. 2024).[10] Photo credits: © CNR-IFAC

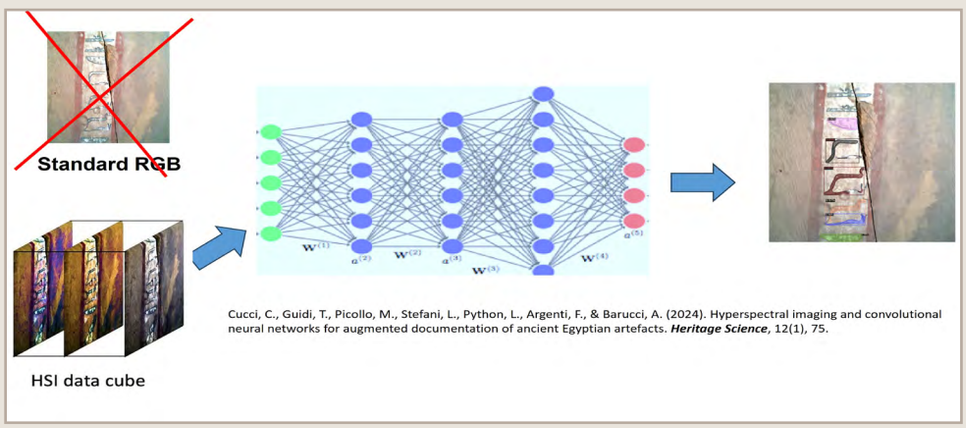


Figure 3: A pilot study for exploring the feasability of using HSI in combination with CNN – conceptual scheme Photo credits: © CNR-IFAC

Conclusive remarks

Nowadays, the Hyper spectral Imaging technique is recognized as a promising approach in the field of documentary heritage, especially for textual sources from archaeological items, because it can provide enhanced documentation and improve the readability of corrupted inscriptions. Besides the standard uses in digital archiving, HSI data can be used to enhance further the performance of AI-based tools for various tasks related to extinct languages. An example of this combination is presented for the segmentation of Egyptian hieroglyphs, for which the proposed approach provided satisfactory results. Despite being a highly specialized and confined application, this ongoing research is unveiling the vast potential of intersecting two advanced technologies, such as HSI and convolutional neural networks, for providing unprecedented solutions to the problem of deciphering ancient languages.

Recommendations for future perspectives

Future developments of this research will involve extending the testing of CNN architectures on HSI data acquired from several other types of inscriptions, varying the typologies of case studies in terms of supports, degree of aging, materials, etc. However, this can be challenging due to the difficulty in accessing items belonging to libraries, collections, and museums. On the other hand, the acquisition of augmented documentation on selected objects could be of high interest for dissemination and musealization purposes. Since a central difficulty in corroborating AI-based algorithms for making them reliable is the availability of significant datasets, it would be highly recommended to promote collaborative programs of free exchanges between scientific laboratories, museum institutions, and archives, to provide mutual advantages in applying advanced technologies to selected case studies of genuine interest.

CHAPTER II

AI and Intangible Cultural Heritage

AI & Culture

Chapter 2

Artificial Intelligence and Intangible Cultural Heritage

The safeguarding of intangible cultural heritage (ICH)—including oral traditions, performing arts, social practices, rituals, festive events, and traditional knowledge—is anchored in the normative framework of UNESCO, particularly through the 2003 Convention for the Safeguarding of the Intangible Cultural Heritage. This convention emphasizes community participation, living transmission, and respect for cultural diversity as core principles of safeguarding. Complementary instruments, such as UNESCO's work on culture and arts education and digital heritage, further reinforce the importance of documentation, transmission, and accessibility of living heritage. In this evolving landscape, artificial intelligence offers significant opportunities to enhance ICH safeguarding, including advanced documentation of ephemeral practices, real-time analysis of performance and sound, and broader dissemination through immersive and interactive technologies. AI can support the identification of patterns, preservation of endangered expressions, and intergenerational transmission through innovative formats. However, these opportunities are accompanied by substantial challenges. AI systems often struggle to capture the embodied, contextual, and community-specific dimensions of ICH, risking oversimplification or decontextualisation. Issues of data ownership, consent, and cultural appropriation are particularly sensitive, as ICH is deeply rooted in community identity and values. Furthermore, biases in training data and algorithmic interpretation may privilege dominant narratives, potentially marginalizing less-documented traditions. These tensions underscore the need for ethically grounded, community-centred approaches to AI deployment in line with UNESCO's normative principles.

Scholarly contributions in this chapter collectively demonstrate that while artificial intelligence offers transformative tools for safeguarding intangible cultural heritage, its effectiveness depends on how deeply it engages with cultural context and human knowledge systems. Dr Giannanchi highlights how AI—combined with mixed reality and robotics—can move beyond passive documentation to actively reveal new perspectives within artistic practices, contribute to creative processes, and enable reinterpretations of heritage. This positions AI not only as a recording tool, but as a co-creative agent in the evolution of living heritage. Complementing this, Dr Guedes emphasizes that AI applications in sonic heritage must adopt a "specialist-in-the-loop" approach, ensuring that socio-cultural meanings—such as ritual, labour, and community identity—are embedded within digital representations, rather than reduced to purely technical sound data.

At the same time, studies reveal important limitations. Dr Bouziane demonstrates that while advanced models such as DeepSeek-V3 can enhance access to poetic traditions like Malhun, they often struggle to preserve rhythm, nuance, and cultural depth, requiring complementary human interpretation. Similarly, Dr Yahyai shows that AI-generated visualisations of folk tales can replicate geographical and environmental elements, yet differ from traditional artistic methods in cultural interpretation and authenticity.

Bringing these insights together, Dr Rodil argues that AI systems frequently fail to capture the multimodal, socially embedded nature of intangible heritage, and may reinforce biases if not carefully designed. He advocates for participatory and socially grounded approaches that involve communities throughout AI development. Overall, these contributions underscore that AI's role in ICH should not be purely technological, but relational—grounded in collaboration, cultural sensitivity, and ethical responsibility to ensure that innovation supports, rather than distorts, living heritage.

Taken together, these contributions highlight a critical rethinking of how AI should be integrated into the safeguarding of intangible cultural heritage. While AI introduces powerful tools for documentation, analysis, creative engagement, and global dissemination, it cannot replace the human, social, and contextual dimensions that define living heritage. The studies collectively emphasize that effective use of AI in ICH must be grounded in interdisciplinary collaboration, ethical responsibility, and active community participation. Approaches such as specialist-in-the-loop systems, participatory design, and culturally informed data modelling offer promising pathways to balance technological innovation with safeguarding principles. Ultimately, AI should be positioned not as a substitute for traditional knowledge systems, but as an enabling tool that supports their continuity, visibility, and resilience. In alignment with UNESCO's role as a standard-setter and catalyst for international cooperation, the integration of AI into ICH safeguarding presents an opportunity to both protect cultural diversity and foster new forms of cultural expression—provided that such efforts remain firmly rooted in respect for the communities who sustain this heritage.

Documenting Intangible Cultural Heritage through Artificial Intelligence[1]

© Gabriella Giannachi



Dr. Gabriella Giannachi

Professor in Performance and New Media and Director of the Centre for Intermedia and Creative Technologies, University of Exeter, United Kingdom.

Abstract

This contribution analyses the benefits offered by AI for the documentation of Intangible Cultural Heritage (ICH). It utilizes three case studies that involve mixed reality, robots, and AI. These show that AI-facilitated documentation could be used to: (a) identify characteristics of and perspectives about artworks that have not been seen before; (b) form part of the creative process; and (c) promote the activation of a new iteration/re-interpretation of an artwork. The case studies demonstrate that new types of dynamic live archives are necessary to host these forms of documentation, serving as repositories and enablers of ICH practice.

The use of AI entails risks, such as bias and hallucinations. Risks brought on by the use of AI can be mitigated through (a) the creation of a healthy AI ecosystem involving a range of stakeholders; (b) the development of shared and open data over a prolonged period to facilitate diverse cultural, linguistic, and EDI perspectives; and (c) the establishment of protocols so that resulting datasets, developed ethically and responsibly, are used in AI training. Ultimately, the use of AI should not replace human labour but complement it by being part of, rather than in charge of, these ecosystems.

II

Documentation is the process carried out by artists, museums, or researchers to capture the salient qualities or identities of ephemeral and hybrid art forms, including performance, interactive, and mixed-media art, so that these artworks may continue to be practiced and preserved over time.[2] Documentation can, for artists, form part of the creative or marketing process; for museums, it forms part of an accession and activation process; and for researchers, it forms part of a data capture process. Typically, documentation attempts to stabilise artworks which, by nature, are often subject to change.

In the case of TCH, AI algorithms can recover the 3D geometry of monuments from images and/or re-form missing parts from damaged structures. Thus, AI can be used to create reconstructions of lost heritage and make visible hidden details,[3] playing a valuable role in restoration.[4] AI can also be utilized for information management, audience engagement, enhancing the visitor experience, and addressing inclusivity.[5]

Examples include a hackathon at New York's MET during which audiences could tag digitised artworks that resulted in a dataset which was then fed into the museum's system;[6] Tate's Recognition project, which used AI to compare artworks in its collection to photojournalism;[7] and the Smithsonian's use of robots to interpret some of its artworks in Swahili.[8] AI can thus protect at-risk TCH, help address intergenerational transmission gaps, and mitigate the loss of cultural memory due to conflict, climate change, neglect, or the natural passage of time.

The use of AI brings further benefits concerning ICH

a) AI-facilitated documentation can reveal characteristics and perspectives about artworks that have not been previously observed.

Blast Theory's[9] Cat Royale (2023)[10] explored the potential impact of robots and AI on humans and animals, offering key insights into the design of 'multispecies robot worlds'.[11]

Three cats inhabited an environment created by the artists, where they had food, water, sleeping dens, litter trats, cart grass, a scratching post, and many hours of play provided by a robot arm which wielded various toys and, over time, learnt from the artists' rating which of the 500 play activities it provided the cats liked the best. Eight cameras captured the interactions between the cats and the robotics arm. The resulting feeds were edited into an eight-hour-long film and marketing materials.

The documentation provided to AI researchers a novel dataset for applying computer vision to automatically recognize and track the locations of individual cats within the environment, revealing possibilities to automatically select previously unseen stories from the cats' experiences, generate new audience engagement, and potentially support animal behavior researchers in analyzing the cats' activities. Instead of using data for development, the artwork's creation generated data that formed part of its resulting ecosystem.



Fig 1: Cat Royale © Blast Theory.



Fig 2: Embrace Angels, performance installation. Photo: Pieter Kers © Lancel&Maat 2025.

b) AI-facilitated documentation can be an integral part of the creative process.

In Embrace Angels (2024-25),[12] artists Karen Lancel and Hermen Maat[13] sought to explore how humans and robots could come together in a shared embrace. During the development phase, Lancel and Maat found that generating AI prompts helped them to research visualizations of the act of embracing and, in particular, of collectively embracing a robot.

Their resulting practical experiments were documented and then fed back to the AI by the film director and researcher Richard Ramchurn, who subsequently adopted prompts to create live visualisations of how the AI reinterpreted the documentation. These were then used again as prompts by Lancel and Maat to inspire the development of their practice. For them, this integration of AI as both a creator and documenter established a novel kind of 'hybrid collective memory',[14] producing a set of iterative human-robot-AI interactions that formed both the artwork and its documentation.

c) AI-facilitated documentation can facilitate the activation of a new iteration or reinterpretation of an artwork.

Blast Theory artist Nick Tandavanitj used the archives of the company's Rider Spoke (2007)[15] to generate a novel iteration of the work. Rider Spoke was a location-based game for cyclists, in which participants cycled through a city for approximately an hour, guided by a handheld device mounted on their handlebars.[16] The archival artwork utilized an audio narrator and soundtrack to encourage participants to record personal memories as they cycled around the city, allowing them to listen to recordings by other participants that had been rated and selected by the artists.

1. This contribution is based on research conducted in the BRAID/AHRC-funded 'Creating a Dynamic archive of responsible Ecosystems in the context of Creative AI' (AH/Z505572/1); the EPSRC-funded Turing AI World Leading Researcher Fellowship: Somabotics: Creatively Embodying Artificial Intelligence (EP/Z534808/1); the BRAID/AHRC-funded 'Responsible Use of AI in the Creation, Archiving, Reactivation and Conservation of Artworks and their Archives' Demonstrator (UKRI/AH/B000509/1); and the AHRC-funded 'An exploration of the use of AI in performance and new media art documentation within collections and archives'.

2. See Annet Dekker, Gabriella Giannachi, Katrina Sluis, and Gaby Wijers, "Documenting Digital Art: Insights or Artists, Audiences, Cultural Organisations, and Policy Makers, including a step-by-step Guide for Organisations doing documentation", https://site24.li-ma.nl/strapi/uploads/Documenting_Digital_Art_Insights_for_Artists_Audiences_and_more_c0a0467461.pdf?updated_at=2024-02-29T12:21:15.000Z. Accessed 12/03/2025; Tancredi Gussman (ed.) Reconstructing Performance Art: Practices of Historicization, Documentation, and Representation (Routledge, 2023); and Annet Dekker, and Gabriella Giannachi (eds) Documentation as Art (Routledge, 2023).

3. Umair Shafquat Malik, Liselore Tissen, and Arnold P.O.S. Vermeeren, "3D Reproductions of Cultural Heritage Artefacts: Evaluation of significance and experience," Studies in Digital Heritage, 5, n. 1 (2021): 1–29, DOI: 10.14434/sdh.v5i1.32323.

4. Sakib Shahriar, "GAN computers generate arts? a survey on visual arts, music, and literary text generation using generative adversarial network," Displays, 73 (2022), https://doi.org/10.1016/j.displa.2022.102237.

5. Kincsö Izsak, Apolline Terrier, Stephan Kreutzer, Thorben Strähle, Conor Roche, Marta Moretto, Stig Yding Sorensen, Malene Hartung, Kristina Knaving, Marlene A. Johansson, Magnus Ericsson, David Tomchak, Opportunities and Challenges of Artificial Intelligence Technologies for the Cultural and Creative Sectors, Publications Office of the European Union (2022): 143, https://data.europa.eu/doi/10.2759/144212.

Tandavanitj used AI to create a platform that analysed the large volume of recordings (over 22K from nearly 30 cities), to explore how AI might assist with understanding the diversity of perspectives within the archive and create novel ways to engage the public while also reflecting on the risks and ethics of using AI in the context of sensitive personal disclosures within artworks.

Discussion

These examples show that the use of AI in artworks and their documentation tends to involve multiple stakeholders, with complex IP implications, often over time, both during and after the creative process. These stakeholders could be described as *'networks of care,*[17] or *'ecosystems,'* tasked with creating healthy datasets enabling the practice of future iterations iterations/re-interpretations of these artworks as part of the conservation process.[18]

Documentation is not only a past-facing record of an event, regarding something that has already taken place, but also a future-facing strategy aimed at prompting the activation and re-interpretation of artworks over time.[19] AI can be used to manage the growing body of documentation, helping to identify synergies between different activations and re-interpretations, as well as detecting and addressing risks to ensure the artworks' futureproofing.

Dynamic and live archives need to be created for conservation, serving as time machines or collective memory, as well as for the use of generative tools that promote future development.

In conclusion, AI can benefit the fields of documentation and archivization of complex and hybrid artworks, as well as ICH more broadly, provided that key stakeholder ecosystems, including industry, are involved and that AI is considered not a substitute for but as an assistant to human-led work.

Recommendations

The use of AI entails risks. These include:

- low quality and monocultural content
- bias
- misinformation
- over-reliance on technology
- mediation of orally transmitted practices
- environmental sustainability

To mitigate risks brought on by the use of AI:

a) Develop a healthy AI ecosystem that involves a diverse range of stakeholders.

ICH should be documented by a healthy ecosystem formed by multiple stakeholders, including those from the AI industry, over a prolonged period.

6. Ibid., 146 and Jennie Choi, "Exploring Art with Open Access and AI: What's Next?" (2019), https://www.metmuseum.org/it/perspectives/met-microsoft-mit-exploring-art-open-access-ai-whats-next. Accessed 12/03.2025

7. Recognition, https://www.tate.org.uk/whats-on/tate-britain/ik-prize-2016-recognition. Accessed 12/03/2025

8. Kate Keller, "The Smithsonian is Using a Swahili-Speaking Robot to Break Down Language Barriers," The Smithsonian Magazine (2018), https://www.smithsonianmag.com/smithsonian-institution/pepper-swahili-speaking-robot-breaks-down-language-barriers-african-art-exhibit-180968902/ Accessed 12/03/2025.

9. https://www.blasttheory.co.uk/ Accessed 12/03/2025.

10. The work was part of the Trustworthy Autonomous Systems Hub funded by UK Research and Innovation.

11. Schneiders et al., "TAS for Cats," TAS '23, art. 36 (2023), https://doi.org/10.1145/3597512.3597517; Schneiders et al., "Designing Multispecies Worlds for Robots, Cats, and Humans," CHI '24 (2024), https://doi.org/10.1145/3613904.3642115.

12. This artwork was funded by the UK Engineering and Physical Science Research Council and forms part of the Somabotics Turing AI Fellowship awarded to Steve Benford.

13. https://www.lancelmaat.nl/ Accessed 12/03/2025.

14. Karen Lancel, email communication, 14/2/2025.

15. Steve Benford and Gabriella Giannachi, Performing Mixed Reality (MIT Press, 2011).

16. This work forms part of Tandavanitj's doctoral research and the Arts and Humanities Research Council BRAID-funded Demonstrator led by the philosopher Lydia Farina explores the responsible use of AI for the creation, archiving, reactivation and conservation of artworks and their archives.

These could ensure that archives include a range of interpretative capabilities, facilitating multiple perspectives, thereby being culturally adaptive, ethical, and accessible.

You might consider:

- make bias explicit
- register awareness of how insufficient data can produce AI hallucinations
- work iteratively to make archives more accessible, sustainable, and respectful of equality, diversity and inclusion (EDI)
- consider using human-in-the-loop AI
- use the resulting datasets to improve the AI's field of knowledge
- mitigate the environmental impact of their use of AI.

b) Develop shared and open data over a prolonged period of time to facilitate diverse cultural, linguistic, and EDI perspectives.

When using AI for documentation, consider building dynamic and live archives, not only repositories but also active, generative tools[20] and sites for the practice of ICH. AI will help:

- catalogue and manage the growing body of documentation related to ICH, making its conservation more effective
- co-ordinate prompting practices necessary for the promotion of a generative use of ICH archives, propagating practices and rituals
- promote audience engagement and participation, making archives more interactive and inclusive.

c) Establish protocols so that resulting datasets, developed ethically and responsibly, are used in AI training

Make sure you champion open data sharing and generate archives that are:

- editable and facilitate annotation
- continue to grow over time
- reconstitute themselves in accordance with keywords set by whoever may wish to consult them
- make visible different time-based versions of themselves
- be used curatorially and creatively as a live (generative) archive
- be culturally adaptive
- provide the context and iterative documentation of artworks, including artworks generated by AI
- deal with issues related to trust, transparency, privacy, copyright, personalization, ethics, and EDI so that dynamic archives could be rhizomatic in nature, growing and spreading from multiple points rather than a single source
- facilitate access to datasets
- establish protocols so that resulting datasets, developed ethically and responsibly, can be used in AI training.

17. Annet Dekker, Collecting and Conserving Net Art. Moving Beyond Conventional Methods (Routledge, 2018).

18. Dekker, and Giannachi, Documentation as Art; and Lydia Farina, Helena Webb, Gabriella Giannachi, John Moore, Steve Benford, Spencer Jordan, Bernd Stahl, Elvira Perez-Vallejos, Craig Vear, Megan R.F. Drury, Oliver Miles, Patrick Brundell, "Structuring a dynamic archive of AI ecosystems in the context of the creative industries," (2024) BRAID/ AHRC OPP18206.

19. Gabriella Giannachi, Archive Everything (MIT Press, 2016).

20. Ibid.

Using Artificial Intelligence in Sonic Intangible Heritage: Reflection and Recommendations

© Carlos Guedes



Dr. Carlos Guedes

Music and Sound Cultures (MaSC) Research Group, New York University Abu Dhabi, United Arab Emirates

Abstract

This paper extends the presentation "Documenting, Analyzing, and Preserving Sonic Intangible Heritage in the 21st Century: Current Challenges and New Opportunities in the era of Generative AI" at the Webinar "Artificial Intelligence and intangible cultural heritage" organized by the UNESCO Cairo Office on February 21, 2025. It provides recommendations on the use of artificial intelligence (AI) in studying sonic intangible cultural heritage (SIH). These recommendations are informed by 1) current discussions by the Music Information Research (MIR) community about ethical and cultural issues in digital music recommendation and on the use of generative AI in music creation, and 2) on the work in the computational study of music from the Arabian Gulf by the Music and Sound Cultures (MaSC) research group.



Figure 1: Women from the Shihuh tribe performing wedding music in Ras Al Khaimah, UAE. © Music and Sound Cultures research group. Used with permission

II

Needs arising from the study of traditional music from the Arabian Gulf

Ethnic diversity is a characteristic of the Arabian Gulf. This diversity is a consequence of trade and political connections with other oceanic societies around the rim of the Indian Ocean and South China sea for millennia.[1] Music from the Gulf is not well known outside of the region; however, it bears strong influences from other cultures in the Western Indian Ocean, namely East Africa and South India, because of the movement of people and cultures, making it an interesting object of study for transcultural influences in music.

Those willing to study the traditional music in Arabian Gulf encounter several challenges. These include the lack of specialized literature about the music that is written in English language, [2] lack of recorded examples, and the advanced age of some of the practitioners that is putting the oral transmission of these practices seriously at risk. [3] Finally, there is an increased depletion of physical formats of recorded music that is pushing its access almost exclusively to the digital domain, through commercial streaming services (Spotify, Anghami, etc.). The emergence of streaming platforms and the access to massive collections of recorded music for very little or no cost has irreversibly transformed the way people consume and listen to music. [4] However, the recommendation systems of these platforms are not value-neutral and the biases in their design discriminate (consciously or unconsciously) against certain musical styles.[5]

In what could be considered as a perfect storm of adversities for the study of this music, the following research question emerges: *How can one digitally encode and train computational systems in a proper way, to document, identify, and analyze music that demonstrates the following features: 1) the music is transmitted orally; 2) the availability of recordings (analog or digital) is sparse; 3) there is not much published theoretical knowledge about it; 4) its continued practice is at risk due to the disappearance of its practitioners; and 5) the music has minimal or no presence on digital streaming platforms?*

The solution to this problem calls for the development of new methodologies that should not only address the challenges highlighted above but also be culturally sensitive and diverse to account for musical concepts and aspects of performance practice that are typical of this music and sound culture. The methodological needs in the computational study of this music can, *mutatis mutandis*, inspire similar approaches in the computational study of traditional music from other cultures.

The search for new methodologies

The Music Information Research (MIR) community has initiated a discussion on cultural and ethical values associated with their research in the past decade and a half or so. The massive recording and digitization of music and its ubiquitous availability coupled with the developments in generative AI that use these collections for training commercial AI-driven generative music systems have brought about complex challenges at many levels. These entail exclusion,[6] copyright infringement,[7] authorship, and cultural appropriation.[8] This has prompted a call for an ethical turn in the field,[9] and for new approaches that address MIR's ontological, epistemological, methodological and axiological aspects.[10]

Music anthropologist Georgina Born[11] recently challenged the MIR community to build new relationships between music computational research and music anthropology and sociology, in a dialogue without hierarchy and achieving what she terms an "agonistic mode of interdisciplinarity"[12] that will lead to the creation of novel and unforeseen methodologies and theories. Rujing Huang, Andre Holzapfel, Bob Sturm, and Anna-Kaisa Kaila[13] expand on Born's challenge by suggesting that the field should diversify beyond the mere diversification of datasets, urging MIR researchers to embrace non-hierarchical form of interdisciplinarity that is sensitive to local practices, traditions, knowledge, and values that constitute the distinct music ecosystems.

In a recent study, Elin Kanhov, Anna-Kaisa Kaila, and Bob Sturm,[14] question how researchers and engineers who develop and apply AI to specific traditional music practices can make meaningful and non-harmful contributions to those practices. They answer the question by critically reflecting on the impacts of AI research and AI commercial systems on Irish traditional music communities and analyze two case studies in which AI is used to generate traditional Irish music, one from commercial application Suno,[15] the other through an open-source system *(folk-rnn)*.[16]

In conclusion to their study, they propose three interlinked ways to move forward: 1) embracing interdisciplinarity; 2) engaging with the communities of practice and soliciting criticism; and 3) prioritizing ethics.

In their efforts to provide an approach to the study of the music from the Arabian Gulf, Andrew Eisenberg and Carlos Guedes[17] propose a field of inquiry called Sonic Digital Humanities (SDH), a branch of Digital Humanities concerned with digital collections of music and other forms of intangible sonic culture. This field is transdisciplinary in Basarab Nicolescu's[18] sense of being situated "between disciplines, across different disciplines, and beyond all disciplines".[19] SDH is a space in which computational approaches to the analysis of music and related forms of sound culture are carried out in a productive dialogue with humanistic modes of data collection and critical inquiry. CaMel,[20] a data-driven generative model of Carnatic music percussive sequences, is an example of this approach (Fig. 2).

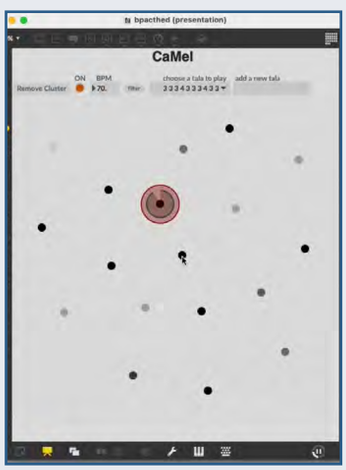


Figure 2: CaMeL, Carnatic rhythm generative application.
© Carlos Guedes

The user can interact with each cluster by travelling in 2D space and generating rhythms based on a set of template partitions in a tempo of choice. Clusters with enough groupings to generate the specific partition of talas are represented with black dots while clusters with insufficient number of groupings are grey. When playing a cluster of rhythms, the user can create rhythmic variations by expanding the circle around the cluster being played.

1. Michael Izady, "The Gulf's Ethnic Diversity," in Security in the Persian Gulf, ed. Lawrence G. Potter and Gary G. Sick (New York: Palgrave Macmillan, 2002), 33–90, doi:10.1057/9780230108189_3.

2. Virginia Danielson, "Introduction," in Music in Arabia: Perspectives on Heritage, Mobility, and Nation, ed. Iman Boulos, Virginia Danielson, and Anne K. Rasmussen (Indiana University Press, 2021), 2–14.

3. Shadiah Abdullah Al Jabry, "Dancers to the Music of Time: The Nuban." The National, April 30, 2013. https://www.thenationalnews.com/arts/dancers-to-the-music-of-time-the-nuban-1.385086 (accessed 3/9/2025).

4. Jack Webster, "Taste in the Platform Age: Music Streaming Services and New Forms of Class Distinction," Information, Communication & Society 23, no. 13 (2019): 1909–24, doi:10.1080/1369118X.2019.1622763.

5. Andre Holzapfel, Bob L. Sturm, and Mark Coeckelbergh, "Ethical Dimensions of Music Information Retrieval Technology," Transactions of the International Society for Music Information Retrieval 1, no. 1 (2018): 44–55, https://doi.org/10.5334/tismir.13.

6. Holzapfel et al., "Ethical Dimensions of Music Information Retrieval Technology."

7. Bob L. T. Sturm, Martín Iglesias, Oded Ben-Tal, Marius Miron, and Emilia Gómez, "Artificial Intelligence and Music: Open Questions of Copyright Law and Engineering Praxis," Arts 8, no. 3 (2019): 115, https://doi.org/10.3390/arts8030115.

8. Elin Kanhov, Anna-Kaisa Kaila, and Bob L. T. Sturm, "Innovation, Data Colonialism and Ethics: Critical Reflections on the Impacts of AI on Irish Traditional Music," Journal of New Music Research (January 2025): 1–17, doi:10.1080/09298215.2024.2442359.

9. Fabio Morreale, "Where Does the Buck Stop? Ethical and Political Issues with AI in Music Creation," Transactions of the International Society for Music Information Retrieval 4, no. 1 (2021): 105–113, https://doi.org/10.5334/tismir.86.

10. Rujing Stacy Huang, Andre Holzapfel, Bob L. T. Sturm, and Anna-Kaisa Kaila, "Beyond Diverse Datasets: Responsible MIR, Interdisciplinarity, and the Fractured Worlds of Music," Transactions of the International Society for Music Information Retrieval 6, no. 1 (2023): 43–59, https://doi.org/10.5334/tismir.141.

The training of the model was done in around 7 hours of recordings from the percussionist and the generation followed strategies for sequence generation gathered from him. What was described above shows a generalized and increased concern by the MIR community in establishing new methodologies that can account for a more ethical and fair approach in dealing with music and SIH digitization and the applications of AI in their treatment. Below, I provide a summary of recommendations that emerge from this discussion.

Recommendations

1. **Engage on a transdisciplinary approach in the study of SIH and AI.** Interdisciplinarity aims at a synthesis and integration of knowledge resulting from the collaboration between researchers from different disciplines.[21] Transdisciplinarity involves re-imagining the disciplines and the possibilities for combining them to "assemble new approaches from scratch, using materials from existing scholarly disciplines for new purposes."[22] This resonates with Born's proposal of an agonistic mode of interdisciplinarity through which "entirely unforeseen, novel methodologies and theories"[23] may be generated.

2. **Educate a new breed of researchers through creating transdisciplinary graduate programs, especially at the doctoral level, which combine areas such as AI, ethnomusicology/anthropology, and ethics.**



Figure 3: Carnatic music percussionist.© Akshay Anantapadmanabhan. Used with permission

The need to engage in transdisciplinary approaches in the study of SIH and AI is connected to the creation of academic programs that can integrate different areas of knowledge that are traditionally isolated from each other, like ethics, ethnomusicology/anthropology, and AI and machine learning.

This will foster an increase in critical mass of researchers able to work in the delicate field of SIH and AI more responsibly.

3. **Ethically and justly compile digital collections of musical traditions that are currently absent from the digital domain, in many cases relatively undocumented in any medium, and in some cases disappearing.** [24] This will imply collaboration with the communities practicing these musical traditions to properly collect the data and understand the limits of its utilization. This collaborative approach will also contribute to providing an emic perspective on the data collection process and its digital representation.

4. **Use a specialist-in-the-loop approach in training AI systems.** The sparsity of data and published theoretical knowledge, and perhaps more importantly, the often extra-musical function of the music (e.g. work songs, lullabies, ritual) together with its socio-cultural importance for the communities who practice it, suggest that these aspects of the music should be embedded in its digital representations (cf. Huang et al.[25]). This will require again collaboration with its practitioners to attain a deeper understanding about its function beyond the mere organization of the sound(s) in time.

5. **Embed agents that can inform the user of their ignorance about certain traditions.** Perhaps as important as training systems to recognize and eventually reproduce different musical traditions, it will be important that these systems also become aware of their ignorance regarding other styles. This will contribute to reducing AI hallucinations that can have adverse effects on the proper treatment of musical traditions.

11. Georgina Born, "Diversifying MIR: Knowledge and Real-world Challenges, and New Interdisciplinary Futures," Transactions of the International Society for Music Information Retrieval 3, no. 1 (2020): 193–204, https://doi.org/10.5334/tismir.58.

12. Born, "Diversifying MIR," 200.

13. Huang et al., "Beyond Diverse Datasets."

14. Kanhov et al., "Innovation, Data Colonialism and Ethics."

15. https://suno.com. Accessed 03/09/2025.

16. https://folkrnn.org. Accessed 03/09/2025.

17. Andrew Eisenberg and Carlos Guedes, "Prolegomena for Sonic Digital Humanities," presented at the British Forum for Ethnomusicology & International Council for Traditional Music Ireland Joint-Annual Conference, Cork, Ireland, April 2024.

18. Basarab Nicolescu, Manifesto of Transdisciplinarity, trans. Karen-Claire Voss (Albany, NY: State University of New York Press, 2002); Nicolescu, "Methodology of Transdisciplinarity—Levels of Reality, Logic of the Included Middle and Complexity," Transdisciplinary Journal of Engineering and Science 1, no. 1 (2010): 19–38.

19. Nicolescu, Transdisciplinarity, 22.

20. Carlos Guedes, Konstantinos Trochidis, and Akshay Anantapadmanabhan, "Modeling Carnatic Rhythm Generation: A Data-Driven Approach Based on Rhythmic Analysis," in Proceedings of the 15th Sound & Music Computing Conference (SMC 2018).

21. Jeremy H. Bernstein, "Transdisciplinarity: A Review of Its Origins, Development, and Current Issues," Journal of Research Practice 11, no. 1, Article R1 (2015), http://jrp.icaap.org/index.php/jrp/article/view/510/412.

22. Bernstein, "Transdisciplinarity," 7.

23. Born, "Diversifying MIR," 200.

24. Eisenberg and Guedes, "Prolegomena"

25. Huang et al., "Beyond Diverse Datasets."

Artificial Intelligence Translation and Cultural Preservation: A Case Study on Moroccan Malhun Poetry

© Karima Bouziane



Dr. Karima Bouziane

Department of Anglophone Literary and Cultural Studies, FLSH, Chouaib Doukkali University, Morocco.

Abstract

This pilot study investigates the role of AI in translating Malhun, a genre of sung poetry that has been an integral part of Moroccan culture for over five centuries. The study focuses explicitly on DeepSeek-V3, an advanced AI language model developed by DeepSeek, known for its high accuracy in understanding, generating, and processing human language. The study evaluates DeepSeek-V3's ability to maintain linguistic precision, poetic preservation, and cultural authenticity. Through case studies of translated Malhun verses into English, the study highlights AI's potential to enhance global accessibility to the linguistic, cultural, and artistic elements of Malhun.

However, it also identifies challenges such as the loss of poetic rhythm and cultural subtleties. The study thus recommends supplementing AI translations with cultural and historical explanations and suggests that training AI models on poetic structures and regional dialects could enhance translation quality.

II

Introduction

Cultural heritage, particularly in its intangible forms, plays a pivotal role in shaping identities, connecting communities, and preserving unique expressions of human creativity. In the context of Morocco, Malhun songs represent a rich, oral musical tradition deeply rooted in the country's religious, social, and cultural history. However, the preservation of such heritage faces numerous challenges, including language barriers, regional variations, and limited accessibility to global audiences. With the rise of artificial intelligence (AI), there is growing potential to address these challenges, primarily through AI-powered translation tools. This article examines the role of AI in translating Moroccan Malhun poetry, aiming to preserve its linguistic, historical, and cultural significance and make it accessible to broader audiences across linguistic and cultural boundaries.

Definition of Malhun

Malhun (الملحون / al-malhūn) or "the melodic poem", is a form of music that originated in Morocco. Rooted in the working-class environment of artisans' guilds, it has historically been an exclusively male-dominated oral tradition, serving as both an artistic expression and a means of cultural transmission. Malhun's poetry, composed in Moroccan Arabic (Darija), combines lyrical storytelling with rich, metaphorical language, often exploring themes of love, spirituality, and social issues. On December 6, 2023, this significant cultural heritage was officially inscribed on UNESCO's List of Intangible Cultural Heritage, recognizing its importance in preserving Morocco's artistic and linguistic traditions.

Objectives

The objectives of this study are as follows:

- To assess the effectiveness of DeepSeek-V3, an advanced AI language model, in translating Moroccan Malhun lyrics into English.
- To explore the extent to which AI preserves and conveys the linguistic, historical, religious, and social messages embedded in the Malhun poetry.
- To evaluate the potential of AI translation tools in promoting the accessibility of Moroccan cultural heritage on a global scale.

Previous Research and Initiatives

This section examines various studies and projects that illustrate the potential and limitations of AI in preserving cultural expressions.

AI techniques, including machine learning and deep learning, have proven valuable in the documentation and restoration of historical texts, sound recordings, and cultural artifacts. Das et al. argue that these AI tools enable more efficient cultural preservation strategies by improving accessibility and accuracy in retrieving cultural data[1].

This is particularly important for intangible heritage such as music and oral traditions, where linguistic subtleties and historical contexts must be preserved.

Language preservation is a core aspect of intangible cultural heritage. AI-driven translation tools, such as ChatGPT, are increasingly utilized to bridge linguistic gaps and preserve traditional languages. Harisanty et al.[2] emphasize AI's role in text processing and translation, making cultural heritage more accessible while maintaining linguistic and cultural integrity.

AI has been successfully applied in several case studies aimed at restoring intangible heritage. For example, the preservation of the Dunhuang Mogao Grottoes in China utilized AI for automatic restoration of murals and texts, showcasing AI's potential to restore cultural expressions[3].

Similarly, the Malhun songs of Morocco represent a rich cultural tradition that can benefit from AI tools to ensure their preservation.

The integration of AI tools for multilingual translation is key to preserving the linguistic diversity embedded in intangible cultural heritage. Constantin and Kavoura[4] discuss how AI, specifically ChatGPT, can enhance the multilingual reach of cultural heritage resources, making them accessible to diverse audiences and fostering intercultural communication.

Although AI offers promising opportunities for cultural heritage preservation, ethical concerns must be addressed. Hutson et al.[5] stress the importance of ensuring that AI-generated translations respect cultural contexts and linguistic diversity. The risk of misinterpretation or loss of cultural nuance is a critical challenge, particularly when translating culturally significant material such as Malhun songs.

The Kouyou project, developed by the Dar Gnawa Museum[6], is an AI-powered cultural assistant designed to preserve and share the heritage of the Gnawa, a UNESCO World Heritage-listed spiritual and musical group from Morocco. The project democratizes access to Gnawa rituals, mystical poems, and historical narratives, making them accessible to a wider audience, including those unfamiliar with the culture.

1. Bishwa Ranjan Das, Hima Bindu Maringanti, and Niladri Sekhar Dash, "Role of Artificial Intelligence in Preservation of Culture and Heritage," in Digitalization of Culture Through Technology: Proceedings of the International Online Conference on Digitalization and Revitalization of Cultural Heritage through Information Technology (ICDRCT-21), 23–24 Nov 2021, KIIT University, Bhubaneswar, ed. Deepanjali Mishra and Sasmita Rani Samanta (London: Routledge, 2022), https://doi.org/10.4324/9781003332183.2.

2. Dessy Harisanty et al., "Cultural Heritage Preservation in the Digital Age, Harnessing Artificial Intelligence for the Future: A Bibliometric Analysis," Digital Library Perspectives 40, no. 4 (2024): 609–630, https://doi.org/10.1108/DLP-01-2024-0018.

3. Tianxiu Yu et al., "Artificial Intelligence for Dunhuang Cultural Heritage Protection: The Project and the Dataset," International Journal of Computer Vision 130 (2022): 2646–2673, https://doi.org/10.1007/s11263-022-01665-x.

4. Felicia Constantin and Androniki Kavoura, "Boosting Multilingualism of Websites in Digital Cultural Heritage with Chat Generative Pre-training Transformer (ChatGPT) in Accredited Museums, Romania," in Strategic Innovative Marketing and Tourism, ed. Androniki Kavoura, Teresa Borges-Tiago, and Fernando Tiago (Cham: Springer, 2024), 70, https://doi.org/10.1007/978-3-031-51038-0_70.

5. James Hutson, Pace Ellsworth, and Matt Ellsworth, "Preserving Linguistic Diversity in the Digital Age: A Scalable Model for Cultural Heritage Continuity," Journal of Contemporary Language Research 3, no. 1 (2024): 10–19, https://doi.org/10.58803/jclr.v3i1.96.

6. Dar Gnawa, "Dar Gnawa Redefines Cultural Heritage with 'Kouyou': A Moroccan AI Marvel," (2025), https://dargnawa.net/dar-gnawa-redefines-cultural-heritage-with-kouyou/.

7. Karima Bouziane and Mohamed Echchaoui, "Leveraging Artificial Intelligence for International Accessibility to Moroccan Linguistic Heritage: The Case of Translating Doukkala's Ancient Proverbs," International Arab Journal of English for Specific Purposes 7, no. 1 (2024): 143–155, https://doi.org/10.34874/PRSM.iajesp-vol7iss1.48417.

Kouyou utilizes a multilingual natural language processing system, trained on resources such as historical manuscripts and interviews with Maâlems (Gnawa masters).Its broader vision includes incorporating African musical traditions by 2030, highlighting AI's potential to promote cultural preservation and foster African cooperation.

While projects like Kouyou demonstrate the power of AI in safeguarding cultural heritage, there is a notable lack of scholarly articles that tackle the role of AI in preserving Moroccan linguistic and cultural heritage. Research on this topic remains limited, yet there are a few notable contributions. For instance, Bouziane et al.[7] explore how AI can aid in making Morocco's linguistic heritage more accessible on a global scale. This work offers valuable insights into the challenges and opportunities presented by AI when translating culturally significant proverbs. These studies provide a foundation for further exploration into the application of AI in preserving Moroccan heritage. However, as the Kouyou project illustrates, the integration of AI with cultural preservation is still in its early stages, and much more research is needed to understand its potential, challenges, and ethical implications.

Procedure

- Selection: The selection of Malhun songs for this study is based on the following criteria: cultural and artistic significance, linguistic complexity, and credible sources.

- AI Translation: DeepSeek-V3, an advanced AI-powered language model, was utilized to translate the selected Malhun lyrics into English. The translation process involves a direct translation prompt, a self-assessment prompt, and contextual refinement.

- Evaluation Criteria: The evaluation was conducted by researchers with expertise in Moroccan Arabic and Malhun traditions. The following criteria were used: Linguistic correctness, preservation of poetic features, cultural and artistic authenticity, and idiomatic expression.

Preliminary Findings

The study is based on a large corpus; however, for this preliminary work, the author chooses to discuss small samples from four Malhun poems.

Case Study 1: Verses from the Poem "The Tormenter"

The poem conveys the pain of unhealed emotional wounds resulting from love and separation. The speaker asks for understanding and forgiveness for their suffering. They reflect on their heartbreak and the torment of unrequited love.

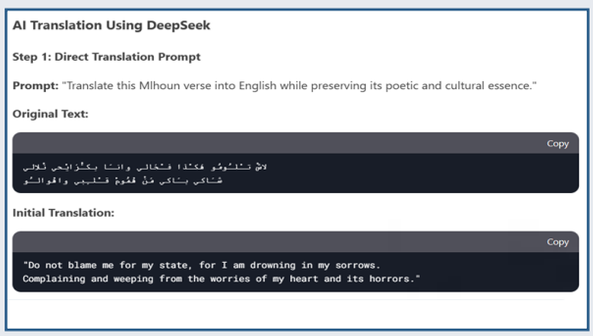


Figure 1: AI Translation using DeepSeek
© Karima Bouziane

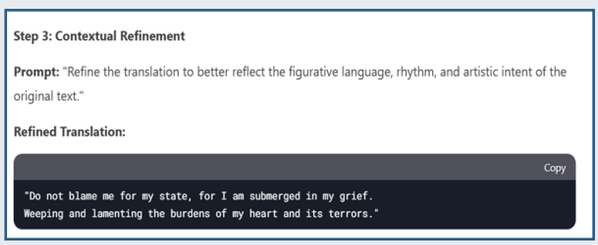


Figure 2: AI Translation using DeepSeek
© Karima Bouziane

Strengths:

- Linguistic Accuracy: Captures core meaning, e.g., "do not blame me for my state."
- Poetic Features: Retains figurative language, e.g., "submerged in my grief."
- Cultural Authenticity: Reflects emotional tone of sorrow and existential struggle.
- Idiomatic Expression: Effective in conveying idioms like "submerged in my grief."

Challenges & Refinements:

- Loss of Rhythm & Rhyme: Difficult to replicate original flow and poetic structure.
- Cultural Subtleties: Figurative language may require further explanation for non-Arabic speakers.
- Contextual Clarity: The need to refine idiomatic expressions to reflect emotional depth better.

Case Study 2: Verses from the Poem "Spring"

This poem celebrates the beauty of spring, nature, and love It describes the arrival of spring, marked by blooming flowers and vibrant colors, symbolizing renewal and happiness.

