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Imagination, Innovation and Opportunity

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Digital Cultural Heritage: Imagination, Innovation and Opportunity
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Front cover image: Mama Kali by Daria Smakhtina, Image courtesy of Sovereign Nature Initiative.

“We counter the feeling that ‘heritage isn’t for me’ by making it clear everyone has something to contribute to digitisation. In this way, we can shift the curatorial power of who decides what we need to preserve.”

— Chao Tayiana Maina, Founder of African Digital Heritage; Museum of British Colonialism; Open Restitution Project and Save the Railway

Editor's Note

This report marks an important first step in the British Council's engagement with Digital Cultural Heritage. It responds to a knowledge gap within the organisation around the opportunities, risks, and considerations of using technology in cultural heritage contexts, particularly as technology becomes an increasingly integral part of heritage protection and practice.

The insights in this report take the British Council's Cultural Protection Fund (CPF) as a starting point. CPF is a long-standing partnership with the UK's Department for Culture, Media and Sport (DCMS) that supports the safeguarding of cultural heritage at risk due to conflict and/or climate change, while contributing to sustainable social stability and economic prosperity.

Developed through close collaboration with the CPF community, the report draws on knowledge from both global and local perspectives. In particular, it reflects the situated experiences and innovative practices of practitioners in Egypt, Ethiopia, Kenya, and Iraq; four of the core countries where CPF operates. Their contributions have been critical to shaping this work, and the British Council is deeply grateful for their insight and generosity.

By listening to cultural heritage practitioners, we aim to better understand not only current approaches to digital heritage but also to imagine future directions that reflect the hopes and aspirations of those most closely connected to preserving human heritage.

We hope this report offers a foundation for the British Council to design future programmes rooted in the realities of the communities we serve. We also hope it proves valuable for practitioners and funders seeking to embed technology in ways that are sustainable, inclusive, and community-led.

At the heart of this work is a belief that technology should not only serve cultural heritage, but also be shaped by it. When cultural knowledge and community values inform the design of technologies, they become more representative, more resilient, and more impactful, both within and beyond the heritage sector.

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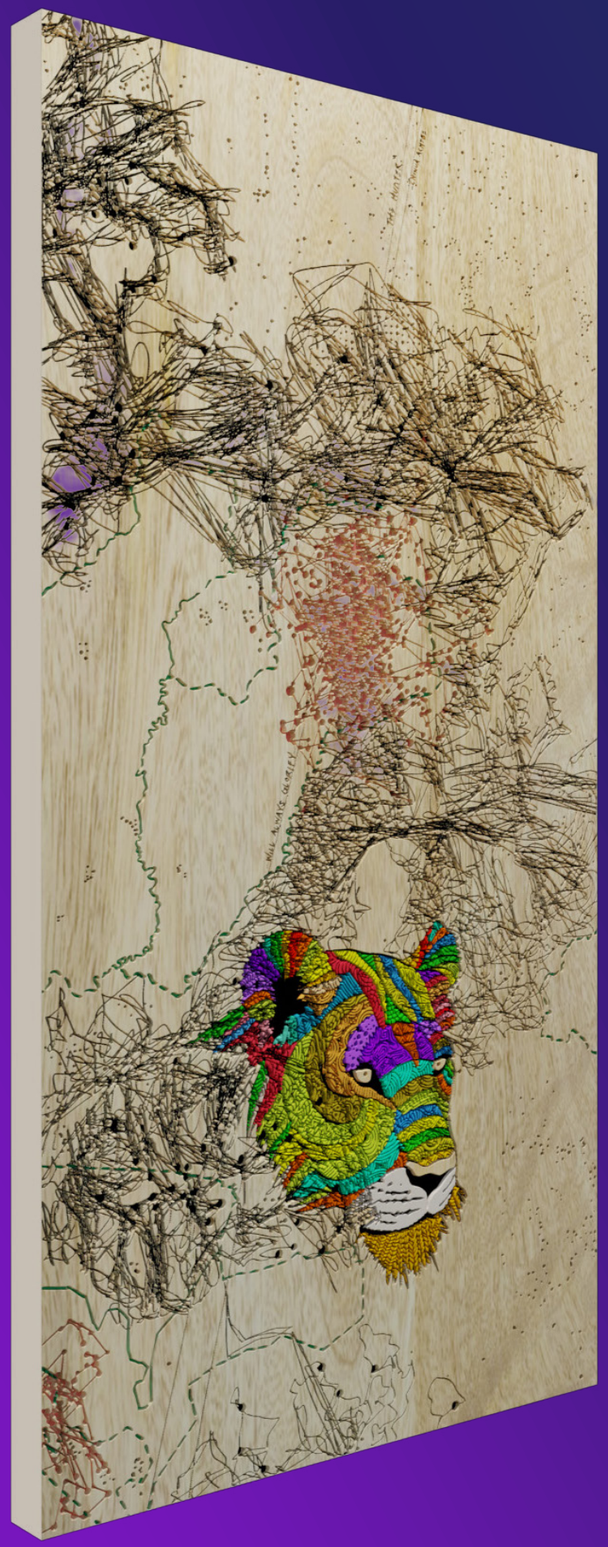