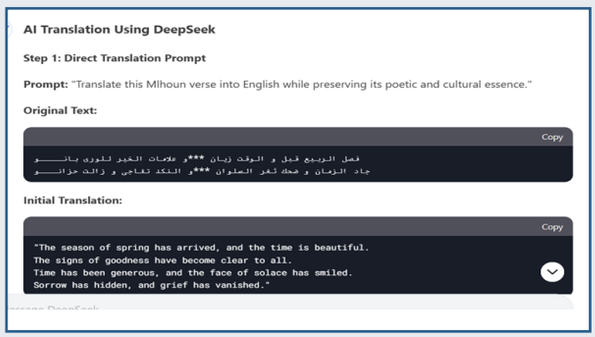


Figure 3: AI Translation using DeepSeek
© Karima Bouziane

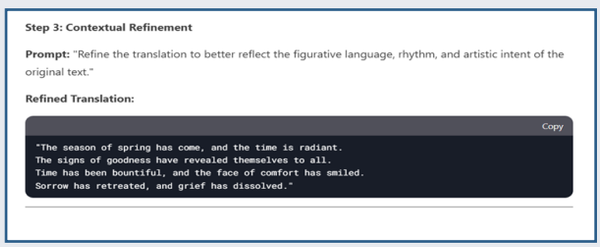


Figure 4: AI Translation using DeepSeek
© Karima Bouziane

Strengths:

- Linguistic Accuracy: The refined translation conveys the literal meaning of the original Malhun text with high fidelity; Phrases like "The season of spring has come" and "The signs of goodness have revealed themselves" are accurately captured.
- Poetic Features: The poetic structure and metaphorical language are retained, as seen in the contrast between sorrow and joy, and the symbolism of spring. The metaphor of comfort as a smiling face is preserved.
- Cultural Authenticity: The translation effectively conveys key cultural symbols, such as spring as a time of renewal, and the emotional tone of joy and relief is well-maintained. The transformative power of spring is effectively conveyed.
- Idiomatic Expression: The idiomatic expressions like "sorrow has retreated" are translated effectively, conveying the cultural context of emotional relief and renewal.

Challenges & Refinements:

- Loss of Rhythm and Rhyme: The rhythm and rhyme of the original text were difficult to replicate; however, the translation still maintains a natural emotional flow.
- Cultural Subtleties: Certain cultural metaphors, such as the significance of "the face of comfort," may require additional explanation to resonate with non-Arabic audiences fully.
- Contextual Clarity: Some phrases like "grief has dissolved" should be more precise to enhance the clarity of the emotional transformation described.

Case Study 3: Verses from the Poem "Feast"

This poem reflects the cultural values of hospitality, generosity, and respect for others. It emphasizes the importance of being kind and welcoming to guests, showing respect to neighbors, and maintaining a good reputation.

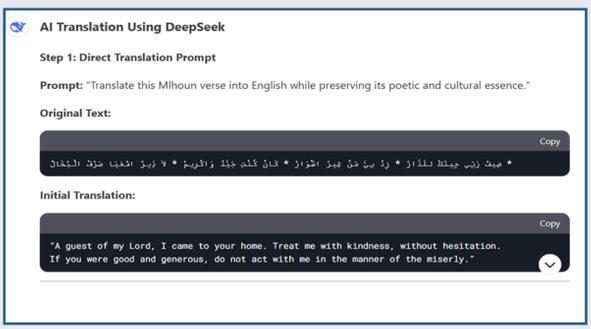


Figure 5: AI Translation using DeepSeek
© Karima Bouziane

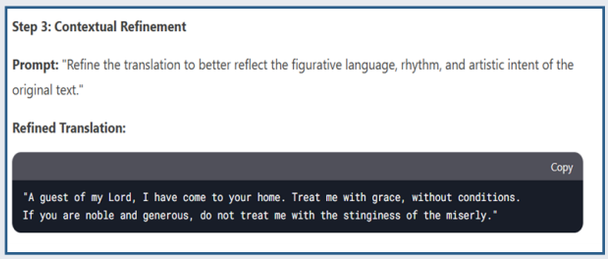


Figure 6: AI Translation using DeepSeek
© Karima Bouziane

Strengths:

- Linguistic Accuracy: Refined translation accurately reflects the literal meaning of the original text, such as "Treat me with grace."

- Poetic Features: Retains the contrast between generosity and miserliness, preserving the metaphorical structure.
- Cultural Authenticity: Reflects the cultural importance of hospitality and generosity in Arabic traditions.
- Idiomatic Expression: "Treat me with grace" effectively conveys the cultural expectations of hospitality.

Challenges & Refinements:

- Loss of Rhythm & Rhyme: The original rhythm and rhyme are difficult to replicate in translation.
- Cultural Subtleties: Some cultural specificities, such as the divine duty of hospitality, may need further elaboration.
- Contextual Clarity: Phrases like "the stinginess of the miserly" could be refined to emphasize the moral contrast more effectively.

Case Study 4: Verses from the Poem "The Most Forgiving"

This poem is a prayer for forgiveness and mercy from God. The poet reflects on life's fleeting nature, expresses regret for past mistakes, and seeks redemption. He calls on God's grace, hoping for protection from sin and the promise of salvation through repentance and devotion.

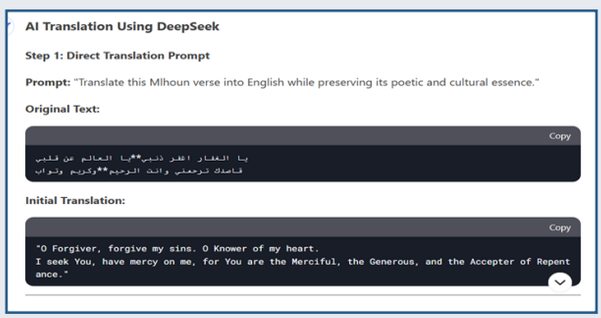


Figure 7: AI Translation using DeepSeek
© Karima Bouziane

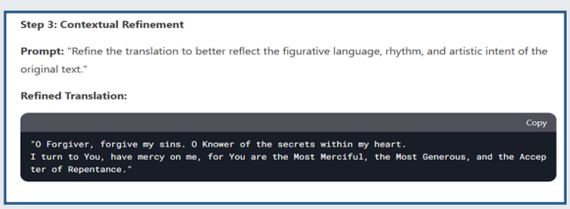


Figure 8: AI Translation using DeepSeek
© Karima Bouziane

Strengths:

- Linguistic Accuracy: Preserves core meaning and key religious references, as in « O Forgiver, forgive my sins. » for يا الغفار اغفر ذنبي.
- Poetic Features: Retains metaphorical depth and emotional resonance, as seen in « O Knower of the secrets within my heart, » for يا العالم عن قلبي.
- Cultural Authenticity: Captures themes of repentance, humility, and divine mercy, as in « For You are the Most Merciful, the Most Generous, and the Accepter of Repentance. » for وأنت الرحيم وكريم وتواب.
- Idiomatic Expression: Adapts figurative language and maintains the intended message, as in « I turn to You, have mercy on me, » for قاصدك ترحمني.

Challenges & Refinements

- Loss of Rhythm & Rhyme: The original verse يا الغفار اغفر ذنبي، يا العالم عن قلبي has a rhythmic and melodic flow that is difficult to replicate in English, making « O Forgiver, forgive my sins. O Knower of the secrets within my heart" sounds more prose-like than poetic.
- Cultural Subtleties: The term التواب At-Tawwab conveys not just "Accepter of Repentance" but the idea of God continuously accepting sincere repentance, which may require additional explanation for the target audience/reader.
- Contextual Clarity: قاصدك ترحمني directly translates as "I turn to You, have mercy on me, "but refining it to "I seek refuge in You, bestow Your mercy upon me" may better reflect the depth of spiritual surrender in the original.

Discussion

The preliminary findings from the analysis of DeepSeek-V3's translations of Malhun poetry highlight both the potential and limitations of AI translation in preserving intangible cultural, linguistic, and artistic heritage.

One of the most significant challenges in AI translation is maintaining poetic integrity. Although DeepSeek-V3 can translate words and phrases accurately, the rhythm, rhyme, and artistic intent of Malhun poetry often suffer in the process. This is evident in the translation of metaphorical language, where AI-generated outputs sometimes fall short in capturing more profound cultural and emotional subtleties.

Despite these challenges, AI translation tools like DeepSeek-V3 offer a promising avenue for enhancing understanding and global accessibility to Malhun's poetry.

By providing an initial translation, these tools can serve as a foundation upon which human translators and scholars can build to refine and contextualize the text. The ability of DeepSeek-V3 to generate self-assessments and analyze its translations is a particularly valuable feature, as it allows for iterative improvements and increased accuracy over multiple revisions.

Recommendations

- AI translation should be used in conjunction with human expertise. Scholars and native speakers should refine AI-generated translations to preserve cultural specificities and poetic integrity.
- AI-generated translations should be supplemented with explanations of cultural and historical contexts to enhance audience understanding, particularly for non-Arabic speakers.
- AI translation models should be trained specifically in poetic structures, figurative language, and regional dialects to improve their ability to translate artistic and metaphorical texts.
- Developing interactive AI tools that allow users to select different translation styles (e.g., literal, poetic, or cultural adaptation) could improve the quality of AI-generated translations.
- The use of AI in cultural heritage preservation must be guided by ethical considerations, ensuring that AI tools do not distort or commodify cultural expressions.
- Involving international scholars, linguists, and poets in refining AI-translated texts can lead to improved cross-cultural accessibility and appreciation of Malhun poetry.

Inclusive Artificial Intelligence: Community-Driven Recommendations for Digitizing Intangible Cultural Heritage

© Kasper Rodil



Dr. Kasper Rodil

Associate Professor in Design and Media Technology, Aalborg University, Denmark

Abstract

Although AI and other digital tools offer opportunities for cultural preservation, they often fail to capture the complexity and multimodality of intangible heritage. Biases in AI training data risk amplifying dominant perspectives while marginalizing others. A participatory design approach ensures technology aligns with diverse cultural values by integrating communities throughout the development process. The article advocates for shifting from technological determinism to a socially constructivist perspective, urging AI developers to adopt inclusive methodologies that enhance transparency, explainability, and cultural sensitivity.



Figure 1: System evaluation with members of the OvaHimba tribe in Northern Namibia © Kasper Rodil

II

The context for this article is 15 years of close collaboration with three distinct Namibian indigenous communities in the co-design of technologies aimed at safeguarding and disseminating their lived and self-determined intangible cultural heritage using digital, interactive display technologies. These technologies range from mobile systems to virtual reality[1]. While I maintain a somewhat agnostic view toward technologies themselves, I operate under the premise that any digitization of ICH will inevitably fail to capture its full multimodality. Therefore, my primary research explores how various forms of technology can assist in digitization, while simultaneously subjecting these technologies to critique for their inaccuracies and limitations in digitally fragmenting reality[2].

For several reasons, I regard generative AI as another 'tool,' constructed to achieve specific tasks and offering many intriguing opportunities. However, in the case of ICH safeguarding, it must be scrutinized for its biases and potential consequences on communities. Similarly, the capture and representation of digital ICH should be examined for biases and embedded cultural perspectives, which often reflect Western views[3].

Unsurprisingly, the field of AI, particularly generative AI[4], where new data is generated based on existing data such as text and images, exhibits traits common to many other technological advancements that have primarily emerged from the Global North. When these technologies reach populations in the Global South, they tend to be well-developed and adapted to their original contexts, often with little consideration for the diverse perspectives and environments of other communities.

Generative AI models are primarily trained on readily available data, mainly sourced from the internet, and predominantly in dominant languages, particularly English. Consequently, the nature of this training process inadvertently prioritizes data—and, by extension, people and their cultures—that are already well-represented, while excluding those who are underrepresented due to their limited presence in these datasets.

This inherent bias further amplifies existing disparities, as the perspectives and contributions of less-represented groups are often overlooked. As Karpouzis[5] notes, "The result is a digital landscape where certain cultural narratives are amplified, while others are barely audible," which in turn leads to "cognitive imperialism"[6]. An example of such misrepresentation is recent work with marginalized communities in Namibia, where AI-generated visuals are overly generic and fail to capture local cultural nuances[7].

Recent studies advocate for the inclusion of indigenous perspectives and values in an otherwise distinctly corporate AI agenda[8], and other colleagues highlight how Explainable AI research tends to overlook cultural variations in explanatory needs, often framing itself within individualistic cultures[9].

Addressing the challenge of using and analysing digital tools and digitization for embedded assumptions, and reconfiguring technologies to align with the culture of the people, can be accomplished through participatory methods rooted in the Participatory Design (PD) tradition.PD emerged as a socio-cultural product of its time in Scandinavia, responding to unfairness and the marginalization of knowledge, to collaboratively design technology[10]. Community-based Co-Design is an offshoot of this PD approach, tailored to the collectivistic contexts of the Global South[11]. It promotes and values collaboration, diverse cultures and knowledge, criticism, and transparency to develop equitable technologies that resonate with the values of these contexts.

Collaborating with indigenous communities, who may have limited experience with technology, to preserve intangible cultural heritage using AI digitally presents a complex challenge.

This complexity arises not only from the AI technology pipeline, which encompasses stages from training to generation, but also from the unique contexts and cultural heritage involved.

I will argue that community participation can and should be integrated throughout the AI pipeline. As suggested by Birhane et al.[12], participation can take many forms; therefore, enhancing explainability and incorporating a community-in-the-loop approach can ensure that the technology is both accessible and open to criticism, respectful of the communities' needs and cultural nuances.

Before providing some recommendations, I find it essential to establish a framework for them. In my work, I approach community participation in the digitization process with at least two distinct perspectives.

The first is a traditional view shared by those most interested in the digitization of ICH: how can we use computing systems to safeguard and disseminate ICH? The alternative perspective focuses on how we can modify these computing devices to better reflect the cultures, communities, and their lived heritage.

Too often, I observe uncritical use of computing devices without a readiness to critique their limitations in safeguarding ICH. This critique is equally applicable to AI in any form it takes. Where does the data originate (not originate) from? Who does it (not) represent? ICH is not static; it is contextual, complex, and multimodal.

1. Rodil, Kasper, Donovan Maasz, and Heike Winschiers-Theophilus. "Moving Virtual Reality out of Its Comfort Zone and into the African Kalahari Desert Field: Experiences from Technological Co-Exploration with an Indigenous San Community in Namibia." In Proceedings of the 26th ACM Symposium on Virtual Reality Software and Technology, 1–10, 2020.

2. Rodil, Kasper, and Matthias Rehm. "A Decade Later: Looking at the Past While Sketching the Future of ICH Through the Tripartite Digitisation Model." International Journal of Intangible Heritage 10 (2015): 47–60.

3. Kasper Rodil, "Reflections on Visualization in Cross-Cultural Design," in At the Intersections of Traditional and Indigenous Knowledges and Technology Design (Santa Rosa, CA: Informing Science Press, 2015), 319–340.

4. GeeksforGeeks. "Generative AI vs. Discriminative AI: Understanding the Key Differences." GeeksforGeeks. Accessed March 10, 2025. https://www.geeksforgeeks.org/difference-between-generative-ai-and-discriminative-ai/.

5. Karpouzis, Kostas. "Plato's Shadows in the Digital Cave: Controlling Cultural Bias in Generative AI." Electronics 13, no. 8 (2024): Article 1457. https://doi.org/10.3390/electronics13081457.

6. Ofosu-Asare, Y. "Cognitive Imperialism in Artificial Intelligence: Counteracting Bias with Indigenous Epistemologies." AI & Society (2024). https://doi.org/10.1007/s00146-024-02065-0.

7. Muashekele, Chris, Kasper Rodil, Heike Winschiers-Theophilus, and Shorty Kandjengo. "Recovering Lost Futures of the Past: Situating Alternative Futures within an Indigenous Afrocentric Orientation and Past Trajectory." In Proceedings of the Participatory Design Conference 2024: Full Papers – Volume 1, 28–40.



Figure 2: Chameleon Innovation Game: blending indigenous culture and contemporary creativity through participatory, technology-supported design © Chris Muashekele, Kasper Rodil, Heike Winschiers-Theophilus, and Shorty Kandjengo. 2024. Recovering lost futures of the past: Situating alternative futures within an indigenous Afrocentric orientation and past trajectory

Any AI-generated content is based on a much weaker foundation than its cultural origin from which it was trained as a snapshot of reality, and it should be made transparent and critically evaluated within a participative framework.

Recommendations:

- Of the highest priority, consider the social constructivist approach to AI and safeguarding, where humans are the agents of change, rather than a technological deterministic view, where technologies shape humans.

- Therefore, encourage AI developers to adopt participatory design methodologies with a readiness to direct criticism inwards, to ensure technologies are aligned with the cultural values and needs of diverse communities.

- Consider enhancing explainability by tailoring Explainable AI methods to accommodate cultural variations in explanatory needs, ensuring that AI systems are interpretable and transparent across different cultural contexts.

- Establish partnerships and develop frameworks to prevent cognitive imperialism by valuing and integrating indigenous perspectives and knowledge systems into AI development agendas.

I acknowledge the research partners at the Namibia University of Science and Technology, international colleagues, and the communities that have shaped these brief viewpoints.

8. Munn, Luke. "The Five Tests: Designing and Evaluating AI According to Indigenous Māori Principles." AI & Society39, no. 4 (2024): 1673–1681.

9. Peters, Uwe, and Mary Carman. "Cultural Bias in Explainable AI Research: A Systematic Analysis." Journal of Artificial Intelligence Research 79 (2024): 971–1000.

10. Spinuzzi, Clay. "The Methodology of Participatory Design." Technical Communication 52, no. 2 (2005): 163–174.

11. Rodil, Kasper, Shorty Kandjengo, Donovan Maasz, Hasib Ahsan, and Lars Rune Christensen. "Comparative Insights for Community-Based Co-design: Bi-directional Inclusive Strategies Between Marginalised Communities and Researchers in Participatory Design." In Proceedings of the Participatory Design Conference 2024: Exploratory Papers and Workshops – Volume 2, 207–210.

12. Birhane, Abeba, William Isaac, Vinodkumar Prabhakaran, Mark Diaz, Madeleine Clare Elish, Iason Gabriel, and Shakir Mohamed. "Power to the People? Opportunities and Challenges for Participatory AI." In Proceedings of the 2nd ACM Conference on Equity and Access in Algorithms, Mechanisms, and Optimization, 1–8, 2022

The Role of Artificial Intelligence in Preserving Intangible Heritage: Using an Omani Traditional Story as a Model

© Al- Yahyai, Fakhriya



Dr. Fakhriya Al Yahyai

Professor of Art, Sultan Qaboos University, Oman

Abstract

Although AI and other digital tools offer opportunities for cultural preservation, they often fail to capture the complexity and multimodality of intangible heritage. Biases in AI training data risk amplifying dominant perspectives while marginalizing others. A participatory design approach ensures technology aligns with diverse cultural values by integrating communities throughout the development process. The article advocates for shifting from technological determinism to a socially constructivist perspective, urging AI developers to adopt inclusive methodologies that enhance transparency, explainability, and cultural sensitivity.

The study aims to explore the potential for intelligence in drawing Omani folktales. The study compared the traditional method of drawing folk tales with artificial intelligence (AI) tools, analyzing the experience of drawing the story "The Enchanted Ring." The study aimed to evaluate various aspects of each, including similarities in location, geographical environment, people's characteristics, and the ability to visually represent the story. The study aims to answer the following questions: How can AI contribute to transforming Omani folk stories, a part of the country's audio heritage, into visual and tangible forms? How can AI be used to digitize the Omani children's literature inspired by popular stories?

A descriptive-analytical approach was adopted to study the theoretical framework related to the use of modern technologies in the digitization of children's literature. The semi-experimental approach was also employed to transform the oral heritage, represented by Omani folktales and stories, into visual literature for children, by taking advantage of the capabilities of AI in producing visual drawings

II

that reflect the characteristics and attributes of the Omani personality, and embody the contents of folktales in narrative images generated under the guidance of the researcher.

The study found that traditional drawing is characterized by the accuracy of details and the artist's ability for personal and creative expression, which allows the addition of symbols and deep cultural meanings; however, the artist may reduce many scenes due to the time spent drawing. In contrast, AI tools such as Bing Image Creator and ChatGPT provide speed and ease in generating images but may lack accuracy in representing complex visual symbols. Additionally, the production of AI relies on the availability of data, which can sometimes result in inconsistencies with the original text. The study emphasized the importance of integrating traditional drawing with AI, as modern technologies can be used as auxiliary tools for artists, allowing for new possibilities to document folk stories and enhance visual heritage. This technology can also contribute to providing educational content suitable for children, improving their interaction with cultural heritage in modern and attractive ways.

Introduction:

Artificial intelligence (AI) is transforming children's literature by creating interactive and immersive reading experiences. For instance, AI-powered applications allow children to engage with stories through touch, swipe, and click interactions, making reading more appealing. Additionally, AI integrates images and verbal representations, enhancing educational experiences and redefining how we interact with literature. [1]

Today, without a doubt, AI is considered one of the important fields that has gained the attention of scientists and researchers as a result of continuous developments in the modern technology sector. These advancements have significantly impacted the future of humanity in all fields, aiming to enhance human participation and harness various methods and means for scientific, social, and health-related aspects of life.

Yang (2020)[2] indicates that the in-depth application of AI technology in the field of education, for example, has led to an improvement in teaching efficiency and the quality of arts specialization. This, in turn, enhances integration, enabling art to serve society better. [3] Through AI, these tales can be analyzed, classified, and reproduced in modern formats, such as interactive applications, augmented reality experiences, and AI-powered digital books. This ensures their survival as a vibrant part of cultural heritage that continues to be shared across generations. [4]

On the other hand, Cultural heritage represents the collective memory of societies, embodying their traditions, history, and identity. To safeguard these invaluable assets for future generations, it is essential to adopt innovative solutions that align with rapid technological advancements. In this context, AI emerges as a leading tool in cultural heritage preservation efforts, offering new possibilities not only for protecting this heritage but also for revitalizing and making it accessible through interactive modern approaches.

Many studies indicate that AI has vast capabilities in transforming folktales into high-quality visual images, allowing children to understand better events and characters studies such as: He and Sun (2021) [5], Kong (2020)[6], and Yang (2020), which agree that AI technology applications can play a vital role in the digitization of children's literature. AI contributes to expanding children's reading horizons and knowledge, making reading an enjoyable and engaging experience. It also enhances the development of their language and creative skills. However, it remains essential to guide this usage cautiously, ensuring the selection of appropriate content and balancing technology with the developmental needs of different age groups while maintaining its connection to children's culture and identity.

Moreover, AI applications appear to play a crucial role in transforming folk stories into visual illustrations, facilitating and accelerating the production of images and visual concepts for these stories. Laura May and others (2017) believe that integrating technology into storytelling has transformed the way we read and interact with literature, providing new ways for exploration and learning. Moreover, combining technology with storytelling offers an in-depth educational experience for students by synthesizing images and verbal representations with their understanding. The use of technology has also enabled children to interact with characters and settings in ways that were previously impossible. Interactive e-books, for example, allow children to touch, swipe, and click their way through the story, creating a more immersive and engaging reading experience. [7]

These capabilities can be summarized as follows:

- Generating images and characters that align with Omani folk stories based on existing textual descriptions.
- Adding movement and interaction to illustrations or animations to make the stories livelier.
- Enhancing illustrations by correcting colors, lighting, details, and overall quality to make them more visually appealing.
- Analyzing story texts to extract key scenes, main characters, and significant events, which can then be used to guide freehand drawing and graphic illustration, as well as animation.
- Providing interactive experiences with the story, allowing users to influence its course.

Despite the great potential of AI, there are some challenges facing its application in transforming popular stories into visual literature for children:

1. Accuracy of textual input: AI models require accurate textual input to produce images that are consistent with the cultural and value context.
2. Preserving cultural character: AI technologies may struggle to capture subtle cultural details, which necessitates the intervention of specialists to manage the content.
3. Ethical considerations: Care must be taken when using AI to produce visual literary content for children, as the content must align with society's moral and cultural values.

1. Yibo Wang, Yuanyuan Mao, Shi-ting Ni, Zeyu Wang, and Pan Hui, "Metabook: An Automatically Generated Augmented Reality Storybook Interaction System to Improve Children's Engagement in Storytelling" (2024), arXiv preprint arXiv:2405.13701, https://doi.org/10.48550/arXiv.2405.13701.

2. R. Yang, "Artificial Intelligence-Based Strategies for Improving the Teaching Effect of Art Major Courses in Colleges," International Journal of Emerging Technologies in Learning (iJET) 15, no. 22 (2020): 146–160, Kassel, Germany: International Journal of Emerging Technologies in Learning, accessed May 5, 2022, https://www.learntechlib.org/p/218414/.

3. Ibid. (répétition de la source précédente)

4. Heba Tawfiqe Abu Eyadah and Anas Adnan Odaibat, "A Forward-Looking Vision to Employ Artificial Intelligence to Preserve Cultural Heritage," Humanities and Social Sciences 12, no. 5 (2024): 275–285.

5. Caixia He and Baoguo Sun, "Application of Artificial Intelligence Technology in Computer Aided Art Teaching," Computer-Aided Design and Applications 18, suppl. 4 (2021): 118–129, https://doi.org/10.14733/cadaps.2021.s4.118-129.

6. Fanwen Kong, "Application of Artificial Intelligence in Modern Art Teaching," International Journal of Emerging Technologies in Learning (iJET) 15, no. 13 (2020): 238, https://doi.org/10.3991/ijet.v15i13.15351.

7. L. Maye, D. Bouchard, G. Avram, and L. Ciolfi, "Supporting Cultural Heritage Professionals Adopting and Shaping Interactive Technologies in Museums," Spaces & Surfaces, June 10–14, 2017, 221–232, https://dl.acm.org/doi/pdf/10.1145/3064663.3064753.

8. Story Summary: A twenty-year-old young man from the Sharqiyah Governorate finds a silver ring with a red gemstone while hunting in the mountains. After taking it home and putting it on in private, he is overwhelmed by drums and terrifying faces—spirits of a jinn tribe. A village elder explains the ring is enchanted and advises returning it to its place of origin, which he does, ending the story.

Objectives of the Study

The process of imagining folktales and stories presents a significant challenge for both children and adults, as these narratives are often linked to the past and contain myths and events that may seem illogical or difficult to believe. However, with modern technological advancements, particularly with AI, it has become possible to bridge the gap between what is read and understood and the visualization of these events and concepts.

AI contributes to accelerating the production of imaginative images in creative and engaging ways, which helps stimulate imagination, especially among children.

From this perspective, this study aims to present a visual and artistic literary experience that reinterprets Omani children's literature and folktales in a visual format, preserving their original identity. The goal is to highlight the potential of modern technologies, particularly AI, in enriching the storytelling experience and enhancing engagement with it.

This study aims to explore the potential of AI in transforming Omani folktales into visual works for children. Its objectives can be summarized as follows:

1. Converting oral heritage, represented by Omani folktales and stories, into a tangible visual literature suitable for children.

2. Utilizing AI applications to digitize children's literature inspired by Omani folktales.

3. Developing visual content in the form of stories that embody Omani cultural and character traits, thereby enhancing national identity among children.

The questions of the study:

1. How has AI contributed to transforming oral heritage, represented by Omani folktales, into children's literature in the form of tangible visual stories?

2. How can AI be utilized in digitizing Omani children's literature inspired by folktales?

Method of Study:

The descriptive-analytical approach was adopted to examine the theoretical framework related to the use of modern technological tools in the digitization of children's literature. Additionally, the quasi-experimental approach was employed to transform oral heritage, represented by Omani folktales and stories, into visual children's literature. This was achieved by leveraging AI capabilities to generate visual illustrations that reflect the characteristics and identity of Omani culture, embodying the meanings of folktales in narrative images produced by the researcher.

The sample of the study (The Enchanted Ring8)

A purposive sample consisting of one story from Omani folk tales was selected to undergo an artistic experiment and the application of contemporary AI programs.

Comparison Between Traditional Illustration and AI Tools in Storytelling: An Analytical Study of "The Enchanted Ring"

With technological advancements, AI tools such as Bing Image Creator and ChatGPT have introduced new methods for generating images and illustrations. This study aims to compare traditional illustration with AI-based tools in terms of artistic accuracy, creativity, ease of use, and fidelity to the story's narrative by analyzing the experience of illustrating The Enchanted Ring using these different approaches.

1. Artistic Accuracy and Visual Expression

Traditional illustration is distinguished by its high level of detail, where artists have complete control over lines, colors, and textures. In contrast, AI tools rely on programmed rules and deep learning models, making their outputs dependent on the available datasets. Bing Image Creator generates high-quality images but may not fully capture an artist's unique style. Meanwhile, ChatGPT can provide precise textual descriptions of images, but their conversion into illustrations depends on external tools like DALL·E.

Bing Image Creator generates high-quality images but may not fully capture an artist's unique style. Meanwhile, ChatGPT can provide precise textual descriptions of images, but their conversion into illustrations depends on external tools like DALL·E.

2. Creativity vs. Automation

Human creativity in traditional illustration remains irreplaceable, as artists infuse their personal touch by selecting and composing elements according to their unique vision. On the other hand, AI-generated creativity is derived from a combination of patterns learned from training data, which may lack the personal or spiritual depth inherent in handcrafted artwork.

3. Interaction and Ease of Use

AI tools offer speed and convenience, allowing users to input textual descriptions and generate images within seconds, whereas traditional illustration requires significantly more time and effort. However, traditional artists have greater control over the final image, enabling them to fully realize their vision without relying on AI algorithms.

4. Accuracy in Story Representation

In traditional illustration, the accuracy of the representation depends on the artist's experience and ability to understand and visually interpret the story, incorporating symbols and elements that reflect deeper meanings. AI-generated images, however, may not always align perfectly with the original narrative, as they rely on available data without fully comprehending the context, which can lead to misinterpretations.

Challenges of using AI to preserve intangible heritage

However, despite the great potential of AI, there are some challenges facing its application in transforming popular stories into visual literature for children:

- Accuracy of textual input: AI models require accurate textual input to produce images that are consistent with the cultural and value context.
- Preserving cultural character: AI technologies may struggle to capture subtle cultural details, which often require the intervention of specialists to ensure accurate content control.
- Ethical considerations: Care must be taken in using AI to produce visual literary content for children, as the content must align with society's moral and cultural values.

The study result:

The study demonstrated the potential of AI in transforming oral heritage, specifically Omani folktales, into children's literature in the form of tangible visual stories.

- AI has great potential, provided that the input data is accurate and of high quality, with carefully selected vocabulary supplied by researchers.
- AI contributed to the development of visual materials in the form of children's stories that reflect Omani identity and cultural traits.
- The AI-generated illustrations helped bring imagined scenes to life, making them tangible and visually engaging.

Recommendation:

- The necessity of utilizing AI technology while being cautious about its data and outcomes.
- There is a need for in-depth studies on the role of AI technology in serving visual arts.
- The importance of focusing on well-crafted textual inputs for AI programs to ensure better and more accurate results.

Conclusion:

Today, the role of AI in the fields of education, art, and heritage cannot be ignored, especially when it comes to drawing or documenting visual images of stories. AI helps clarify stories, attract children's attention, and enhance their reading skills.

In the field of folktales, AI offers an opportunity to revive classic stories in a modern way, adding a unique charm that appeals to young readers. This study discusses how AI can be utilized to illustrate folktales and structure the imaginative process in shaping events, thereby deepening the understanding of scenes and narratives. Furthermore, AI opens new horizons for exploration and learning, offering a profound educational experience in studying events, locations, and historically accurate settings.

CHAPTER III

AI and Underwater Cultural Heritage



AI & Culture

© Maël BALLAND on Unsplash, 2019*

Chapter 3

Artificial Intelligence and Underwater Cultural Heritage

The protection of underwater cultural heritage (UCH)—including shipwrecks, submerged cities, and maritime archaeological sites—is guided by the normative framework of UNESCO, most notably the 2001 Convention on the Protection of the Underwater Cultural Heritage. This convention establishes principles for the in situ preservation of underwater heritage, prevention of illicit trafficking, and promotion of international cooperation, while emphasizing that UCH should not be commercially exploited. It also underscores the importance of scientific research, capacity building, and public access to submerged heritage as part of humanity's shared history. In recent years, artificial intelligence has emerged as a transformative force in this domain, offering new possibilities for large-scale mapping, monitoring, and interpretation of underwater sites that are otherwise difficult to access. AI-powered tools—such as remote sensing, computer vision, and predictive modeling—enable faster identification of submerged structures, automated classification of artefacts, and real-time environmental monitoring. At the same time, these technological advancements introduce significant challenges, including limited availability of high-quality training datasets, uncertainties in algorithmic interpretation, and ethical concerns regarding digital reconstruction, ownership of data, and potential commercialization. These developments call for careful alignment with UNESCO's normative principles to ensure that innovation supports sustainable, ethical, and scientifically grounded heritage management.

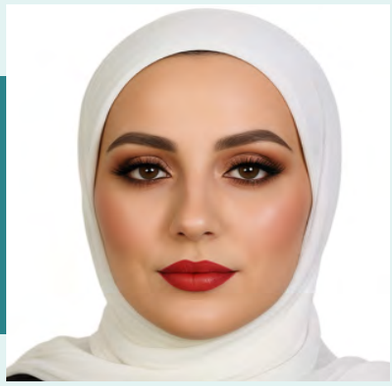
Building on this framework, recent research highlights both the practical applications and critical considerations of AI in underwater cultural heritage. Dr Ababneh demonstrates how AI and digital technologies can revolutionize the preservation and promotion of Jordan's underwater heritage, particularly in contexts such as the Underwater Military Museum. Her work highlights the use of tools including remote sensing, 3D photogrammetry, predictive maintenance models, and augmented reality to monitor submerged artefacts, anticipate risks, and expand public access through virtual experiences. Complementing this, Dr Bruno presents advanced research from the University of Calabria on AI-powered applications for underwater surveying, documentation, and degradation monitoring. These include autonomous marine vehicles capable of mapping sites, recognizing biological colonization on artefacts, improving scene understanding through opto-acoustic systems, and enabling safe and efficient dive planning through automated path optimization.

Dr Varinlioglu further explores AI's role in artefact classification, decomposition prediction, and digital reconstruction, while critically examining the limitations of current models, including constrained datasets and ethical concerns surrounding AI-generated reconstructions. Drawing on extensive fieldwork, she proposes a framework for context-aware and ethically grounded AI adoption in underwater archaeology. In parallel, Dr Karamitrou investigates how AI combined with open-access remote sensing imagery can support large-scale detection and analysis of submerged and coastal archaeological features. Her work also raises important methodological and ethical questions related to data ownership, transparency, algorithmic bias, and the need for interdisciplinary collaboration to ensure inclusive and culturally sensitive applications of AI technologies.

In summary, these contributions collectively illustrate that AI is reshaping the field of underwater cultural heritage by enhancing the capacity to detect, document, analyze, and share submerged cultural resources at unprecedented scales. From autonomous exploration systems and predictive conservation models to immersive digital reconstructions and large-scale remote sensing analysis, AI expands both the technical capabilities and public accessibility of underwater archaeology. However, these advancements are accompanied by critical challenges related to data limitations, ethical governance, and the risk of misinterpretation or over-reliance on automated systems. The studies consistently emphasize the importance of integrating technological innovation with human expertise, interdisciplinary collaboration, and culturally sensitive approaches. In alignment with UNESCO's role as a standard-setter and catalyst for international cooperation, the responsible integration of AI into underwater cultural heritage management requires not only technical investment but also robust ethical frameworks and global partnerships. By balancing innovation with accountability, AI can serve as a powerful enabler in safeguarding submerged heritage for future generations while preserving its historical integrity and cultural significance.

Artificial Intelligence and Cultural Heritage Preservation in Jordan: Underwater Heritage

© Alaa Ababneh



Ms. Alaa Ababneh

Digital Technology Researcher, Universidad Autónoma de Barcelona, Spain.

Abstract

This paper builds upon the presentation at the webinar "Artificial Intelligence and Intangible Cultural Heritage," organized by the UNESCO Cairo Office on March 27, 2025. Jordan's rich cultural heritage spans millennia, yet its underwater heritage remains underexplored and underprotected. Underwater Military Museum in Aqaba, Jordan—first in the Middle East—presents a unique blend of military history, cultural significance, and environmental preservation. However, its underwater location exposes it to complex risks, including corrosion, marine biofouling, and broader impacts of climate change. Research examines how artificial intelligence (AI) and digital technologies can revolutionize the preservation and promotion of Jordan's underwater cultural heritage.

AI-powered tools, such as remote sensing, 3D photogrammetry, predictive maintenance modeling, and augmented reality (AR), offer innovative solutions for monitoring the condition of submerged artifacts, predicting threats, and expanding public access through virtual experiences. Jordan's current digital heritage efforts are in their early stages, highlighting the urgent need for intensified national and international collaborations. By investing in AI-driven conservation strategies, Jordan can safeguard the Underwater Military Museum's historical assets and establish itself as a regional leader in underwater heritage management, setting a precedent for the sustainable protection of submerged cultural resources worldwide.

III

Introduction

Jordan's cultural heritage is internationally renowned, encompassing archaeological wonders such as Petra, Jerash, and the Dead Sea Scrolls. Yet, its underwater cultural resources have received comparatively little attention. The Underwater Military Museum in Aqaba, which opened in 2019, marks a significant milestone by transforming decommissioned military vehicles into an artificial reef that commemorates Jordan's military history while contributing to marine biodiversity.[1] As the first underwater military museum in the Middle East, it captures a critical era of Jordanian national identity. However, preserving underwater heritage presents unique challenges that require innovative, technology-driven solutions.

Current Challenges

Artificial intelligence (AI) offers transformative tools for monitoring, analyzing, and preserving underwater heritage.[2] AI-powered underwater drones (ROVs) equipped with computer vision can autonomously detect signs of corrosion, structural damage, and environmental changes, providing real-time assessments without frequent human intervention.[3] Machine learning models further enhance preservation efforts by analyzing ecological data—such as temperature, salinity, and microbial activity—to predict patterns of artifact degradation, enabling proactive conservation measures.

Jordan's Position and the Way Forward

Currently, Jordan's use of AI in cultural heritage conservation is in its early stages. A few pilot projects in archaeological documentation and museum management exist, but comprehensive initiatives focused on underwater heritage are lacking. The Underwater Military Museum, due to its symbolic and regional importance, offers an ideal starting point for launching targeted projects to integrate AI with heritage preservation.[4]

Case Study: Underwater Military Museum

The Underwater Military Museum is a unique initiative to preserve Jordan's military history through underwater artifacts. Located in the Red Sea near Aqaba, the museum showcases a diverse collection of military relics, offering insight into the country's naval heritage. This project preserves history and promotes cultural tourism, attracting visitors interested in military heritage.

Visitors explore the first underwater military museum in the Gulf of Aqaba, located in the Red Sea, which features 21 unique battle objects. Military machines were placed along the coral reefs. They imitate a tactical battle formation. Indeed, the museum is an exciting underwater spot. It intrigues divers and snorkelers to discover more and more.



Figure 1: The Aqaba underwater military museum and the major features and components of the seabed around the vehicles. © Mohammad Salem Al-Tawaha*

AI-driven photogrammetry produces high-resolution 3D models of submerged structures, creating digital twins of sites like the Underwater Military Museum. These digital replicas support ongoing monitoring, restoration planning, and virtual museum experiences.[5]

AI applications in augmented and virtual reality can make underwater exhibits accessible to a global audience, thereby minimizing the impact of physical tourism on fragile marine environments. AI streamlines the documentation process, automating conservation reports and tracking visual changes for local and international stakeholders over time.[6]

In Jordan, the integration of AI into cultural heritage conservation is still in its early stages, with some pilot projects underway, but comprehensive efforts for underwater heritage remain limited.Underwater Military Museum presents a prime opportunity to pioneer preservation initiatives.

International collaboration with organizations like UNESCO, universities, marine archaeologists, AI specialists, and cultural institutions will be vital. Building local expertise in digital conservation, AI programming, underwater robotics, and heritage management will ensure the sustainable and long-term protection of Jordan's submerged cultural treasures.[7]

Recommendations

1. Establish a National Digital Heritage Program for Underwater Conservation.

Jordan should initiate a comprehensive national program to preserve its underwater cultural heritage digitally. This program must integrate AI tools for continuous monitoring, risk assessment, and documentation of underwater sites, beginning with the Underwater Military Museum in Aqaba as a flagship project.

2. Develop International Partnerships for Capacity Building and Knowledge Exchange

Given the technological complexity and resource intensity of AI-driven conservation, Jordan must collaborate with global organizations, including UNESCO, academic institutions, and private tech companies specializing in AI and underwater technologies. Joint research projects, exchange programs, and training workshops should be prioritized for Jordanian marine archaeologists and conservationists.

I. K. Bazazo and O. A. Alananzeh, "The Implementation of International Standards and Specifications (ISO-SCUBA) on Improving the Quality of Diving Tourism in Aqaba, Jordan," Geo Journal of Tourism and Geosites 33 (2020): 1557–1563.

2. A. Ababneh, "Review Future Technologies in Underwater Cultural Heritage," Journal of the General Union of Arab Archaeologists 9, no. 2 (2024): 1–19.

3. F. Gîrbacia, "An Analysis of Research Trends for Using Artificial Intelligence in Cultural Heritage," Electronics 13, no. 18 (2024): 3738.

4. J. Xie, "Innovative Design of Artificial Intelligence in Intangible Cultural Heritage," Scientific Programming 2022, no. 1 (2022): 6913046.

5. J. Zhang and Y. Jing, RETRACTED: "Application of Artificial Intelligence Technology in Cross-Cultural Communication of Intangible Cultural Heritage," Mathematical Problems in Engineering 2022, no. 1 (2022): 6563114.

6. F. F. da Silva, "The Protection of the Underwater Cultural Heritage: An Important Soft Power Strategy," in Soft Power and Heritage (Cham: Springer Nature Switzerland, 2023), 235–243.

7. A. Althuwaini, How Effectively Are Current Heritage Management Strategies for Maritime Archaeology in the Red Sea Contributing to the Saudi Arabian Vision of 2030? Using the Umluj Shipwreck and Jeddah Port as Case Studies (PhD diss., Flinders University, College of Humanities, Arts and Social Sciences, 2023).

8. A. Ababneh, "Digital Heritage Law in Jordan: The Need for Clear Legislation," Art, Antiquity & Law 29, no. 4 (2024).

9. A. Tsatsanashvili, "Artificial Intelligence in the Protection of Intangible Cultural Heritage," European Journal of Transformation Studies 12, no. 1 (2024): 163–178.

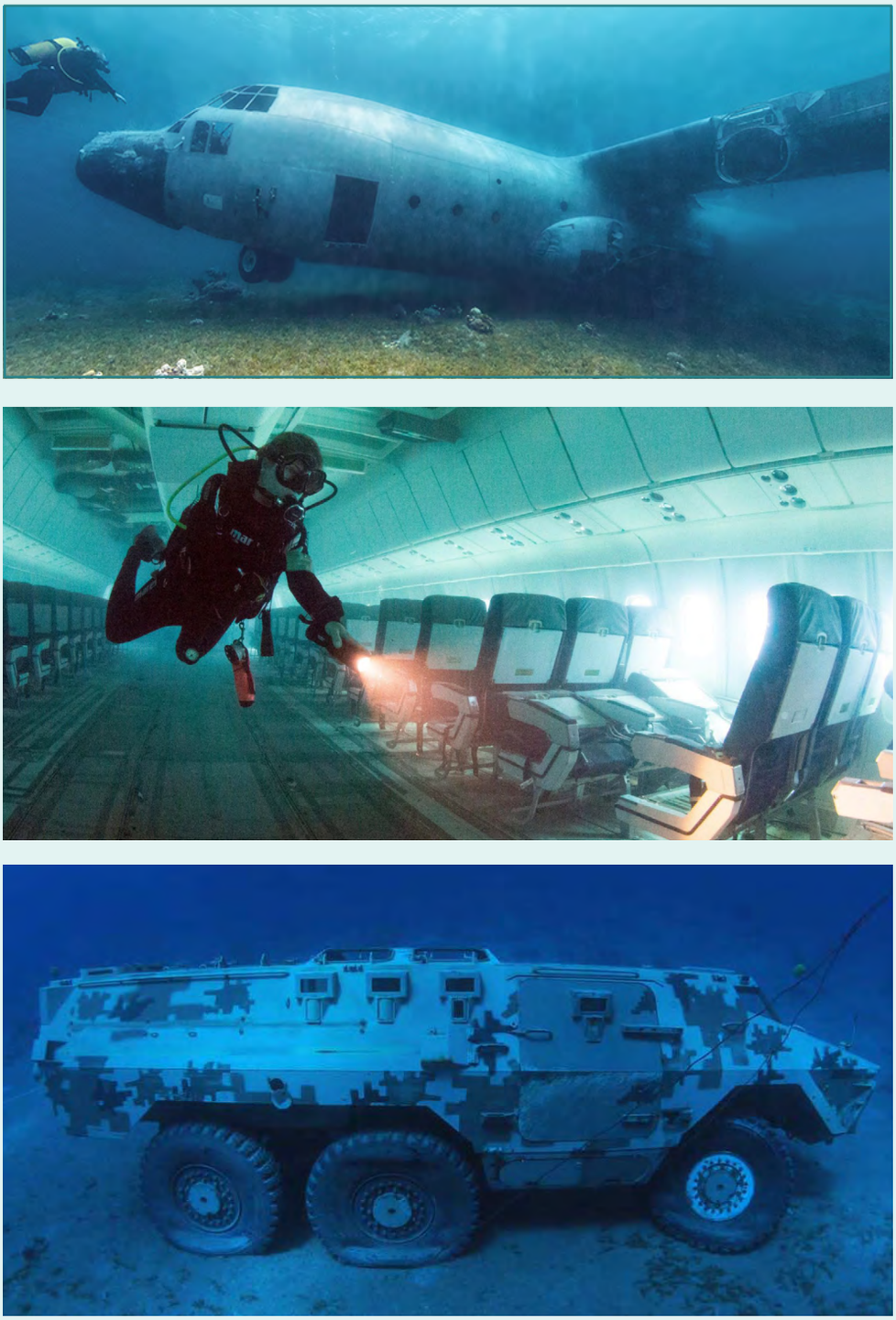


Figure 2: Underwater military museum dive site, Aqaba, Jordan
© Mohammad Salem Al-Tawaha*

3. Promote Public Engagement Through Virtual Access and AI-Enhanced Education Tools

To raise awareness and generate broader support for underwater heritage preservation, Jordan should invest in AI-powered AR and VR applications that provide immersive virtual tours of the Underwater Military Museum. These experiences can be shared with schools, museums, and online platforms, making underwater heritage accessible and minimizing physical tourism pressure on the underwater site.

4. Create a Legal and Policy Framework for the Use of AI in Cultural Heritage

Jordan should strive to establish legal and ethical frameworks that govern the use of AI and digital technologies in the conservation of cultural heritage. This will ensure that digital preservation efforts adhere to international best practices, protect data integrity, and safeguard the authenticity and cultural significance [8] of heritage sites.

5. Secure Sustainable Funding and Resource Allocation

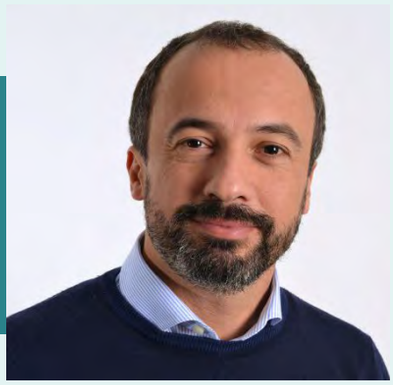
Preserving underwater heritage through AI and digital technologies requires sustained investment. To ensure long-term project sustainability, Jordan should explore diverse funding mechanisms, including public-private partnerships, international grants, and heritage tourism revenues. [9]

6. Monitor and Evaluate Progress through Open-Access Reporting

Transparent reporting mechanisms must accompany the use of AI. Regularly updated open-access databases documenting the condition, conservation actions, and digital assets of the Underwater Military Museum would enhance scientific research, public trust, and international collaboration.

Exploring AI-powered Applications for Mapping and Monitoring Underwater Cultural Heritage: The Experiences of The University of Calabria

© Fabio Bruno Department of Mechanical Energy and Management Engineering - University of Calabria Rende (CS), Italy



Dr. Fabio Bruno

Department of Mechanical Energy and Management Engineering - University of Calabria Rende (CS), Italy

Abstract

This paper extends the presentation "Exploring AI-powered applications for mapping and monitoring Underwater Cultural Heritage: the experiences of the University of Calabria" at the Webinar "AI & Underwater Cultural Heritage" organized by the UNESCO Cairo Office on March 27, 2025.

The work provides an overview of the current research activities at the University of Calabria, conducted in collaboration with several partners, on AI-powered applications for enhancing surveying, documentation, 3D mapping, and degradation monitoring of underwater cultural heritage. Applications include the control model of autonomous marine vehicles, recognizing, mapping, and monitoring species that colonize the surface of underwater artifacts; improving the scene understanding capabilities of opto-acoustic vision systems; and automatic path planning for survey dives under safety constraints.

Introduction

The adoption of advanced sensing and robotic technologies has revolutionized many of the activities related to the monitoring and documentation of Underwater Cultural Heritage (UCH). Remotely controlled and autonomous robots can explore deep-sea environments, and thanks to optical and acoustic imaging systems, they can acquire detailed information about the morpho-bathymetry of the seabed, the presence of archaeological artifacts, and the preservation state of cultural assets.

All these tasks generate a massive amount of data that requires processing by experienced professionals to achieve a correct interpretation. AI has the potential to speed up and improve many data processing tasks and to perform them even in real-time during the mission execution. These opportunities cover a wide range of challenging research topics that span from the enhancement of underwater images [1,2] to the recognition and classification of targets in optical and acoustic datasets [3], up to the implementation of automated control strategies applicable to underwater navigation of marine vehicles in unknown environments, and the manipulation of objects through robotic arms.

Since 2019, the University of Calabria has been actively engaged in documenting and monitoring underwater archaeological sites through the application of advanced 3D imaging techniques, marking a significant step forward in the preservation of underwater heritage. The following sections present some of the most relevant research fields in which the application of AI-based methods is significantly improving the state-of-the-art.

The NERITES project for the protection of Underwater Cultural Heritage

The NERITES project [4] is a collaborative initiative aimed at developing an integrated system for the autonomous remote surveying of underwater cultural heritage monuments and artifacts using non-destructive, cost-effective, and transportable digital solutions. The partnership comprises 13 partners from Italy, Greece, Cyprus, Germany, and Switzerland.

The architecture of the NERITES project comprises an Autonomous Underwater Vehicle (AUV) and its docking station, which provides power and data transfer functions. The station is connected to a buoy that offers internet connectivity, solar power, and data processing capabilities.

The AUV payload includes:

- 1Dof LIBS (Laser-induced breakdown spectroscopy) is capable of ensuring metering in-water accuracy from a target distance of 20 cm to map the presence and concentration of metals (e.g., Iron, Aluminum, Zinc, Copper) on target surfaces.

- QCL (mid-IR quantum cascade laser-based sensor system) can monitor hydrocarbons and carbonates concentration (phosphates, nitrates, dissolved CO2, and VOCs) in seawater at various depths without the need for a water sampling mechanism.

- A photogrammetric system for monitoring visual evidence of visually detectable biodeteriogens, structural cracks, collapses, detachments, etc.

Given this complex and advanced set of sensors, AI-powered techniques are being investigated to support some of the most challenging tasks, such as identifying and characterizing biological colonization on underwater surfaces and evaluating the structural integrity of monuments and artifacts over time.

Since high-resolution photogrammetry can create detailed three-dimensional reconstructions of submerged artefacts, these models can be used to precisely identify and map biological colonization, including the presence of algae, encrusting organisms, and other marine life that contribute to the biodeterioration of archaeological artefacts. In a previous case study, conducted at the Nymphaeum of Punta Epitaffio in Baiae [5], photographic and geometric data were used to assess not only the distribution of biological growth but also its potential impact on the structural integrity of the site.

This methodology provided a robust, non-invasive tool for long-term monitoring and preservation planning, demonstrating the effectiveness of combining 3D documentation with ecological observation in protecting underwater cultural heritage.

In the context of NERITES, the team at the International Hellenic University (IHU) is attempting to automate this approach by developing a Data-Driven UCH Deterioration Assessment and Preservation Advisor using cross-validated deep learning mechanisms that enable the soft-sensing of complex features and condition forecasting.

The AI-driven algorithms aim to identify and characterize degradation processes, as well as assess structural integrity at UCH sites. Specifically, these algorithms should be capable of a) detecting and mapping biological and organic surface coverings; b) analyzing the structural composition of submerged artefacts; and c) identifying surface-level defects or signs of material deterioration.

1. M. Mangeruga, F. Bruno, M. Cozza, P. Agrafiotis, and D. Skarlatos, "Guidelines for Underwater Image Enhancement Based on Benchmarking of Different Methods," Remote Sensing 10 (2018): 1652.

2. N. Kumar, J. Manzar, S. Shivani, and S. Garg, "Underwater Image Enhancement Using Deep Learning," Multimedia Tools and Applications 82, no. 30 (2023): 46789–46809.

3. S. Xu, M. Zhang, W. Song, H. Mei, Qi He, and A. Liotta, "A Systematic Review and Analysis of Deep Learning-Based Underwater Object Detection," Neurocomputing 527 (2023): 204–232.

4. "NERITES: Systematic Autonomous Remote Surveying of Underwater Cultural Heritage Monuments and Artifacts Using Non-Destructive, Cost-Effective and Transportable Digital Solutions," NERITES, funded by the European Union's Horizon Europe research and innovation program under grant agreement No. 101132575, accessed on 27 July 2025, https://www.nerites.eu.

5. F. Bruno, A. Lagudi, M. Collina, S. Medaglia, B. Davidde Petriaggi, R. Petriaggi, S. Ricci, and C. Sacco Perasso, "Documentation and Monitoring of Underwater Archaeological Sites Using 3D Imaging Techniques: The Case Study of the 'Nymphaeum of Punta Epitaffio' (Baiae, Naples)," The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences XLII-2/W10 (2019): 53–59, https://doi.org/10.5194/isprs-archives-XLII-2-W10-53-2019.

6. Zhicheng Tang, Xiang Cao, Zihan Zhou, Zhoubin Zhang, Chen Xu, and Jianbin Dou, "Path Planning of Autonomous Underwater Vehicle in Unknown Environment Based on Improved Deep Reinforcement Learning," Ocean Engineering301 (June 1, 2024): 117547, https://doi.org/10.1016/j.oceaneng.2024.117547.

7. Tianci Qu, Gang Xiong, Hub Ali, Xisong Dong, Yunjun Han, Zhen Shen, and Fei-Yue Wang, "DWAS-RL: A Safety-Efficiency Balanced Reinforcement Learning Approach for Path Planning of Unmanned Surface Vehicles in Complex Marine Environments," Ocean Engineering 317 (February 1, 2025): 119641, https://doi.org/10.1016/j.oceaneng.2024.119641.

Given the vast amount of data that needs to be analyzed, a Single-Stage Object Detection Model has been adopted as a fast and lightweight solution that maintains high accuracy in recognition compared to two-stage detectors. The development is still in progress, and although preliminary results are encouraging, the validation and performance analysis of the proposed method is expected to be completed by the end of the project.



Figure 1: Visual recognition of physical degradation and classification of biological colonization on the mosaics in the Underwater Archaeological Park of Baiae © Barbara Davidde and Carlotta Sacco Perasso - National Superintendency for Underwater Cultural Heritage - Ministry of Culture of Italy

Reinforcement learning method for the autonomous navigation of marine vehicles

The application of reinforcement learning (RL) to the autonomous navigation of marine vehicles has emerged as a promising approach for enhancing the survey and documentation of UCH. RL algorithms enable AUVs to learn optimal navigation policies through adaptive interaction with complex, unstructured marine environments,[6] which could be particularly valuable in UCH sites where human intervention may be risky or impractical and when precise maneuvering around sensitive archaeological structures is required. By integrating sensor data and feedback from the environment, RL-based systems enable real-time decision-making for obstacle avoidance and energy-efficient routing in Autonomous Surface Vehicles (ASVs).[7] Such intelligent navigation minimizes the risk of accidental damage to fragile artefacts and enables consistent, non-invasive monitoring over time.

Moreover, recent advancements in deep reinforcement learning (DRL) have further enhanced AUV autonomy, incorporating safety-aware and mapless navigation strategies to operate in unknown environments typical of submerged archaeological sites. These innovations not only improve operational efficiency but also align with ethical and preservation standards in cultural heritage management, offering a sustainable technological pathway for protecting submerged historical resources.

The University of Calabria is currently developing a 3D simulation environment that enables the accurate simulation of AUVs and ASVs in complex environments.[8] This simulation tool is crucial for training AI models because it provides a safe and cost-effective way to test and refine algorithms. These environments mimic real-world conditions, allowing AI systems to experiment, make mistakes, and improve without real-world consequences. This approach helps overcome data scarcity, accelerates AI model development, and reduces the overall cost of acquiring and labeling data.

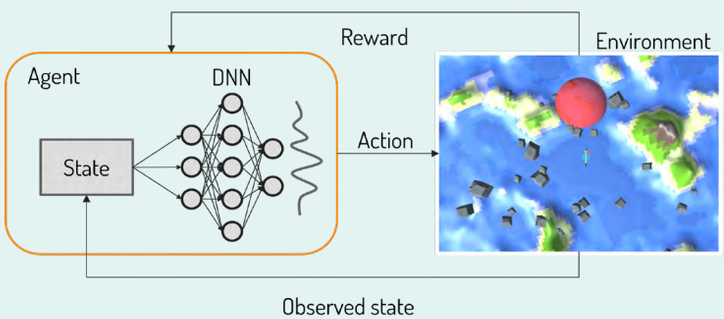


Figure 2: The integration of simulation and Deep Reinforcement Learning can enhance AUV autonomy in unknown environments
© Fabio Bruno

8. Antonio Lagudi, Umberto Severino, and Fabio Bruno, "Optimizing Underwater Acoustic Survey Strategies with Autonomous Underwater Vehicles: A Simulation-Based Framework," in Distributed Computing and Artificial Intelligence, Special Sessions II, 21st International Conference, ed. Goreti Marreiros et al. (Cham: Springer Nature Switzerland, 2025), 154–163.

9. F. Bruno, A. Lagudi, M. Muzzupappa, M. Lupia, G. Cario, L. Barbieri, S. Passaro, and R. Saggiomo, "Project VISAS: Virtual and Augmented Exploitation of Submerged Archaeological Sites—Overview and First Results," Marine Technology Society Journal 50, no. 4 (August 2016): 119–129.

10. Bruno F., Barbieri L., Mangeruga M., Cozza M., Lagudi A., Čejka J., Liarokapis F., Skarlatos D., "Underwater Augmented Reality for Improving the Diving Experience in Submerged Archaeological Sites," Ocean Engineering 190 (2019): Article no. 106487.

11. D. Scaradozzi, S. Zingaretti, N. Ciuccoli, D. Costa, G. Palmieri, F. Bruno, G. Ritacco, M. Cozza, P. Raxis, and T. Tzifopanopoulos, "Lab4Dive Mobile Smart Lab for Augmented Archaeological Dives," in IOP Conference Series: Materials Science and Engineering (2018).

12. M. Mangeruga, A. Casavola, F. Pupo, and F. Bruno, "An Underwater Pathfinding Algorithm for Optimised Planning of Survey Dives," Remote Sensing 12 (2020): 3974.

13. "uBlueTec – Training Framework on Underwater Techs as Key Enabler for Blue Careers Development," uBlueTec, funded by the European Union under the EMFAF program (European Maritime, Fisheries, and Aquaculture Fund), project No. 101124893, accessed on 27 July 2025, https://ubluetec.eu.

Automatic path planning of survey dives

Both scientific and recreational divers often encounter low visibility conditions that make orientation at underwater sites particularly difficult. In recent years, various technologies and tools have been developed to support divers in better orienting themselves in underwater environments and simplifying their understanding of the context. The University of Calabria and 3D Research have developed various recreational and technical/scientific solutions through a novel tablet-based system for underwater navigation and exploration, providing divers with underwater geo-localization, contextualized information, augmented reality content, and recommendations on the optimal path to follow during the dive. This development began with the VISAS project [9] and continued with H2020 iMareCulture, focusing on the implementation of Underwater Augmented Reality for recreational divers.[10] Additionally, it involved Lab4Dive in developing an underwater mobile lab to support underwater archaeologists in surveying and documentation activities.[11]

To further enhance assistance to divers surveying the seabed, the MOLUX project introduced a novel system that calculates the optimal path to follow to maximize the number of points of interest (POI) that can be reached and explored during the dive, while considering several safety factors.[12] This work proposes, for the first time, considering the 3D space in which the survey dive takes place to adapt the path planning to the obstacles in the environment. The system is based on a novel underwater pathfinding algorithm that analyzes a 3D map of the site to calculate the best path, considering decompression limits and avoiding obstacles.

This original approach can be applied in two different scenarios: before the dive, when underwater activities are being planned, and in an even more challenging scenario, i.e., during the dive, when the path needs to be adapted to unexpected situations and the time remaining for completing the dive.

In the latter case, the system enables the diver to constantly know the best path that maximizes the number of visited POIs and minimizes the path cost. The latter, in an underwater environment, can be defined in different ways. This information is provided to the diver on the underwater tablet or smartphone, housed in a waterproof case and coupled with an acoustic localization system. This tablet is equipped with a dedicated app that enables the diver to access various features, including the visualization of a 3D map of the underwater site, the diver's geo-position, a set of POIs, and a path that optimizes the visit to the selected POIs while maintaining safety conditions.



Figure 3: Divers surveying a UCH site by using two underwater tablets equipped with acoustic modems that enable localization and messaging under the sea surface. © Fabio Bruno

Recommendations

1. **Stimulate an interdisciplinary discussion about the potential applications of AI for the preservation and monitoring of underwater cultural heritage.**

UCH presents complex challenges across multiple domains, including archaeology, marine biology, computer science, oceanography, heritage conservation, and policy studies. To harness the full potential of artificial intelligence (AI) in the preservation and monitoring of UCH, it is essential to adopt an interdisciplinary approach by integrating knowledge, tools, and perspectives from all the involved fields of expertise, enabling the development of AI systems that are not only technically robust, but also culturally and environmentally sensitive. By bridging disciplinary boundaries, researchers can address the multifaceted nature of UCH more comprehensively, from data acquisition and interpretation to long-term conservation strategies.

2. **Develop specific training programs that merge fields of expertise such as artificial intelligence, cultural heritage preservation, and monitoring of marine biodiversity**

In the Era of Blue Growth, the development of transdisciplinary training programs that merge AI, remote sensing, UCH preservation, and monitoring of marine biodiversity is essential to inspire a new generation of researchers and empower them to navigate the complexities of ocean sustainability. As demonstrated in the uBlueTec project,[13] these programs should integrate education and research approaches that transcend traditional disciplinary boundaries, enabling scholars to understand and address the interconnections among technological innovation, heritage protection, and marine environment preservation. Such an educational framework not only responds to current scientific and policy imperatives but also anticipates future challenges, positioning researchers to make meaningful contributions to the goals of sustainable maritime development and the responsible advancement of the Blue Economy.

3. Ensure that AI solutions are aligned with both scientific objectives and ethical considerations

The development, training, and validation of AI systems aimed at preserving and monitoring UCH needs the direct participation of domain experts, such as archaeologists, conservation scientists, and marine ecologists. They have to be actively involved throughout the entire AI development lifecycle, from data curation and model design to validation and interpretation of results. By integrating expert knowledge into the training process, AI systems can be better aligned with the nuanced realities of UCH contexts, improving their accuracy, relevance, and ethical robustness. Moreover, this collaborative model mitigates the risk of algorithmic bias, enhances contextual understanding, and supports the creation of transparent and trustworthy tools. This participatory strategy also aims to reinforce interdisciplinary dialogue and co-creation, which are essential for advancing sustainable and culturally sensitive solutions in the marine domain.

4. Leverage AI applications for Predictive Analysis to enhance UCH protection from natural and anthropogenic threats

AI could effectively support the integration and analysis of data from various sources, including underwater sensors, satellite imagery, historical records, and environmental monitoring systems. This comprehensive dataset could provide a holistic view of the conditions affecting underwater sites for improving real-time monitoring capabilities. AI-driven platforms can analyze this massive amount of data to foster a more comprehensive understanding of the threats that affect UCH. By identifying patterns and trends, AI can facilitate the early detection of potential risks and aid in developing proactive measures to protect these sites from both natural and human-induced damage.

Underwater Cultural Heritage in the Age of AI: Reflections from Pre-AI Practices to Emerging Possibilities

© Guzden Varinlioglu



Dr. Guzden Varinlioglu

Lecturer in Digital Architectural Technology, School of Architecture, University of Liverpool, United Kingdom.

Abstract

Integrating Artificial Intelligence (AI) into underwater archaeology opens new possibilities for documenting, preserving, analysing, and presenting submerged cultural heritage. This article examines the transformative potential of AI in underwater cultural heritage (UCH), focusing on artefact classification, decomposition prediction, and digital reconstruction. It reviews advances in AI-assisted photogrammetry, immersive mixed reality experiences, and automated analysis. The article also critically addresses the limitations of current AI models, including restricted training datasets and ethical concerns related to AI-generated reconstructions. Drawing on over fifteen years of fieldwork and digital documentation, it compares pre-AI practices with current developments. It proposes a framework for the ethical, context-aware adoption of AI tools in underwater archaeology.

III

In recent years, AI has transformed traditional approaches to discovering, documenting, and disseminating cultural heritage. [1] These advances follow decades of work in archaeological computing, remote sensing, and digital reconstruction. Building on the previous work of the author, [2] this essay analyses the field's evolution while remaining rooted in the ethical framework provided by the 2001 UNESCO Convention on the Protection of Underwater Cultural Heritage (UNESCO, 2001). Before the emergence of artificial intelligence, early digital practices, such as those implemented by the Underwater Research Society (Sualtı Araştırmaları Derneği - SAD) in Turkey, focused on accessible technologies and community engagement. In this work, we describe our achievements using non-AI techniques and evaluate the new opportunities and difficulties that AI presents.

Discovery

Since 2007, we have been conducting underwater cultural heritage surveys along the Mediterranean coast of Turkey, prioritising in situ preservation. Our teams—comprising trained local divers and volunteers—documented artifacts such as amphorae, anchors, and ballast stones using buoys and handheld GPS devices.[3] We compiled the data into GIS platforms for public access. While robotic technologies were not part of our original workflows, future integration was likely. Building on earlier research in autonomous marine robotics and sensor integration4, recent advances, such as FathomNet —an open-source database that standardizes labeled marine data5 and AI-guided underwater robots, suggest the possibility of semi-automated artifact detection. Machine learning algorithms, trained on data collected from divers, can distinguish cultural materials from the natural seabed, facilitating real-time mapping and proactive risk management.

Documentation

Our Underwater Cultural Heritage (UCH) surveys in Turkey combined archaeological practice with public outreach. Divers used low-cost tools—such as measuring tapes, plexiglass boards, and cameras—to record visible artifacts digitized for open access. This participatory, sustainable model adhered to the non-invasive documentation principles outlined in the UNESCO Convention.6 Today, photogrammetry allows us to expand and refine this work (Drap, 2012)7. AI-powered photogrammetry automates image stitching, object segmentation, and 3D reconstruction, even in low-visibility waters. These improvements reduce processing time and enhance accuracy. Integration with underwater robots and smart sensors will enable real-time data capture, scalable documentation, and anomaly detection, offering new dimensions to heritage preservation efforts.

Analysis

Parametric modelling and close collaboration with archaeologists guided earlier reconstructions. Using typological data and measurement inputs, I developed a shape grammar system to reconstruct amphoras via Rhino/Grasshopper and Python scripting. [8]

We visualised these models interactively for expert review (Figure 1). With the aid of AI, such analysis has advanced significantly. Machine learning now supports material classification, typology detection, and analysis.

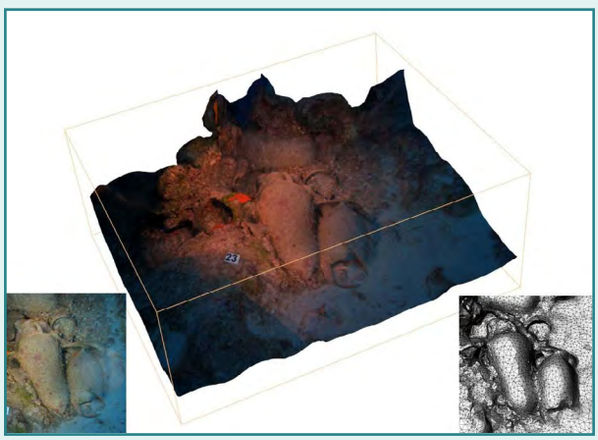


Figure 1: Photogrammetric modelling of an amphora
© Guzden Varinlioglu

Improved automatic detection of deep-sea amphorae in underwater archaeological sites enhances object detection accuracy by extending 2D object detection to 3D via photogrammetry[9]. These tools streamline workflows and improve accuracy, marking a shift from manual interpretation to data-driven archaeology.

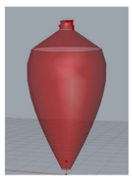
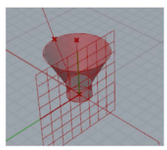
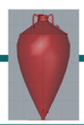
Categories	KE-23-A	2D symbols	3D model	Rules
Body type	Ovoid			pt1=(shoulderRad,0,bodyStart) pt2=(objRad,0,(bodyStart-baseLength)*3/4+baseLength) pt3=(objRad*0.4,0,(bodyStart-baseLength)*1/4+baseLength) pt4 = bodyEndX create body curve with 4 pts Revolve bodyCurve
Rim type	Beaded			Trace through the curve of the rim revolve the curve
Neck type	Conical			ptStart = rimEnd ptEnd =(shoulderRad,0,bodyStart) create line1 with ptStart ptEnd revolve line 1
Base type	Knobbed			ptStart=(baseRadMax,0,baseLength) pt1=(baseThicknessRad,0,baseLength*0.3) ptEnd=(baseThicknessRad,0,0) create line1 with (ptStart,pt1) create line2 with (pt1,ptEnd) revolve line1 and line 2
Shoulder type	Rounded			Round the two curves joining neck and body
Profile handle	Short Vertical			Trace through curve of the rim Scale move and mirror in place
Handle in section	Grooved			Trace the curve Loft the curve with profile
Handle type	Handle on neck – shoulder			Start point pick a point in the neck curve End Point pick a point in the shoulder curve

Figure 2: Parametric analysis and reconstruction of amphorae © Guzden Varinlioglu

Monitoring

The Archaeopark project [10] documented the decay of a submerged replica shipwreck using photomosaics and 3D photogrammetry over a decade. The evolving models captured structural degradation of the wreck and biological impact, contributing to our understanding of underwater decay. AI-based monitoring platforms, such as those developed in the NERITES[11] project, now introduce real-time predictive capabilities.

Machine learning, trained on data acquired by divers, can distinguish cultural material from the natural seabed, enabling real-time site interpretation and risk mitigation. Using inputs from underwater robots and sensors, AI detects corrosion and decomposition of artefacts and changes in the seabed, allowing for continuous, non-invasive monitoring and proactive conservation of underwater heritage.

Modelling and Reconstruction

We explored several modeling techniques, from using photogrammetry for 3D reconstructions of artifacts[12] to testing Neural Radiance Fields (NeRF) on archival photographs. NeRF generates accurate 3D models from minimal input, making it particularly valuable when artefacts are inaccessible.

AI now plays a central role in addressing underwater challenges such as low visibility and data loss. Wang et al. [13] introduced a real-time dense 3D reconstruction pipeline for underwater robots, while AI-optimised photogrammetry pipelines enhance model accuracy and usability in large-scale archaeological contexts.

Presentation and Dissemination

Initially developed as a virtual museum for underwater cultural heritage, my PhD work laid the foundation for digital public engagement. Online platforms allowed researchers and the public to explore documented sites interactively.

Today, AI expands these efforts. Tools like Sora[14] and Luma AI[15] generate immersive text-to-video experiences, transforming static data into dynamic storytelling.

These innovations build on early virtual heritage projects (Addison, 2000) but go further, personalising content and adapting narratives based on user interaction.

AI-generated simulations of animated artifacts and the application of virtual reality technologies in the exploitation and preservation of underwater cultural heritage enrich public understanding and academic discourse.[16]

By bridging temporal and physical gaps, AI enhances accessibility and democratises underwater cultural heritage.

Conclusion

AI has opened new frontiers for underwater archaeology, from autonomous discovery and precision modelling to immersive dissemination. However, this shift raises ethical and epistemological questions: How do we ensure authenticity in AI-generated reconstructions? Who controls the datasets and algorithms? How do we maintain context-aware interpretations?

How do we prevent technological advances from reinforcing biases or excluding local narratives? As we move forward, can we build systems that prioritise transparency, collaboration, and critical reflection over speed and efficiency?

1. Gabriele Gattiglia, "Managing Artificial Intelligence in Archaeology: An Overview," Journal of Cultural Heritage 71 (2025): 225–233, https://doi.org/10.1016/j.culher.2024.11.029.

2. Varinlioglu, Guzden. Digital in Underwater Cultural Heritage. Cambridge Scholars Publishing, 2016.

3. Varinlioglu, Guzden. "Data Collection for a Virtual Museum on the Underwater Survey at Kas, Turkey." International Journal of Nautical Archaeology 40, no. 1 (2011): 182–188.

4. Bingham, Brian, Brendan Foley, Hanumant Singh, Richard Camilli, Kostas Dellaporta, Kostas Katsaros, and Alex Mallios. "Robotic Tools for Deep Water Archaeology: Surveying an Ancient Shipwreck with an Autonomous Underwater Vehicle." Journal of Field Robotics 27, no. 6 (2010): 702–717.

5. Katija, Kakani, et al. "FathomNet: A Global Image Database for Enabling Artificial Intelligence in the Ocean." Scientific Reports 12 (2022): 15914.

6. "Virtual Museum of Underwater Cultural Heritage in Turkey" (case study presented in 2011). https://www.themua.org.

7. Pierre Drap, "Underwater Photogrammetry for Archaeology," in Special Applications of Photogrammetry, ed. Daniel Carneiro da Silva (IntechOpen, 2012), https://doi.org/10.5772/33999.

8. Guzden Varinlioglu, "Parametric Modelling of Archaeological Heritage in the Age of Digital Reconstruction," SIGraDi 2014: Design in Freedom 2 (2014): 614–617.

9. Luca Lombardi, Francesco Mercaldo, and Alessandra Santone, "Automatic Classification and Localization of Ancient Amphorae through Object Detection in Underwater Archeology," in Intelligent Decision Technologies (KESIDT 2024) (Springer, 2025), 147–156.

10. Guzden Varinlioglu, "Assessing a Decade of Kaş Underwater Archaeopark," International Journal of Nautical Archaeology 00, no. 0 (2020): 1–13.

Recommendations

Based on our experiences in pre-AI digital heritage documentation and current research trends, the following recommendations aim to support ethical, sustainable, and inclusive use of AI in underwater archaeology.

1. Prioritise Ethical Guidelines and Human Oversight

Human expertise and ethical standards should guide the development and use of AI systems in underwater cultural heritage. All AI-generated reconstructions or classifications must remain transparent about the levels of certainty and interpretation involved. Archaeologists must maintain control over decision-making processes, particularly when AI suggests reconstructions or fills gaps in data. Strong ethical oversight ensures critical evaluation of AI outputs and preserves the integrity of cultural heritage.

2. Invest in Contextual and Inclusive Datasets

Training data for AI models in underwater archaeology often lacks cultural and typological diversity. Institutions and research teams should collaborate to develop open-access, inclusive datasets that represent diverse regions, periods, and object types. Such efforts will enhance model accuracy, mitigate cultural bias, and foster global knowledge exchange.

3. Encourage Interdisciplinary Collaboration

Integrating AI successfully demands active collaboration across archaeology, computer science, marine biology, conservation, and heritage management. Researchers must strengthen interdisciplinary networks to ensure AI tools tackle real-world archaeological challenges and advance both research and conservation efforts.

4. Adopt Hybrid Documentation Models

Rather than replacing traditional documentation practices, researchers should use AI to enhance them. Combining human-led surveys with AI-assisted processing optimises time and resources while preserving scholarly rigour and field expertise. This approach builds on existing workflows and actively supports training and knowledge transfer.

5. Promote Open-Access Tools and Community Training

To democratise access, researchers must adapt AI-powered tools to different levels of technical infrastructure. Prioritising low-cost, open-source platforms and delivering training programs can empower local communities, divers, and students to lead documentation efforts. These efforts build local capacity and strengthen sustainable heritage management.

6. Foster Transparent Dissemination and Public Engagement

AI offers powerful opportunities for public engagement, but researchers must use it responsibly. They should clearly label outputs to distinguish evidence-based reconstructions from speculative visualisations. Maintaining transparency strengthens public trust and enhances the educational value of these efforts.

In summary, adopting AI in underwater heritage must proceed with caution, creativity, and care, striking a balance between innovation and integrity, while embracing both human expertise and machine potential.

11. NERITES, "About," NERITES Project, accessed April 20, 2025, https://nerites.eu/about/.

12. Guzden Varinlioglu, "In Situ Visualization of Underwater Cultural Heritage," in Heritage in Context 2: Archaeology and Tourism, ed. G. Ercan and S. T. Altay (Ege Publications, 2018), 191–200.

13. Weichao Wang, Bhavan Joshi, Noah Burgdorfer, Konstantinos Batsos, Adriana Quattrini Li, Philippos Mordohai, and Ioannis Rekleitis, "Real-Time Dense 3D Mapping of Underwater Environments," in Proceedings of the IEEE International Conference on Robotics and Automation (ICRA) (2023): 5184–5191.

14. sora.chatgpt.com, accessed July 27, 2025.

15. https://lumalabs.ai/, accessed July 27, 2025.

16. Fabio Bruno, Antonio Lagudi, Luigi Barbieri, Mario Muzzupappa, Michele Mangeruga, Mario Cozza, Antonio Cozza, Gianfranco Ritacco, and Rocco Peluso, "Virtual Reality Technologies for the Exploitation of Underwater Cultural Heritage," in Latest Developments in Reality-Based 3D Surveying and Modelling (2018), 220–236.

Artificial Intelligence for Coastal Heritage: Responsible Detection and Monitoring

© Alexandra Karamitrou, Fraser Sturt, Petros Bogiatzis



Dr. Alexandra Karamitrou

Department of Archaeology, University of Southampton, United Kingdom.

Abstract

In recent years, the incorporation of Artificial Intelligence (AI) into coastal and underwater heritage research has significantly advanced how archaeologists identify, document, and monitor cultural sites at risk from environmental and human-induced pressures. Through three case studies, detection of crannogs, detection of offshore platforms and the detection of shipwrecks this paper investigates how AI tools in combination of open access remote sensing images can support the detection and analysis of submerged and coastal archaeological features, emphasizing the potential of these technologies to operate at scale across diverse marine environments. In addition to highlighting practical applications, this study also explores broader ethical and methodological questions, including the transparency of AI models, data ownership, and the importance of developing equitable and culturally sensitive digital practices. Key challenges, including algorithmic bias, the interpretability of results, and the importance of interdisciplinary collaboration, are discussed to ensure the responsible and inclusive use of AI in archaeological research.



Figure 1: A world map displaying the locations of offshore platforms detected using AI and open-access satellite imagery, marked with red pins.
© Alexandra Karamitrou

III

Introduction

The rapid advancement of artificial intelligence, combined with expanded access to openly available high-resolution satellite imagery, geophysical datasets, and high-performance computing, is reshaping how archaeologists investigate and monitor submerged and coastal heritage. These tools allow for the large-scale detection, analysis, and monitoring of cultural sites that are otherwise difficult to access through traditional means. As AI systems are increasingly used to process and interpret complex environmental and spatial data, they offer the potential to uncover previously undocumented archaeological features beneath water or in remote landscapes.

While these developments mark a transformative shift in archaeological practice, they also raise important questions around ethics, transparency, and inclusivity. Issues such as data ownership, the interpretive role of AI in heritage decision-making, and the risk of reinforcing existing biases or overlooking non-Western forms of knowledge must be considered carefully. The deployment of AI tools in archaeology is not just a technical undertaking; cultural values, institutional policies, and global inequalities in access to information and resources inherently shape it.

This paper contributes to a growing body of research that critically engages with the intersection of AI and archaeology. It highlights the opportunities that AI provides for enhancing archaeological prospection and monitoring in marine and coastal environments, while also reflecting on the ethical obligations that come with its use. Through an interdisciplinary lens, the paper calls for the responsible integration of AI technologies in heritage research, one that fosters collaboration, respects cultural diversity, and promotes data stewardship grounded in accountability and inclusivity.

2. AI applications in Coastal Heritage Sites

This work explores three innovative applications of artificial intelligence in the study and preservation of coastal and underwater cultural heritage. Each project targets a unique aspect of archaeological detection and monitoring. Yet, they are united by their use of AI, remote sensing technologies, and high-performance computing to overcome traditional limitations in fieldwork. The first case involves the automated identification of crannogs, artificial or semi-artificial islets found in lakes, using advanced image processing and high-resolution remote sensing data. The second focuses on the detection and surveillance of offshore structures, a timely issue given the rapid expansion of marine renewable energy projects and the implications for submerged heritage sites. The third project focuses on identifying shipwrecks by detecting indirect environmental changes, such as the emergence of black reefs, which can signal pollution and ecological disruption. Collectively, these projects demonstrate the transformative potential of AI in archaeological prospection, providing scalable, data-driven solutions for the identification and preservation of vulnerable underwater heritage. The following sections provide a detailed overview of each application.

2.1 Automatic Detection of Crannogs in Scotland

Crannogs are ancient artificial islands predominantly found in lakes across Scotland, Ireland, and Wales. [1] These features offer unique insights into prehistoric and early historic communities. However, manual detection and field investigation of crannogs are resource-intensive and impractical, especially given the scale of the Scottish landscape, where over 8,000 lochs exist. To address this, we developed a computational workflow capable of automatically identifying islets (Figure 2).

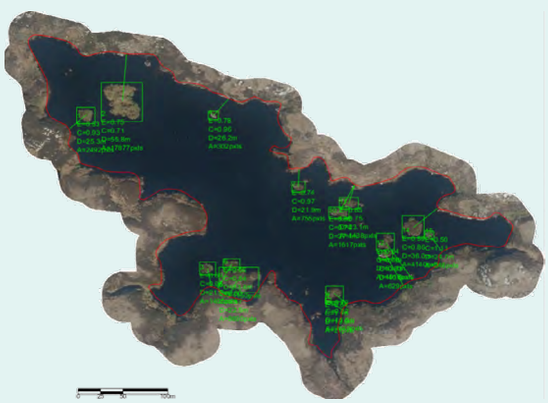


Figure 2: Example of an islet detected through computational analysis. The red contour outlines the islet's perimeter, which was either sourced from existing datasets or derived automatically during processing. Green squares indicate buffer zones around each identified islet. In addition to mapping their geographic positions, the algorithm extracted key attributes such as perimeter length, surface area, and proximity to the shoreline; features that are particularly valuable for distinguishing potential crannogs.
© Alexandra Karamitrou and Stephanie Blankshein.

Subsequently, we trained a Convolutional Neural Network (CNN) using the results extracted from the first process to determine their potential as crannogs. Using three types of remote sensing imagery, aerial images at 0.25m resolution, colour infrared imagery at 0.5m resolution, and Sentinel-1 radar data at 5m resolution, we scanned the entire landmass of Scotland. Image segmentation and morphological analyses were employed to isolate and analyse lakes, within which potential islets were extracted. This process identified over 7,000 islets, each catalogued with spatial and morphological attributes such as size, shape, proximity to the shoreline, and circularity. Features that usually characterize crannogs.

These islets were subsequently analysed using a deep learning model based on the Faster R-CNN (Regions with Convolutional Neural Networks) architecture. Trained with a dataset of 125 verified crannogs, the model evaluated each islet and produced a probability score indicating its likelihood of being a crannog. This AI-assisted prioritization enables archaeologists to direct fieldwork toward high-probability targets, significantly increasing efficiency and reducing cost.

2.2 Mapping Offshore Structures

The growth of offshore renewable energy infrastructure presents both opportunities and challenges for the management of cultural heritage.[2] Many planned and existing offshore structures are situated near sensitive archaeological sites; however, governments and industries often restrict access to location data due to national security or commercial interests. Furthermore, decommissioned structures left underwater for extended periods may attain heritage status or pose environmental risks. [3]

1. A. Crone, The History of a Scottish Lowland Crannog: Excavations at Buiston, Ayrshire (Edinburgh: Society of Antiquaries of Scotland, 2014); Ionas Stratigos, "Crannogs, Lake Settlements, and Occupation Practice in Prehistoric Scotland," Oxford Journal of Archaeology 40, no. 2 (2021).

2. Susan Gourvenec, Fraser Sturt, Emily Reid, and Federico Trigos, "Global Assessment of Historical, Current and Forecast Ocean Energy Infrastructure: Implications for Marine Space Planning, Sustainable Design and End-of-Engineered-Life Management," Renewable and Sustainable Energy Reviews (2022), https://doi.org/10.1016/j.rser.2021.111794.

3. J. Ekins et al., Evaluating Alternatives for Decommissioning California's Offshore Oil and Gas Platforms (Oakland, CA: California Ocean Science Trust, 2006); Dorota Jarząbek and Kinga Drwięga, "Ecological Aspects of Vessel Decommissioning Market," European Research Studies Journal 24, no. 5 (2021).

4. J. Hatcher, The Western Mediterranean Shipwreck and the Ecology of Fuel Leak (Cambridge: Cambridge University Press, 1984); Kelly et al., "Oil and Metals from Shipwrecks: Ecological Risks," Marine Pollution Bulletin 64, no. 2 (2012): 201–212; Rotjan et al., "Emerging Threats from World War II Shipwrecks in the Pacific Northwest," Frontiers in Ecology and the Environment 12, no. 11 (2014).

5. Kendall, Alex, and Yarin Gal. "What Uncertainties Do We Need in Bayesian Deep Learning for Computer Vision?" Advances in Neural Information Processing Systems 30 (2017), https://doi.org/10.48550/arXiv.1703.04977.

6. A. Karamitrou et al., "Towards the Use of Artificial Intelligence Deep Learning Networks for Detection of Archaeological Sites," Surface Topography: Metrology and Properties 10, no. 4 (2022).

7. A. Karamitrou, Fraser Sturt, and Petros Bogiatzis, "Identification of Black Reef Shipwreck Sites Using AI and Satellite Multispectral Imagery," Remote Sensing 15, no. 8 (April 11, 2023): 2030, https://doi.org/10.3390/rs15082030.

On the other hand, some of these structures, which have been underwater for decades, are part of our cultural heritage, and their location, state, and future are of great importance in archaeological and artistic heritage research. Their documentation, monitoring, and long-term management are therefore essential. From an archaeological perspective, understanding the location, condition, and future of such structures is crucial for preserving submerged cultural heritage. Additionally, their presence can affect the health and safety of surrounding marine ecosystems and coastal communities, making their systematic monitoring a matter of both heritage preservation and environmental stewardship.

In collaboration with academic institutions from around the world, government bodies, and NGOs, we developed a system for the automatic detection of offshore structures using Google Earth Engine to download Sentinel-1 radar imagery. Radar imagery offers the advantage of consistent acquisition regardless of weather or daylight, enabling the monitoring of oceanic regions that optical sensors might miss. Calm waters typically appear black in radar images, with surface structures reflecting radar signals as bright spots. Using thousands of satellite images captured between 2020 and 2023, and supported by high-performance computing, we processed and analysed over a million square kilometres of coastal areas. The system successfully identified a wide array of offshore structures, aiding in the documentation of both contemporary and heritage marine infrastructure (Figure 3).



Figure 3: Map Data © 2025, Google/ Google Earth image (Google Earth Pro 7.3.6.9345, 2025, viewed 10 May 2025, (http://www. google.com/earth/index. html), displaying the locations of offshore structures identified by the trained network. Red pins mark the detected structures, highlighting their spatial distribution across the surveyed marine area.
Author: Alexandra Karamitrou

2.3 Shipwreck Detection via Black Reef Identification

Our oceans conceal an estimated three million shipwrecks, of which only about 10% have been documented. Beyond their archaeological significance, these submerged vessels can pose environmental hazards, releasing toxic substances such as fuel, heavy metals, and ammunition into marine ecosystems. [4]

One novel approach to identifying undocumented shipwrecks is the detection of "black reefs", a phenomenon where coral reef discoloration occurs due to the release of iron from deteriorating metallic wrecks.

This project involved training a neural network based on the architecture of Semantic Segmentation,[5] specifically SimpleNet,[6] which is designed to handle limited amounts of labeled data. This trained network is capable of recognizing the signature discoloration patterns associated with black reefs using historical satellite imagery.[7]

Iron released into iron-poor waters alters the ecological balance, promoting microbial growth and causing visible darkening of coral reefs. The algorithm was trained on known black reef locations and demonstrated high accuracy in detecting these anomalies within coral-rich environments.