Naramat by Chuma Anagbado, Image courtesy of Sovereign Nature Initiative

Executive Summary

There is a rich and growing global ecosystem of cultural heritage practitioners using technology to reimagine what heritage is, who it belongs to and how we may preserve it for future generations. Striking a balance between local needs and a constantly evolving technological landscape, these practitioners are developing increasingly imaginative technical solutions and fostering creative innovation to safeguard rich histories, from the digital preservation of physical buildings and artefacts to intangible songs, dance, recipes, hairstyles and languages.

This work requires navigating a path that balances the creative potential of technologies with their evidenced complexities and limitations. While technology can democratise tools, create new public spaces and break down long-standing barriers to cultural information, it can also reinforce historic biases, perpetuate economic, social and cultural inequalities, and have damaging environmental impacts.

The people and practices that constitute Digital Cultural Heritage are well placed to navigate this complex socio-technical landscape, with heritage innovation often resulting in novel technical solutions that both preserve culture and lay foundations for more representative, sustainable technologies.

This report illustrates the innovative potential of Digital Cultural Heritage, providing insights into key areas where Digital Cultural Heritage is advancing technologies. It takes the work of the British Council's Cultural Protection Fund (CPF) as a starting point and spans outwards to incorporate wider voices and case studies that reflect both local and multi-national perspectives on Digital Cultural Heritage. With a focus on Egypt, Ethiopia, Iraq and Kenya, it draws on CPF projects, desk research, case studies and expert interviews to provide an in-depth analysis of the current state of Digital Cultural Heritage, the technologies at use and recommendations for where further support is required for achieving the full potential of heritage innovation.

The people and practices that constitute Digital Cultural Heritage are well placed to navigate this complex socio-technical landscape, with heritage innovation often resulting in novel technical solutions that both preserve culture and lay foundations for more representative, sustainable technologies.

Digital Cultural Heritage: Key Insights

This section introduces five future-facing ways in which technologies are transforming and being transformed by Digital Cultural Heritage.

Leveraging Immersive Environments:

As the Internet becomes increasingly spatial, cultural heritage practitioners are incorporating immersive technologies such as VR (Virtual Reality), AR (Augmented Reality) and 3D printing into their practice to facilitate off-site research and training and reimagine public engagement initiatives.

Enhancing Archiving:

The increasing availability of open-access computer programmes and automated features are enhancing the capture, preservation and accessibility of cultural heritage data, but cultural heritage practitioners require substantial resources to align existing technologies with the heritage sector's needs and to avoid perpetuating non-inclusive practices.

Decolonising Artificial Intelligence (AI):

With the advancement of AI technologies such as Large Language Models, cultural heritage practitioners are integrating AI across the Digital Cultural Heritage pipeline. Practitioners are increasingly aware that this integration of AI must be developed with diversity and inclusion at its core, to ensure that automated systems do not perpetuate historical biases and that local communities can build and have agency over their own AI models.

Engaging through User-Generated Content:

Building on the growth of user-generated content on social media platforms, cultural heritage practitioners are looking to harness interactive opportunities for engaging audiences in learning about heritage, advocating for heritage and sustaining living heritage, such as intangible practices like language and dance.

Decentralising Curation:

The digitisation of cultural heritage offers opportunities for the decentralisation of decision making and data curation traditionally established by museums.

Digital Cultural Heritage in Egypt, Ethiopia, Iraq & Kenya: Insights

Cultural practitioners working in Egypt, Ethiopia, Iraq, and Kenya highlight opportunities and considerations for the development and application of technologies in their specific contexts. While practitioners in each of these countries face distinct challenges, this section aims to articulate key insights relevant across the four contexts, introducing a multi-perspectival viewpoint for how technology is being leveraged to engage with complex cultural histories and on-the-ground technological capabilities.