A case study conducted at the Kwajalein Reef in the Pacific revealed the emergence of a black reef in 2022, correlating with the fragmentation of a nearby WWII-era shipwreck. By employing temporal image analysis through Google Earth, the AI model detected changes in reef coloration corresponding to the deterioration and dispersion of materials from the shipwreck.

This approach offers a promising method for the early identification of underwater cultural heritage sites and potential environmental threats.

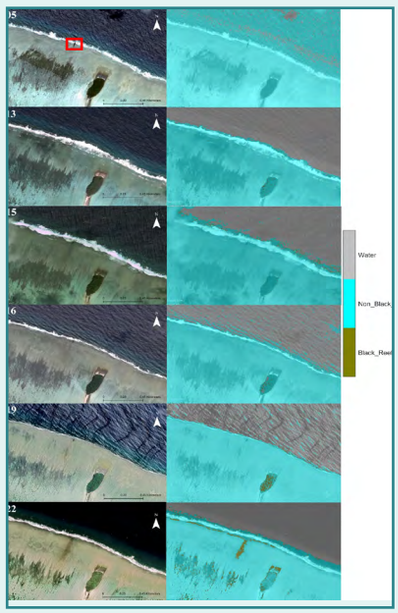


Figure 4: Map Data © 2005, 2013, 2015, 2016, 2019, and 2022, Google/ Google Earth images from the Kwajalein Reef (9.331000, 166.8457), captured in the years 2005, 2013, 2015, 2016, 2019, and 2022. The red rectangle indicates the position of the shipwreck. The right column shows the corresponding segmented images, highlighting changes in the surrounding reef environment, including the development of discoloration patterns associated with black reef formation.
Author: Alexandra Karamitrou

3. Ethical Considerations

The integration of artificial intelligence into archaeological research introduces new possibilities for discovery, monitoring, and preservation in coastal and underwater cultural heritage sites.

However, these technological advancements also bring significant ethical responsibilities. One of the central concerns lies in how heritage data is collected, processed, and interpreted. AI models rely heavily on large datasets, some of which may include information about culturally significant or protected sites.

Without clear frameworks for responsible data use, there is a risk of overlooking community rights, especially when the data involves locations that hold spiritual or historical value for Indigenous groups or local populations.

Another ethical challenge relates to transparency and data accessibility. While open data sharing promotes collaboration and education, it also raises concerns about site security. Public release of detailed location information, for instance, can unintentionally expose archaeological sites to threats such as looting, vandalism, or unregulated tourism.

To address this, institutions involved in archaeological research, such as universities, museums, and government bodies, should develop clear policies on data governance. These policies must aim to strike a balance between promoting open access and ensuring that sensitive information remains protected. Furthermore, efforts should be made to address disparities in digital access by supporting inclusive participation from underrepresented communities in the use of AI technologies for heritage protection.

The increasing use of AI in public engagement and educational tools also demands careful ethical oversight. While these technologies can make archaeological knowledge more accessible, they may also simplify or misrepresent complex cultural histories.

There is also a risk that heritage could be commodified through AI-driven platforms. Therefore, AI systems designed for public use must incorporate safeguards to ensure cultural accuracy and prevent the spread of misinformation.

Ultimately, while AI can enhance the efficiency of archaeological workflows, it should support rather than replace expert human judgment. Respect for the cultural significance of heritage and ethical responsibility toward both people and the environment must guide the design and deployment of AI in this field.

4. Conclusion

AI technologies are reshaping the landscape of archaeological research, offering new tools for detecting and monitoring coastal and underwater heritage. By combining remote sensing, machine learning, and high-powered computing, we can achieve unprecedented scale and precision in identifying features such as crannogs, offshore structures, and shipwrecks.

These innovations not only enhance efficiency but also broaden the scope of what is possible in archaeological exploration. However, ethical considerations must remain central to the development and application of such technologies. Through interdisciplinary collaboration, transparency, and cultural stewardship, AI can serve as a powerful ally in preserving our shared heritage for future generations.

Acknowledgements

The author acknowledges support from the Southampton Marine and Maritime Institute, the Royal Academy of Engineering, Engineering X, Lloyd's Register, and Daphne Jackson Trust.

CHAPTER IV

AI and Creative & Cultural Industries



AI & Culture

© Pavel Danilyuk on Pexels, 2021

Chapter 4

Artificial Intelligence and and Creative and Cultural industry

The creative and cultural industries (CCIs)—encompassing sectors such as visual arts, music, film, design, publishing, and digital media—are central to cultural diversity, economic development, and social cohesion. Within the normative framework of UNESCO, the 2005 Convention on the Protection and Promotion of the Diversity of Cultural Expressions serves as the cornerstone instrument guiding this field. The Convention recognizes the dual nature of cultural goods and services as both economic and cultural, and emphasizes the sovereign right of states to adopt policies that support diverse cultural expressions, artists, and creative ecosystems. It also highlights the importance of international cooperation, equitable access, and the integration of culture into sustainable development strategies. In recent years, the rapid advancement of artificial intelligence—particularly generative AI—has introduced profound transformations across CCIs. AI enables new forms of cultural production, lowers barriers to creative expression, and expands access to cultural content globally. At the same time, it raises complex challenges related to authorship, intellectual property, labour conditions, and cultural representation. These tensions directly intersect with the principles of the 2005 Convention, particularly in safeguarding the rights of creators, ensuring fair remuneration, and protecting the diversity and authenticity of cultural expressions in an increasingly algorithm-driven landscape.

Building on this framework, recent scholarship critically examines how AI is reshaping artistic practice, cultural production, and regulatory systems. Dr Caramiaux interrogates dominant narratives surrounding generative AI in the arts, revealing how they often promote particular cultural and ideological assumptions about creativity, innovation, and technological progress. His work highlights a divergence between mainstream representations of AI and the lived practices of artists, emphasizing the importance of material engagement, situated learning, and the development of craft-like skills when working with AI systems. Dr Elkins further explores the intersection of generative AI with cultural production and labour, identifying both opportunities for preservation and analysis and challenges related to the interests of diverse stakeholders involved in artistic output. Her work underscores the need to address labour concerns and ensure that AI systems do not undermine the livelihoods and rights of creators.

From a regulatory perspective, Dr McDonagh and Ms Abbass argue that generative AI fundamentally disrupts existing legal frameworks, particularly copyright law and cultural policy mechanisms under the 2005 Convention. They highlight two pressing issues: whether the use of protected cultural materials for training AI constitutes a legal breach, and how ownership should be assigned to AI-generated outputs. These questions expose critical gaps in current regulatory systems. Complementing this, Dr Vinchon examines the philosophical implications of AI creativity, questioning notions of authorship, intentionality, and artistic value. Through concepts such as the "Next-GenAI-rtist," he describes emerging co-creative practices between humans and AI, while also drawing attention to broader ethical, ecological, and epistemological concerns, including data ethics, copyright, and cultural representation.

In summary, these contributions collectively demonstrate that AI is not only transforming how cultural content is produced and consumed, but also challenging the foundational concepts and governance structures of the creative and cultural industries. While generative AI opens new possibilities for artistic experimentation, accessibility, and cultural preservation, it also raises urgent questions about authorship, labour rights, legal accountability, and the protection of cultural diversity. The studies consistently point toward the need for updated regulatory frameworks, ethical guidelines, and inclusive policies that reflect the realities of AI-driven cultural production. In alignment with UNESCO's role as a standard-setter and catalyst for international cooperation, the integration of AI into CCIs must be guided by principles that balance innovation with fairness, creativity with responsibility, and technological advancement with the protection of human-centred cultural values.

Narratives and Practice of Artifical Intelligence in the Arts: Four Recommendations

© Baptiste Caramiaux



Dr. Baptiste Caramiaux

CNRS, Sorbonne University, France

Abstract

Artificial intelligence (AI), and particularly generative AI, is playing an increasingly prominent role in the creative, artistic, and cultural sectors. While widely promoted by private developers and mainstream media as tools that enhance or democratize artistic production, these dominant narratives may not fully reflect the experiences and perspectives of artists and creative practitioners.

This report critically examines the dominant narratives surrounding generative AI in the arts, analyzing the values they promote and the implicit assumptions they carry. We present what cultural and ideological positions they convey, and how they influence public perception, innovation, and artistic practice. In parallel, we show how artistic uses of AI often diverge from mainstream representations. In particular, we highlight the importance of material engagement, situated learning, and the development of craft-like skills in artists' work with AI technologies.

Combining a critical study of AI narratives with practice-based perspectives, this report proposes four recommendations to promote a constructive and inclusive discourse about AI artistic practice.

IV

Introduction

Artificial intelligence (AI) systems are playing an increasing role in the creative, artistic and cultural sectors. Generative AI, a specific branch of AI capable of producing text, images, audio, and video, typically in response to textual prompts, has led to the emergence of an expanding array of tools that incorporate this technology. These tools are predominantly developed by private players and are widely promoted in mainstream media as being able to assist or enhance artistic production. But is this really the shared opinion of those working in the field, i.e. artists and creative people?

To answer this question, it is critical to first better understand the dominant narratives of AI in the arts, that is to say stories that convey particular points of view or sets of values.[1] Narratives are powerful instruments as they accompany technological innovation as an element of communication for various audiences, including the general public, promoting cultural views and representation.[2] These narratives become an important vector of adoption or rejection by people. For example, fictions around AI fuel existential fears that are taken up by actors in the field,[3] particularly in a number of companies and think tanks, and have a significant impact on innovation and policy making.[4]

When narratives engage with themes of creative work and culture, they significantly influence public perceptions of AI, as well as broader understandings of artistic creation and creativity. Particularly salient are the narratives that frame AI in terms of democratic accessibility and effortless creativity, which can have profound cultural implications in contemporary society. This article examines the dominant narratives surrounding generative AI technologies within the domains of creativity and artistic production.

In a recent article we examined the overlooked aspects of AI narratives in the arts, with a particular focus on how advances in generative AI technology and its implication in creative practices contribute to narratives about creative work.[5]

We address the following questions: Who are the key actors shaping and disseminating narratives about the benefits of AI for artistic creation? What explicit values do these narratives promote? What implicit assumptions underpin these values, and in what ways might they enable or constrain creative practices?

In parallel with this line of inquiry, several studies have documented how artists engage with AI technologies, revealing that their practices often diverge from the dominant discourses typically associated with these tools. In a recent article,[6] we demonstrated the significance of the material dimensions of these technologies in shaping artistic practice, as well as the uncertainties and ambiguities that arise in the process of their creative appropriation.

In this article, we present a summary of these two lines of research in order to provide a series of recommendations in terms of discourse on AI in the arts.

AI (dominant) narratives in the arts

This section presents a summary of the key findings from our recent research. To conduct this study, we compiled a corpus of press articles, news reports, and blog posts discussing the role of AI in the arts. These materials were sourced from a range of online media outlets, including those with a specialized focus on technology or the arts, as well as more general-interest platforms.

The corpus was constructed using two major search engines that dominate web search engines in Europe and the United States—the primary geographical contexts of this study. Each search query was specified to return content published between 2020 and the present.

Using thematic analysis, we identified and examined the recurring patterns and discursive features within the corpus. This approach enabled us to delineate the dominant narratives about generative AI in artistic contexts, which are organized around five explicit value frameworks.

1. Automation over manual work. Creativity is a process that can be rationalised and streamlined, with the potential impact of a loss of autonomy and agency.

2. Efficiency over exploration. Standard metrics of productivity are equally valid in artistic spheres, with the potential impact of overlooking artists' nuanced needs, less willingness among artists to explore and increased pressure to produce

3. Concept over execution. Dominance of a cultural hierarchy of the "big idea" over the "small scale tasks" needed to bring that idea to life, with the potential impacts of less diversity in the outcomes, effect of style exhaustion, creative and cultural stagnation

4. Artifact over process. Value in the final deliverable, rather than the transformation, self-reflection, cultural positioning, and growth occurring throughout the creative process, with the potential impacts of new market standards.

5. Short-term over long-term skills. Time invested in deeply learning a craft does not add value to the final output, with the potential impacts of continued defunding of art programs, organizations, and institutions.

AI practices in the arts

This investigation into AI narratives within the creative domain should be situated alongside recent research examining the practices of artists who incorporate AI systems into their work. Notably, this line of inquiry has been further developed within the field of Human-Computer Interaction (HCI) and Science and Technology Studies (STS).

1. Mieke Bal, Narratology: Introduction to the Theory of Narrative (Toronto: University of Toronto Press, 2009).

2. Fred Turner, From Counterculture to Cyberculture: Stewart Brand, the Whole Earth Network, and the Rise of Digital Utopianism (Chicago: University of Chicago Press, 2010).

3. Stephen Cave and Kanta Dihal, "Hopes and Fears for Intelligent Machines in Fiction and Reality," Nature Machine Intelligence 1, no. 2 (2019): 74–78, https://www.nature.com/articles/s42256-019-0020-9.

4. Timnit Gebru and Émile P. Torres, "The TESCREAL Bundle: Eugenics and the Promise of Utopia through Artificial General Intelligence," First Monday (2024), https://firstmonday.org/ojs/index.php/fm/article/view/13636.

5. Baptiste Caramiaux, Kate Crawford, Q. Vera Liao, Gonzalo Ramos, and Jenny Williams, Generative AI and Creative Work: Narratives, Values, and Impacts, arXiv preprint arXiv:2502.03940 (2025), https://arxiv.org/pdf/2502.03940.

6. Baptiste Caramiaux and Sarah Fdili Alaoui, "'Explorers of Unknown Planets': Practices and Politics of Artificial Intelligence in Visual Arts," Proceedings of the ACM on Human-Computer Interaction 6, no. CSCW2 (2022): 1–24.

In a recent study, we conducted interviews with prominent artists actively engaging with AI (starting before the latest advances in generative AI), which provided valuable insights into the distinctive characteristics and dynamics of artistic practice involving these technologies.

We first find that their practice relies on crafting algorithms and data as materials. Starting from the experience of the technology rather than its analytical understanding is essential in the artists' practice. This learning-by-doing approach leads them to develop specific skills related to the types of algorithms used. These skills do not refer to the ability to build better models in the sense of AI research (better accuracy, better data efficiency). Instead, they refer to the ability to better predict the behaviour of the system, so that it is more in line with their expectations. We relate this specific set of skills as those of crafting, in the sense that artists favour a direct relationship with the algorithmic and data material.

Our analysis reveals that artistic practice with AI frequently involves engaging with algorithms and datasets as materials to be shaped and manipulated. Rather than approaching the technology through a primarily analytical or theoretical lens, artists often begin with direct, experiential interaction of these materials—what might be described as a learning-by-doing approach. This mode of engagement enables the development of a distinct set of skills tailored to specific algorithms in use. Importantly, these skills are not aimed at improving model performance in the conventional sense of AI research (e.g., enhancing accuracy or data efficiency), but rather at cultivating an intuitive understanding of the system's behavior.

This allows artists to guide the outputs in ways that align more closely with their creative intentions. We understand these practices as a form of crafting, insofar as they emphasize a hands-on, iterative relationship with algorithmic and data-driven materials. And the corollary is that the notion of craftsmanship shows the importance of the process on the final product contrary to the dominant discourse put forward above.

In addition, we uncover how they explicitly use this material unpredictability rather than avoid it. AI is used by artists because of its ability to provide surprising results, unexpected errors and glitches.

Recommendations

By combining a critical analysis of AI narratives with insights from practice-based research, this report proposes four key recommendations aimed at fostering a more constructive, inclusive, and context-sensitive discourse around AI in artistic practice.

1. **Foster the multiplicity of narratives:** Encourage a diverse range of voices—including artists, cultural practitioners, and marginalized communities—to contribute to the discourse around AI in the arts. This helps counter dominant, often commercially driven narratives and promotes context-sensitive understandings of creative technologies.

2. **Go beyond the myth of democratization of creative labor for the sake of simplicity:** Critically assess claims that generative AI universally democratizes creativity, as such narratives often overlook structural inequalities, access barriers, and the complexities of creative work. Simplifying these issues can obscure power dynamics and reinforce dominant industry interests.

3. **Consider creativity more than a problem-solving process:** Acknowledge that artistic creativity involves exploration, ambiguity, surprises, and meaning-making—not just efficiency or output optimization. Recognizing this broader perspective challenges reductive views of creativity often embedded in AI dominant narratives.

4. **Encourage interactivity, and agency with AI technology:** Encourage interactive engagement and empower users with greater agency in their use of AI technologies, fostering hands-on exploration, discoverability and creative control. This contrasts with the current approach leveraging opaque, black-box AI-as-a-service models that limit understanding and reduce users to passive consumers.

Acknowledgements

This research was conducted in collaboration with (by alphabetical order): Kate Crawford, Sarah Fdili Alaoui, Q. Vera Liao, Gonzalo Ramos, and Jenny Williams. Part of this research was supported by the Microsoft Research AI & Society Program (2024).

The Dual Edge: Artificial Intelligence's Impact on Cultural Production and Preservation

© Katherine Elkins



Dr. Katherine Elkins

Professor of Humanities and Computing; Founding Co-Director, The AI Lab, Kenyon College, United States of America.

Abstract

This paper extends the presentation "AI and Culture" from the Webinar "Artificial Intelligence and Cultural and Creative Industries," organized by the UNESCO Cairo Office on April 29, 2025. It details the complex set of opportunities and challenges for preserving and fostering a diverse cultural heritage considering the new realities of Generative AI.

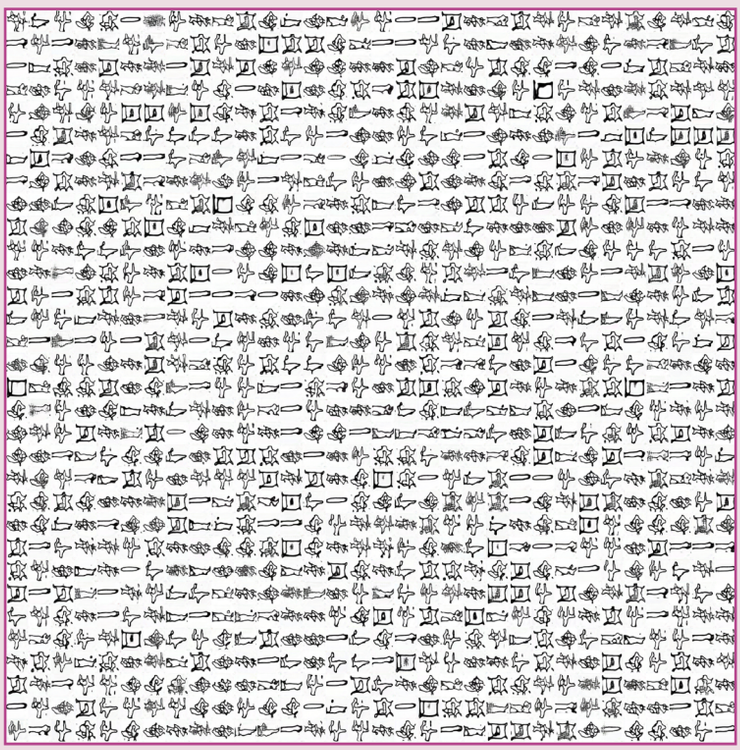


Figure 1: StyleGAN training output at various stages (1)
© Katherine Elkins.

IV

Introduction

Generative AI offers both challenges and opportunities for cultural production and preservation. In this paper, I examine the intersection of computational creativity and labor concerns, analyze the distinct interests of stakeholders of artistic output, and end with a discussion of the opportunities for cultural preservation and analysis alongside considerations of AI safety. I conclude by offering specific recommendations that address these many challenges and opportunities.

Computational Creativity, Labor, and Deskilling

The field of computational creativity considers the multiple dimensions of creativity through the "Four P's": Person, Process, Product, and Press.[1] Creativity can be understood as a characteristic of the person or AI system itself, of the process of creation, as located in the artifact produced, or as defined by its reception. Demis Hassabis, founder of DeepMind, describes three levels of creativity: simple recombination, novel creation, and genre invention.[2]

Most researchers agree that AI has achieved the second level of creativity. AI art has won art competitions, as seen in Boris Eldagsen's "The Electrician" in Sony's 2023 World Photography Competition.[3] Human annotators have even ranked AI-generated poetry as more human-like than the original. [4] Unlike earlier AI systems, current Generative AI isn't simply remixing data. Instead, it seems to be generalizing from training data [5] in ways that, as legal scholar Pamela Samuelson argues, current copyright law is not adequately designed to address.[6]

The Screenwriters' Guild strike highlighted legitimate concerns about the impact of Generative AI on creative industries.[7] As early as 2022, researchers from DeepMind were already demonstrating how AI could be helpful for screenplay writing.[8]

The new contract for Hollywood screenwriters is set to expire in 2026, at which point further negotiations will likely take place. Meanwhile, we have seen many of the kinds of work that artists routinely engage in to earn a living wage — such as technical writing and graphic design — being automated away.[9]

There are two concerns here: the first is for artists' livelihoods, and the second is the possibility that our cultural heritage will be lost as artists turn to alternative ways of earning a living. Even more concerning will be the pipeline of future artists, who may become discouraged and turn to other professional paths if creative industries no longer offer a viable option.

Equally concerning is the possibility of substantial deskilling, as more assignments, whether in art school or writing programs, can be easily completed using AI.

Already, there are reports of art students using AI to generate ideas instead of developing their creative skills. Education must keep pace by both tracking areas of deskilling and offering new methods for encouraging and developing the skills needed to ensure a robust ecosystem of cultural producers.

Whose Interest? Creators, the Public, and Cultural Diversity

Many of the conversations from artists opposed to Generative AI revolve around the use of their work for training data without compensation. The public, however, has an interest in supporting the development of AI systems on diverse cultural data. As AI systems are increasingly adopted for widespread use, they will become a central vehicle for how people discover and understand culture. This creates a fundamental tension between protecting artists' rights while ensuring AI systems represent cultural diversity.

Risks and Opportunities: Cultural Preservation & Analysis, and AI Safety

Despite challenges to continued cultural production, AI offers real opportunities for cultural preservation and analysis. Recently, AI has been used to decipher the Herculaneum Papyri[10] and assist in the restoration of Yangshao pottery.[11] Meanwhile, our lab is collaborating on ways to use AI to restore poorly digitized cultural artifacts from New Orleans. We are also exploring new ways to leverage AI to analyze this cultural heritage.

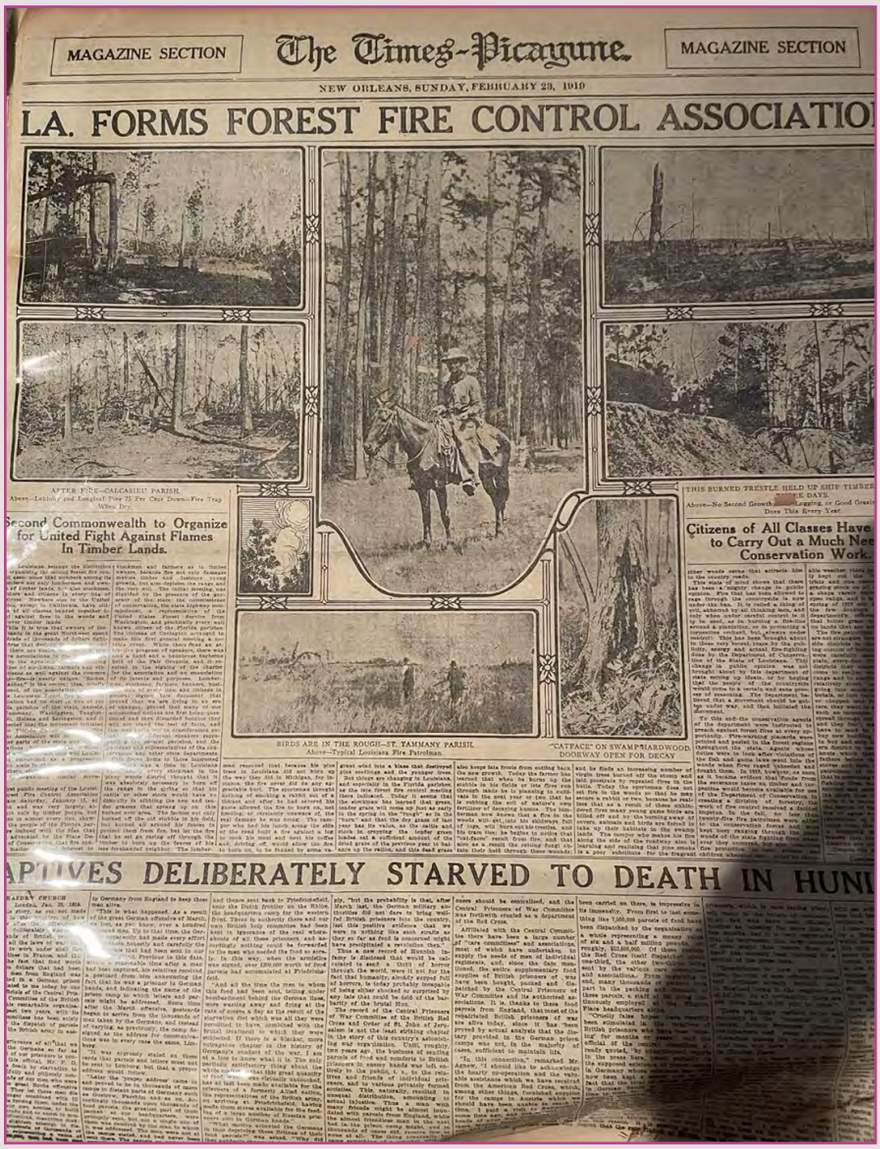
Copyright litigation, however, creates some downstream effects on AI safety and development that are less than ideal. Companies' secrecy about training data hinders academic AI safety research, which requires understanding connections between model behavior and the data it was trained on. Equally concerning is the emerging trend for companies to seek alternative training approaches, either by excluding cultural data entirely [12] or developing methods of training on synthetic data.[13] Some argue that these are the last AI models to be trained on human data, and that now more than ever, it is in both artists' and the public's interest for our work to be "known" by the model.

How would purely synthetic-trained AI systems impact our cultural future? Without thoughtful policy interventions, we risk creating a technological future divorced from our human cultural capital.

Recommendations

1. **Supporting Artists in an AI-Transformed Economy:** As Generative AI becomes increasingly capable, it is displacing many of the jobs that typically support artists. Targeted approaches to supporting cultural production, particularly as artistic livelihoods are eroded, should be developed with a comprehensive view to supporting artists across a wide range of media, including text, image, and audio cultural artifacts.

2. **Mitigating Educational Deskilling:** Careful thought should be given to training the next generation of cultural producers and to anticipating and counteracting the real downstream effects of deskilling. Generative AI excels in both intellectual and creative arenas, and the current education system has not yet evolved to anticipate, assess, and compensate for increasing dependence by student populations on AI. Deskilling, if unaddressed, will have potential long-term effects on cultural production.


MAGAZINE SECTION

The Times-Picayune.

MAGAZINE SECTION

NEW ORLEANS, SUNDAY, FEBRUARY 23, 1919

LA. FORMS FOREST FIRE CONTROL ASSOCIATIO

Second Commonwealth to Organize for United Fight Against Flames In Timber Lands.

Citizens of All Classes Have to Carry Out a Much Nee Conservation Work.

APTIVES DELIBERATELY STARVED TO DEATH IN HUNI

Figure 2: One of the many poorly digitized cultural artifacts targeted for AI reconstruction by the "Archival Intelligence" collective © Katherine Elkins.

3. Leveraging AI for Heritage Preservation: Newly performed Artificial Intelligence offers unprecedented opportunities for the restoration, preservation, and analysis of our shared cultural heritage. A more effective system of inventory and prioritization would help direct efforts to areas of cultural heritage that are most at risk of disappearing without immediate intervention.

4. Balancing Stakeholder Interests: The interests of stakeholders should be carefully balanced, with particular attention to the needs of the public versus those of artists. While priority should be given to supporting the continued production of cultural artifacts through the support of artists, withholding the wide variety of cultural artifact diversity as training data leads to impoverished AI systems that lack cultural diversity and often exhibit bias towards specific cultural values and systems. As more citizens of the world employ these impoverished systems, this will lead to further cultural impoverishment. Considering a range of stakeholders is crucial.

5. Ensuring Transparency in AI Development: Currently, many commercial AI companies refuse to allow access to their training data, fearing lawsuits; many are also exploring alternative methods to train models that include synthetic data. This lack of transparency raises significant concerns for AI safety researchers, who are unable to investigate models thoroughly. The possibility of a future in which AI models are no longer trained on human cultural data is also concerning. Care must be taken to consider this question of culture within a much larger complex ecosystem in which actions taken in one sphere can have unintended downstream effects on AI development and deployment.

1. Mark A. Runco and Daehyun Kim, "Four Ps of Creativity and Recent Updates," in Encyclopedia of Creativity, Invention, Innovation and Entrepreneurship, ed. Elias G. Carayannis (Cham: Springer, 2020), https://doi.org/10.1007/978-3-319-15347-6_429.

2. Demis Hassabis, interview, Possible FM, April 9, 2025, https://www.possible.fm/podcasts/demis/.

3. "AI-Generated Image Wins Top Prize in Prestigious Art Competition," Artnet News, June 22, 2023, https://news.artnet.com/art-world/boris-eldagsen-photography-award-sony-ai-generated-images-dall-e-2286622.

4. Brian Porter and Edouard Machery, "AI-Generated Poetry vs. Human Poetry," Scientific Reports 14 (2024): 26133, https://doi.org/10.1038/s41598-024-76900-1.

5. John Schulman, Jacob Hilton, Jared Kaplan, and Leo Gao, "Tracing Thoughts in Language Models," Anthropic, January 2024, https://www.anthropic.com/research/tracing-thoughts-language-model.

6. Pamela Samuelson, "Generative AI Meets Copyright," Science 381 (2023): 158–61, https://doi.org/10.1126/science.adi0656.

7. "Hollywood Writers' Strike Against Generative AI: A Landmark Victory," Brookings Institution, May 23, 2024, https://www.brookings.edu/articles/hollywood-writers-went-on-strike-to-protect-their-livelihoods-from-generative-ai-their-remarkable-victory-matters-for-all-workers/.

8. Piotr Mirowski et al., "Co-Writing Screenplays and Theatre Scripts with Language Models," arXiv preprint arXiv:2209.14958 (2022), https://arxiv.org/abs/2209.14958.

9. "Replacement of Human Artists by AI Systems," UNCTAD, March 28, 2024, https://unctad.org/news/replacement-human-artists-ai-systems-creative-industries.

10. Brent Seales et al., "Virtual Unwrapping of the Herculaneum Papyri Using Machine Learning," Scientific American, February 2024, https://www.scientificamerican.com/article/inside-the-ai-competition-that-decoded-an-ancient-scroll-and-changed/.

11. "AI-Assisted Restoration of Yangshao Painted Pottery," Heritage 7, no. 11 (2024): 295, https://doi.org/10.3390/heritage7110295.

12. Keziah Weir, "Meta Believes Your Books 'Are Individually Worthless,'" Vanity Fair, April 2025.

13. "Generative AI for Synthetic Data Generation," arXiv preprint arXiv:2403.04190 (March 2024), https://arxiv.org/abs/2403.04190.

Artificial Intelligence and Cultural Expressions: Regulatory Challenges in the Age of Generative Technology

© Luke McDonagh and Reem Abbass Moustafa



Dr. Luke McDonagh

Associate Professor, London School of Economics (LSE), United Kingdom.

&

Ms. Reem A. Abbass

PhD Candidate, London School of Economics (LSE), United Kingdom.

Abstract

The emergence of generative Artificial Intelligence (AI) presents unprecedented regulatory challenges. AI does not fit neatly within the existing legal frameworks designed to protect traditional human cultural expressions, such as art, literature, and music. The current legal-regulatory framework protects cultural expressions, and those involved in their creation, through two primary mechanisms: (i) copyright law, which protects original works of authorship by individuals; and (ii) intangible cultural policy via the 2005 UNESCO Convention on the Protection and Promotion of the Diversity of Cultural Expressions (hereafter, the 2005 Convention), which complements copyright law by recognizing non-market values of culture and diverse cultural identities. AI-generated content fundamentally challenges these existing regimes because it blurs the line between authorship and attribution.

As a result, two legal issues emerge: (a) Is the use of protected or culturally significant materials to train AI models without consent or compensation a breach of the law? (b) Who, if anyone, owns the outputs generated by AI? These challenges require urgent attention, as the proliferation of AI systems continues to reshape cultural production globally.

IV

Introduction

Generative AI systems rely on the large-scale ingestion of existing human-created content to produce new works. This process disrupts the legal assumptions underlying copyright protection, which are based on individual, human authorship. These systems analyse patterns in massive datasets of human-created works, including books, artwork, music, and other cultural expressions, to generate new content that mimics, combines, or transforms these patterns.

This means that the lines between creation, imitation, and transformation are increasingly blurred, which not only raises urgent questions of authorship, appropriation, and compensation but also may result in the mass extraction of value across industries, as well as the disruption of labor markets and the replacement of human creativity by AI-generated output. Creative professionals, from visual artists to musicians and writers, now face competition from algorithms that can produce content at incomparable speeds and a low marginal cost.

Copyright: Philosophical and Legal Contradictions

The current regulatory regime is not equipped to protect cultural expressions from this form of cultural appropriation.[1] Philosophically, the rise of AI poses a challenge to foundational copyright theories. The labor theory of copyright, inspired by John Locke,[2] and the personality theory, drawing on Kantian thought,[3] both assume a human creator who invests intellectual labor or personal expression. AI, lacking both consciousness and intention, does not fit either model.

Most jurisdictions protect works only if they are original creations of natural persons. For example, the US Copyright Office guidance explicitly requires human intellectual input as a condition of protection.[4]

In the absence of human authorship, AI-generated outputs are generally considered to fall into the public domain; however, if a human has contributed some work to the AI-generated material, then the human should be able to claim it.[5]

This situation poses challenges for creators, companies, and regulators, particularly as AI systems become increasingly sophisticated and capable of mimicking human styles, voices, and cultural formats.[6] The line between human-created, human-assisted, and fully AI-generated content is growing increasingly difficult to define and enforce.

Legal uncertainty is further heightened by active litigation and legislative debate. Lawsuits such as those filed by Getty Images and individual artists raise the issue of both input (training data) and output (resulting content) infringement.[7]

Jurisdictions are grappling with whether AI training constitutes infringement and whether legal exceptions, such as fair dealing and fair use, apply to training large language AI models.

The EU has already taken a position by requiring licensing and transparency in its new AI regulatory framework.[8] The UK and the US have not yet taken a position on an approach to regulating AI training and outputs.

Cultural Heritage: International Frameworks Under Pressure

Beyond economic concerns, AI poses a threat to the integrity of cultural expressions that are often deeply embedded in specific historical and community contexts. AI works are divorced from the critical context of the life world and daily practices of the people who created the initial cultural activities and works of art.[9]

For indigenous communities and minority cultures, whose expressions have historically been subjected to appropriation, AI represents a new digital frontier of potential exploitation.

By decontextualizing and remixing cultural expressions without providing the necessary knowledge or context, AI can replicate and distort traditional music, language, and imagery, often in ways that strip them of their meaning.

This process can marginalize communities of origin and undermine efforts to protect intangible heritage.

As in the case of copyright, the applicable international law on cultural heritage, specifically the 2005 UNESCO Convention, is being challenged by AI technology.[10]

The 2005 Convention promotes the diversity of artistic expressions, but it was developed without the technological advancement of generative AI in mind and thus lacks guidance on machine-produced cultural production.

The ability of AI to analyze and reproduce stylistic elements of traditional artwork or ceremonial music without understanding their sacred or communal significance poses profound ethical dilemmas.

These effects constitute a form of cultural appropriation, particularly when tech firms monetize AI outputs without providing equitable benefits. When technology companies profit from AI systems trained on diverse cultural traditions without acknowledging or compensating the source communities, this perpetuates historical patterns of exploitation.

1. Enrico Bonadio and Luke McDonagh, "Artificial Intelligence as Producer and Consumer of Copyright Works: Evaluating the Consequences of Algorithmic Creativity," Intellectual Property Quarterly (2020): 112–137.

2. John Locke, Two Treatises of Government (Oxford: Oxford University Press, 2009; originally published 1690).

3. Immanuel Kant, Critique of Judgment (Oxford: Clarendon Press, 1952; originally published 1790).

4. U.S. Copyright Office, Compendium of U.S. Copyright Office Practices § 306.

5. Miriam Lord, "US Copyright Office on AI: Human Creativity Still Matters, Legally," WIPO Magazine (April 24, 2025).

6. D. Bondy Valdovinos Kaye, Kylie Pappalardo, and Joanne Gray, "In the Style of: Exploring Industry, Creator and Legal Implications of Copying Style through Generative AI," Information, Communication & Society (2025): 1–17.

7. Getty Images (US) Inc v Stability AI Inc [2025] EWHC 38 (Ch).

8. Regulation (EU) 2024/1689 of the European Parliament and of the Council of 13 June 2024 laying down harmonised rules on artificial intelligence and amending various regulations and directives, OJ L, 2024/1689, 12.7.2024, ELI.

9. Fan Bu, Zheng Wang, Siyi Wang, and Ziyao Liu, "An Investigation into Value Misalignment in LLM-Generated Texts for Cultural Heritage," arXiv preprint arXiv:2501.02039 (2025).

10. UNESCO, Convention on the Protection and Promotion of the Diversity of Cultural Expressions, October 20, 2005; and UNESCO, Convention for the Safeguarding of the Intangible Cultural Heritage, October 17, 2003.

11. Joseph Guenzler, "Exclusive: Adobe Slammed for Use of AI-Generated Images of Indigenous People and Artworks," National Indigenous Times (March 10, 2025).

12. Kalin Hristov, "Artificial Intelligence and the Copyright Dilemma," Idea 57 (2016): 431, 439.

13. Bonadio and McDonagh, "Artificial Intelligence," 112, 134.

14. Anne Lauber-Rönsberg and Gregor Hetmank, "The Concept of Authorship and Inventorship under Pressure: Does Artificial Intelligence Shift Paradigms?" GRUR International 69 (2020): 709–718.

15. Regulation (EU) 2024/1689 of the European Parliament and of the Council of 13 June 2024, OJ L, 2024/1689, 12.7.2024, ELI. (Duplicate entry; same as #8)

AI's ability to mass-produce content risks undermining the very diversity the 2005 UNESCO Convention seeks to promote.

A recent case involving the firm Adobe is striking. Adobe's generative AI program produced 'numerous AI-generated images labelled as Indigenous Australians, many of which do not resemble Aboriginal and Torres Strait Islander people', images which featured 'random markings that have no cultural or clan significance, raising concerns about authenticity and consultation'.[11]

In this vein, without safeguards AI may flatten cultural expressions into generic, decontextualized commodities, far from the approach set out in the 2005 Convention. The convention's emphasis on the unique value of diverse human creative processes stands in tension with AI's capacity to homogenize cultural expressions through algorithmic processing.

Recommendations

About copyright, there are several potential legal and policy responses to address these challenges:

1. **Public Domain Approach:** Leave AI outputs in the public domain, accessible to all, but owned by no one. Since there is no human author directly involved in the creative production of the output, no one should be able to claim exclusive rights over it. This approach mitigates the risk of excessive monopoly resulting from AI-generated outputs owned by corporate entities. However, it has potential drawbacks. It could ultimately decrease investment into research on AI applications[12] and encourage (human) dishonesty in disclosing the use of AI technologies to avoid the resulting work being deemed unprotectable.[13]

2. **Sui Generis Rights:** Create specific new rights for AI-generated content that acknowledge its unique character. This could be a form of protection aimed at incentivizing the development of AI creative platforms while also safeguarding human ingenuity.[14]

3. **Licensing and Transparency:** Institute licensing requirements and/or transparency obligations for AI training data and generated outputs. Licensing schemes typically require the payment of license fees, fair dealing or fair use, and opt-out regimes.

Transparency measures, on the other hand, could include the disclosure of training datasets and tagging outputs as AI-generated. The European Union's AI Act, for example, contains mandates for the transparency and disclosure of copyrighted works used in training data, aiming to prevent the unauthorized use of copyrighted works in AI training.[15]

Such measures represent critical first steps but may require complementary cultural policy approaches, beyond copyright, to protect traditional cultural expressions and indigenous knowledge that might otherwise be viewed as in the public domain (and therefore 'fair game' for AI training).

These might include:

1. **Community consent protocols:** Recognition of collective and communal oversight of cultural expressions could enable a right to require consent for the use of traditional expressions in AI training.

2. **Benefit-sharing mechanisms:** Where AI firms use cultural content, one proposal would be to require firms to share revenue when AI systems commercialize outputs based on traditional artistic forms.

Conclusion: Toward a New Framework

In conclusion, proactive legal and ethical engagement is essential to address the challenges posed by AI to copyright and cultural heritage. The existing frameworks are inadequate, and reforms are needed to uphold cultural integrity, ensure community consent, and create mechanisms for recognition and redress in cases of cultural appropriation by AI systems.

The future of global creativity and cultural diversity depends on rethinking the legal architecture of authorship in the age of machines. This requires not only technical solutions but also deep engagement with fundamental questions about the value of human creativity, the rights of cultural communities, and the ethical boundaries of technological innovation. As AI capabilities continue to advance, the need for coherent legal frameworks that protect both individual creators and collective cultural expressions grows increasingly urgent.

Ethics and Philosophy: the nature and future of Artificial Intelligence's creativity

© Florent Vinchon



Dr. Florent Vinchon
Laboratory of Psychology and Applied Ergonomics, University of Paris, France

Abstract

This contribution explores how Generative Artificial Intelligence (GenAI) redefines the contours of creativity in the digital age, drawing from philosophical, technical, and ethical perspectives. Based on my presentation at the UNESCO webinar "Artificial Intelligence and Cultural and Creative Industries," and informed by recent chapters co-authored with Franck Rolland and Todd Lubart, this paper investigates the limitations and possibilities of AI as a creative agent. AI's current creative capacities raise profound questions about authorship, intentionality, and artistic value. Through thought experiments such as the Chinese Room and Mary's Room, the paper contextualizes GenAI's statistical output within the broader framework of human subjective experience. The concept of the "Next-GenAI-rtist", a new generation of artists who co-create with GenAI, is introduced as a central figure in this evolving landscape. These hybrid practices reflect a shift toward co-creativity, highlighting the need for new ethical frameworks.

In parallel, this contribution outlines the ecological, legal, and epistemological challenges of GenAI, including concerns over data ethics, copyright, and cultural representation. It concludes with actionable recommendations for policymakers and practitioners to foster ethical, inclusive, and sustainable AI integration in creative sectors.

IV

Introduction : AI's Emergence in the Creative Arena

As GenAIs become more accessible, their use in artistic production is rapidly transforming the creative industries. From visual arts and literature to music and photography, GenAIs are enabling new modes of co-creation. However, this technological leap also raises critical questions: What does it mean for AI to be creative? Can it replace the human artist? And what ethical responsibilities do we have when integrating AI into cultural contexts?

Understanding AI Creativity: Thought Experiments and Conceptual Limits

Four philosophical analogies —Searle's Chinese Room,[1] Jackson's Mary's Room,[2] Borel's Infinite Monkey Theorem,[3] and Bostrom's Paperclip Maximizer [4] — help elucidate the limitations of GenAI in creative contexts.

These thought experiments illustrate that, despite producing outputs that may appear novel or expressive, AI lacks experiential feeling, consciousness, intent, and emotional understanding. Its "creativity" is derived from pattern recognition and statistical modeling, a mimicry of creativity rather than creativity itself. Yet these limitations do not negate the potential of AI. They reposition it as a collaborator, a powerful tool that, when guided by human intent and aesthetic vision, can lead to genuinely innovative and meaningful outcomes.[5]

The Next-GenAI-rtist: A New Paradigm of Co-Creativity

We introduced the concept of the Next-Gen AI-artist in a previous chapter,[6] an emerging archetype of artists who collaborate with GenAI in producing creative works. These practitioners are proficient not only in artistic expression but also in prompt engineering, coding, ethical data curation, and cross-disciplinary thinking. Notably, they embody a co-creative spirit, engaging with AI systems in iterative feedback loops to refine outputs.

This dynamic is underpinned by the Hybrid Intelligence Technology Acceptance Model (HI-TAM),[7] which emphasizes domain-specific adaptation, shared languages between humans and AI, continual training loops, and psychological safety. The co-creative relationship is not passive: human creators maintain creative control and responsibility while drawing from AI's expansive generative capacity.

Ethical and Cultural Implications

Despite its promise, AI-driven creativity poses significant ethical concerns. GenAI systems are trained on vast datasets, often scraped without consent, raising issues of intellectual property and cultural appropriation. Moreover, AI creativity incurs environmental and social costs, including the carbon footprint of training large models and exploitative labor practices involved in data preparation.

These challenges necessitate a new ethical framework for AI in the arts, which we propose through four foundational laws:

1. **Do No Harm** – Prevent the generation of harmful or discriminatory content.
2. **Cooperation Over Competition** – Promote collaborative human-AI relationships.
3. **Transparency** – Identify sources of training data.
4. **Cultural Equity** – Ensure inclusivity and respect for underrepresented voices.

These principles align with UNESCO's broader goals of ethical digital transformation and cultural equity.

Recommendations

To support responsible, inclusive, and innovative integration of GenAI into cultural and creative sectors, we propose the following recommendations:

1. **Promote AI Literacy in the Arts.** Introduce transdisciplinary education combining AI, ethics, and the humanities in creative curricula. Artists and cultural workers should also be equipped with the technical and critical tools needed to engage with GenAI.

2. **Foster Human-AI Co-Creation Models.** Encourage models of Hybrid Intelligence where AI is treated as a collaborative partner rather than a replacement. Research into co-creative practices should also be funded, and the development of tools designed for ethical interaction between humans and AI should be promoted.

3. **Ensure Transparency and Accountability.** Require that the sources of data used for generative tools be acknowledged and that authors and artists have the option to choose whether their work is used. In line with this idea, work created using AI should also be acknowledged and recognized.

4. **Address Ethical and Environmental Concerns.** The data used by AI must come from varied and diverse environments and be contextualized within their respective cultures. Similarly, the ecological impact of AI must also be taken into account, and the production of generative AI tools that consume fewer rare materials and require lower environmental costs must be considered.

By taking these steps, policymakers, researchers, and cultural practitioners can ensure that GenAI serves as a tool for enrichment not erasure of human creativity and cultural heritage that can appear in the Shut-Down scenario[8] akin to creative mortification,[9] where the question of "Why should a human be creative when an AI can do it better?" arise.

1. Searle, John R. "Minds, Brains, and Programs." Behavioral and Brain Sciences 3, no. 3 (September 1980): 417–424. https://doi.org/10.1017/S0140525X00005756.

2. Jackson, Frank. "What Mary Didn't Know." The Journal of Philosophy 83, no. 5 (May 1986): 291. https://doi.org/10.2307/2026143.

3. Borel, Émile. "La mécanique statique et l'irréversibilité." Journal de Physique Théorique et Appliquée 3, no. 1 (1913): 189–196. https://doi.org/10.1051/jphystap:019130030018900.

4. Bostrom, Nick. Superintelligence: Paths, Dangers, Strategies. Reprinted with corrections, 2017. (Oxford, United Kingdom: Oxford University Press, 2014).

5. Florent Vinchon, Franck Rolland, and Todd Lubart, "Artificial Intelligence & Creativity: The Ethical Debate," in Generative Artificial Intelligence and Creativity: Possibilities, Precautions, and Perspectives, ed. Matthew Worwood and James C. Kaufman (Academic Press, 2026).

6. Florent Vinchon, Janet Rafner, Jacob Sherson, Marion Botella, and Todd Lubart, "The Next GenAI-Rtist: A New Generation of Artist with Generative Tools," in Human-Computer Creativity, Generative AI in Education, Art, and Healthcare, ed. Vladimir Geroimenko (Cham: Springer, 2025), Springer Series on Cultural Computing, https://link.springer.com/book/9783031865503.

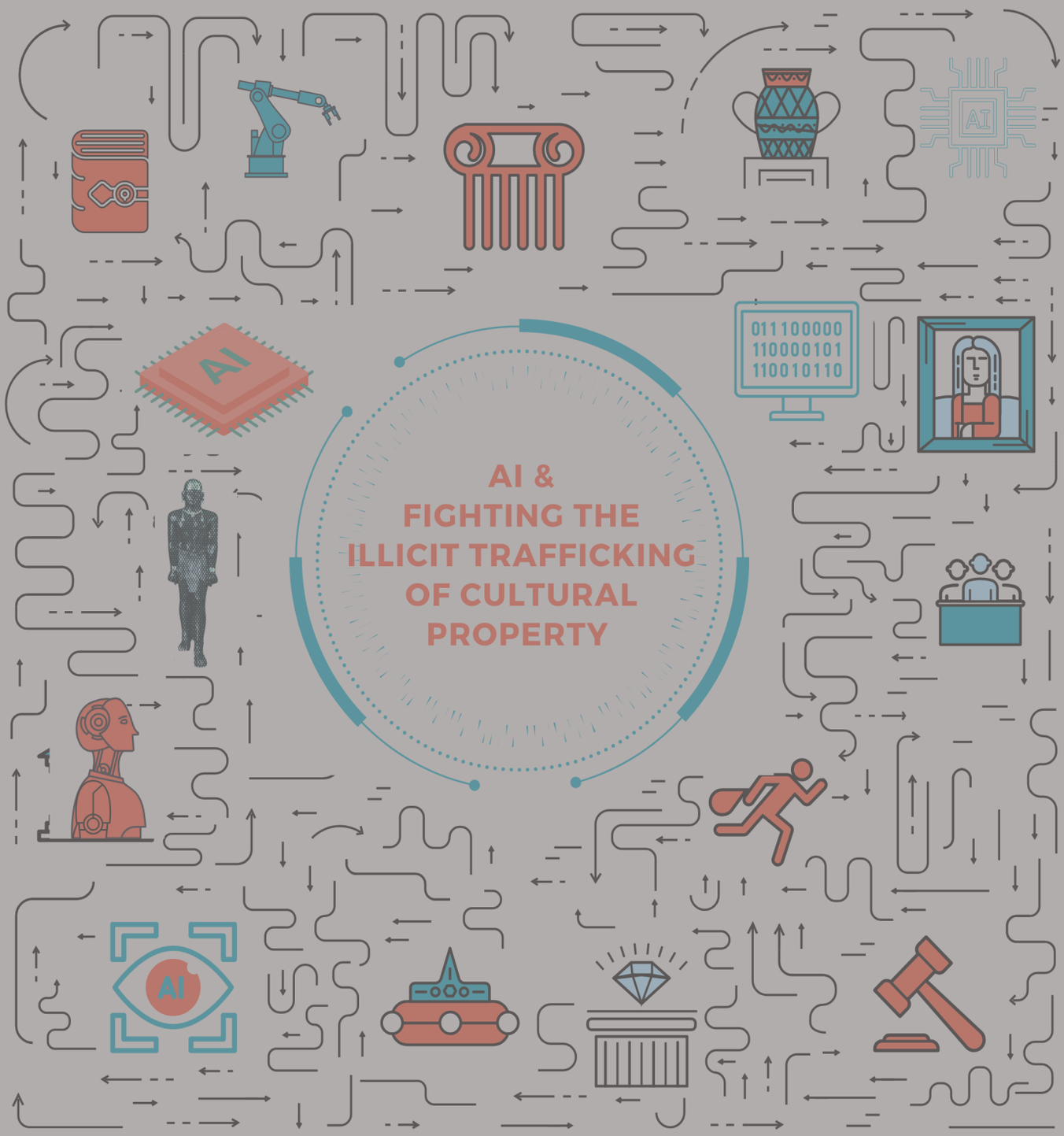
7. Yaoli Mao, Janet Rafner, Yi Wang, and Jacob Sherson, "A Hybrid Intelligence Approach to Training Generative Design Assistants: Partnership Between Human Experts and AI Enhanced Co-Creative Tools," in Frontiers in Artificial Intelligence and Applications, ed. Paul Lukowicz et al. (IOS Press, 2023), https://doi.org/10.3233/FAIA230078.

8. Vinchon, Florent, Todd Lubart, Sabrina Bartolotta, Valentin Gironnay, Marion Botella, Samira Bourgeois-Bougrine, Jean-Marie Burkhardt, et al. "Artificial Intelligence & Creativity: A Manifesto for Collaboration." The Journal of Creative Behavior 57, no. 4 (2023): 472–484. https://doi.org/10.1002/jocb.597.

9. Beghetto, Ronald A. "Creative Mortification: An Initial Exploration." Psychology of Aesthetics, Creativity, and the Arts8 (2014): 266–276. https://doi.org/10.1037/a0036618.

CHAPTER V

AI and UNESCO Cultural Conventions in Emergency



© Adapted from UNESCO, Fighting the Illicit Trafficking of Cultural Property, 2018*

Chapter 5

Artificial Intelligence and Protection of Cultural Properties in Emergencies

The protection of cultural property in times of conflict has long been a central concern of the international community, and UNESCO has established a robust normative framework to address this challenge. Two cornerstone instruments are the 1954 Hague Convention for the Protection of Cultural Property in the Event of Armed Conflict and the 1970 Convention on the Means of Prohibiting and Preventing the Illicit Import, Export and Transfer of Ownership of Cultural Property. The 1954 Convention focuses on safeguarding cultural heritage during armed conflict through preventive measures, respect obligations, and international cooperation, while the 1970 Convention addresses illicit trafficking through legal and institutional mechanisms for prevention and restitution. Together, these frameworks recognize cultural property as carriers of identity, memory, and social cohesion. In recent years, the rapid development of artificial intelligence (AI) has introduced new possibilities for strengthening their implementation. AI tools—such as image recognition, satellite monitoring, and predictive analytics—can support documentation, detection of looted artefacts, and real-time monitoring of damage to heritage sites. However, these benefits are accompanied by significant challenges, including data bias, unequal technological capacities across countries, risks to data sovereignty, and ethical concerns surrounding surveillance and accountability. As such, the integration of AI into cultural property protection must be carefully aligned with international legal and ethical standards.

Building on this foundation, the scholarship in this chapter highlights both the urgency of the threat and the promise of technological responses. Dr Amr Al-Azm emphasizes that cultural property embodies the collective memory, identity, and history of societies, making it particularly vulnerable during conflict. Looting and trafficking not only deprive communities of their heritage but also finance armed groups, perpetuate violence, and destabilize post-conflict recovery.

While such practices have historically accompanied warfare, their scale and speed today are unprecedented, largely due to digital platforms and social media, which enable illicit actors to connect and profit globally. At the same time, emerging technologies—especially AI—offer new tools to counter these threats. Dr Zingaretti, drawing on the EU-funded SIGNIFICANCE project, demonstrates how AI can enhance detection and prevention of illicit trafficking through advanced data analysis and pattern recognition. He underscores that effective deployment requires AI systems to be personalized, explainable, and ethically grounded to ensure trust and accountability. Complementing this perspective, Dr Fuentes-Loureiro examines the use of algorithmic tools such as web scraping and Social Network Analysis to identify trafficking networks and monitor online activities. While these approaches offer strong potential for law enforcement and heritage protection, they also introduce complex legal risks, including issues of privacy, jurisdiction, and the admissibility of digital evidence. Accordingly, she highlights the need for robust legal frameworks to ensure that AI deployment remains both appropriate and effective.

In summary, the intersection of UNESCO's normative frameworks and AI technologies represents a critical frontier in protecting cultural property. While the 1954 and 1970 Conventions provide a solid legal foundation, contemporary challenges driven by digitalization and transnational crime demand more adaptive responses. AI can significantly enhance monitoring, enforcement, and international cooperation, but its effectiveness depends on responsible governance, interdisciplinary collaboration, and adherence to ethical and legal standards. Ultimately, safeguarding cultural heritage in the 21st century requires not only technological innovation but also sustained commitment to cultural diversity, shared humanity, and international solidarity.

New Solutions for Old Problems: Threats and Challenges to Cultural Property in Times of Conflict and the Role of New Technologies

© ATHAR Project



Dr. Amr Al-Azm

Professor of Middle East History and Anthropology, Shawnee State University, United States of America.

Introduction

Cultural property (CP) embodies the collective memory, identity, and history of societies. In times of conflict, however, cultural heritage becomes uniquely vulnerable. The looting and trafficking of antiquities not only deprive communities of their heritage but also finance armed groups, perpetuate violence, and destabilize post-conflict recovery efforts. Historically, this phenomenon has been a persistent feature of warfare, but the scale, speed, and global reach of today's trafficking are unprecedented. The digital revolution, particularly the rise of social media platforms, has created vast new opportunities for illicit actors to connect, advertise, and profit.

At the same time, emerging technologies—especially artificial intelligence (AI)—offer innovative tools to address these challenges. This paper examines the threats to cultural property in conflict zones, the role of online platforms in amplifying illicit trade, and the ways in which AI and other technologies may assist in implementing UNESCO's protective conventions, notably the **1954 Hague Convention** and the **1970 Convention on the Means of Prohibiting and Preventing the Illicit Import, Export and Transfer of Ownership of Cultural Property.**[1]

V

Looting as the Greatest Threat

The destruction of cultural heritage in armed conflicts often makes international headlines when iconic monuments are damaged or destroyed. Yet, research shows that the greatest and most lasting damage comes from systematic looting. Unlike the spectacular images of monuments reduced to rubble, looting is often invisible, dispersed across thousands of sites, and harder to monitor.

Looting occurs under several conditions:

- **Opportunistic or subsistence looting** by local populations whose livelihoods have been destroyed by war and instability.
- **Organized criminal networks** with longstanding smuggling routes operating with impunity during conflict.
- **Armed non-state actors** exploiting chaos to generate income through trafficking of antiquities.[2]

Examples abound across the Middle East: the extensive looting of **Apamea in Syria after 2011,** the devastation of Bronze Age cemeteries in Jordan, and large-scale illicit digging around Dashur's pyramids in Egypt.[3] These cases underscore the vulnerability of archaeological sites once state authorities can no longer safeguard them.



Figure 1: Looting pits-Site of Apamea © Amr Al-Azm

The Trafficking Bottleneck and Its Transformation

For decades, a key limitation in the antiquities trade lay in the difficulty of connecting the supply side (looters in conflict zones) with the demand side (wealthy collectors in Europe, North America, and Asia). Traditional smuggling required physical transport, trusted intermediaries, and risk of seizure. These bottlenecks acted as natural restraints.
However, with the rise of digital technologies, particularly social media, the situation has shifted. Platforms now provide traffickers with tools to market, advertise, and sell directly to international buyers, bypassing traditional middlemen. Facebook, with its billions of users, has become "ground zero" for illicit antiquities trade, vastly outstripping platforms such as eBay in reach and functionality.[4]

Social Media as a Digital Trafficking Toolkit

The ATHAR Project, which monitors online trafficking, has documented more than 550 groups with over 20 million members. These groups host tens of thousands of images of looted artifacts, ranging from Syrian mosaics to Libyan statues, Yemeni bronzes, and even Afghan Buddhist heads. Some posts have included museum-marked items, demonstrating theft from institutional collections.[5]



Figure 2: Screenshot from a Facebook trafficking group advertising a mosaic from Syria (ATHAR Project Report, 2019). © ATHAR Project

Social media enables traffickers to:

- Post photos and videos of objects.
- Connect internationally through algorithmic recommendations
- Use encrypted messaging to finalize deals.
- Arrange payment through digital systems.
- Monetize content via ad algorithms, sponsorships, or platforms like YouTube and TikTok.

The ATHAR Project has shown that even weapons, such as hand grenades in Afghanistan, are trafficked in the same groups.[6] Thus, social media has democratized and globalized trafficking, making it accessible to anyone with a smartphone. Tech companies, by failing to regulate such activity, inadvertently provide a "digital trafficking toolkit" for organized crime.

Facilitating Pillage for Profit

The consequences of this digital revolution on amplifying the looting and trafficking of cultural property are severe. Platforms not only host illicit activity but also profit from it. For example, Facebook has run advertisements alongside antiquities sales, monetizing traffic from groups that openly violate its policies.[7] YouTube has allowed traffickers to earn revenue through staged looting videos, while TikTok influencers use viral content to redirect audiences to monetized YouTube channels.

This monetization of looting highlights the complicity of global platforms in fueling the antiquities trade. They create financial incentives for criminals, weaken cultural protection efforts, and directly undermine international conventions aimed at halting illicit trafficking.

1. UNESCO, Convention for the Protection of Cultural Property in the Event of Armed Conflict (The Hague Convention), 1954; UNESCO, Convention on the Means of Prohibiting and Preventing the Illicit Import, Export and Transfer of Ownership of Cultural Property, 1970.

2. Al-Azm, A, "New Solutions for Old Problems: Threats and Challenges to Cultural Property in Times of Conflict and the Role of New Technologies," presentation for MONDIACULT 2025 Conference Webinar Series Session-5.

3. Ibid.

4. Al-Azm, A. and Paul, K. 2019. Facebook's Black Market in Antiquities: Trafficking, Terrorism and War Crimes, ATHAR Project.

5. Al-Azm, A. and Paul, K. 2020. Facebook's Flawed Plan to End Antiquities Trafficking, Foreign Affairs, July 1.
Achilles Research Group, MONDIACULT 2025 presentation.

6.Ibid.

7.Ibid.

8.UNESCO, 1954 Hague Convention; UNESCO, 1970 Convention.

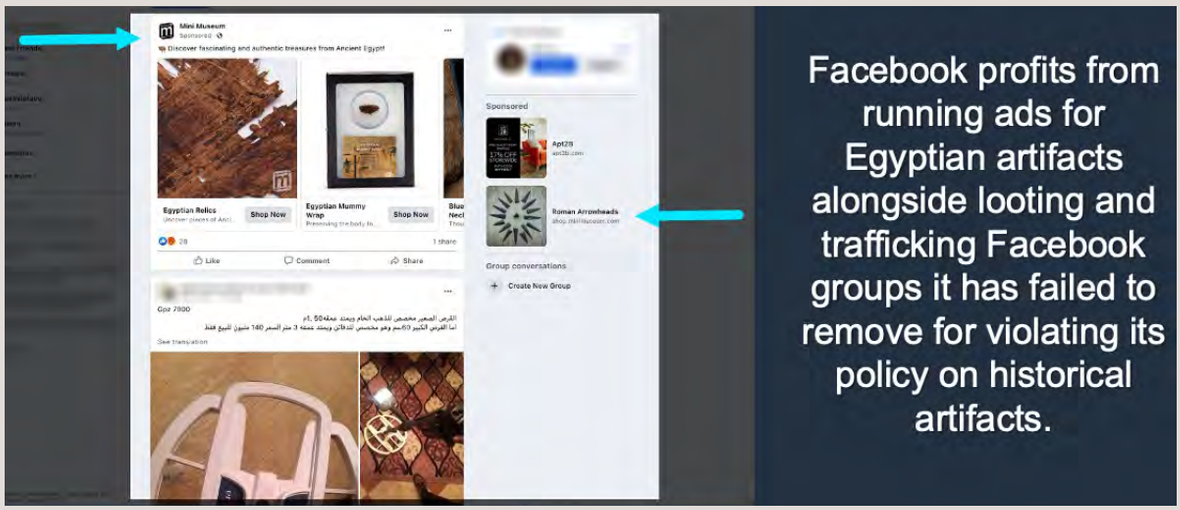


Figure 3: Sponsored ad placement next to a antiquities trafficking group on Facebook
Source: (ATHAR Project Report, 2019). © ATHAR Project

AI and New Technologies: Emerging Solutions

While technology has intensified the challenges, it also provides solutions. Artificial intelligence, in particular, offers significant opportunities to support the monitoring, documentation, and prevention of looting and trafficking.

Satellite Imagery and Site Monitoring

AI can analyze vast quantities of satellite data to detect looting activity at archaeological sites. Syria and Iraq alone have over 10,000 documented sites; Yemen has 12,000, while Egypt and Sudan host hundreds more.[8] Manual monitoring is impossible, but machine-learning algorithms can identify new pits, track changes over time, and alert authorities to ongoing looting.

Social Media Monitoring and Object Recognition

Given the sheer volume of online content, AI is can be useful for scanning images and videos across platforms. Algorithms can:

- Identify and classify objects.
- Match looted artifacts with museum catalogues or excavation records.
- Map trafficking networks through group analysis and social-network mapping.

This helps uncover trafficking routes, establish provenance, and provide evidence for law enforcement. The challenge however lies in overcoming the restrictions imposed by the social media platforms on scraping data and gathering information from them using AI assistance.

Content Analysis on Video Platforms

With the rise of looting videos on TikTok and YouTube, AI can assist in detecting staged digs, flagging suspicious uploads, and identifying patterns. Such tools could help platforms proactively remove harmful content before it goes viral.

Supporting International Conventions

The integration of AI into heritage protection strengthens the enforcement of UNESCO's **1954 Hague Convention** (safeguarding heritage during armed conflict) and the **1970 Convention** (combatting illicit trafficking). By providing real-time data, AI enhances the ability of states, NGOs, and international organizations to uphold their legal obligations.[9]

Challenges and Limitations

Despite its potential, AI is not a silver bullet. Several obstacles must be addressed:

Data quality:
Algorithms require accurate training datasets, but looted artifacts often lack reliable documentation.

Access and equity:
Many conflict-affected states lack the technological infrastructure to deploy advanced AI tools.

Legal and ethical issues:
Using AI for surveillance raises concerns about privacy, sovereignty, and accountability.

Corporate responsibility:
Without genuine cooperation from tech companies, efforts to regulate illicit activity will remain limited.



Figure 4: Satellite Imagery-Site of Dura Europos. Source: (Courtesy of 2014: DigitalGlobe, Inc). © DigitalGlobe Inc

Challenges and Limitations

The looting and trafficking of cultural property in conflict zones represent one of the gravest threats to global heritage. Social media has transformed the problem, by dismantling old bottlenecks and providing unprecedented reach to traffickers. Yet, the same technological revolution also offers hope. Artificial intelligence and other innovations present powerful tools for identifying looted objects, tracking trafficking patterns, and monitoring archaeological sites from space.

Addressing the threats to cultural property in times of conflict therefore requires a multi-layered strategy that integrates technological innovation, international cooperation, and stronger regulatory accountability.

For these solutions to succeed, they must be embedded and strengthened within international legal frameworks, supported by governments, and reinforced by genuine corporate responsibility from technology companies.

These efforts should be matched by supporting capacity building in conflict affected states and fostering multi-stakeholder collaboration as well. The UNESCO Mondiacult 2025 Conference underscores the urgency of this task: safeguarding cultural heritage is not only about protecting the past but also about ensuring the foundations for peace, identity, and human security in the future.

The potential of Artificial Intelligence for protecting Cultural Heritage and what else is needed

© Primo Zingaretti



Dr. Primo Zingaretti

Vision, Robotics and Artificial Intelligence (VRAI) Research Group, Università Politecnica delle Marche, Italy

Abstract

This paper builds upon the presentation "What does AI need to combat the illicit trade in Cultural Heritage?" at the webinar "Artificial Intelligence and the Protection of Cultural Property in Crisis," organized by the UNESCO Cairo Office on May 27, 2025. It presents an overview of AI's capabilities in CH protection, outlines its technological and ethical requirements, and discusses the outcomes of the EU-funded SIGNIFICANCE project, which aims to combat cultural property trafficking through AI-based methods.

After recalling the requirements and challenges for effective AI implementation, it provides prospects and recommendations on the use of AI for protecting cultural heritage. We argue that AI, when personalized, explainable, and ethically deployed, can significantly enhance international efforts to safeguard humanity's shared heritage.

Introduction

Given that the protection of Cultural Heritage (CH) is not only a matter of preserving objects but of safeguarding identity, memory, and the historical continuity of civilizations, the illicit trafficking of CH objects has become a lucrative global business, especially in times of armed conflict, social instability, and natural disasters.

V

Digital transformation has brought both new vulnerabilities and new solutions. The illicit trade of artifacts has intensified due to the rise of digital platforms, which have shifted to online marketplaces and social media. At the same time, Artificial Intelligence (AI), particularly its most recent advances in Machine Learning (ML), Deep Learning (DL), and Foundation Models, offers new tools to detect, predict, and prevent cultural crimes. In contrast, conventional monitoring and investigative tools have proven insufficient in countering these crimes.

This paper examines the application of AI in the context of cultural heritage protection, with a focus on emergency and post-crisis scenarios. After reviewing technological advances, analyzing practical challenges, and recalling the requirements and challenges for effective AI implementation, this study describes a case study of the SIGNIFICANCE project. It provides prospects and recommendations on the use of AI for protecting CH.

Background

From its early theoretical foundations in the 1950s (e.g., Turing's Imitation Game, McCarthy's AI definition, the Perceptron), to the AI winters of the 1970s and 1990s, and the resurgence through ML and DL since the 2010s, AI has evolved into a powerful and ubiquitous technology.

Its key advantages relevant to CH protection at least include automation (repetitive analysis tasks that can be handled with greater speed and fewer errors), decision support (AI can provide decision-makers with risk assessments, predictions, and insights), data-driven learning (DL algorithms can be trained directly on raw data, reducing the need for manual feature engineering), scalability (AI can process vast volumes of heterogeneous data (from images to social media text) more efficiently than any human team).

The protection of cultural heritage through digital technologies has become an active area of research and policy. International organizations, such as UNESCO[1] and INTERPOL, have emphasized the need for more advanced tools to combat the increasingly sophisticated methods used in illicit trafficking networks (UNESCO, 2022).The use of AI in CH contexts has been explored in several domains, including digital cataloguing, reconstruction of damaged artifacts, and site monitoring.[2]

More recently, AI has been employed in the automatic identification and classification of cultural objects, in combination with computer vision and natural language processing (NLP) tools for monitoring digital marketplaces and dark web platforms. However, challenges such as data scarcity, lack of ontologies, and algorithmic bias remain largely unresolved.

The SIGNIFICANCE project [3] builds upon this background by providing a concrete implementation of AI tools for law enforcement agencies, specifically designed to target online channels used for trafficking CH items.Its integrated framework contributes to both the technological advancement of AI applications and the methodological standardization of data handling in this sensitive domain.

AI applications in Cultural Heritage protection

Next are just a few examples, albeit very explicit ones, of the potential applications of artificial intelligence as a scalable, adaptable, and indispensable tool in global efforts to safeguard cultural heritage.

- Image recognition and object matching: DL models, particularly Convolutional Neural Networks, can be trained on photographic archives (databases) of registered CH artifacts to recognize stolen or trafficked items. These systems can identify similarities between known, catalogued artifacts and new images circulating on auction sites, social media, or seized inventories. By detecting visual patterns, even partial or low-resolution images of looted objects can be analyzed.

- **Metadata and provenance analysis:** through the use of NLP and semantic ontologies, AI can compare known provenance data with sale listings and associated documentation. Discrepancies (such as missing dates, implausible origins, or absent ownership trails) can be automatically flagged for review. AI systems can detect inconsistencies in the provenance of artifacts by comparing known documentation with marketplace records, flagging suspicious items lacking proper origin histories.

- **Online monitoring and cyber-surveillance:** AI can continuously scan digital ecosystems (including the clear web, marketplaces, forums, and dark web) for illicit activity. Natural language models trained on trafficking terminology, hashtags, and transaction metadata can identify suspect posts or patterns. Alerts can then be routed to relevant authorities. By scraping marketplaces, social media platforms, and even dark web sources, AI can identify key terms, hashtags, or user behavior that indicate illicit activity, helping law enforcement intercept trafficking operations in real-time.

- **Predictive modeling of trafficking flows:** AI systems can integrate historical data and socio-political factors to forecast high-risk regions and trafficking routes. This allows proactive protection measures and targeted investigations. AI models can analyze spatial and temporal trends of known trafficking routes, helping authorities anticipate movements and implement pre-emptive protective measures.

1. Magdalena Pasikowska-Schnass and Young-Shin Lim, Artificial Intelligence in the Context of Cultural Heritage and Museums: Complex Challenges and New Opportunities (European Parliamentary Research Service, 2023), https://www.europarl.europa.eu/RegData/etudes/BRIE/2023/747120/EPRS_BRI(2023)747120_EN.pdf.

2. Lafta R. Al-Khazraji and Rihab Qassim, The Role of Artificial Intelligence in Digitizing Cultural Heritage: A Review (2025), https://www.researchgate.net/publication/390773608_The_Role_of_Artificial_Intelligence_in_Digitizing_Cultural_Heritage_A_Review.

3. E. S. Malinverni, D. Abate, A. Agapiou, F. Di Stefano, A. Felicetti, M. Paolanti, R. Pierdicca, and P. Zingaretti, "SIGNIFICANCE Deep Learning Based Platform to Fight Illicit Trafficking of Cultural Heritage Goods," Scientific Reports 14, no. 1 (2024), https://doi.org/10.1038/s41598-024-65885-6.

4. L. Stacchio, E. Balloni, L. Gorgoglione, A. Mancini, B. Giovanola, S. Tiribelli, and P. Zingaretti, "An Ethical Framework for Trustworthy Neural Rendering Applied in Cultural Heritage and Creative Industries," Frontiers in Computer Science 6 (2024): 1459807, https://doi.org/10.3389/fcomp.2024.1459807.

- **Reconstruction and restoration of artifacts:** generative AI models can synthesize or reconstruct 3D digital versions of fragmented or damaged cultural artifacts, aiding restoration efforts and virtual repatriation. AI-generated 3D models can reconstruct damaged or destroyed objects based on archival data, which is vital for virtual repatriation or digital preservation.

- **Remote site monitoring:** AI-enabled drones and satellite imagery analysis can help detect unauthorized excavations or looting activities in real time, especially in conflict zones or remote archaeological areas. AI-powered drones and satellite imagery analysis can monitor archaeological and cultural sites in real time, detecting looting or destruction during conflicts or disasters.

Requirements and challenges for effective AI implementation

To be successfully deployed, however, AI in CH protection must meet several technical and organizational prerequisites:

- **Data availability:** digitized records, photos, 3D scans, and descriptive metadata must be available for AI training. In many cases, such records are scarce or incomplete.

- **Ontologies and annotation:** domain-specific ontologies are essential for labeling data meaningfully. Collaborative input from archaeologists, historians, and museum professionals is critical for effective annotation.

- **Personalization of AI models:** different contexts require different AI solutions; object classification, detection, and tracking must be adapted to the specific artifact types and trafficking patterns involved.

- **Coordination and interoperability:** AI systems must be integrated with existing law enforcement tools and databases, requiring strong inter-agency cooperation and data-sharing protocols.

- **Legal and ethical barriers:** the deployment of AI in surveillance and policing raises significant concerns regarding privacy, fairness, accountability, and algorithmic bias. Systems must be explainable and transparent to ensure public trust and compliance with human rights norms.

The SIGNIFICANCE project: a case study

This paper also quickly describes a case study on how AI can be utilized in the fight against the illicit trade in cultural property, with a special focus on the European project SIGNIFICANCE, which developed an AI-based system to detect and prevent the circulation of stolen CH items through digital platforms.

SIGNIFICANCE (Stop Illicit heritaGe traffickiNg wIth artiFICiAl iNtelligenCE) was a research initiative funded under the EU ISFP-2019-AG-OPC call (2021–2023). Its primary goal was to improve the responsiveness of public authorities and law enforcement agencies (LEAs) in combating online CH trafficking.

The project involved academic institutions, CH experts, and LEAs from three European countries (Cyprus, Greece, and Italy). One key outcome was a prototype platform capable of recognizing four types of patterns/artifacts (see Figure 1) in digital environments and assisting authorities in initiating preventive or corrective actions.



(a) coins **(b)** frescoes **(c)** icons **(d)** manuscripts

Figure 1: SIGNIFICANCE'S types of artifacts. © Primo Zingaretti

The project's objectives and methodology (see figure 2) included the following main components:

- Ontology development: defined standard ontologies to describe trafficking-related artifacts and processes.
- Data population: created datasets representing four types of commonly trafficked artifacts.
- Annotation and labeling tools: developed scalable interfaces for data labeling and process mapping.
- AI algorithm development: deployed DL-based tools optimized for image classification, pattern recognition, and marketplace monitoring.
- Search and query capabilities: Integrated systems that allow for complex search functionalities across various digital sources.

The core of the system relied on data collected through web scraping, social media post analysis, and image/text mining, stored in structured formats (JPEG, TXT, JSON) for training and evaluation.

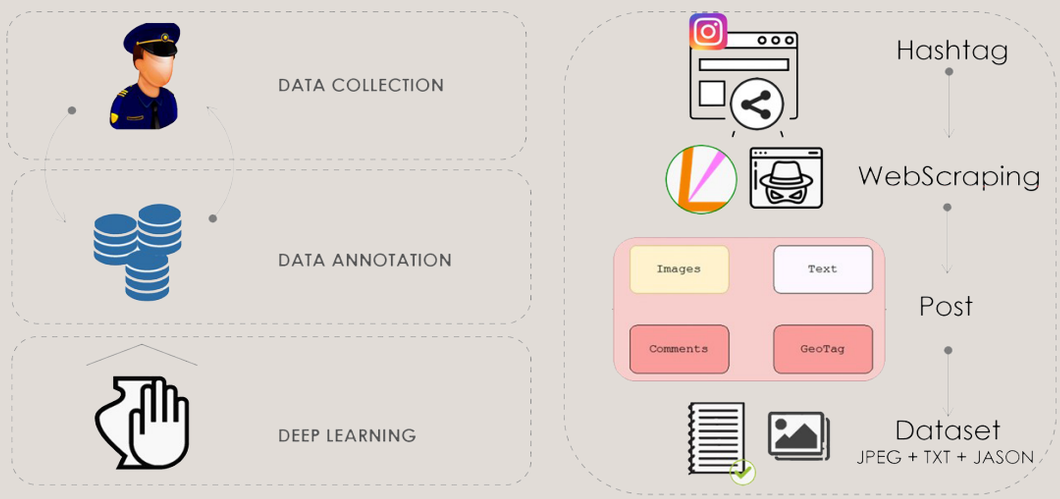


Figure 2: SIGNIFICANCE'S Methodology © Primo Zingaretti

The project's objectives and methodology (see figure 2) included the following main components:

- **Ontology development:** defined standard ontologies to describe trafficking-related artifacts and processes.
- **Data population:** created datasets representing four types of commonly trafficked artifacts.
- **Annotation and labeling tools:** developed scalable interfaces for data labeling and process mapping.
- **AI algorithm development:** deployed DL-based tools optimized for image classification, pattern recognition, and marketplace monitoring.
- **Search and query capabilities:** Integrated systems that allow for complex search functionalities across various digital sources.

The core of the system relied on data collected through web scraping, social media post analysis, and image/text mining, stored in structured formats (JPEG, TXT, JSON) for training and evaluation.

Prospects and recommendations

To maximize the positive impact of AI in cultural heritage protection, several key strategies must be pursued:

- **Explainable AI (XAI):** the use of black-box AI models, while effective, must be balanced with the development of explainable systems, especially when legal actions are at stake. It is crucial that AI decisions, particularly those that could influence legal actions or international interventions, be interpretable by humans. This requires moving beyond black-box models to systems that can justify their conclusions with transparent logic and evidence.

1. **Awareness and training:** The awareness of the technological potential of AI must be disseminated more widely by involving specialists, as well as others, in a human-in-the-loop approach, particularly in the training of AI systems. Museums, government agencies, customs authorities, and law enforcement agencies need structured education on the capabilities and limitations of AI systems. This includes training in the use of AI interfaces, interpreting alerts, and understanding algorithmic bias. Stakeholders involved in CH protection must receive dedicated training in AI tools, from museum staff to border officials, to ensure proper usage and interpretation of results.

2. **Use of extended reality (XR):** Virtual Reality (VR) and Augmented Reality (AR) can support education, awareness campaigns, and virtual access to at-risk heritage. These tools can complement AI systems by making endangered artifacts digitally accessible in immersive environments. Augmented and Virtual Reality (AR/VR) applications can enhance public engagement, education, and digital access to endangered heritage, complementing AI-driven preservation efforts.

3. **Ethical governance and guidelines:** strong ethical frameworks[4] must govern AI deployment in heritage contexts. These include safeguards against surveillance overreach, mechanisms for data protection, and community-based approaches for representing cultural identities fairly and equitably. As AI systems expand their reach, robust ethical guidelines covering fairness, accountability, and human oversight must be embedded into their design and policy.

4. **International cooperation:** the global nature of cultural trafficking requires standardized AI tools, interoperable databases, and data-sharing protocols. Organizations such as UNESCO, INTERPOL, and EUROPOL should lead in defining these collaborative frameworks.

In sum, the future of AI in heritage protection depends not only on technological innovation but also on cultural sensitivity, legal robustness, and inclusive policy design.

Conclusions

Artificial Intelligence is not a distant promise but a present-day tool with immense potential to support the fight against the illicit trade in cultural property. Its success depends not only on technological readiness but also on ethical awareness, interdisciplinary collaboration, and political will. Projects like SIGNIFICANCE demonstrate the feasibility and relevance of AI-based approaches, offering a model for future initiatives at national and international levels.

By leveraging AI intelligently and responsibly, we can better protect the cultural legacy of humanity-preserving not only artifacts but the values and stories they embody.

Using Artificial Intelligence in the fight against trafficking in cultural property: Opportunities and legal risks[1]

© María Ángeles Fuentes Loureiro



Dr. María-Ángeles Fuentes-Loureiro

ECRIM Research Group, University of A Coruña, Spain.

Abstract

This paper extends the presentation "Ethical-legal risks of algorithmic and AI tools developed to fight against trafficking in cultural property" at the Webinar "Artificial Intelligence and UNESCO Conventions for the protection of Cultural Property in Emergencies" organized by the UNESCO Cairo Office on May 27, 2025. It firstly examines the opportunities offered by Artificial Intelligence (AI) and algorithmic tools based on web scraping and Social Network Analysis in the fight against certain types of crimes, specifically trafficking in cultural property. Secondly, it highlights the legal risks associated with developing these technologies and provides recommendations on their development from a legal perspective, ensuring it is both appropriate and efficient.

Introduction

In recent years, various algorithmic and AI technologies have been developed to facilitate police prevention and investigation,[2] giving rise to tools of Police Artificial Intelligence (PAI).[3] Many of these tools are based on web scraping, a technique for extracting information from the internet, transforming it into structured data,[4] and storing it in a database for later consultation or analysis.[5] However, web scraping must be accompanied by a technology that allows for the analysis of such information, which is generally algorithmic and usually involves machine learning, enabling the analysis of large volumes of data.[6]

V

The applicability of AI and algorithmic technologies in the fight against trafficking in cultural property (TCP)

PAI tools, based on web scraping and algorithmic technology, are designed to collect data from cyberspace about the criminal phenomenon they are targeting and to draw conclusions about its dynamics and actors. Thus, it is beneficial for crimes that generate a wealth of information. The growing internationalization of some criminal activities and the use of the internet for communication generate a large amount of data, making these criminal activities particularly susceptible to detection using AI tools based on web scraping.

This is the case for TCP, as in recent years, there has been a trend towards the introduction of looted goods into the market through online platforms.[7] Thus, the RITHMS project has developed a digital platform that has been tested by Law Enforcement Agencies (LEAs) in their investigations into this type of criminality. The RITHMS platform combines satellite imaging technology with algorithms based on web scraping and Social Network Analysis (SNA). Thus, satellite imaging technology provides images of archaeological sites that have been looted.

It extracts data from websites, social networks, and open-access digital marketplaces where cultural assets are advertised for sale. With this, the platform can provide information on TCP and on social connections between individuals, groups of individuals, and, where appropriate, criminal organisations. The platform will thus enhance the accessibility and accuracy of information available to LEAs in combating TCP.

Ethical and legal risks of AI for the fight against TCP (and other types of crime).

In addition to the technical complexity, the development of these technologies often involves a range of ethical and legal risks that must be identified and mitigated. However, their use in the Criminal Justice system makes these ethical-legal risks even stricter, as fundamental rights and procedural guarantees are involved.[8]

We can identify three types of legal and ethical risks: internal AI risks, inherent to AI technology; operational AI risks, related to the interaction with the real world; and User risks, which appear when the user applies the technology.Regarding Internal AI risks, opacity and lack of accountability stand out. The lack of transparency regarding how the algorithm works can lead to the potential incomprehensibility of automated decisions for human reasoning[9] and, consequently, to a lack of explainability and justification of the decisions made, which is a fundamental requirement of many legal systems. The opacity of algorithms would violate the principle of contradiction and the right to a defence in criminal proceedings.[10] Defendants must know the basis of the prosecution´s claims; therefore, if algorithms are secret or incomprehensible, this right is undermined.[11] Hence, AI tools in criminal investigation must ensure transparency in decision-making to maintain their legitimacy. Privacy interference arises as Operational AI risk. Platforms using web scraping and SNA may violate data protection legislation when collecting, storing, and processing data.

Risk Description	Type	Legal Risks and Consequences
Opacity and lack of accountability	Internal AI risks.	-Lack of explainability and justification of the decisions. ↓ -Commitment to the principle of contradiction and the procedural right of defense. ↓ Inadmissibility of the proof.
Privacy interference	Operational AI risks	-Violations of data protection law. ↓ ↓ -Sanction - Inadmissibility of the proof.
Discrimination and bias	Internal AI risk, Operational Risk, and Users risk.	-Violation of fundamental rights and procedural guarantees. ↓ -Inadmissibility of the proof.

These risks affect both the development and use phases, requiring adequate privacy and data governance policies.

Discrimination and bias are risks across all AI levels -Internal, Operational, and user-based. Bias can stem from algorithm design, feature selection, or flawed data. If the data are mislabelled, inaccurate, incomplete, or reflect human prejudice, the AI will reproduce them. This could lead to a violation of due process and fair trial guarantees,[12] resulting in the invalidity of the evidence due to the lack of legitimacy.

Recommendations for the development of algorithmic and AI technologies

Conduct a needs analysis of the scope of application and the end consumer. In the area of Criminal Justice, it is necessary to involve Law Enforcement Agencies (LEAs) in the development of the project and to carry out a criminological analysis of the criminal dynamics to be investigated or prosecuted.

Conduct a preliminary study of the legal requirements for the development of the project. This study must take into account the legislation of the States where the technology is developed, as well as that of the States where the information on which it is based is collected, and the States where the platform is tested and ultimately used.

Identification of specific risks and proposal of mitigation measures. These measures must be shared with all partners and implemented throughout all phases of development, testing, and deployment. Communication between all parties involved in the project, including LEAs, technology partners developing the technology, and experts in ethical and legal risks, is essential.

1. This paper has been prepared within the framework of the research project RITHMS – Research, Intelligence and Technology for Heritage and Market Security (GA101073932) [HORIZONCL3-2021-FCT-01-08]. Funded by the European Union.

2. Interpol and UNICRI – United Nations Interregional Crime and Justice Research Institute, Artificial Intelligence and Robotics for Law Enforcement (2019): 7–9, https://unicri.it/artificial-intelligence-and-robotics-law-enforcement.

3. F. Miró Llinares, "Inteligencia Artificial y Justicia Penal: Más Allá de los Resultados Lesivos Causados por Robots," Revista de Derecho Penal y Criminología 20 (2018): 87–130, https://doi.org/10.5944/rdpc.20.2018.26446.

4. S. Sirisuriya, "A Comparative Study on Web Scraping," in Proceedings of 8th International Research Conference, Kotelawala Defence University, November 2015, 135–140, http://ir.kdu.ac.lk/bitstream/handle/345/1051/com-059.pdf.

5. Z. Gold and M. Latonero, "Robots Welcome? Ethical and Legal Considerations for Web Crawling and Scraping," Washington Journal of Law, Technology & Arts 13, no. 3 (2018): 275–312, https://digitalcommons.law.uw.edu/wjlta/vol13/iss3/4/.

6. K. N. Hylton, "Digital Platforms and Antitrust Law," Nebraska Law Review 98, no. 2 (2019): 273.

7. C. C. Armberger et al., Policymaking and the Role of Online Intermediaries in Preventing and Combating Illicit Trafficking (UNODC, 2021): 9–10, https://sherloc.unodc.org/cld/uploads/pdf/Online_intermediaries_eBook.pdf; Neil Brodie, Donna Yates, and ECORYS, Illicit Trade in Cultural Goods in Europe: Characteristics, Criminal Justice Responses and an Analysis of the Applicability of Technologies in the Combat Against the Trade (Brussels: European Commission, 2019), https://op.europa.eu/en/publication-detail/-/publication/d79a105a-a6aa-11e9-9d01-01aa75ed71a1.

8. A. García Adán and M. A. Fuentes Loureiro, "Ethical and Legal Risks of Algorithmic and AI Tools Developed to Fight Against Trafficking in Cultural Property in the RITHMS Project," in VI Congreso XoveTIC: Impulsando el Talento Científico (Servizo de Publicacións UDC, 2023): 344, https://doi.org/10.17979/spudc.000024.51.