Mitigating Conflict and Destruction:

Where political conflicts have led to the intentional and unintentional damage and looting of heritage sites, cultural heritage institutions and community initiatives are harnessing technology to document, report, share and safeguard heritage.

Enhancing Digital Tourism:

Cultural heritage practitioners are engaging digital technologies to promote lesser-known heritage sites and divert traffic from overvisited sites, supporting both economic and conservation efforts.

Advocating for Post-colonial Identity Restitution:

While advocating for the restoration of cultural artefacts to their origins, practitioners in numerous origin communities are using digital technologies to engage with cultural artworks in their material absence, enhancing cultural cohesion, and promoting autonomous ownership.

Tailoring Devices to Local Usage:

Cultural heritage practitioners are using digital devices to bypass the slow development of established cultural protection practices and broaden engagement.

Cultivating Home-Grown Heritage Expertise:

Local grown training programmes and startups are emerging, focusing on capacity building and indigenous solutions while decreasing dependence on foreign technology, boosting innovation and sustainability.

Digital Cultural Heritage Technology Deep-Dives

The second section provides detailed analyses of nine technologies used in Digital Cultural Heritage, which have been selected from previous Cultural Protection Fund applications and through desk and expert-led research. The following Deep-Dives detail each technology's applications, benefits and challenges in preserving, protecting and engaging with cultural heritage.

3D Printing:

3D printing is an additive manufacturing process that creates a physical object from a digital design by laying down successive layers of material. It is used in various fields, from prototyping to production. 3D printing can be used in Digital Cultural Heritage to create physical replicas of artefacts for educational purposes, exhibitions and preservation, allowing for hands-on interaction with historical objects.

Anti-theft Technology:

Anti-theft technology refers to various systems and devices designed to prevent or deter theft or track down stolen items. Anti-theft technology in Digital Cultural Heritage can be applied to protect valuable artefacts from theft and loss by integrating tracking and security measures into both physical and digital collections.

Artificial Intelligence:

Artificial Intelligence (AI) is an umbrella-term for a range of algorithm-based technologies that simulate forms of human intelligence and complex problem-solving, either on their own or combined with other technologies. AI can be applied to Digital Cultural Heritage by automating the categorisation of artefacts, enhancing digital restorations and creating interactive virtual experiences that engage with historical data in novel ways.

Blockchain:

A blockchain is digital ledger where transactions are logged and stored across multiple computers in a decentralised network. The network uses complex cryptography to ensure security and integrity and once logged, the ledger cannot be changed retroactively. Blockchains vary by degrees of transparency, cost and energy efficiency. Blockchains can be used in Digital Cultural Heritage to create stable and unchanging records of provenance and ownership for digital artefacts, ensuring authenticity and traceability.

Databases:

A database is an organised collection of structured information or data, typically stored electronically either on local, cloud or distributed systems. Databases are often managed by Database Management Systems (DBMS) and can be used to store, retrieve and manage data efficiently. Databases are essential in Digital Cultural Heritage for storing and managing vast amounts of digitised artefacts, plus associated metadata and research data.

Digitising:

Digitising is the process of converting information into a digital format. This can involve manual methods but is increasingly adapting to volume conversion. Digitising processes in Digital Cultural Heritage involve converting physical artefacts, texts, audio and images into digital formats in a way that ensures their preservation, widens access to them and facilitates research into them.

Extended Reality (XR):

Extended Reality (XR) is an umbrella term for immersive technologies that merge material and digital worlds to create multi-sensory experiences. XR technologies can be used in Digital Cultural Heritage to create immersive tours of historical sites, virtual reconstructions of ancient buildings and interactive educational experiences that bring history to life.

Gaming:

Gaming refers to interactions between players and an electronic device, including computers, gaming consoles, XR headsets and mobile devices, in which the player (or group of players) control some element of the electronic device. Gaming can be used in Digital Cultural Heritage to create engaging and educational experiences that immerse users in historical environments and narratives.

Social Media:

Social media refers to Internet-based platforms that allow users to create, share and interact with content and other users. Social media can be utilised in Digital Cultural Heritage to promote awareness, engage the public with historical content and crowdsource information or funding for heritage projects.