9. J. Danaher, "The Threat of Algocracy: Reality, Resistance and Accommodation," Philosophy & Technology 29, no. 3 (2016): 245–268.

10. T. Marquenie, The Impact of Predictive Policing and Law Enforcement AI on Human Rights: The Right to Fair Trial Under Pressure (2019).

11. J. V. Virginia Foggo, "Artificial Intelligence, Due Process, and Criminal Sentencing," Michigan State Law Review(2020): 295–354, https://core.ac.uk/download/pdf/327102171.pdf.

12. K. Quezada-Tavarez et al., "Legal Challenges in Bringing AI Evidence to the Criminal Courtroom," New Journal of European Criminal Law 12, no. 4 (2021): 531–551.

CHAPTER VI

AI and UNESCO Cultural Conventions in Emergency



AI & Culture

© Virtual Hawara and Labyrinth Project, 2025

Chapter 6

Artificial Intelligence and World Heritage Sites

The UNESCO World Heritage Convention, adopted in 1972, provides the principal international framework for identifying, protecting, and transmitting cultural and natural heritage of Outstanding Universal Value to future generations. It establishes a system of international cooperation, legal protection, and technical assistance, recognizing that heritage—whether monuments, landscapes, or living environments—embodies the shared legacy of humanity. In recent years, the integration of artificial intelligence (AI) into World Heritage processes has opened new pathways for conservation, monitoring, and interpretation. AI-enabled tools such as satellite imagery analysis, 3D scanning, predictive risk modelling, and digital documentation have significantly enhanced the ability to detect threats, assess site conditions, and support informed decision-making. Moreover, AI-driven virtual reconstruction and immersive technologies allow for broader public engagement and access, including through virtual exhibitions and educational platforms. However, the growing reliance on AI also raises critical concerns. These include the risk of over-reliance on automated interpretations, uneven access to technological resources between countries, and challenges related to data governance, authenticity, and ethical representation. Ensuring that AI applications align with the principles of the World Heritage Convention, particularly authenticity, integrity, and community participation — remains essential to preserving the cultural and social meanings embedded within heritage sites.

The scholarly contributions here provide deeper insight into how AI is transforming heritage preservation while highlighting the need for critical reflection. Dr Ioannides introduces the concept of the "Memory Twin," an evolution of the digital twin paradigm that integrates AI, big data, and 3D reconstruction to create semantically enriched representations of heritage. Unlike conventional digital replicas, Memory Twins embed historical narratives, cultural meanings, and intangible values into digital models, offering a more holistic and interpretive reconstruction of heritage assets. Central to this approach is the use of paradata—comprehensive documentation of the processes and decisions underlying digital reconstruction—which ensures transparency, reproducibility, and scientific validity.

Ioannides further emphasizes the importance of establishing standardized "Certificates of Quality" to assess the reliability of AI-generated outputs. Complementing this, Dr Abdelmonem highlights the transformative potential of AI and machine learning in developing innovative preservation techniques, enhancing global outreach, and facilitating knowledge-sharing across borders. At the same time, he stresses the need for coordinated and policy-driven approaches to ensure that AI supports authentic narratives and filters out misinformation, particularly in contexts such as Egypt where heritage is deeply interconnected with global collections. Meanwhile, Dr Sakai's interdisciplinary research on the Nasca geoglyphs in Peru demonstrates the practical application of AI in heritage discovery and management. Through the use of satellite imagery, drones, and AI models, his team identified over 300 new geoglyphs and improved mapping efficiency, revealing previously unknown spatial patterns. However, despite these technological advances, the site remains vulnerable to environmental and human pressures, underscoring the need to integrate AI with legal protection, community engagement, and sustainable development strategies.

In summary, the convergence of the World Heritage Convention and AI technologies marks a significant shift in how cultural heritage is understood, managed, and shared. While AI offers powerful tools for documentation, discovery, and engagement—from Memory Twins to remote sensing applications—it also introduces new ethical, technical, and governance challenges. The future of heritage protection lies in balancing innovation with responsibility: ensuring that AI enhances, rather than replaces, human expertise; that it respects cultural diversity and local knowledge; and that it operates within robust policy and legal frameworks. Ultimately, safeguarding World Heritage in the digital age requires not only technological advancement but also a continued commitment to authenticity, inclusivity, and international cooperation.

The Evolution from 3D Digital Twin to Memory Twin in Cultural Heritage Preservation

© Marinos Ioannides and Drew Baker



Dr. Marinos Ioannides

Research Centre MNEMOSYNE, Cyprus University of Technology; UNESCO Chair on Digital Cultural Heritage, Cyprus.

Abstract

Through the integration of artificial intelligence (AI), big data analytics, and advanced 3D reconstruction techniques, the traditional paradigm of the "Digital Twin" evolves into the more comprehensive and visionary concept of the "Memory Twin." This next-generation model transcends the mere digital mirroring of physical heritage assets by incorporating a semantically enriched and intelligent replica that captures not only structural attributes but also the historical narratives, cultural significance, intangible knowledge, and values embedded within those assets.

At the core of this transformation lies the integrity and quality of information, which is secured through the rigorous inclusion of Paradata[1], which refers to the systematic documentation and certification of all processes and decisions involved in the creation of digital representations. This ensures transparency, reproducibility, and scientific validity, allowing AI to have high quality of data and to move beyond geometric replication toward a faithful interpretive reconstruction of cultural heritage.

Therefore, there is a growing need for a "Certificate of Quality" for the final results of Data Acquisition (Digital Twin: 2D and/or3D models)- or, alternatively, a standardised set of parameters grounded in Paradata - that can assess the reliability generated results. Thus, we propose the integration of Artificial Intelligence (AI) technologies to embed knowledge and historical narratives directly into the final 3D models.

VI

This process enriches the models with contextualised stories and structured information, made available under open access and IPR-free terms. Such enriched models form the basis for creating a Memory Twin - a digitally intelligent and holistic record of Data in an accessible representation of cultural heritage objects or sites.

To ensure the integrity[2] and reliability of these enriched outputs, we emphasise the necessity of certification of quality not only for the input data and metadata, but also for the AI-generated enhancements. This includes validation of the AI-inferred knowledge, semantic annotations, and story layers. Accordingly, in our position paper, we recommend the adoption of quality standards specifically designed for AI-enriched 2D and 3D models, ensuring that they are IPR-free, their reusability from the multidisciplinary community, trustworthiness, and long-term preservation.

Such a framework would not only evaluate the outputs of AI but also reflect the complexity and contextual depth required in the creation of a Memory Twin. By explicitly linking the quality of digital outcomes to the processes and challenges involved, we can establish protocols for trust, accuracy, and cultural authenticity. By embedding authenticity into digital models, Paradata enables the Memory Twin to serve as a trusted medium for conveying cultural identity. It faithfully preserves both the material and immaterial dimensions of heritage, offering a holistic representation that supports dynamic conservation practices, real-time monitoring, and immersive storytelling through extended reality (XR) technologies.

Moreover, the Memory Twin paradigm fosters inclusive access, supports resilient research ecosystems, and promotes sustainable heritage management. Ultimately, Memory Twins empower cultural monuments not only to be digitally seen but also to speak - truthfully and powerfully - about their history, meaning, and enduring cultural identity.

Introduction

In Charles Babbage's book, Passages from the Life of a Philosopher,[3] the originator of the concept of a digital programmable computer, wrote, *"On two occasions I have been asked, 'Pray, Mr. Babbage, if you put into the machine wrong figures, will the right answers come out?' I am not able rightly to apprehend the kind of confusion of ideas that could provoke such a question"*. Today, we stand at a similar junction to Babbage in 1864, with the advances in artificial intelligence and machine learning, with questions and concerns about how these technologies can be trusted and employed in cultural heritage and beyond.

The Power and Potential of Paradata

Like any system, AI relies on two key factors to produce meaningful results: (1) the quality and diversity of data available for analysis, and (2) the integrity of the algorithms used to interpret both explicit and implicit relationships within that data. No matter how advanced an algorithm may be, poor-quality input data will inevitably lead to poor-quality output. Since AI is driven by data, it is essential to ensure that cultural heritage datasets intended for AI applications meet the highest standards of quality and integrity. This standard applies not only to the raw data itself but also to the accompanying metadata and Paradata.

Cultural heritage is fragile - not just in its physical form but also in its importance to identity, community, and meaning. It faces threats from globalisation, commercialisation, climate change, and conflicts. To protect both the physical and memory aspects of heritage, the documentation must be done to the highest standards of ethics and quality. This detailed documentation is called Paradata.

There exist well-established guidelines for creating strong Paradata when digitally capturing tangible cultural heritage, like the EU VIGIE study from 2020.[4] These guidelines estimate the complexity of digitising objects and set quality standards. The Memory Twin framework builds on this by combining 3D data with other types like images, text, and audio, linked through metadata and Paradata. This richer data helps deepen understanding of heritage.

Having high quality of Paradata and metadata around digital cultural heritage data also helps AI developers better analyse these datasets. The Memory Twin framework connects objects to many different resources, some rarely explored by traditional methods. AI can find new connections and help improve understanding, manage risks, and develop ways to protect heritage.

By following strong Paradata practices, two important principles are met: FAIR [5] (making data findable, accessible, interoperable, and reusable) and CARE [6] (focused on ethics, respect, and rights). These principles are essential to prepare data for AI use, ensuring moral, legal, and ethical concerns are addressed. Without verified and high-quality data, there's a risk of damaging intellectual honesty and harming people's safety and rights. For example, the EU AI Act requires AI systems to use high-quality data and provide clear information about the system and its goals to avoid biased or harmful outcomes.

Paradata is core to understanding the motivation for the creation of 3D cultural heritage objects, the audience for whom it was intended, how the data can be (re)used, as a validation of provenance, complexity [7] and quality analysis, and authenticity. Paradata is a familiar concept for cultural heritage and is originally defined within the domain as "information about human processes of interpreting and creating data objects in order to enable understanding and evaluation."[8,9], but also known within the AI spheres and defined as "information about the procedure(s) and tools used to create and process information resources, along with information about the persons carrying out those procedures."[10] Regardless of the domain, the objectives are the same: to provide transparency for the data transformation processes to ensure confidence, authenticity, validity, and accountability of results.

1. Marinos Ioannides et al., "Integrating Paradata, Metadata, and Data for an Effective Memory Twin in the Field of Digital Cultural Heritage," in Lecture Notes in Computer Science, December 2024, 24–35, https://doi.org/10.1007/978-3-031-78590-0_3.

2. UNESCO, Recommendation on the Ethics of Artificial Intelligence (Paris: United Nations Educational, Scientific and Cultural Organization, 2021), https://www.unesco.org/en/articles/recommendation-ethics-artificial-intelligence.

3. Charles Babbage, Passages from the Life of a Philosopher (Cambridge: Cambridge University Press, 2012), https://doi.org/10.1017/cbo9781139103671.

4. European Commission, Study on Quality in 3D Digitisation of Tangible Cultural Heritage: Mapping Parameters, Formats, Standards, Benchmarks, Methodologies, and Guidelines: Final Study Report (Luxembourg: Publications Office of the European Union, 2022).

5. Mark D. Wilkinson et al., "The FAIR Guiding Principles for Scientific Data Management and Stewardship," Scientific Data 3, no. 1 (2016), https://doi.org/10.1038/sdata.2016.18.

6. Stephanie Russo Carroll et al., "The CARE Principles for Indigenous Data Governance," Data Science Journal 19 (2020), https://doi.org/10.5334/dsj-2020-043.

7. Marinos Ioannides and Petros Patias, "The Complexity and Quality in 3D Digitisation of the Past: Challenges and Risks," in Lecture Notes in Computer Science, 1–33, 2023, https://doi.org/10.1007/978-3-031-35593-6_1.

8. Council Regulation (EU) 2024/1689, "Laying Down Harmonised Rules on Artificial Intelligence and Amending Regulations (EC) No 300/2008, (EU) No 167/2013, (EU) No 168/2013, (EU) 2018/858, (EU) 2018/1139 and (EU) 2019/2144 and Directives 2014/90/EU, (EU) 2016/797 and (EU) 2020/1828 (Artificial Intelligence Act)," Official Journal of the European Union L 2024/1689, June 13, 2024.

9. Drew Baker, "Defining Paradata in Heritage Visualization," in Paradata and Transparency in Virtual Heritage(London: Routledge, 2012), 163–175.

10. Jeremy E. Davet, Babak Hamidzadeh, Patricia C. Franks, and Jenny Bunn, "Tracking the Functions of AI as Paradata & Pursuing Archival Accountability," Archiving Conference 19, no. 1 (2022): 83–88, https://doi.org/10.2352/issn.2168-3204.2022.19.1.17.

The way forward: Standardisation in the digital documentation of the past

The current state-of-play in the development of a standardisation for Paradata, specifically in the area of digital acquisition of tangible cultural heritage objects (sites, monuments, and artefacts), is the proposed certification of quality of documentation for digital cultural heritage assets, based upon the sum of the data, metadata, and Paradata. This is necessary to ensure that a high-quality data resource is not only produced but also that it can be seen as a trusted asset able to be (re)used with confidence. However, if AI systems are to engage with this data fully, there clearly needs to be a comprehensive dialogue between cultural heritage and AI developers to ensure that there are common standards on both sides, facilitating a two-way flow of confidence:

On one side of this equation are the originators of cultural heritage data sets who have the obligation to provide the highest quality of data in accessible and interoperable formats for use by AI systems.

On the other side are the developers of AI systems who have the obligation to provide the necessary technical and organisational Paradata to ensure that cultural heritage professionals can not only use the results but also place them under scholarly scrutiny to assess and validate the output.

Both have a responsibility to ensure that the input and output meet the highest standards of academic review, providing a clear notification of the extent of organic/synthetic collaboration, allowing the explanation, interpretation, and justification of outcomes to be transparent, and, where necessary, the procedure and mechanisms to contest or correct erroneous results.

Such an endeavour is challenging, given the rapid development of AI systems' capability and presence within all aspects of society. The greatest risk to the application of AI to the cultural heritage domain is not, ironically, technological but one of public perception.

Those domains in which AI is seen to encroach on areas that are viewed as being intrinsically human in nature. For instance, the arts and creative industries have witnessed a rejection of AI; in contrast, science and medicine applications of AI have been applauded. The application of AI to cultural heritage, arguably the most valued of humankind's perceptions of itself, must learn from the recent experiences of AI deployment to ensure that its use and results are explainable, useful, and defendable within both the academy and public domains. This can only be achieved through mutual cooperation between data providers from cultural heritage and developers of AI systems, and the confidence and trust built through transparent Paradata and quality certification of cultural heritage datasets.

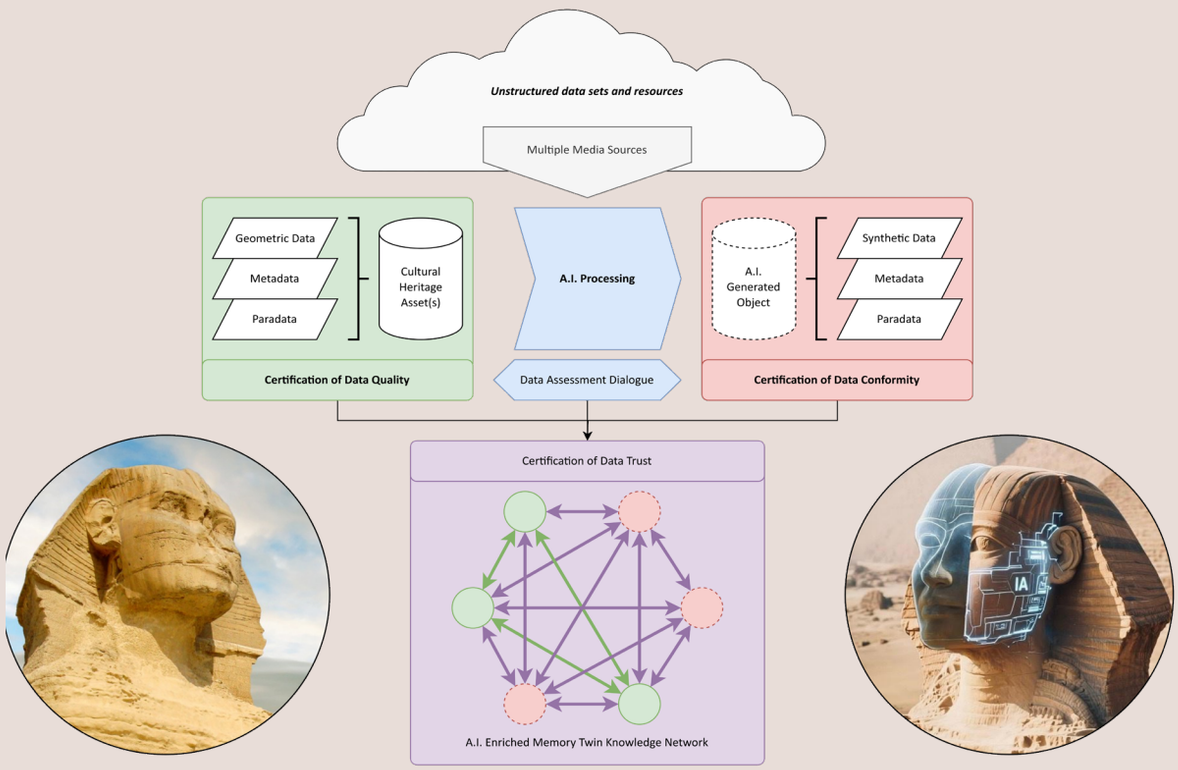


Figure 1: General overview of the AI enrichment of 3D content and the creation of the Memory Twin.
© Marinos Ioannides and Drew Baker

Recommendations

1. **Digitisation as a core strategy for safeguarding the past.** Digitisation ensures long-term preservation, provides global access, and enables innovative reuse in education, research, and tourism. By documenting artefacts, sites, and intangible heritage in certified high fidelity, we protect cultural memory against loss while empowering communities to engage with their heritage. This is essential for resilience, identity, and inclusive cultural sustainability.

2. **Establishing and Adopting Standards for Digital Cultural Heritage** To ensure the sustainable, trustworthy, and meaningful use of digital assets in the cultural heritage sector, we strongly recommend the development and adoption of comprehensive standards covering the entire lifecycle of digital cultural heritage content: from data acquisition to 2D / 3D modelling, archiving and dissemination.

3. **UNESCO digital transformation strategy** It should promote interoperability by aligning national and international standards for digitisation, metadata, multilingualism and digital asset management. UNESCO cooperation must be strengthened to ensure shared methodologies and best practices across cultural heritage institutions. Cross-sector collaboration should be promoted, involving technology providers, academic institutions, creative industries (such as gaming and film), and government agencies to create synergies that support cultural heritage innovation.

- Worldwide cooperation must be strengthened to ensure shared methodologies and best practices -especially in the areas of digitisation and application of AI- across cultural heritage institutions.

- Cross-sector collaboration should be promoted, involving technology providers, academic institutions, creative industries (such as gaming and film), and governmental agencies to create synergies that support cultural heritage innovation.

- A focus should be placed on ensuring that digital assets can be reused and adapted for various applications, including education, research, and tourism.

4. Special Standards for Data and Metadata Quality High-quality, interoperable, and FAIR and CARE metadata must accompany all 2D/3D digitisation efforts. This includes provenance, contextual, technical, and semantic metadata aligned with existing ontologies and vocabularies relevant to cultural heritage.

5. International Glossaries and Thesaurus The development, harmonisation, and widespread adoption of international and multilingual glossaries and thesauri to support the documentation, interpretation, and dissemination of cultural heritage in all its forms: tangible, intangible, and digital.

Such tools are essential to:

- Ensure Semantic Interoperability

Shared vocabularies allow consistent understanding and integration of data across institutions, disciplines, and countries, facilitating collaboration and knowledge exchange.

- Support Multilingual Access and Inclusion

Multilingual glossaries promote access to cultural heritage by diverse linguistic communities, enabling more inclusive digital platforms and educational tools.

- Preserve Cultural Specificity and Context

Carefully curated thesauri can reflect the cultural, historical, and linguistic nuances of heritage concepts, especially when co-developed with local and Indigenous communities.

- Enhance AI and Semantic Technologies

Structured vocabularies improve the performance and reliability of AI-based tools in tagging, translating, enriching, and interpreting heritage data.

- Strengthen Standardisation and Certification

Aligning terminologies with existing international standards (e.g., ISO, CIDOC-CRM, Getty Vocabularies) supports the quality assurance and certification of heritage-related digital outputs.

We encourage UNESCO and its member states to lead or support initiatives aimed at creating open-access, regularly updated, and community-driven multilingual resources that serve as foundational infrastructure for digital cultural heritage.

6. **Mandatory Certification of AI-Enriched Outputs** As Artificial Intelligence is increasingly used to embed knowledge and stories into digital models (e.g., advancing Digital Twins, forming Memory Twins), we recommend the creation of certification mechanisms for AI-generated results in the digital cultural heritage. These certifications should be developed in cooperation with the cultural heritage owners / stakeholders and the multidisciplinary community and validate the accuracy/precision of geometry, transparency, and ethical compliance of AI annotations, reconstructions, and narratives.

7. **Quality Assurance Frameworks for 2D/3D Models** The final 2D and 3D models - especially when enhanced through AI - should comply with clearly defined quality assurance frameworks, covering aspects such as resolution, fidelity, semantic richness, and usability for research, conservation, education, and public display.

8. **Open Access and IPR-Free Dissemination** To maximise reuse, education, and public engagement, all enriched digital heritage outputs should be made available under open access and IPR-free terms, whenever possible, while respecting the rights of source communities.

9. **Interdisciplinary and International Standardisation** We advocate for the establishment of a robust standardisation ecosystem that can support the credibility, openness, and richness of digital cultural heritage, ensuring that Memory Twins and other AI-enriched digital surrogates serve as enduring and trusted vessels of our shared memory. Therefore, we encourage the alignment and coordination of standard-setting efforts across disciplines (e.g., heritage science, AI, digital humanities, engineering, etc) and institutions, promoting interoperability and long-term preservation. UNESCO-WHC can work together with the International Organization for Standardisation (ISO), the European Committee for Standardisation (CEN), ICOMOS and ICCROM for the establishment of recommendations and standards exclusively in the area of digital Cultural Heritage Documentation.

10. **Human Resources: Capacity building, education, lifelong training** Keeping up with the changing socio-economic climate and pace of technological advances requires long-term investment in maintenance and development of skills, expertise and collaborative relationships (from the requirements in data acquisition, digitisation, modelling, to long term preservation, AI, use and re-use, etc). A consolidated and high-impact initiative in education and training for Digital Cultural Heritage specifically is needed to ensure the availability of sufficient capacity of skilled human resources at all levels of activity, involving the UNESCO DG Education - activities (especially in the tertiary area: development of new syllabi and curricula in archaeology, museology, etc) as an essential basis to cover education at BA, BSc, MA, MSc, PhD and training at vocational and professional, technical, academic research levels and in schools.

- Training should cover not only advanced digitisation techniques but also metadata and Paradata standards, project and data management, protection, data's long-term digital preservation, and the use of emerging technologies such as AI and 3D modelling.

- Networking (staff exchanges), collaboration and knowledge exchange between experienced and less-experienced institutions should be encouraged to foster peer learning.

- National and worldwide-level competence centres should be strengthened to provide ongoing support and demonstrate best practices in digital cultural heritage management, regarding documentation, archiving, protection, data's long-term preservation, use and re-use of high-quality content in other sectors such as education, tourism, etc. (for example our UNESCO Chair in Cyprus).

- The UNESCO's Recommendation on the Ethics of AI should be actively supported, with structured methodologies, focused awareness and capacity-building efforts to ensure alignment across member states.

11. Technology Integration, Innovation and adaption to UNESCO Initiatives

Advanced technologies such as AI, 2D/3D holistic digitisation, extended reality (XR), and linked open data should be integrated into digital transformation strategies with concrete milestones and KPIs that are assessed and reviewed on a regular basis.

- Technology adoption should be phased according to institutional capacity, ensuring that organisations at different digital maturity levels are supported at national level and through engagement with European competence centres.

- Clear priorities should be established for digitisation efforts, focusing on sustainable high-quality digital documentation and preservation (based on international standards) rather than digitising everything indiscriminately.

- It is essential that owners and stakeholders of tangible cultural heritage across UNESCO Member States are adequately informed about the UNESCO initiatives, such as the Dive into Tangible Heritage, Dive into Intangible Heritage and the Virtual Museum.

12. Policy Alignment & Regulatory Frameworks by UNESCO member States

- Digital transformation strategies must align with ALL existing UNESCO Conventions -especially the UNESCO Convention concerning the Protection of the World Cultural and Natural Heritage.

- There should be clear obligations and expectations for member states to implement digital transformation policies at the national level and in line with the UN SDGs.

- Regulatory frameworks should support the integration of digital cultural heritage into national digital strategies, ensuring cultural heritage is recognised as a priority sector.

- The role of national aggregators and cultural heritage networks should be strengthened to ensure digital assets are properly curated, shared, and preserved for future generations.

13. The Development of a Worldwide Atlas for the WHC registered Monuments and Sites MemoryTwin

We recommend UNESCO to initiate and endorse the creation of a Global Atlas of World Heritage Memory Twins, with the following objectives:

- Digitally document all World Heritage Sites using the Memory Twin model—integrating spatial data, oral histories, archival content, multimedia records, traditional knowledge, and environmental metadata.

- Preserve cultural memory at risk, particularly in sites vulnerable to a high-risk climate change, conflict, or neglect.

- Promote inclusive and participatory heritage documentation, allowing local communities to contribute their narratives and practices (and/or link to the Dive into Heritage Initiative).

- Enable immersive access and education, through open-access platforms that leverage XR, 3D models, AI, and linked open data.

- Support global collaboration in conservation, research, and policy-making by providing a unified, interoperable #WHC #MemoryTwin platform.

This last recommendation is fully in line with UNESCO's Convention Concerning the Protection of the World Cultural and Natural Heritage, the UNESCO Recommendation on the Historic Urban Landscape (2011), the UNESCO Open Science and Open Educational Resources Recommendations and finally all the UN Sustainable Development Goals, particularly SDG 11.4 (Strengthen efforts to protect and safeguard the world's cultural and natural heritage)

Towards Collaborative Models for Artificial Intelligence for Egyptian Cultural Heritage Preservation: Innovations, Frameworks and Recommendations

© Virtual Hawara and Labyrinth Project, 2025



Dr. Mohamed Gamal Abdelmonem

Professor and Chair of Architecture, York School of Architecture, University of York, United Kingdom.

Abstract

With the growing influence of Artificial Intelligence, AI and Machine Learning are rapidly developing tools and methodologies that offer novel and efficient solutions to the multitude of challenges that are associated with the preservation of cultural heritage for decades. The potential of AI to support new discoveries and preservation techniques, global outreach and share heritage knowledge is tremendous. However, there is a need to coordinate a coherent approach to understanding global connections and cross-cultural exchange, ensuring that AI support authentic heritage narratives, accounts, and visual representations, while filtering out unsubstantiated information and false interpretations. This paper explores the potential opportunities and challenges of Artificial Intelligence and Virtual Technology for cultural heritage in Egypt. It will highlight essential policy needs and recommendations for collaborative AI models that could benefit the preservation of Egyptian cultural heritage by linking its heritage sites with their vast museum collections worldwide.

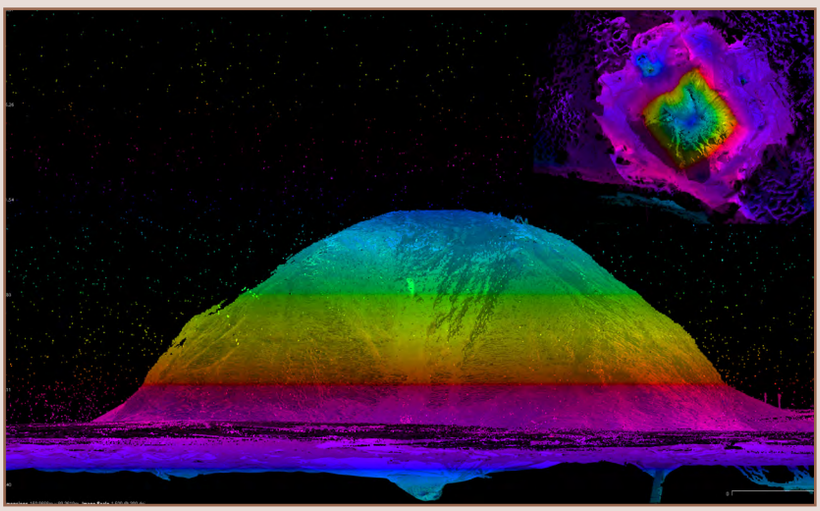


Figure 1: Hawara Pyramid: Accurate laser scanning and virtual model.
© Virtual Hawara and Labyrinth Project, 2025

VI

Introduction

Digital technology has transformed our scientific research and public engagement in interpreting, understanding, and connecting vast amounts of data to fill in the gaps of process analysis that would have taken researchers decades to reach or represent through manual means. By processing highly accurate laser scanning, geophysical analysis, remote sensing, satellite images, and environmental data for heritage sites, we can now obtain precise analysis of heritage data and findings.[1] We are now utilising AI to develop new scientific methods, global connections, share a heritage knowledge base, and link valuable heritage assets and artefacts to their original sites and community culture.

Yet, with the increasing use of AI in generating digital representations of cultural heritage and ancient history, scientists and heritage professionals face automated processes that may conflate imagination with reality in the interpretations of cultural heritage knowledge. The emergence of AI as a critical source of knowledge creation and imagination highlights the duality of its benefits and risks. In this paper, I summarise those issues and highlight a novel and practical approach to heritage preservation in Egypt in an authentic and scientific manner.

Evolution of AI-enabled digitisation and recording of cultural heritage

For decades, the preservation of heritage sites was laborious process with digital recording and documentation, which have suffered from missing gaps, lack of accuracy and inaccessible areas or objects. Research teams spent months recording tangible heritage and sites, missing their critical assets or artefacts that had either deteriorated, disappeared or moved to museums By combining AI-enhanced scientific methodologies, virtual heritage technology, and archaeological and geophysical techniques, new methods enable us to reexamine assumptions and hypotheses while fostering interdisciplinary collaboration, public engagement, and cultural preservation.

Most recently, Microsoft has developed an AI Model to process over 400,000 point-cloud images of St Peter's Basilica in the Vatican, filling in many holes and inaccessible gaps in the data, enabling the production of the Basilica's first complete virtual model.[2] Processing thousands of images and point-cloud information, Selim et al., have deployed a multi-layered approach to utilising digital and virtual technologies, including laser scanning, aerial photogrammetry, virtual tours, and digital storytelling, thus, to enable the first virtual tours and visits to a virtual living museum of the remote and inaccessible ancient Greco-Roman Gadara city in Northern Jordan.[3]

Yu et al.[4] have produced a novel AI dataset for identifying and analysing the astronomically enormous items to address the deterioration of the 14th-century Dunhuang Mogao Grottoes, a World Heritage site in western China.[5] Employing a simulated degradation of damaged and undamaged images, the AI-enabled virtual restoration model's outcomes were evaluated, resulting in two types of verified masks that replicated the various deteriorations and helped indicate what the original engraving and colours look like.[6]

Allal-Cherif[7] studied the transformative immersive technologies in tourism and heritage preservation through case studies of Notre-Dame de Paris, Exeter Cathedral, and Seville's Cathedrals of Saint Mary of the See, linking the use of augmented reality (AR), virtual reality (VR), to artificial intelligence (AI) in proposing novel methods to restore inaccessible or damaged sacred sites. Virtual environments, in this sense, provide users with profound cultural and spiritual experiences, particularly during periods of inaccessibility, such as the 2019 Notre-Dame fire and the COVID-19 pandemic.[8]

Ethical Issues of AI in Cultural Heritage: Algorithmic processes vs cultural values.

The use of AI in cultural heritage presents new challenges when it comes to intellectual property rights, reliable applications with high accessibility, and a feasible economic model that enables knowledge sharing and distributed economic benefits. This has been addressed in multiple UNESCO reports to help achieve UN Sustainable Development Goals (SDGs).[9] While there is limited reference to cultural heritage, AI-enabled frameworks that address pervasive problems in education, knowledge sharing,[10] and issues of hate speech and misinformation on the internet can be related to similar concerns regarding cultural heritage.[11] Giannini and Makri reviewed and analysed European frameworks when it comes to using AI in cultural heritage preservation,[12] highlighting key values and principles to guide AI applications in the heritage sector that include:

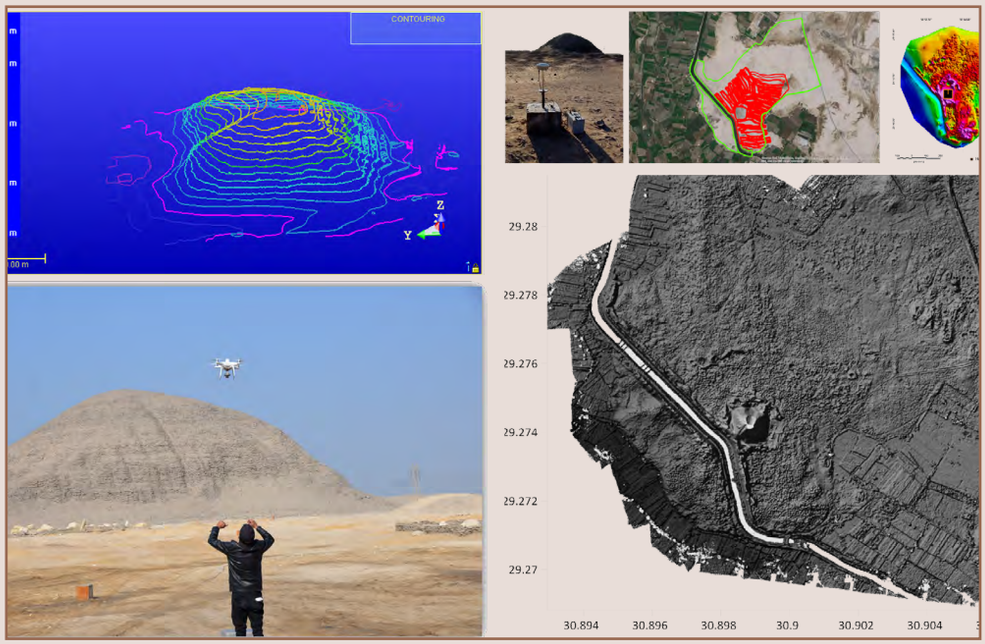


Figure 2: The use of digital technology and advanced survey techniques to digitally record ancient heritage sites in Egypt. © Virtual Hawara and Labyrinth Project, 2025

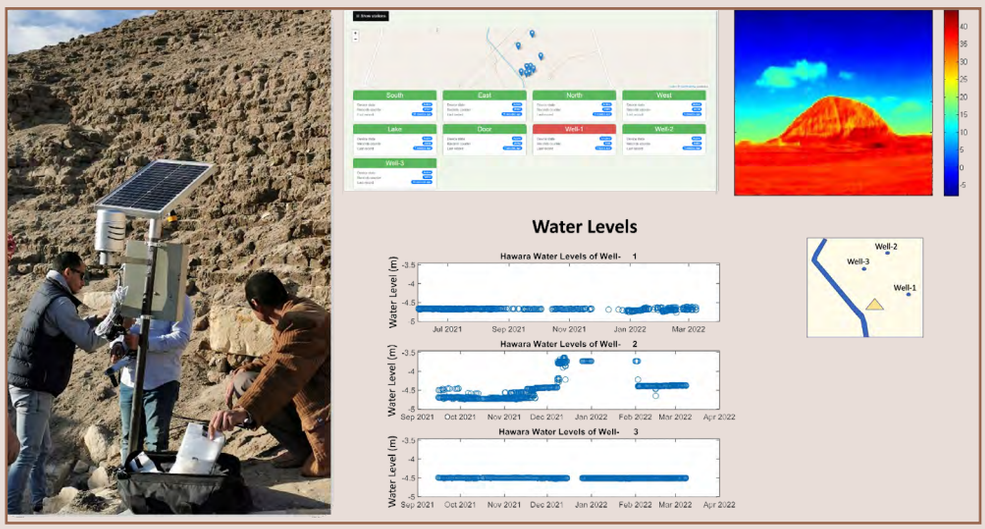


Figure 3: The use of remote sensing and environmental analysis to monitor the endangered Hawara Pyramid site in Egypt. © Virtual Hawara and Labyrinth Project, 2025

1) preservation of the natural environment and ecosystem; 2) support for diversity and inclusivity; 3) protection of a peaceful society with justice and interconnections; 4) defence of human rights, liberties, and dignity. Yet, this framework has key prerequisites to fulfil as a basis, including the protection of data privacy, transparency in administration, collaboration in AI adoption, and safety guarantees.[13]

To create principles, norms, regulations, and decision-making processes for successful AI programs, AI governance should rely on genuinely cooperative systems.[14] Chang[15] proposed incorporating the analytical strengths of AI with human expertise in arbitration procedures, investigating issues of restitution and repatriation, authenticity cases, and copyright infringement. Whilst AI significantly improves the effectiveness, transparency, and accuracy of data analysis, provenance investigation, and forgery identification, it cannot offer interpretations linked to human values and cultural viewpoints and hence may not lead to fair judgments. Meanwhile, modes, logics, and resources in successful practices will continue to emerge and should be replicable in different contexts, supporting further innovations in AI and better social and economic development.[16]

BECAIVE: New methodologies for the digital preservation of Egyptian cultural heritage

In forging meaningful systems to enable, cultivate and utilise the powers of AI, at the British Egyptian Centre of Artificial Intelligence and Virtual Heritage technologies [BECAIVE] we are building a novel framework to utilise open-source tools and AI models to link heritage sites and artefacts at world museums.

The BECAIVE-AI Framework aims to create a virtual hub for Egyptian Heritage that combines virtual space (an AI-enabled database linking artefact metadata to geolocated heritage sites) and virtual time (Gen-AI: visual reconstructions of ancient sites with integrated artefacts).

This international and collaborative effort will bring together Egyptian archaeological sites and artefact collections, ensuring accessibility to digital datasets, digitised artefacts, and actual heritage sites. It is a gateway to the real-time exchange of information, as well as virtual visits and examinations of artefacts, with regards to authenticity and associated legacies.

Our approach incorporates UNESCO's shared principle of common universal values and demonstrates how AI can bring our cultural heritage knowledge together. This builds on a systemic procedure we developed to preserve the endangered and one of the most significant antiquity sites in Egypt, the Hawara Pyramid and Labyrinth.[17] Located 80 km southeast of Cairo in the Fayoum area, the burial site was the ultimate resting place of Amenemhat III (Twelfth Dynasty; 1855-1808 BCE).

With over 16,000 artefacts, including the Fayoum and Mummy Portraits spread over 36 world museums, our comprehensive preservation and digitisation methods offered the first virtual environment for the site (VirtualHawara).[18]

Only through systematic and large-scale digitalisation, archiving, and AI-enabled association between artefacts (objects), sites (contexts), and time (legacies), can we reposition objects virtually and digitally back to their home site, uncovering understudied relationships, cultural meanings, and stories of the pyramid and its mystery.[19]

1. Gehan Selim et al., "The Virtual Living Museum: Integrating the Multi-layered Histories and Cultural Practices of Gadara's Archaeology in Umm Qais, Jordan," Sustainability 14, no. 11 (May 2022): 6721, https://doi.org/10.3390/su14116721.

2. Gehan Selim et al., "The Virtual Living Museum: Integrating the Multi-layered Histories and Cultural Practices of Gadara's Archaeology in Umm Qais, Jordan," Sustainability 14, no. 11 (May 2022): 6721, https://doi.org/10.3390/su14116721. (Duplicate of #1)

3. Selim et al., "The Virtual Living Museum." (Short reference to #1/#2)

4. Tianxiu Yu et al., "Artificial Intelligence for Dunhuang Cultural Heritage Protection: The Project and the Dataset," International Journal of Computer Vision 130, no. 11 (August 2022): 2646–2673, https://doi.org/10.1007/s11263-022-01665-x.

5. Yu et al., "Artificial Intelligence." (Short reference to #4)

6. Konstantin Sofiiuk et al., "f-brs: Rethinking Backpropagating Refinement for Interactive Segmentation," Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition (August 2020), https://doi.org/10.48550/arXiv.2001.10331.

7. Oihab Allal-Chérif, "Intelligent Cathedrals: Using Augmented Reality, Virtual Reality, and Artificial Intelligence to Provide an Intense Cultural, Historical, and Religious Visitor Experience," Technological Forecasting and Social Change 178 (March 2022): 121604, https://doi.org/10.1016/j.techfore.2022.121604.

8. Allal-Chérif, "Intelligent Cathedrals." (Short reference to #7)

9. Leslie Loble, "Learning to Live in the Time of AI," UNESCO Documents, UNESCO Digital Library (Paris: UNESCO, 2018), https://unesdoc.unesco.org/ark:/48223/pf0000265249.

10. UNESCO, AI and Education: Guidance for Policy-Makers, UNESCO Documents (2021), https://unesdoc.unesco.org/notice?id=p::usmarcdef_0000376709.

11. Stefania Giannini, "Generative AI and the Future of Education," UNESCO Documents (July 2023), https://unesdoc.unesco.org/notice?id=p::usmarcdef_0000385877.



Figure 4: BECAIVE generates a curated and speculative virtual experience and a walkthrough of the lost Sobek (Crocodile) Temple. © Virtual Hawara and Labyrinth Project, 2025

Recommendations

1. **Support international collaborative models of AI for Cultural Heritage:** AI has developed its processes based on the vast digital databases that are accessible to feed their models. As the digitisation of cultural heritage continues to grow and intensifies, the outcome becomes more accurate and reliable. As those digitised datasets are produced at heritage institutions, the management of datasets must be enhanced through sustainable and international collaborations.

2. **Policy Frameworks, legislation, and public-private partnerships:** There is a lack of essential regulatory frameworks to manage and support the use of AI, as well as its accessibility to open-source or closed-source datasets of cultural heritage. Member states need to develop regional policy guidance and protocols to facilitate and support the development of context-based AI for cultural heritage. Working with UNESCO20 Conventions and recommendations, there is a need to review and update legislation governing heritage preservation and associated data.

3. **Interdisciplinary research and education programmes:** AI will grow substantially diverse and there is a need to enhance local knowledge and expertise, catering to -local needs, addressing local challenges and reflecting regional identities. Young researchers and graduate students must have access to professional training that focuses on AI applications for cultural heritage management, particularly regarding ethical practices, such as the risks and impacts of unregulated AI use.

4. **Investing in local human resources and technology acquisition:** Due to the high-level technicality in the practices of AI and cultural heritage, there is a need to invest in building specialised teams that grasp the know-how, with a strong support of digital infrastructure, including data centres and cloud-storage capabilities for a sustainable safeguarding of authentic digital records and information.

12. Eugenia Giannini and Evi Makri, "Cultural Heritage Protection and Artificial Intelligence: The Future of Our Historical Past," International Conference on Transdisciplinary Multispectral Modeling and Cooperation for the Preservation of Cultural Heritage (September 2023): 375–400, https://doi.org/10.1007/978-3-031-42300-0_32.

13, Eugenia Giannini and Evi Makri, "Cultural Heritage Protection." (Short reference to #12)

14. UNESCO, Steering AI and Advanced ICTs for Knowledge Societies: A Rights, Openness, Access, and Multi-stakeholder Perspective, UNESCO Documents (2019), https://unesdoc.unesco.org/notice?id=p::usmarcdef_0000372132.

15. Floriane Chang, "Artificial Intelligence in Art Dispute Resolution: A Hybrid Model for Balancing Efficiency and Cultural Nuance," Contemporary Asia Arbitration Journal 18, no. 1 (May 2025): 123–156, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=5270255.

16. UNESCO, Artificial Intelligence and Digital Transformation: Competencies for Civil Servants, UNESCO Documents (Paris: UNESCO, 2022): 1–79, https://unesdoc.unesco.org/notice?id=p::usmarcdef_0000383325.

17. Labyrinth Project. A joint funding by the UK (Arts and Humanities Research Council) and Egypt (Science and Technology Development Fund, STDF) in collaboration with National Research Institute of Astronomy and Geophysics (NRIAG), Nottingham Trent University (UK), and University of Leeds (UK) (May 2025), project website: www.virtualhawara.com.

18. Labyrinth, Virtual Hawara. (Short reference to #17)

19. Abbas M. Abbas et al., "Geophysics' Role in Investigating and Mitigating Groundwater Hazards on Archaeological Sites: Case Studies from Sphinx-Giza, Kom Ombo Temple-Aswan and Hawara Pyramid-Fayoum," in Sustainable Conservation of UNESCO and Other Heritage Sites Through Proactive Geosciences, ed. Gad El-Qady and Claudio Margottini (London: Springer International Publishing, 2023), 287–312, https://doi.org/10.1007/978-3-031-13810-2_16.

20. UNESCO, Recommendation on the Ethics of Artificial Intelligence, UNESCO Global Standard on AI Ethics, Mandatory Policy Document: SHS/BIO/PI/2021/1, last updated: 26 September 2024 (Paris: UNESCO, May 2023), https://www.unesco.org/en/articles/recommendation-ethics-artificial-intelligence.

Artificial Intelligence and Remote Sensing–Driven Conservation of the Nasca Geoglyphs: Innovations and Implications for World Heritage Management

© Masato Sakai



Mr. Masato Sakai

Distinguished Research Professor, Yamagata University, Japan.

Abstract

This paper presents an interdisciplinary approach to the documentation and preservation of the Nasca geoglyphs, a UNESCO World Heritage Site in Peru, through the application of remote sensing and artificial intelligence (AI). Since 2010, our research team at Yamagata University has studied geoglyphs through on-site investigations using high-resolution satellite imagery, aerial photographs, and drone images. In collaboration with IBM Research, AI models were developed to accelerate the detection of geoglyphs, leading to the discovery of over 300 new figurative geoglyphs during large-scale surveys. AI-assisted fieldwork improved mapping efficiency and revealed spatial patterns in the distribution of geoglyphs that had previously been overlooked.

Despite ongoing conservation efforts, the geoglyphs remain increasingly vulnerable to urban development, agriculture, mining, and climate-induced events—even within officially designated protection zones. In response, a heritage park was established near Nasca city to integrate conservation with community engagement. The paper concludes with policy recommendations to institutionalize AI in heritage management, strengthen legal protections, and promote sustainable local development. The Nasca case exemplifies how digital technologies, when ethically and thoughtfully applied, can contribute to the global safeguarding of cultural landscapes.

VI

Introduction

The Nasca geoglyphs, located on the arid plains of southern Peru, have captured the attention of both scholars and the general public. Inscribed as a UNESCO World Heritage Site in 1994,[1] these geoglyphs are internationally recognized for their monumental scale, antiquity, and cultural significance. Despite their protected status, these geoglyphs remain vulnerable to multiple threats, including unauthorized vehicle incursions and unregulated development, such as agricultural expansion and mining activity.[2] In addition to such anthropogenic damage, they are also at risk from sudden natural events, particularly flash floods, which eroded or washed away parts of the fragile surfaces.[3] It is noteworthy that anthropogenic and climatic hazards have shown a significant increase in recent years.[4] Traditional methods—ground-based surveys—are often inadequate for addressing the increasing scale and complexity of these risks.

To meet these challenges, our research team has developed an interdisciplinary methodology that integrates the technologies of high-resolution remote sensing and artificial intelligence (AI). This approach allows for rapid and systematic documentation of large and inaccessible areas, increasing the efficiency and accuracy of geoglyph identification while enabling proactive heritage management.

Nasca Geoglyphs and Their Cultural Context

The Nasca geoglyphs were created beginning around 100 BCE and were in use for over 1,500 years. Spanning over 400 km² of desert Pampa, the geoglyphs consist of both geometric and figurative motifs. While some large-scale figurative geoglyphs—such as the Hummingbird and the Monkey—are well known, other smaller-scale figurative geoglyphs remain undocumented, particularly those located along ancient trails.

Both types of figurative geoglyphs can be broadly categorized into two morphological types: large line-type figures, averaging around 90 meters in length and composed of continuous lines, and smaller relief-type figures, averaging 9 meters and characterized by contrasts between dark and light tones on the ground surface. Recent studies by Yamagata University and IBM have significantly advanced our understanding of their spatial patterns and cultural functions, identifying over 600 previously unknown relief-type geoglyphs.[5]

Remote Sensing and AI Integration

The integration of satellite imagery into our archaeological surveys in the early 2000s marked a turning point in Nasca research. High-resolution imagery from platforms like QuickBird allowed for the digital mapping of large-scale line-type geoglyphs. Since 2015, our team has conducted field surveys by integrating high-resolution aerial photographs (10 cm ground resolution) with drone imagery—an approach that has enabled the detection of previously invisible relief-type features. Despite these advances, the manual review of vast image datasets remained a bottleneck. In 2018, we initiated a collaboration with IBM Japan to develop AI-assisted detection techniques. A pilot project in a 27 km² area employed a grid-based classification AI using a ResNet50 CNN, trained on just 42 annotated samples. This initial model successfully identified four new geoglyphs, including a humanoid figure approximately five meters in length.[6]

Following this success, we expanded the project in collaboration with the IBM Thomas J. Watson Research Center. The full-scale survey divided the Nasca Pampa into over 16 million 5×5 m grid cells. A two-stage AI system was developed: a lightweight classifier first flagged candidate regions, followed by a probability-map-based model that evaluated spatial patterns in high-resolution aerial photographs.

The AI flagged 47,410 candidate cells, from which 1,309 high-confidence targets were selected for field validation. Between September 2022 and February 2023, we conducted on-site investigations at 341 locations, confirming 303 previously undocumented geoglyphs.

Approximately half matched the AI-predicted coordinates, while others were found nearby—suggesting spatial clustering.[7] This finding has important methodological implications, as it indicates that the discovery of one geoglyph increases the likelihood of others in close proximity, thereby optimizing field survey strategies.

Ongoing Threats to the Nasca Geoglyphs

Despite technological progress in documentation, the geoglyphs face intensifying threats. One early example is the construction of the Pan-American Highway in the 20th century, which destroyed part of the "Lizard" geoglyph.[8] In the 21st century, satellite data and fieldwork have confirmed increasing damage from urban growth, agriculture, and vehicular traffic. In one instance, a trapezoid geoglyph was lost to residential construction near the city of Nasca. In response to such threats, Yamagata University and the Peruvian Ministry of Culture established the "Pampas de los Camelidos" Geoglyph Protection Park in 2017. While it was previously known that geoglyphs of camelids and humans existed in this area, a detailed distribution survey confirmed the presence of 77 geoglyphs. The second phase of the project, launched in 2022, focused on improving the visibility of deteriorated figures and promoting sustainable tourism through community engagement. However, new threats continue to emerge. Since 2023, mining activities near the protected areas have expanded, leading to excavation and construction in close proximity to several geoglyphs.These incidents were discovered during field inspections and, after being reported to the Ministry of Culture, prompted official site visits by the ministry. This series of events underscored the urgent need to establish stronger monitoring systems and enforcement mechanisms capable of responding to rapid changes on the ground.

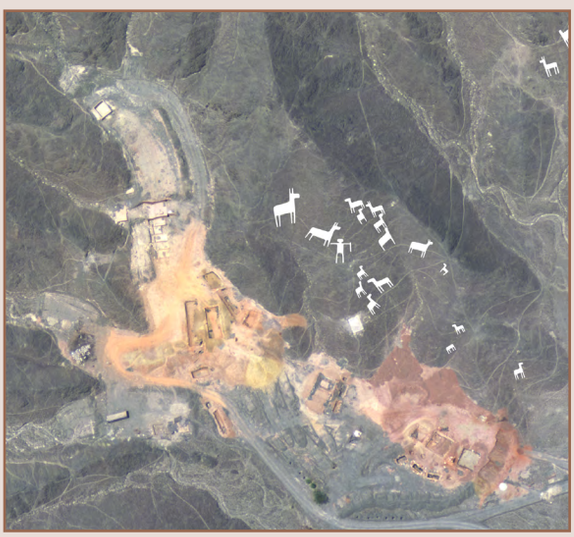


Figure 1: Aerial photograph of a section of the "Pampas de los Camelidos" Geoglyph Protection Park. Geoglyphs depicting animals and human figures are highlighted in white to enhance visibility. Areas shaded in red and yellow indicate zones of mining-related activities, which extend in close proximity to the geoglyphs.
© Masato Sakai



Figure 2: A large excavation pit opened for soil extraction on the reverse slope of a hill bearing geoglyphs (photographed in October 2024).
© Masato Sakai

Conclusions

The integration of AI and remote sensing has revolutionized our capacity to document and monitor the Nasca geoglyphs. By enabling efficient, high-resolution mapping over expansive areas, this approach overcomes the limitations of traditional fieldwork and opens new possibilities for large-scale archaeological survey and conservation. The discovery of over 300 new geoglyphs through AI-assisted methods represents a significant advance in the understanding of Nasca cultural landscapes. Nevertheless, the effectiveness of technological solutions depends on complementary legal, administrative, and community-based strategies. Without robust site monitoring, policy enforcement, and stakeholder collaboration, even the most advanced detection systems cannot ensure the long-term protection of cultural heritage. Moving forward, our work highlights the importance of combining technological innovation with integrated heritage governance to preserve irreplaceable archaeological resources for future generations.

Policy Recommendations

The case of the Nasca geoglyphs illustrates both the transformative potential of digital technologies for heritage preservation and the urgent need to reform existing management systems. Based on the findings and field experiences presented in this study, we propose the following four priority recommendations to improve the long-term protection and management of the site and to inform broader heritage policy.

1. Institutionalize AI and Remote Sensing in Heritage Management. By combining high-resolution aerial imagery with machine learning–based field surveys, we identified over 300 previously unknown geoglyphs. These findings underscore the importance of integrating such digital tools into institutional heritage management frameworks to enable proactive monitoring and systematic documentation of large-scale archaeological sites.

2. Strengthen Legal and Enforcement Mechanisms. Although the Nasca geoglyphs have been designated as a UNESCO World Heritage Site and a protection park has been established in areas where the geoglyphs are concentrated, mining and construction activities continue to take place both within and around the protected zones.

In particular, the expansion of industrial operations since 2023 has revealed serious deficiencies in legal enforcement and monitoring systems. We recommend a fundamental review of cultural heritage protection frameworks at both national and regional levels, with particular emphasis on strengthening on-site monitoring and enforcing stricter development controls within protected areas.

3. **Promote Community-Based and Sustainable Conservation.** Heritage conservation is the most effective when it actively involves local communities. Initiatives such as the creation of educational signage, walking trails, and cultural tourism in the "Pampas de los Camelidos" area have begun to foster engagement. Future efforts should focus on long-term partnerships with local residents to promote sustainable development practices that align with heritage values. Local economic benefits from heritage tourism must be balanced with site preservation goals to ensure community support and stewardship.

In conclusion, the Nasca geoglyphs offer a timely example of how advanced technologies, when strategically applied, can enhance cultural heritage conservation in the face of accelerating environmental and human pressures. These recommendations are intended to guide not only national stakeholders in Peru but also UNESCO and the broader international community in developing more adaptive and forward-looking systems for heritage management.

1. L. G. Lumbreras, Formulación de los Lineamientos para la Elaboración de un Plan de Manejo de las Líneas de Nasca 1: Contexto Arqueológico (Lima: Instituto Nacional de Cultura del Perú & UNESCO, 2000).

2. F. Cigna and D. Tapete, "Tracking Human-Induced Landscape Disturbance at the Nasca Lines UNESCO World Heritage Site in Peru with COSMO-SkyMed InSAR," Remote Sensing 10, no. 4 (2018): 572, https://doi.org/10.3390/rs10040572.

3. D. C. Comer, B. D. Chapman, and J. A. Comer, "Detecting Landscape Disturbance at the Nasca Lines Using SAR Data Collected from Airborne and Satellite Platforms," Geosciences 7, no. 4 (2017): 106, https://doi.org/10.3390/geosciences7040106.

4. M. Sakai, M. Freitag, A. Sakurai, C. M. Albrecht, and H. F. Hamann, "Climatic & Anthropogenic Hazards to the Nasca World Heritage: Application of Remote Sensing, AI, and Flood Modelling," in IGARSS 2024–2024 IEEE International Geoscience and Remote Sensing Symposium (Piscataway, NJ: IEEE, 2024), 2212–2215, https://ieeexplore.ieee.org/document/10642513.

5. M. Sakai, A. Sakurai, S. Lu, J. Olano, C. M. Albrecht, H. F. Hamann, and M. Freitag, "AI-Accelerated Nazca Survey Nearly Doubles the Number of Known Figurative Geoglyphs and Sheds Light on Their Purpose," Proceedings of the National Academy of Sciences 121, no. 40 (2024): e2407652121, https://doi.org/10.1073/pnas.2407652121.

6. M. Sakai, Y. Lai, J. O. Canales, M. Hayashi, and K. Nomura, "Accelerating the Discovery of New Nasca Geoglyphs Using Deep Learning," Journal of Archaeological Science 155 (2023): 105777, https://www.sciencedirect.com/science/article/pii/S0305440323000559.

7. Sakai et al., "AI-Accelerated Nazca Survey," e2407652121. (Répétition abrégée de la référence #5)

8. M. Reiche, Contribuciones a la Geometría y Astronomía en el Antiguo Perú (Lima: Asociación María Reiche para las Líneas de Nasca, 1993).

CHAPTER VII

AI and Culture in the Arab Region

AI & Culture



© Jenna Khalil, 2026*

Chapter 7

Artificial Intelligence and Culture in the Arab Region

Across the Arab region, artificial intelligence (AI) is rapidly emerging as a transformative tool in the protection, interpretation, and revitalization of cultural heritage and creative sectors. Recent studies highlight that AI is already being applied across multiple domains, including archaeological documentation, museum curation, conservation planning, creative industries, education, and linguistic research.

In Egypt and neighbouring countries, as Dr Medhat demonstrates, AI is moving from theory to practice—supporting site monitoring, climate adaptation, and conservation strategies, such as at Tell Timai, where it assists in addressing climate-induced erosion. In North Africa, Dr Bachagha shows how deep learning models and satellite imagery are used to detect archaeological features, such as Roman structures in Tunisia, enhancing efficiency and scale in heritage discovery. Meanwhile, in Egypt's creative industries, AI is enabling new forms of cultural production—from digitizing manuscripts to co-creating art—while in Sudan, it is envisioned as a tool to preserve intangible heritage, including oral traditions and storytelling, and to position culture as a driver for peacebuilding and soft power.

Beyond preservation, AI is also reshaping cultural expression and knowledge systems. Dr Nawar's work on generative pictographic language illustrates how machine learning can synthesize ancient scripts to create new visual languages, opening innovative pathways for understanding cultural continuity and communication. Similarly, across the Arab creative sector, as noted by Dr Mellor, AI is fostering innovation and experimentation, particularly in Gulf countries such as the UAE, which lead in adoption and investment.

However, these applications also reveal common features of AI use in the region: reliance on large datasets, integration of visual and geospatial analysis, and increasing emphasis on interdisciplinary collaboration between technology, heritage, and creative fields. At the same time, significant challenges persist.

These include infrastructural and capacity gaps between countries, limited AI literacy among cultural professionals, ethical concerns over authenticity and misrepresentation, and the need for culturally sensitive design. Educational contexts further highlight these tensions, as Dr Abou-Khatwa notes the risks of superficial learning and over-reliance on AI-generated content among students.

In summary, AI in the Arab region is being deployed across a wide spectrum of cultural domains, offering powerful tools for preservation, creativity, and knowledge production. Yet, its success depends on addressing structural inequalities, strengthening policy frameworks, and ensuring that technological innovation remains grounded in cultural authenticity, ethical responsibility, and regional collaboration.

From Preservation to Transformation: Artificial Intelligence, Climate Resilience, and Cultural Heritage in the Arab Region: A Contribution to MONDIACULT 2025

© AbdelRahman Medhat



Dr. AbdelRahman Medhat

Multilingual Heritage Scientist, Scientific Advisor, and Cultural Policy Maker.

Abstract

This contribution examines how artificial intelligence (AI) is being utilized to enhance cultural heritage preservation and climate resilience in the Arab region, with a particular focus on Egypt and its surrounding countries. Through practical case studies, field experience, and institutional collaborations, it highlights how AI is shifting from theoretical promise to implementation across archaeological documentation, museum curation, and conservation planning. It also considers the ethical, educational, and infrastructural gaps that must be addressed to align digital innovation with UNESCO's mission.

The paper builds on my presentation at the UNESCO Cairo Office during the AI and Culture series and proposes an integrated approach for AI-powered climate adaptation. Grounded in the 1972 and 2003 UNESCO Conventions and the 2021 Recommendation on the Ethics of AI, this article proposes ways in which AI can empower interdisciplinary teams and engage young people in safeguarding vulnerable heritage. It calls for coordinated regional efforts, sustainable digital infrastructures, and AI literacy programs tailored for cultural professionals. Drawing on the site of Tell Timai as a primary case study, it illustrates how AI can support conservation planning and site monitoring in response to climate-induced erosion. This contribution ultimately supports UNESCO's global cultural policy efforts, leading to MONDIACULT 2025 through a forward-looking, field-grounded approach.

VII

Introduction

AI and Climate Resilience in the Delta: A Case Study from Tell Timai

Climate change presents an escalating threat to cultural heritage in the Arab region, particularly to archaeological sites composed of earthen architecture (Fig. 1). This contribution focuses on the site of Tell Timai (ancient Thmuis) in the Nile Delta of Egypt, where climate-induced deterioration of mudbrick structures is intensifying.

Specifically, the study examines the 4th-century church at the site (Fig. 2), investigating how rising environmental stressors—including humidity, temperature fluctuations, and groundwater salinity—contribute to the loss of its structural integrity.

This work also explores how the integration of artificial intelligence (AI) and green conservation practices can offer new, sustainable methods for protecting such vulnerable heritage.

Tell Timai,[1] once a prominent ecclesiastical center in Late Antiquity, continues to provide insights into early Christian architecture and liturgy. The church is referenced in historical sources and depicted on the 6th-century Madaba Map—a Byzantine mosaic that serves as one of the earliest cartographic representations of the Holy Land.[2]

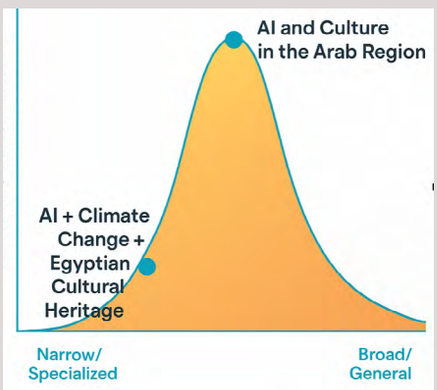


Figure 1: Bell Graph showing thematic alignment with UNESCO'S core values
© AbdelRahman Medhat

Despite the site's historical significance, conservation[3] efforts have been intermittent and limited in scope. Today, new digital tools are allowing for a more systematic approach to documentation and preservation.

AI-Enhanced Damage Assessment and Conservation Planning

A combination of natural and anthropogenic pressures drives the deterioration at Tell Timai.[4] Mudbrick erosion is accelerating due to seasonal rainfall patterns,[5] salt crystallization, and the destabilization of wall foundations by stray animals, particularly dogs that burrow near the structures, attracted by a nearby refuse site.

Initial conservation efforts in 2012 involved reinforcing the church walls using traditionally crafted mud bricks. Local artisans replicated the historic material composition through morphological[6] and chemical analysis,[7] and red ochre was added to the new bricks to distinguish them from the original fabric.

However, without ongoing monitoring, these efforts could not keep pace with evolving environmental conditions.[8]



Figure 2: Front view of the church looking North.
© Tell Timai Project used with permission *

To address this gap, an AI-based platform was developed and deployed as part of this study. The system integrates multispectral drone imagery, satellite data, and ground-based surveys to create a dynamic deterioration index across the site. Using machine learning algorithms, the platform quantifies erosion patterns and structural vulnerabilities with seasonal precision, enabling the development of a predictive conservation model.[9]

1. Damage Mapping and Erosion Modeling (Figs. 3 and 4)

2. Material Cataloguing and Analysis

3. Green Chemistry Integration

4. Historical-Ecological Correlation

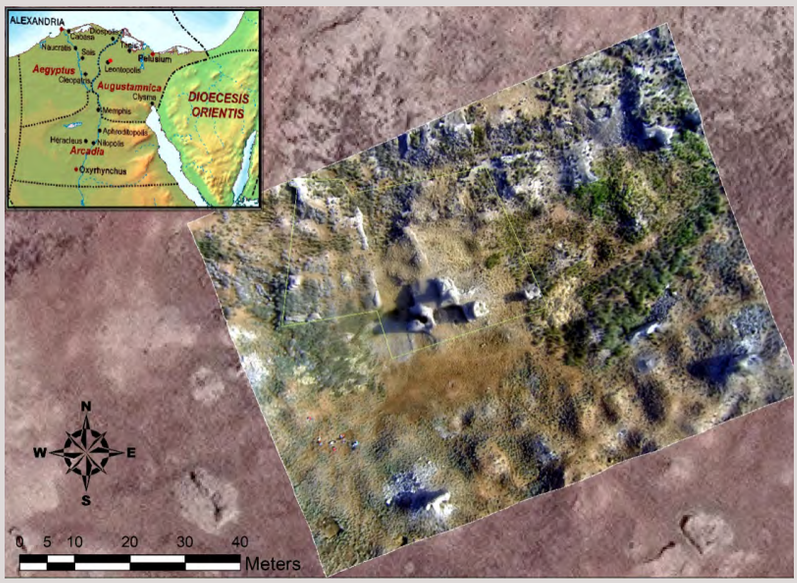


Figure 3: Drone/ Satellite Hybrid Image of the Church Yellow Outline indicates the estimated extent of the church compound. © Tell Timai Project used with permission*



Figure 4: Model in 3d of the church. © Tell Timai Project used with permission *

This AI platform is embedded with ethical safeguards aligned with the 1972 UNESCO [10] World Heritage Convention, the 2003 Convention for the Safeguarding of the Intangible Cultural Heritage,[11] and the 2021 Recommendation on the Ethics of Artificial Intelligence.[12]

Moreover, it contributes to Sustainable Development Goals 11,[13] 13,[14] and 17.[15] by advancing climate action, promoting sustainable cities, and facilitating cross-sectoral partnerships. The use of open-source code and integration with national climate databases ensures transparency and adaptability for future applications in other heritage sites across the Arab region.

Reccomendations

To ensure that artificial intelligence contributes effectively to climate-resilient cultural heritage protection in the Arab region, a coordinated strategy across policy, practice, and infrastructure is essential.

The following five recommendations are drawn from field experience and aligned with UNESCO frameworks, particularly the 2021 Recommendation on the Ethics of Artificial Intelligence and the Sustainable Development Goals (SDGs 11, 13, and 17).

1. Strengthen Capacity-Building for Cultural Professionals

UNESCO and its regional offices should invest in field-based training programs that equip archaeologists, conservators, and museum professionals with practical skills in AI tools for climate risk assessment, site monitoring, and documentation. These short-term workshops can be co-designed with universities and local heritage authorities to ensure contextual relevance and long-term impact.

2. Establish a Regional AI-for-Heritage Data Observatory

A centralized, open-access platform should be developed to aggregate satellite imagery, environmental data, and site-specific conservation information. This observatory would enable the real-time monitoring of climate impacts on heritage across the Arab States and support cross-border collaboration in emergency response, planning, and funding applications.

3. Develop Ethical and Contextual AI Literacy Guidelines

AI literacy and ethics should be embedded into cultural heritage curricula and institutional policies. Tailored guidance based on the 2021 AI Ethics Recommendation must be made accessible in Arabic and other regional languages, with special attention to preventing algorithmic bias and ensuring inclusivity in heritage data representation.

4. Support Sustainable Digital Infrastructure and Green Data Centers

Public–private partnerships should be fostered to develop low-energy, climate-resilient data storage systems that can house digital archives, support AI computation, and ensure long-term preservation. Emphasis should be placed on utilizing renewable energy sources and siting infrastructure in areas less susceptible to heat waves, flooding, or water scarcity.

5. Promote Interdisciplinary Research and Youth Engagement

Funding mechanisms should prioritize interdisciplinary research that brings together climate scientists, AI engineers, archaeologists, and experts in cultural policy. Initiatives that engage students and early-career professionals—particularly from underrepresented regions—can foster innovation and ensure generational continuity in safeguarding heritage through emerging technologies.

Herman de Meulenaere and P. A. MacKay, eds., Mendes II (Warminster: Aris & Phillips; distributed by International Scholarly Book Services, 1976).

J. R. Knipfing, "The Date of the Acts of Phileas and Philoromus," The Harvard Theological Review 16, no. 2 (1923): 198–203, https://www.jstor.org/stable/1508138.

Serena Love, "Field Methods for the Analysis of Mud Brick Architecture," Journal of Field Archaeology 42 (2017): 1–13, https://doi.org/10.1080/00934690.2017.1345222.

AbdelRahman Medhat, "A Testimony of Hydraulic Constructions in Tell Timai," paper presented at the Missouri Egyptological Symposium, Columbia, MO, September 21–23, 2024. Video, 24:33. YouTube. Posted October 2024. https://www.youtube.com/watch?v=GjUhbOxfC4Q.

AbdelRahman Medhat, "Application of Vibrational Spectroscopy on Experimental Samples in the Study of Ancient Perfume: Nile Discharge and Material Culture due to Climate Change," paper presented at the Annual Meeting of the American Research Center in Egypt (ARCE), Pittsburgh, PA, April 19–21, 2024.

AbdelRahman Medhat, Mona Ali, and Mohamed Abdel-Ghani, "Analytical Investigation on a Coptic Wooden Icon from the 18th Century Using SEM-EDX Microscopy and FTIR Spectroscopy," Mediterranean Archaeology and Archaeometry 15, no. 1 (2015): 151–161, https://doi.org/10.5281/zenodo.15048.

AbdelRahman Medhat, E. G. Zaki, K. Nagar, and M. Aly, "Raman Spectroscopy and Dynamic Light Scattering Analysis of Egg Hen Binder Behaviors," Egyptian Journal of Chemistry 67 (2024): 77–85.

AbdelRahman Medhat, "Impact of Climate Change on Archaeological Earthen Structures in the Delta: A Case Study of the Church in Tell Timai," post-doctoral research project, American Research Center in Egypt (ARCE), 2024.

AbdelRahman Medhat, "AI and Climate Resilience in Heritage Conservation" (presentation, UNESCO Cairo Office, June 2025).

UNESCO, Convention Concerning the Protection of the World Cultural and Natural Heritage, adopted November 16, 1972, https://whc.unesco.org/en/conventiontext/.

UNESCO, Convention for the Safeguarding of the Intangible Cultural Heritage, adopted October 17, 2003, https://ich.unesco.org/en/convention.

UNESCO, Recommendation on the Ethics of Artificial Intelligence, adopted November 23, 2021, https://unesdoc.unesco.org/ark:/48223/pf0000381137.

United Nations, "Goal 11 – Make Cities and Human Settlements Inclusive, Safe, Resilient and Sustainable," Sustainable Development Goals, UN Department of Economic and Social Affairs, accessed July 4, 2025, https://sdgs.un.org/goals/goal11.

United Nations, "Goal 13 – Take Urgent Action to Combat Climate Change and Its Impacts," Sustainable Development Goals, UN Department of Economic and Social Affairs, accessed July 4, 2025, https://sdgs.un.org/goals/goal13.

United Nations, "Goal 17 – Strengthen the Means of Implementation and Revitalize the Global Partnership for Sustainable Development," Sustainable Development Goals, UN Department of Economic and Social Affairs, accessed July 4, 2025, https://sdgs.un.org/goals/goal17.

Using Artificial Intelligence to Detect Roman Fortified Sites in Tunisia: Reflection and Recommendations

© Nabil Bachagha



Dr. Nabil Bachagha

University of Leeds, United Kingdom

Abstract

The purpose of this paper is to develop the recent research presented at the International Symposium on AI and Cultural Heritage in 2025. It provides sensible insights and future-oriented suggestions on the use of artificial intelligence (AI)—specifically, deep learning models and high-resolution satellite imagery—in the detection and examination of archaeological panoramas in North Africa. These insights are informed by 1) the author's current efforts to apply convolutional neural network (CNN) models to SAR and optical data for the automatic detection of Roman fortified structures in Tunisia; and 2) broader considerations within the geospatial and digital archaeology communities, particularly concerning the ethical, technical, and preservation-related aspects of AI-assisted archaeological research.

Introduction

Artificial Intelligence (AI) is increasingly reshaping the field of archaeological research, offering powerful tools for the detection[1], classification, and interpretation of ancient sites through satellite imagery. For instance, in Tunisia, where Roman fortified structures are often concealed by desertification,[2] AI-driven approaches—particularly deep learning models applied to high-resolution remote sensing (RS) data—present transformative possibilities for uncovering hidden heritage.[3]

VII

This paper, titled "Using Artificial Intelligence to Detect Roman Fortified Sites in Tunisia: Reflection and Recommendations," examines the methodological and practical outcomes of integrating convolutional neural networks (CNNs) with satellite imagery in North African archaeological contexts. It further reflects on broader implications such as data scarcity, model bias, ethical considerations, and the importance of interdisciplinary collaboration in digital heritage workflows.

Archaeologists and land managers are increasingly turning to advanced technologies in search of faster and more cost-effective alternatives to traditional field surveys, particularly in remote regions such as southern Tunisia. The vast and often inaccessible terrain poses significant logistical and financial challenges, resulting in limited and sometimes unrepresentative field data.

To address these limitations, recent studies have successfully combined remote sensing with machine learning algorithms to automate site detection and design survey strategies, based on archaeological potential. Platforms like Google Earth Engine (GEE), when integrated with deep learning models, have proven highly effective in scanning large-scale environments, detecting subtle architectural features, and refining predictive models of site distribution. This fusion of RS and AI offers a promising approach to surveying under-researched landscapes such as the Tunisian hinterland, enabling the identification of new Roman-era archaeological sites while reducing both time and resource costs.[4]

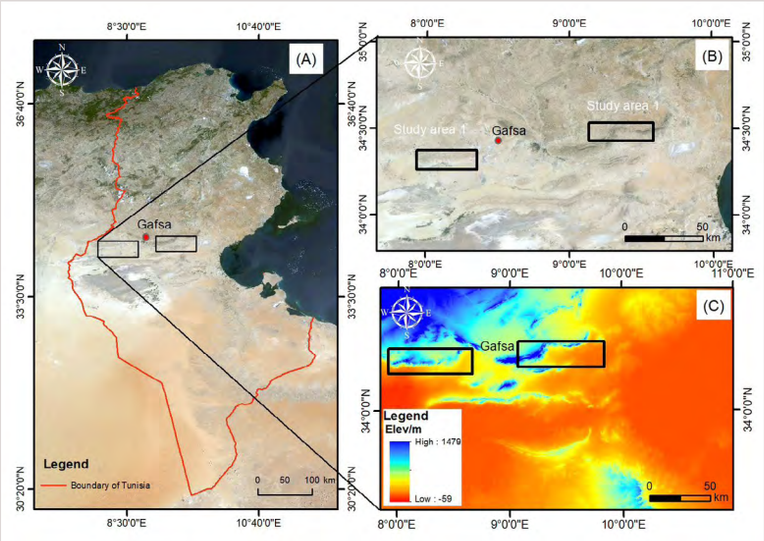


Figure 1: Geospatial Analysis of Study Areas in Tunisia: (A) Landsat 8 OLI Composite Imagery, (B) Study Areas Location Map: Study area 1: Wadi Elmaleh Valley , Study area 2: Blad Talh (B) (C) ASTER GDEM map of the study areas 1 and 2. © Nabil Bachagha

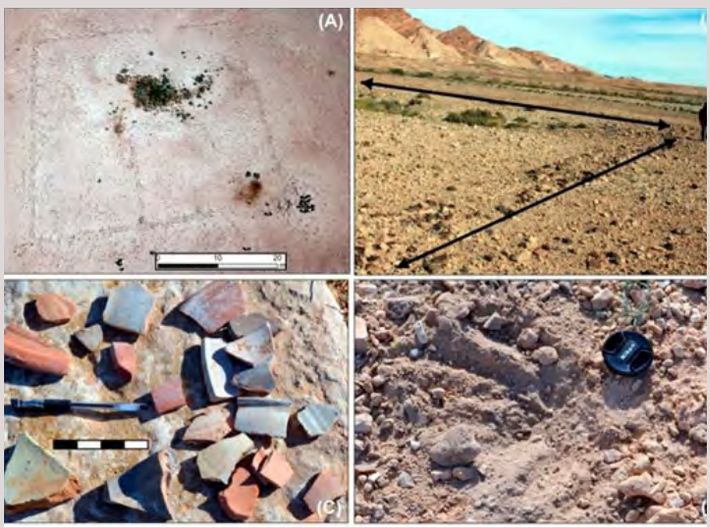


Figure 2: RF probability results. (A) Illustration of fortified detection sites. (B) Clustering of high- probability pixels in the area that show the detection structures of fortified sites. (C) Pan sharpened Pleiades imagery. Image was interpreted as signifying the existence of a fort hidden underground. © Nabil Bachagha

The search for new methodologies

The objective of this study is to develop an automated system that leverages deep learning to detect potential Roman-era archaeological sites in Tunisia using satellite imagery. The research is structured into three key phases: target detection, post-processing, and survey validation.

In the first phase, satellite imagery is segmented into patches and analyzed using the Faster R-CNN[5] algorithm to identify possible architectural remnants.

The post-processing phase refines these initial detections, aiming to reduce false positives and improve overall accuracy.

The final phase, survey validation, assesses the archaeological significance of detected sites through remote sensing-based surveys. By integrating deep learning, satellite imagery, and Global Navigation Satellite Systems (GNSS), this approach enables the discovery of previously undocumented Roman-era sites, offering new opportunities for archaeological investigation across the region.

The paper proposes a methodological and integrated framework to detect ancient archaeological sites in Tunisia via satellite remote sensing images. The study is divided by three consecutive steps:

1) primary detection via a deep-learning algorithm; 2) manual filtration of false positives; and 3) on-site verification. The accuracy and efficiency of archaeological site detection have witnessed a tremendous boost, as the two methods of highly advanced AI techniques and conventional field methods can be efficiently mediated through this hybrid strategy.

1. A. Agapiou, A. Vionis, and G. Papantoniou, "Detection of Archaeological Surface Ceramics Using Deep Learning Image-Based Methods and Very High-Resolution UAV Imageries," Land 10 (2021): 1365; H. A. Orengo et al., "Automated Detection of Archaeological Mounds Using Machine-Learning Classification of Multisensor and Multitemporal Satellite Data," Proceedings of the National Academy of Sciences of the United States of America 117 (2020): 18240–1850.

2. M. Euzennat, "Quatre années de recherches sur la frontière romaine en Tunisie méridionale," Comptes Rendus des Séances de l'Académie des Inscriptions et Belles-Lettres 116 (1972): 7–27; P. Trousset, "De la montagne au désert: limes et maîtrise de l'eau," Revue des mondes musulmans et de la Méditerranée 41 (1986): 90–115.

3. N. Bachagha, X. Wang, L. Luo, L. Li, H. Khatteli, and R. Lasaponara, "Remote Sensing and GIS Techniques for Reconstructing the Military Fort System on the Roman Boundary (Tunisian Section) and Identifying Archaeological Sites," Remote Sensing of Environment 236 (2020): 111418.

4. N. Bachagha et al., "On the Discovery of a Roman Fortified Site in Gafsa, Southern Tunisia, Based on High-Resolution X-Band Satellite Radar Data," Remote Sensing 14 (2022): 2128; N. Bachagha, A. Elnashar, M. Tababi, F. Souei, and W. Xu, "The Use of Machine Learning and Satellite Imagery to Detect Roman Fortified Sites: The Case Study of Blad Talh (Tunisia Section)," Applied Sciences 13 (2023): 2613; N. Bachagha, L. Luo, X. Wang, N. Masini, T. Moussa, H. Khatteli, and R. Lasaponara, "Mapping the Roman Water Supply System of the Wadi el Melah Valley in Gafsa, Tunisia, Using Remote Sensing," Sustainability 12 (2020): 567.

5. W. B. Verschoof-Van der Vaart and K. Lambers, "Learning to Look at LiDAR: The Use of R-CNN in the Automated Detection of Archaeological Objects in LiDAR Data from the Netherlands," Journal of Computer Applications in Archaeology 2 (2019): 31–40.

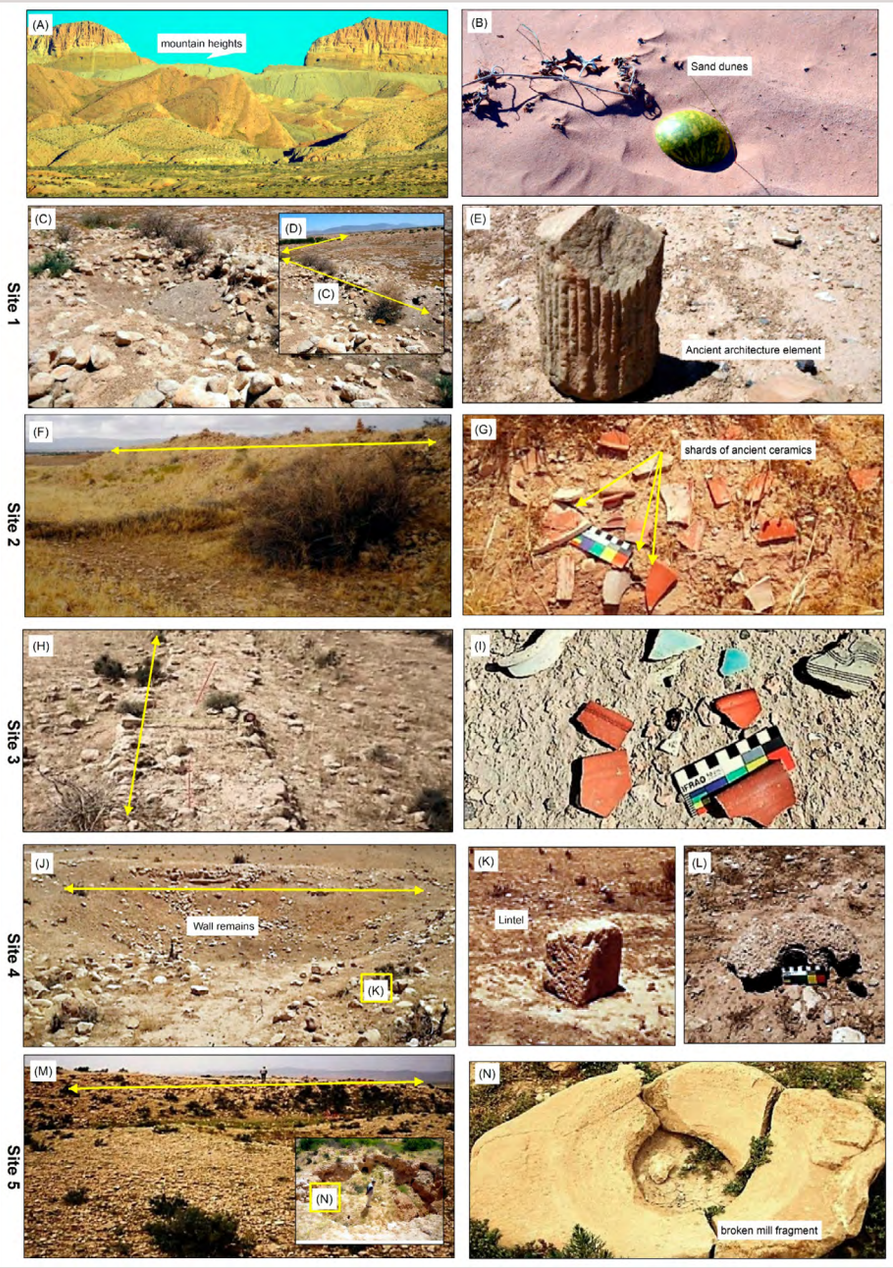


Figure 3. Magnified views of anomalies 1 to 5. (A,B) Landscape of the study area. (G,I,N,L) Shards of ancient ceramics. (E) Ancient Architectute element (K) Lintel photographed at the entrance to a fortress. (C,D,F,H,J,M) Field photos of wall remains. © Nabil Bachagha

Policy Recommendations

1. **Use transdisciplinary method in AI and archaeological remote sensing research.**The multifaceted challenge of the location of the ancient Roman fortified sites needs more than the technical skills; this challenge demands the combination of the archaeology, the geoinformatics, the computer science, and the historical geography. Transdisciplinary framework would not only promote joint work among these areas, but also induce development of new research methods that are unique to cultural, environmental, and spatial specifics of the region.

2. **Create a fusion of AI, archaeology, and heritage ethical skills through all academic programs and training.** It is important to develop high-level curricula, especially, graduate level, on AI technologies, to integrate them with archaeological theory, landscape heritage, ethical management of heritage, and related areas. Such programs would yield a new crop of scholars who would be able to do more than merely theorize about the development of machine learning models; instead, they would be able to interpret the history and culture of the models as well as what they may contribute to it.

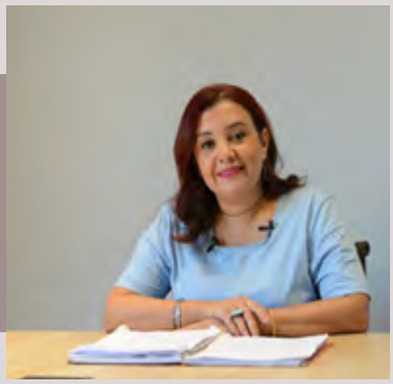
3. **Build sharing and socially responsibility archaeological data alongside local professionals.** North African Roman sites are mostly unchecked or unstudied. The establishment of the training datasets on the scale cannot be made without engaging the local historians, and archeologists as well as the national areas of heritage to guarantee the accuracy of the data received and the respect of the national cultural priorities. This form of cooperation reduces bias as well and adds context to AI outputs.

4. **Introduce an expert-in-the-loop system to train and validate AI models.**The characterization of sites should be continuously improved by incorporating feedback from archaeological professionals who possess knowledge of material culture, geomorphology, and site variability in the region. Field-based, iterative collaboration helps to instill interpretive nuance into the models, mitigate false positives, and enhance reliability in complex or challenging terrains.

5. **Acknowledge the shortcomings of AI models and make uncertainty explicit.** In addition to improving accuracy, AI systems must also be designed to recognize and communicate their limitations. Integrating uncertainty quantification or alerts into detection outputs can help researchers avoid misinterpretation. Such systems should indicate when a prediction is speculative—particularly in cases where verification is not possible due to a lack of supporting data—to prevent inflated results or overextended interpretive claims.

Artificial Intelligence meets Culture: Innovation at the crossroads of creativity and technology

© Riham Arram



Dr. Riham Arram

Chairwoman, iCulture for Creative Industries, Egypt.

Abstract

This paper is built on the author's presentation at the "Artificial Intelligence (AI) and Culture in the Arab region: Regional Vision from Cairo" workshop organized by the UNESCO Cairo Office on June 25, 2025. This paper will explore the hypothetical uses, applications, challenges, and future potential of AI in Egypt's cultural and creative sectors.

Artificial Intelligence (AI) is reshaping how states preserve, interpret, and celebrate their cultures. Cultural heritage and creative industries in Egypt, with its millennia-old legacy, is positioned to lead this digital transformation through a creative approach. From digitizing ancient manuscripts to co-creating art, AI offers groundbreaking tools yet also demanding thoughtful regulation and culturally sensitive design.



Figure 1: Bibliotheca Alexandrina © Riham Arram

VII

The use of AI in the preservation of Egypt's Cultural Legacy

There are several examples, such as the Project Revival in NMEC & the Egyptian Museum in Tahrir, Cairo, Egypt, that have actively endorsed the use of AI for heritage management. For instance, on the 122nd anniversary of Egyptian Museum, the Ministry of Tourism and Antiquities has announced to partner with Meta to launch an innovative augmented reality (AR) project called "Project Revival." This initiative shall allow visitors to experience ancient Egyptian artefacts in a virtual and engaging way. In addition to well-used tools in abovementioned applications, such as Google's cameras, laser scanning or technologies such as AR&VR that provide the physical and technical means to capture data, it is the integration of AI-powered software—ranging from deep learning for artifact analysis to digital restoration solutions—that enables Egyptian cultural institutions and creative professionals to not only preserve but also dynamically present and enhance the country's rich cultural heritage. These examples demonstrate how AI is intersecting with traditional fields, adding a new dimension to cultural research and creative production in Egypt. Thanks to AI-driven AR and VR tools, curators and the public can explore and reconstruct heritages through detailed 3D models without the necessity to access original artefacts.