Introduction

Recommendations:
Where increased support is needed

This section outlines key areas where increased support is needed for Digital Cultural Heritage based on the examples from Egypt, Ethiopia, Iraq and Kenya. It outlines five distinct elements of the Digital Cultural Heritage pipeline: Infrastructure, Data Stewardship, Data Management, Audience Engagement and Long-term Maintenance as critical interventions in ensuring future sustainability and adaptability.

Infrastructure:

Digital Cultural Heritage infrastructure should be approached from a holistic perspective that considers interconnected social, ecological and technological systems. For example, if a project is investing in reliable Internet access, it should also consider clean, stable energy supply for servers and harnessing community engagement and local knowledge.

Data Collection:

Cultural heritage data collection processes should be designed to engage community stakeholders in data collection and management, including decisions about which data to preserve and why.

Audience Engagement:

Creative applications of technologies can engage new audiences in cultural heritage, particularly young audiences or those without pre-existing access to or interest in heritage. This is often particularly relevant in the context of protecting living heritage and can incorporate approaches such as user-generated content, distribution via social media, or gamification.

Data Stewardship:

Investment in clear and robust data stewardship models are required at all levels of Digital Cultural Heritage preservation to ensure that culturally informed and transparent practices are followed. Projects that support long-term communities of practice, sustained learning and critical thinking about technologies, or small-scale, community-led models of data ownership are key.

Long-term maintenance:

Digital Cultural Heritage maintenance models need to prioritise sustainability and resilience over continuous innovation to ensure that existing, previously funded, projects remain functional. Technical maintenance should be combined with holistic processes that enable institutional or community agility, responsiveness and ability to adapt in the face of change.

Technology has fundamentally reshaped every aspect of our lives. Previously considered a layer separate from our material reality, the digital is now inextricable from the ways we see, speak and communicate.

Cultural heritage is no exception to this transformation: technologies that were once the stuff of science fiction only a few decades ago now shape material and intangible heritage alike. In this context, cultural heritage practitioners are developing increasingly imaginative technical solutions, fostering creative innovation to safeguard rich histories.

Navigating a path that balances the creative potential of technologies with their evidenced complexities and limitations is of critical significance. Technology has been celebrated for democratising tools, creating new public spaces and breaking down long-standing barriers to accessing information and cultural products [101]. It is also clear that in many cases, however, technologies can reinforce historic biases and misrepresentations, perpetuate economic, social or cultural inequalities and have damaging environmental impacts [154].

Digital Cultural Heritage is a growing field of practice, well-placed to engage with and navigate these complexities, building on our histories to imagine and engineer shared futures. Cultural heritage practitioners have already been navigating hybrid realities for some time, fostering an emergent approach that is part-material, part-digital and inherently networked. Museums and heritage sites offer digital collections, virtual tours, immersive audio-guides and game-style visitor experiences; archaeologists and conservationists use a vast array of 3D scanning tools and bio-technologies to further their research [22, 55, 63, 66, 72, 80, 84, 86, 135]; community groups use immersive technologies to facilitate decolonial re-curations of displaced heritage materials; preservation specialists leverage 3D printing to reconstruct destroyed sites; and archaeologists utilise Artificial Intelligence (AI) to detect new sites and objects [10, 85, 94, 134, 153].

In Ethiopia, for example, Yatreda's 'Strong Hair' Project uses Non-Fungible Tokens (NFTs) to preserve the unique cultural expressions woven into in traditional hairstyles, whilst ensuring ownership of these digital artefacts remains with the community. In Kenya, Black Rhino's MediAR platform is offering opportunities for everyday people to create Extended Reality (XR) designs and monetise their home-grown XR projects, thus affording a localised means for Kenyan culture and heritage to be integrated in the fast-growing field of spatial computing. In Egypt, the development of the video game, 'Assassin's Creed: Origins', by a team of commercial game developers and historical researchers has resulted in millions of players worldwide engaging with historic sites such as the Memphis temple and intangible experiences like fishing in 49BC Ptolemaic Egypt.

The expertise, creativity and cultural sensitivity deeply encoded in Digital Cultural Heritage make it exceptionally important at a moment in time when technology is having seismic social and cultural impact. This report both platforms Digital Cultural Heritage as a practice that drives innovation, often in diverse and sustainable ways, whilst acknowledging the complexities and limitations of many current technologies.