The use of AI in cultural and creative industries

- "Music in the Age of Artificial Intelligence" Cairo Opera House (2024 & 2025)

Recognizing the significance of AI, the Cairo Opera House organized salons in June and December 2024, entitled "Music in the Age of Artificial Intelligence." These events convened composers, conservatory scholars, legal experts, and AI technologists to facilitate Egypt's evolving integration of AI in contemporary music composition, classification, its associated debate of intellectual property rights, and creative processes. A set of recommendations were proposed to restructure and enhance the application of AI in the field of music.

- AI-driven art, performance and film

In 2024, Cairo film festival hosted a performance showcasing AI-generated short film scripts and visuals, which reflected the rich Egyptian legacy. Choreographers also presented AI generated designs for stage lighting.

While it is important to note that it could never replace human creativity, AI-generated cultural content is enhancing and improving live performance and cultural artistic production.

Using AI for cultural expression helps to reinterpret, disseminate, and share cultural expressions in new forms. This opened a new domain for the 2005 UNESCO convention on cultural diversity to explore. Would AI-generated cultural content be considered contributing to cultural diversity? More policy dialogue is needed in this regard.

- Arabic Music Generation Research

A research team from the Egypt–Japan University of Science & Technology (E-JUST) and Alexandria University co-published "Arabic Music Classification and Generation using Deep Learning"[1] that applied convolutional neural networks (CNNs) on the Egyptian/classical pieces produced by local composers. The research also used CNN auto encoders to produce new music reminiscent of Egyptian classical music scales. Therefore, the study contributed to the development of creative industries in Egypt by creating one of the first AI systems for composer-level classification in Egyptian music. It also demonstrates the potential of AI-assisted creativity, such as composition support, music recommendation, and education.

AI in visual and architectural arts.

- AI and art design

Other individual initiatives used AI to model abstract Pharaonic & Mamluk motifs into futuristic architectural art, as showcased in international designs. For instance, the Cairo sketchers,[2] an initiative launched by Egyptian designer Hassan Ragab, reimagined Egyptian designs by applying computational creativity into heritage aesthetics.[3]

- iCulture for creative industries

The iCulture is a cultural innovation hub dedicated to promoting knowledge, art, and creativity through curated platforms and initiatives. It fosters cross-disciplinary engagement and public access to culture by designing programs that amplify heritage and creative expression. In its two platforms, iCCI (iCulture Creative Industries) and recently launched "Howeya" educational platform, iCulture provides a learning and networking hub for emerging talents and learners in the field ofhistory and archaeology. By integrating AI to Howeya platform, the Heritage online learning hub seeks to offer multilingual voiceover and audio versions of course materials through ElevenLAbs or Google TTS to support learners with visual impairments or low literacy. The main value of AI integration in educational platforms is to help reach a wider audience and support inclusivity for all learners. Richer engagement and personalized education are among the added values of using AI.

Opportunities and Challenges

- Addressing Cultural Bias in AI

Many AI models are trained on Western datasets and risk misinterpreting Arab or Islamic aesthetics. For instance, Islamic calligraphy might be labeled as "ornamental" rather than symbolic. Training AI on local datasets offers a promising solution to this challenge. The archives of the Museum of Islamic Art in Cairo are an excellent resource for this purpose.

- Balancing Innovation with Tradition

While AI can modernize heritage arts, it must respect cultural integrity and authenticity. Collaborations with artistic and heritage institutions—such as Egypt's Folk Art Authority, faculties of fine arts, and the Ministry of Culture—are essential to ensure that innovation honors tradition.

Recommendations

While encouraging the integration of AI into all cultural and creative activities, it is crucial to emphasize that human expertise remains central. AI should be used as a tool—not as a replacement—for human creativity. All AI-generated content must be validated by human experts. AI presents unprecedented opportunities to preserve, reimagine, and share Egypt's creative richness; however, its successful application depends on several key factors:

- **Ethical governance:** Defining authorship, intellectual property rights, and ethical standards is fundamental.
- **Localization:** Training AI on Egyptian and Arab datasets is essential to ensure cultural relevance and accuracy.
- **Collaboration:** Cultural and creative productions should result from collaboration between AI and human experts. It is risky to accept cultural outputs generated solely by AI without human validation.

1. Mohamed Elshaarawi, Ashrakat Saeed, Mariam Sheta, Abdelrahman Said, Asem Bakr, Omar Bahaa, and Walid Gomaa, "Arabic Music Classification and Generation Using Deep Learning," Egypt-Japan University of Science and Technology, Alexandria, Egypt (2024): 1, https://doi.org/10.48550/arXiv.2410.19719.

2. Naser Nader Ibrahim, "Amazing Architecture," Amazing Architecture, accessed July 10, 2025, https://amazingarchitecture.com/.

3. Liliana Alvarez, "The Cairo Sketches by Hassan Ragab," Amazing Architecture, accessed July 10, 2025, https://amazingarchitecture.com/futuristic/the-cairo-sketches-by-hassan-ragab.

Protecting Sudanese Cultural Heritage Through Innovation and Artificial Intelligence: Sudan AI Initiative

© Emad Blake



Mr. Emad Blake

Writer and Intellectual, United Kingdom.

Abstract

Sudanese culture is rich and diverse, reflecting a vast land with multi-ethnic traditions. Despite the ongoing war in the country, the current era of artificial intelligence presents a historic opportunity to shape the future. This digital revolution can be harnessed to support Sudan's multifaceted cultural heritage—be it oral, practiced traditions, language diversity, storytelling, or modern and classical literary arts. It also includes aesthetic and functional arts such as architecture, photography, and visual arts. These cultural treasures offer a wide array of opportunities.[1]

From this vision, the idea of the Sudan AI cultural initiative emerged: to leverage AI to preserve and develop this richness and reimagine it in ways that make culture a soft power for ending conflict and building a better life for the Sudanese people. With deep conviction that culture holds solutions to the country's crises—beyond politics and economics—this initiative seeks to transform how technology is perceived in Sudan. It connects with global transformation and aims to make culture a true vehicle for action, highlighting Sudan's image regionally and globally.

VII

Introduction

The initiative, presented at the "Artificial Intelligence and Culture in the Arab Region: Regional Vision from Cairo" seminar held on 25 June 2025 by UNESCO Cairo Office, focuses on using AI to build a national cultural archive as a first step. This archive will be analysed, critiqued, and used to inform better visions for life in Sudan. It encompasses languages, literature, images, architecture, daily life practices, and cultural traditions. The project uses AI technologies such as computer vision, natural language processing, generative models, and knowledge deconstruction tools to digitally document, reconstruct, and revive cultural elements. It also aims to build interactive virtual museums and living catalogues—physically or digitally—culminating in a national digital archive that serves future generations.

Project Pillars

The initiative consists of four primary pillars integrating human and machine efforts within the cultural space:

- Culture Pillar: Celebrates ethnic diversity and artistic expressions in Sudan, incorporating oral, written, and visual cultural knowledge.
- Digital Archive: Encourages public contributions to build an open, inclusive knowledge base of Sudan's cultural sources.
- AI Integration: Utilizes machine learning to organize, summarize, and reproduce historical and cultural content in accessible and engaging ways.
- Collaboration: Builds partnerships with communities, creators, and government institutions to ensure comprehensive documentation. Everyone, regardless of age, education, or background, can contribute to the project's progress.

Project Domains

The initiative spans four vital areas of Sudanese heritage and culture:

- **Texts and Writings:** Digitizing literature, manuscripts, and books with AI assistance in summarization, translation, and indexing. It also aims to build a digital library of Sudanese publications, both historical and contemporary.

- **Architecture:** Digitally reconstructing heritage sites by using 3D modelling to establish virtual museums. It covers all architectural styles across Sudan—from Beja in the East, Nubians in the North, Nile structures, to Christian and Islamic models—reflecting the country's environmental and cultural diversity.[3]

- **Images and Daily Life:** Documenting Sudanese rituals and occasions (e.g., weddings, markets, funerals) through videos, photos, and audio. Many such traditions are vanishing or already extinct, necessitating urgent preservation.

- **Oral Culture and Dialects:** This vast field includes Sudanese songs—where the people have a profound love for music—local languages and dialects, proverbs, and traditional storytelling. AI can be trained to understand and analyse such texts, supporting studies in this field.

Main Initiatives

From these domains emerge four key initiatives that serve as the project's core:

- **Sudanese Digital Library or Sudanese House of E-Books:** A digital repository for literature, manuscripts, documents, and written heritage.

- **Sudanese Dimensions Project:** Focused on reconstructing architecture and heritage landmarks virtually, represented through museums and visual simulations.

- **Sudan 360 Project:** A panoramic, immersive showcase of Sudanese life—covering markets, riverbanks, weddings, funerals, and more.

- **Sudanese AI Research Program or AI4Research:**Trains systems to understand local dialects and cultural contexts, analysing oral and written heritage like songs, narratives, and folklore.

Technological Innovation

AI here is not just a tool—it is a bridge between past and future, enabling previously unimaginable capabilities for documentation, analysis, and envisioning a better future. The innovation draws from four main technological elements:

- **Computer Vision:** Analyses images, symbols, and cultural scenes to generate insightful knowledge rather than just visuals.
- **Natural Language Processing (NLP):** Helps understand, analyse, and translate Sudanese texts, giving them new dimensions beyond conventional analysis methods.
- **Generative AI:** Reproduces lost or fragmented cultural elements, restoring their presence in today's cultural discourse.
- **Virtual and Augmented Reality or Culture visually - VR/AR experiences:** Creates interactive experiences for museums and imaginative, educational journeys through time and space.

Challenges and Opportunities:

While ambitious and future-focused, the initiative must acknowledge the current challenges:

- **Limited Digital Infrastructure:** Requires significant efforts from both public and private sectors.

1. Emad Blake, The Evil Cocoon: A Cultural Introduction to Sudan's Contemporary Crises (Juba, South Sudan: Al-Mawsua Al-Sagheera, 2024).

2. All images, logos, and visual illustrations presented in this article were generated using artificial intelligence tools. These visual elements are conceptual and were created specifically for illustrative purposes within the framework of the Sudan AI Cultural Heritage Initiative. They do not depict real individuals or events and are intended to support the narrative and cultural vision of the project.

3. Architecture in the World: Sudan, A Journey Through the Varied Constructions of the African Country, a Voyage Through Its Millenary History, Amusement Logic, 2025, accessed July 14, 2025, https://amusementlogic.com/general-news/architecture-in-the-world-sudan/.

4. UNESCO, "Towards a National Strategy for the Use of AI and IT in the Educational System," project no. 3210183031, accessed July 14, 2025, UNESCO CORE, https://core.unesco.org/en/project/3210183031.

- **Authenticity and Classification:** Lack of knowledge centers in Sudan means building data from scratch, requiring rigorous curation.

- **Funding:** Financial sustainability is difficult. Government resources are limited and prioritized elsewhere; the private sector's support is minimal, and international funding is insufficient. Creative solutions are needed for long-term success.

Despite this, the project offers great promise:

- **Youth Training:** Prepares younger generations in digital skills and cultural understanding to support societal development.[4]

- **Community Documentation:** Encourages creativity, critical thinking, and cultural talent development through public contributions.

- **International Collaboration:** Opens avenues for cooperation with global bodies like UNESCO for cultural advancement.

A New Society

Above all, the biggest opportunity lies in building a new cultural consciousness rooted in shared knowledge and AI-enhanced creativity. The slogan becomes:

"The community is the foundation."

- **Local Governments:** To support policy, legal, and logistical frameworks.

- **Civil Society:** For awareness, engagement, and driving grassroots participation.

- **Cultural Producers**: Writers, artists, photographers contributing creatively.

- **Community Volunteers:** To collect local data and document traditions, especially disappearing ones.

Policy Recommendations for UNESCO:

- Digital Mapping and Archiving: Support initiatives that use AI tools to digitize and map Sudan's tangible and intangible cultural heritage — including endangered archaeological sites, oral traditions, and indigenous knowledge — to prevent permanent loss due to conflict or environmental degradation.

- Language and Oral History Preservation: Promote the use of natural language processing (NLP) to document and preserve Sudanese local dialects, oral poetry, and storytelling traditions, particularly among marginalized and nomadic communities.

- AI for Cultural Education and Public Engagement: Develop AI-driven educational platforms, virtual museums, and mobile apps to make Sudanese heritage more accessible to younger generations and diaspora communities, encouraging cultural pride and continuity.

- Capacity Building and Ethical AI Use: Partner with local institutions to build capacity in AI technologies and digital humanities, ensuring that Sudanese professionals lead the development of ethical AI applications tailored to their cultural context and priorities

Conclusion:

It is said a journey of a thousand miles begins with a single step. This Sudanese AI Cultural Heritage Initiative is not just a tech project—it is a national movement for change, rebuilding cultural and creative thought for a peaceful future.

In pursuing it, we ask:
Can we use the tools of tomorrow to preserve the soul of yesterday?
The answer—with cooperation and a holistic vision—is yes.Preserving heritage is not merely a cultural task. It is a pathway to identity, resilience, and global contribution.

Artificial Intelligence in the Arab Creative Sector: Opportunities and Challenges

© Noha Mellor



Dr. Noha Mellor

College of Communication, University of Sharjah, United Arab Emirates.

Abstract

This paper examines the evolving role of artificial intelligence (AI) in the Arab creative sector, highlighting the opportunities, challenges, and regional disparities. While rich Gulf countries, like the UAE, lead regional AI innovation and adoption, progress in other states has been uneven due to infrastructural and educational disparities across Arab states. Surveys indicate that Middle Eastern professionals are relatively optimistic about the impact of AI, yet organizational strategies and upskilling efforts remain to match with individual-level enthusiasm. This situation highlights an active yet understudied domain, which requires more extensive research to address the sociotechnical, cultural, and ethical challenges that Arab cultural sectors face during their rapid digital transformation.

Among the recommendations are to map the applications of AI across creative sub-sectors, to invest in research on adoption barriers, to support lifelong learning, and to foster local content creation. The paper argues that AI's cultural and ethical implications demand coordinated and inclusive policies and cross-sector collaboration to ensure the Arab world shapes its own digital future, fostering originality, innovation, and local authorship.

VII

Introduction

In recent years, artificial intelligence (AI) has emerged as a transformative force, reshaping creative industries across the world. From journalism to film, from advertising to music production, AI is not just enhancing workflows—it's redefining creativity itself. The Arab world, with its youthful population and growing digital ambitions, is well-positioned to capitalize on these changes. Yet, the path forward is not without friction. If the region is to become a genuine producer—not just a consumer—of technological futures, it must urgently bridge the gap between visionary policy and on-the-ground implementation.

In 2018, the Arab League established the Arab Federation for Digital Economy, followed by the adoption of the "Arab Digital Economy Vision" in 2022.[1] These initiatives have demonstrated a strong commitment toward regional digital integration across the region, but political instability, vast disparities in infrastructure, and competing national agendas have slowed down substantial advancement.[2] What was envisioned as a shared strategy has fragmented into separate national digital projects, which serve individual countries' goals instead of promoting regional coherence.

AI in the Arab workplace

The current discussion about AI in the Arab region tends to focus on its ability to boost efficiency and productivity, which creates a sense of optimism about its positive effects. For instance, a recent survey [3] indicates some regional differences in attitudes toward generative AI, with professionals in the Middle East expressing the least concern about AI's impact on jobs, compared to those in Europe and North America.

On the other hand, another survey[4] examines attitudes about the impact of AI among media professionals in Egypt, France, and the United Arab Emirates (UAE), and it shows shared worries about AI, particularly in relation to information verification.

Generally, the Gulf countries, especially the UAE, have emerged as a frontrunner, positioning itself as a regional hub for innovation, particularly in the field of AI. In fact, the UAE leads the region in subscriptions to the online learning platform Coursera,[5] particularly for courses in AI skills and business skills, not to mention its leading position in the AI maturity index.[6]

But ambition alone is not enough. For example, a more recent study[7] conducted through interviews and a survey among selected media professionals in the UAE, shows mixed feelings about AI adoption in the creative sector.

At the surface level, there is clear excitement about AI's potential to enhance creativity and increase productivity. Professionals across the creative industries are experimenting with generative tools—from ChatGPT for idea generation, to AI-powered editing software and automated voiceovers.

However, this positive attitude conceals an underlying tension, with the fact that many creatives actively work on their skills development even when their organizations lack clear training strategies. Creative professionals often face organizational uncertainty regarding strategic direction, and therefore, organizations need to establish clear guidelines about which AI tools matter, what skills are needed, and how to properly implement them in specific roles.

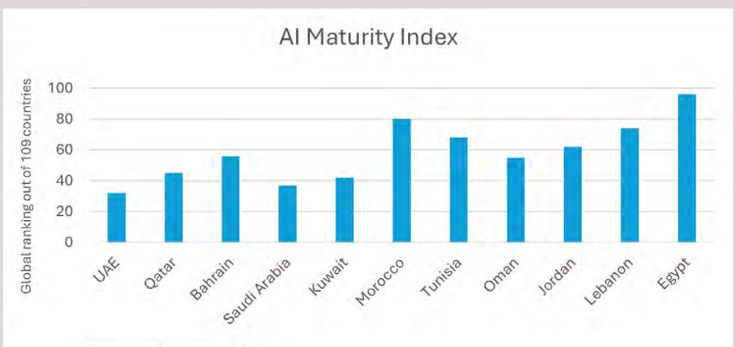


Figure 1: AI maturity index in selected Arab countries. © Noha Mellor

Currently, there is a disconnect between national ambition and organizational execution that poses significant risks, chief among them is the emergence of a new digital divide, not between those with or without internet access, but between those with or without AI fluency.

In the cultural sector that is already marked by inequality between freelancers and salaried staff, the uncoordinated introduction of AI could exacerbate existing hierarchies. Those with time, money, and technical confidence will thrive, while others may find themselves sidelined.

Moreover, as the number of freelancers and expat creatives rises in the UAE and the entire GCC region, it is natural for expatriate workers to feel growing anxiety about job displacement.[8] AI's ability to automate tasks once performed by entire teams has sparked concerns about redundancy.

These fears are legitimate, and the solution is a strategic adaptation. Rather than framing AI as a threat, organizations must treat it as an opportunity for structured transformation, beginning with AI skills' training that aligns with actual roles and evolving industry demands.[9]

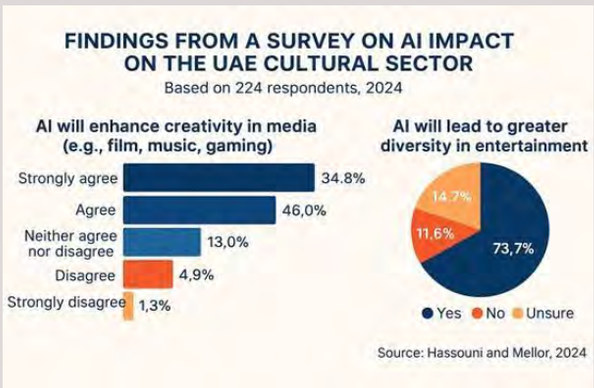


Figure 2: Attitudes toward AI in the creative sector in the UAE. © Noha Mellor

There is also a need for alignment that extends beyond the workplace to the region's higher education systems, which are diverse in terms of ranking and capacity.While the Gulf states have invested heavily in university infrastructure, including international university branches, innovation parks, and AI institutes, the quality of education and its responsiveness to labor market needs remain uneven.

Many graduates enter the job market without the skills required for AI-driven roles, resulting in a general mismatch between what is taught and what is needed.[12] Thus, despite the proliferation of international universities and campuses across the Arab region, particularly in the GCC states, there is an acute need for regional integration to ensure that such an internationalization strategy yields tangible outcomes and a solid foundation for universities throughout the region.



Figure 3: Surge in freelancing in the MENA. © Noha Mellor[10]



Figure 4: Total number of international branch campuses in the Arab region. © Noha Mellor[11]

Policy Recommendations

Based on the above, the following actions are recommended:

1. Mapping out the use of AI in the cultural sector in each Arab state

Arab states should focus on collaboratively mapping the integration and application of AI within their creative sectors. This initiative should not only identify disparities between different countries but also highlight the variations and gaps that exist within sub-sectors of the creative industry, such as visual arts, music, film, and digital media.

2. Investing in new research about perception, adoption, and obstacles among creatives

Research on AI and the Arab creative sector is still in its early stages, highlighting the need for more in-depth analysis. As Arab media rapidly undergoes digital transformation, understanding the sociotechnical, cultural, and ethical impacts of AI becomes crucial through more commissioned research.

3. Reimagining education itself

Arab universities need to shift their focus from traditional credentials to skills-based learning. The universities need to establish stronger ties with the creative industry while developing adaptable curricula and integrating AI fluency into all academic disciplines. Education, therefore, must not be a siloed stage of life, but a lifelong and career-spanning process, especially in the fast-moving creative sector.

4. Capitalizing on human capital

The Arab region has the world's youngest population, with 60% of its population under the age of 30.[13] However, it also has one of the highest youth unemployment rates. In places like Egypt, Jordan, and Iraq, where formal employment opportunities are limited, young people are turning to the digital gig economy, offering design, editing, and content services to global clients. These young freelancers are the beating heart of the region's creative future—but they often lack institutional support, access to training, and recognition.[14]

1. League of Arab States, Arab Digital Economy Vision: Towards a Sustainable Inclusive and Secure Digital Future(January 2020), https://www.arab-digital-economy.org/09.pdf.

2. Noha Mellor, Arab Digital Journalism (London: Routledge, 2022).

3. Boston Consulting Group, "Middle East Workers among the Least Worried about Generative AI," Consultancy-me.com, July 13, 2023, https://www.consultancy-me.com/news/7012/middle-east-workers-among-the-least-worried-about-generative-ai.

4. Mohammad N. Al Adwan, Maha El Hajji, and Heba Fayez, "Future Anxiety among Media Professionals and Its Relationship to Utilizing Artificial Intelligence Techniques: The Case of Egypt, France, and UAE," Online Journal of Communication and Media Technologies 14, no. 2 (2024): e202425, https://doi.org/10.30935/ojcmt/14426.

5. Coursera, Global Skills Report: MENA Region (2025), https://www.coursera.org/skills-reports/global.

6. AI maturity is calculated by considering the number of AI courses, AI publications, and the AI preparedness index from the IMF, which assesses a country's readiness to leverage AI (see Coursera, 2025). See also Cody Combs, "UAE Learners Will Prioritise AI in 2025, the Report Says," The National, December 18, 2024, https://www.thenationalnews.com/future/technology/2024/12/18/uae-ai-courses-coursera/.

7. Asma Hassouni and Noha Mellor, "Perceptions of AI Integration in the UAE's Creative Sector," Informatics 11, no. 4 (2024): 82, https://doi.org/10.3390/informatics11040082.

8. Noha Mellor, "Navigating Precarity: Freelancers in Dubai's Creative Economy," Journal of Creative Communications(2025), https://doi.org/10.1177/09732586251337571.

9. Hassouni and Mellor, "Perceptions of AI Integration in the UAE's Creative Sector." (Référence abrégée du n°7)

10. Investopia, The Gig Economy 2.0: Challenges and Opportunities in the MENA Region. White paper, 2024, https://investopia.ae/whitepaper/the-gig-economy-2-0-challenges-and-opportunities-in-the-mena-region.

Meanwhile, the Gulf's creative economy is booming with massive investments in museums, festivals, production studios, and cultural hubs. There is a need for intentional investment in human capital for skills training and joint content production.

5. Investing in more local content

Only 3% of global online content is in Arabic, despite the region having over 420 million Arabic speakers.[15] AI offers the tools to change this—through automated translation, content generation, and personalization—but tools alone are insufficient. We need collaboration across public, private, and academic sectors to co-create a truly Arab AI future.

6. Localizing technology

Crucially, developing a future-ready creative sector also demands serious investment in AI regulation and Arab data governance. At present, many AI tools used are trained on datasets that do not reflect Arab societies, cultures, or languages, which limits the effectiveness of these tools in Arabic contexts while risking reinforcing cultural biases, inaccuracies, and erasures. If AI-generated content becomes the norm, but that content is based on non-Arab norms, then the region risks digital self-alienation, producing stories, visuals, and voices that feel "off" to their local audiences.

7. Introducing inclusive cultural policies

The region also needs to develop policies that prioritize inclusive AI training based on locally sourced data. It therefore needs to fund Arabic language corpora, alongside digital archiving of regional documents, and provide incentives for local content producers. Establishing regulatory frameworks should be a priority to create transparent AI systems for education, media, and arts applications. Otherwise, the Arab region will continue to depend on imported algorithms, which represent different perspectives and operational priorities.

Conclusion

Ultimately, AI is not just a technical challenge, but a cultural one, as it forces us to ask: Who gets to create? Who gets to be visible? Who gets to shape the future? The Arab region has the talent, as well as the ambition.

What it needs now is strategic coordination across sectors, across countries, and across communities. If we can achieve that, then the future of AI in the Arab creative sector will not be a story of catch-up or dependency. It will be a story of originality, innovation, and self-authorship.

11. Burton Bollag, "International Branch Campuses Spread in Mideast amid Concerns about Costs, Impact," Al-Fanar, December 31, 2024, https://www.al-fanarmedia.org/2024/12/international-branch-campuses-spread-in-mideast-amid-concerns-about-costs-impact/.

12. Noha Mellor, "Using AI to Develop Capabilities in Arab Universities," in Artificial Intelligence in Education: The Power and Dangers of ChatGPT in the Classroom, ed. A. Al-Marzouqi et al. (Cham: Springer, 2024), https://link.springer.com/chapter/10.1007/978-3-031-52280-2_16.

13. Arab Youth Centre, Arab Youth Technology Fellowship, 2nd ed. (Abu Dhabi: Arab Youth Centre, 2020), https://technology.arabyouthcenter.org/static/AYC_WHY5Research%20AI_Report%2029-08-2022%20EN.pdf.

14. Mellor, "Navigating Precarity: Freelancers in Dubai's Creative Economy." (Référence abrégée du n°8)

15. Invest in Dubai, "Growing Demand for Arabic Content," accessed July 2025, https://www.investindubai.gov.ae/en/insights-and-resources/news-insights/design-media-entertainment-guide/growing-demand-arabic-content.

Generative Pictographic Language: Rethinking Ancient Scripts through Artificial Intelligence

© Haytham Nawar



Dr. Haytham Nawar

Associate Professor in Design, American University in Cairo, Egypt.

Abstract

This essay explores the intersection of ancient visual languages and artificial intelligence through the research project Generative Pictographic Language. Rooted in historical writing systems and proto-writing traditions such as Egyptian hieroglyphs, Sumerian cuneiform, and North African scriptural forms, the project investigates the potential of machine learning to generate new pictographic symbols by synthesizing data from diverse ancient scripts. Drawing on over 180 vector-based writing systems and employing tools such as StyleGAN, the study explores the aesthetic, semiotic, and cultural implications of machine-generated characters.

These computationally derived glyphs are not only visual artefacts but also metaphors for a universal visual language, one that transcends cultural and temporal boundaries while respecting the particularities of civilizational identity. The essay reflects the broader cultural and epistemological implications of delegating the generative act to machines and offers critical insights into future research trajectories. Recommendations include the integration of AI tools in deciphering and reconstructing lost or partially understood scripts, particularly at sites with rich archaeological heritage, such as Saudi Arabia, Egypt, and Algeria. By blending art, computation, and historical inquiry, Generative Pictographic Language proposes a radical new method for understanding the evolution and future potential of human visual communication.

VII

Introduction

From the earliest cave markings to the development of modern alphabets, the history of writing is a history of visual innovation. At its core, the development of script represents humanity's attempt to visualise thought, communicate across time, and preserve knowledge. In the context of a digital and post-human era, this essay introduces the project Generative Pictographic Language, an artistic and research-based investigation into the aesthetic and cultural significance of ancient writing systems when interpreted through the lens of artificial intelligence.

The project revisits early pictographic traditions using computational tools, inviting reflection on the possibility of a universal visual language generated not by humans alone, but in collaboration with machines. This hybrid creative method not only unearths deep visual genealogies but also opens new pathways for design, heritage interpretation, and speculative semiotics.

Revisiting Proto-Writing and the Origins of Visual Language

Visual communication has long been the cornerstone of human civilisation. From early cave carvings and petroglyphs to sophisticated writing systems, humanity's pursuit to visualise language has evolved in tandem with its cultural and technological development. In this context, the project Generative Pictographic Language serves as a bridge between ancient semiotics and contemporary computation, asking a fundamental question: Can a machine, trained on humanity's oldest scripts, generate a new universal visual language?

The earliest known writing systems—pictographs etched on cave walls—date back between 27,000 and 40,000 years. These were proto-writing systems, grounded not in phonetic representation but in ideographic and symbolic expression.

They relied on the viewer's interpretative capacity and cultural context, rather than syntactic structure. As Adrian Frutiger observed, such images were "an early attempt to visualise language and make a record of linguistic discourse." Later developments, particularly in Ancient Egypt and Mesopotamia, elaborated these systems into formalised scripts. The rebus principle—where symbols represent phonetic sounds rather than objects—further deepened this transition from image to language.[1]

Machine Learning and the Generation of New Glyphs

The Generative Pictographic Language project adopts this visual tradition as a starting point and rethinks it through the lens of machine learning. At its core, the project leverages algorithms to analyse and synthesise data from a vast dataset of historical scripts—including Arabic, Coptic, Tangut, Hieroglyphs, Cuneiform, and Mayan glyphs, among others.

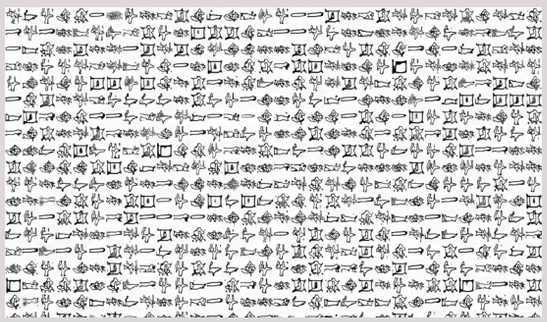


Figure 1: Screenshot of StyleGAN training output at various stages. © Haytham Nawar

The process uses StyleGAN, a generative adversarial network architecture, modified to accommodate visual complexity and symbolic variation.

The project was implemented using Unicode and Omniglot datasets, which provided standardised and wide-ranging representations of global scripts



Figure 2: Screenshot of StyleGAN training output at various stages. © Haytham Nawar

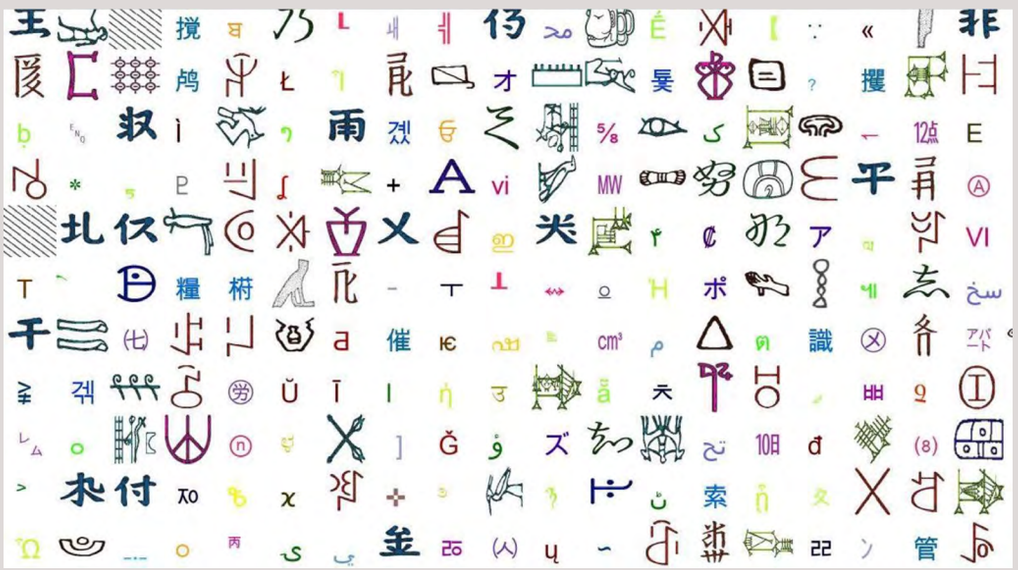


Figure 3: Screenshot of StyleGAN training output at various stages. © Haytham Nawar

Two core methodologies structured the project

The first involved mixing characters from various scripts, enabling the machine to identify cross-scriptual visual relationships. The second approach restricted input to characters from individual scripts. The latter strategy proved more aesthetically and conceptually compelling, as it allowed the generated characters to retain the essence of their original civilisation. In doing so, the machine became a curator of cultural heritage, offering glyphs that bore the trace of both human and machinic agency.[2]

The Aesthetic and Cultural Logic of Machine-Generated Scripts

Unlike human-generated designs, these machine-made scripts are devoid of conscious bias. Their objectivity—though shaped by the limitations of training data and algorithmic design—offers a unique lens through which to interpret the visual DNA of global civilisations. In this context, the machine is not merely a tool but a co-creator. The resulting glyphs become speculative artefacts—situated between past and future, history and possibility.



Fig 4: 3D-printed artefact based on machine-generated script-Hieroglyphs.
© Haytham Nawar

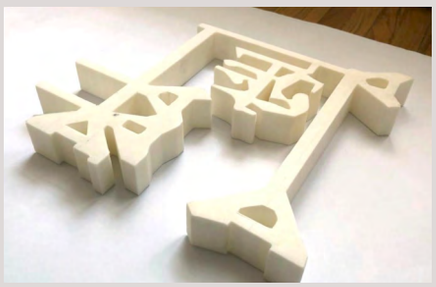


Figure 5: 3D-printed artefact based on machine-generated script-Cuneiform.
© Haytham Nawar

This computationally driven inquiry directly relates to my broader research, as outlined in The Language of Tomorrow, where I advocate for a multicultural visual communication system that is attuned to the needs of a global, post-human society. In both projects, the question persists: How can we design communication systems that are inclusive, non-linear, and capable of honouring cultural specificity while advancing universal intelligibility? [3]

Recommendations

To further develop Generative Pictographic Language and align with the objectives of future academic webinars and exhibitions, the following recommendations are proposed:

1. Regional AI Training Modules: Develop site-specific AI models focused on under-studied ancient scripts from Ancient rock art, which can be found in Saudi Arabia, Algeria, and Egypt, offering glimpses into the lives and cultures of past civilizations. In Saudi Arabia, sites such as Jubbah in the Hail region feature petroglyphs depicting animals, hunting scenes, and human figures from various historical periods, some of which date back over 12,000 years. Algeria's Tassili n'Ajjer plateau boasts a vast collection of prehistoric rock art, estimated to be approximately 10,000 to 11,000 years old. Egypt's ancient art includes hieroglyphs, rock carvings, and painted ceramics, with complex carvings dating back to 4000 BCE.

1. Adrian Frutiger, Signs and Symbols: Their Design and Meaning (Cham: ABC Verlag, 1980).

2. Geoffrey Sampson, Writing Systems: A Linguistic Introduction (Stanford: Stanford University Press, 1985).

3. Unicode Consortium, Unicode Home Page, accessed July 13, 2025, https://www.unicode.org/; Omniglot, the Online Encyclopedia of Writing Systems & Languages, accessed July 13, 2025, https://www.omniglot.com/ ; Haytham Nawar, The Language of Tomorrow: Towards a Multicultural Visual Communication System in a Post-Human Era (Bristol: Intellect Books, 2020).



Fig 6: Installation view from the exhibition 2021 Saudi National Museum Riyadh
© Haytham Nawar

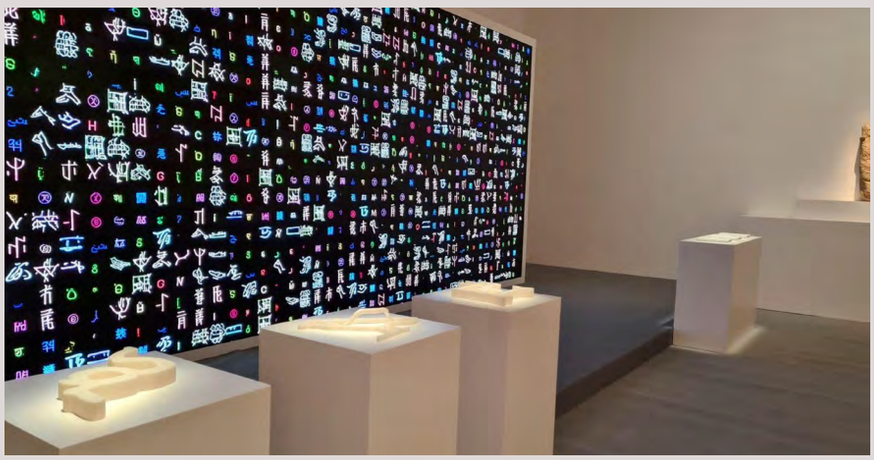


Fig 7: Installation view from the exhibition 2021 Saudi National Museum Riyadh
© Haytham Nawar

2. **Cross-Disciplinary Collaborations:** Partner with archaeologists, linguists, epigraphists, and digital humanists to create hybrid research teams. Such collaboration would ensure historical accuracy and foster broader interpretative frameworks, facilitating both scientific and artistic engagement.

3. **Open-Source Frameworks and Databases:** Release the training datasets and GAN architecture as open-source tools. This would enable other artists, scholars, and developers to expand on the work and encourage global contributions to the pictographic archive.

4. **Integration with Natural Language Processing (NLP):** Future iterations could explore the correlation between generated symbols and semantic meaning by integrating NLP models. This would facilitate basic "reading" of the generated script, potentially transforming the output from pure aesthetic forms into legible language prototypes.

Develop new immersive installations or AR experiences for educational institutions. These could present real-time script generation or allow users to "write" messages using the generative system, thereby fostering public engagement with AI and ancient cultures.

Conclusion

In sum, Generative Pictographic Language challenges the historical linearity of writing systems by proposing a speculative loop: a return to image-based language via AI, informed by millennia of visual experimentation. It offers a new lens for interrogating not just how we wrote, but how we might write again.



Fig 8: The Language of Tomorrow publication book cover © Haytham Nawar

Teaching the History of Islamic Art and Architecture in the time of AI: Challenges and Opportunities

© Noha Abou-Khatwa



Dr. Noha Abou-Khatwa

Assistant Professor of Islamic Art and Architecture, The American University in Cairo, Egypt.

Abstract

Teaching the history of Islamic art and architecture in the age of artificial intelligence (AI) has brought about fast changing opportunities and challenges to teachers everywhere. We all found ourselves in a nascent leaning space; whether we like it or not we had to be educated on the inevitable use of new technologies, their shortcomings and the ethical applications in our classroom. This is why my initial engagement with AI in the classroom was characterized by apprehension and resistance. This resistance led to my banning of the usage of AI when asking students to deliver reflection papers on articles and monuments. Notwithstanding this prohibition of AI usage, I was flooded with student submissions that appeared formulaic, lacked proper analysis and critical engagement (Fig. 1), on account of the improper use of AI. The experience was dismaying to say the least.

the prayer space(sahn). The sensation of the difference between the outer and inner experience was really unique. I was especially impressed by its historical significance, apparent in every detail of the structure. The inner courtyard created a sense of tranquility. The expansive wood doors conveyed a sense of richness and magnificence. The mosque conveyed peacefulness due to the harmony and balance between calligraphy and geometric patterns present . The architectural aspects I enjoyed most were the pointed arches, stucco decorations(got its name from internet), the design of the columns(as shown in the below picture), and the parapet design that look like crenellations. I

Fig 1: Sample student personal reflection on a mosque we visited. The highlighted parts are found in other reflections denoting an AI generated text.
© Noha Abou-Khatwa

VII

A significant shift in perspective occurred to me last year when the Center for Learning and Teaching at The American University in Cairo engaged us as educators with the technicalities and meaning of AI usage. Several workshops and talks targeted the 'why' and 'how' behind such technologies. Their sustained support enabled my perspective to shift from a prohibitive one to one of a deep appreciation of the pedagogical value of adopting a more integrative approach. One that acknowledges the inevitability of AI while fostering the necessity to train students to become critical and responsible, especially since they had to be constantly reminded that they are the authors of their academic productions and as such they are responsible for the originality and integrity of this work. We had to focus more on the meaning of 'authorship' when we taught.

Having removed the fear and prohibition enabled an open conversation with students. I had earnest conversations with them seeking their help to enable me to understand why and how they use AI. They were eager and happy to help! I was able to learn that they use it to:

- Brainstorm research questions
- Proofing and grammar correction
- Summarizing or paraphrasing content of articles
- Synthesizing research from multiple sources
- Writing parts of an article

In addition to my own pedagogical goals in teaching Islamic art history, these answers aided me in focusing on my efforts towards certain issues. I had to start with stressing the importance of 'authorship' as mentioned earlier. I had to calmly and methodically explain why it is unethical to have AI write parts of essays or articles on our behalf, or to have it paraphrase someone else's work without proper citation. They needed to understand why such activities fall under the umbrella of cheating. They also needed to learn the limitations of AI.

Accordingly, I began to devise assignments and activities that challenge and use AI. In an introductory course on Islamic architecture, I assigned students an AI-generated PowerPoint presentation on the theme of monumentality in Islamic architecture. Students were provided with a scholarly article on the topic and instructed to revise the presentation, correct inaccuracies, verify the claims made in it as well as the images used, based on the article I assigned them.[1]

Meanwhile, they were permitted to retain the visual design and structural outline provided by AI. In other words, they were assigned to deconstruct what was provided by AI and to come up with their original work using ideas that were provided to them by the AI in question. Pedagogically this exercise was beneficial for two reasons: first, it allowed students to recognize the limitations of AI while learning how to use its framework effectively. Second, it prompted them to engage with an article I routinely assign but that is often overlooked– it got them to read!

Like all the subfields of art history, Islamic art history is a discipline that is heavily reliant on cultivating visual literacy and memory. Students are instructed to train and strengthen their visual memories, a skill that has become increasingly challenging due to the overreliance on phone apps and the widespread habit of passive scrolling. In the hopes of cultivating this memory I devised an in-class activity where students, working in groups, are provided with images of monuments they never studied.

However, these monuments belong to dynastic styles they are familiar with, having studied other buildings from the same geopolitical areas. They are then instructed to use AI to help identify these buildings. Students then compare how quickly they can recognize the buildings using their trained visual memory versus relying on AI to identify the images. This exercise encourages reflection on the effectiveness of their memory skills, helping them to appreciate the necessity of garnering these skills, and how AI can be helpful as a supporting tool.

AI can also serve as a tool to assess the depth of student's understanding of the art historical context of a building or an artefact, thus offering insights into how well they processed the knowledge imparted onto them. Certain AI bots are able to create objects of art or monuments representing specific dynastic styles when prompted to do so. I have incorporated this capability into another exercise, where students are asked to analyze AI-generated images without being informed of the original prompt. Their task is identifying the style and provenance of each building or object, explaining the visual details and historical cues that helped them reach their conclusions. After I inform them of the prompt, they are also asked to comment on if and how the AI went wrong in its design.

Generative AI technologies are constantly changing, and the challenge is to keep up with their development and be creative in our teaching methodologies and assessment strategies. The assignments and activities I have thus far used need constant reworking as the AI bots become more advanced. As educators we will have to focus our energies in being creative in the classroom, in asking questions and in devising evaluation methods.

Besides the activities and the assignments where AI was integrated, I have allowed students to use it to brainstorm research questions and to revise their grammar and punctuation, checking fluency in sentence structure. I have also permitted them to use it to translate readings and research material that are not in English or Arabic.

Recommendations:

- Establish clear guidelines for the use of AI in our syllabi
- Educate students on its ethical use and responsible application
- Focus on developing critical thinking and creativity
- Foster an open dialogue about AI with students



Artificial Intelligence and Culture

Artificial Intelligence is transforming the ways culture is created, preserved, interpreted and shared.

As this technology continues to redefine the relationship between culture and technology, it is imperative to underscore a human-centred vision of digital transformation, while connecting innovation with cultural governance.

Bringing together multidisciplinary perspectives from the Arab region, this publication examines how AI is transforming a wide range of cultural fields as well as critically addresses ethical, legal and policy questions. Grounded in UNESCO's cultural Conventions and its Recommendation on the Ethics of Artificial Intelligence, it offers a timely resource for all stakeholders to navigate the challenges and opportunities of AI in the Arab States context. It ensures that culture remains a driver of inclusion, creativity and sustainable development in the digital age.