The report addresses four research questions:

- **What technologies are being used to protect cultural heritage?**
- **How are Digital Cultural Heritage initiatives innovating with technologies?**
- **How are Digital Cultural Heritage initiatives innovating with technologies?**
- **How does Digital Cultural Heritage differ place to place?**

This report first lays the foundations by defining Digital Cultural Heritage and outlining the key considerations and methodology of this research. It then foregrounds key insights across Digital Cultural Heritage, with detail specific to the four countries of focus: Egypt, Ethiopia, Iraq and Kenya. The following section takes a deep-dive into nine emerging technologies and their applications, opportunities and challenges in Digital Cultural Heritage, with stories of their implementation in these four countries. Building on these socio-technical contexts, the report then concludes with five recommendations for how to support considered, innovative and diverse approaches to Digital Cultural Heritage.

Defining Digital Cultural Heritage

Given the dynamic nature of Digital Cultural Heritage and its constant evolution under both external influences and internal advancements, it is helpful to define our terms. We propose a distinction between Digital Cultural Heritage as (1) *digital tools in cultural heritage*, (2) *digitising cultural heritage* and (3) *digital-born cultural heritage*. We define these terms as follows:

(1) Digital tools in cultural heritage
Technologies and methods used to enhance the management, protection and sharing of cultural heritage (e.g. lasers, drones, scanners, or mobile phones).

(2) Digitising cultural heritage

The process of converting cultural heritage assets into digital formats (e.g. photographing a manuscript, mapping a heritage site, or 3D-scanning an amphora).

(3) Digital-born cultural heritage

Cultural heritage content which exists in digital form, whether it was digital at its conception (e.g. social media posts about the 'Black Lives Matter' movements, or digital artworks such as those created by Linda Dounia Reibez, Morehshin Allahyari or Danielle Braithwaite-Shirley, amongst many others), or has been digitised after its original creation (e.g. a virtual model of a statue).

Frequently, Digital Cultural Heritage projects involve working with more than one of these three types. For instance, the Zaydi Manuscript Tradition Project [183] uses digital tools such as 2D scanners to digitise material cultural artefacts, annotate them in photo-editing software and host digital versions of these manuscripts on a publicly accessible website. To acknowledge these overlaps and ambiguities, we have developed a working definition of Digital Cultural Heritage, informed by the principles of the Digital Preservation Coalition: [184] *Digital Cultural Heritage refers to digitally created or digitised cultural materials that hold historical, artistic, or cultural significance. It includes the preservative processes, tools and policies that are needed to facilitate long-term access to these materials.*

> **What's wonderful about the language of new media is that it's flexible, it gives you unlimited solutions. All we need as tools to work with it are different ways of thinking.**
>
> **— Ahmed El Shaer, New Media Artist and Doctoral Researcher**

> **I think the digital realm enables you to excite people and get them to discover and pique their curiosity, and explore heritage and culture for themselves.**
>
> **— Seif El Rashidi, Director of the Barakat Trust, Art and Architecture Historian and Heritage Manager**

Considerations

This report has approached Digital Cultural Heritage considering the complexity and limitations of practices established in Western contexts and applied elsewhere. It also recognises the natural resources and power consumption required by technologies and and the uneven distribution of access to the Internet and devices. Based on the insights from this report, Digital Cultural Heritage practitioners are also encouraged to bear these considerations in mind when designing, developing and implementing cultural heritage projects with technology.

Decolonising Digital Cultural Heritage

As cultural heritage conventions and communities of practice become increasingly international [185], the immense value of international collaboration has been well evidenced [27]. A fundamental part of this internationalisation has been an acknowledgement of the limitations of many historic cultural heritage conventions established in Western contexts, specifically from European and American institutions. While it is impossible to fully encapsulate the diversity of approaches to Digital Cultural Heritage in European and American contexts, it is well evidenced that many Euro-American heritage conventions are tied to extractive, colonial legacies and data cultures unrepresentative of non-Western heritage [31, 71, 106, 147, 152]. Significant leaps forward have been made in recognising these limitations and encouraging more nuanced, locally-representative approaches to cultural heritage within international frameworks [172]. This process of promoting international exchange of knowledge and resource, whilst addressing the more problematic Euro-American legacies of historic cultural practice, is complex and ongoing.

Unsurprisingly, Digital Cultural Heritage mirrors these opportunities, complexities and tensions. Many Digital Cultural Heritage practices, such as digital archiving of objects, sites and artefacts have carried with them the same classification systems that existed in the older, analogue collections — and with those systems, the same simplifications and biases [53, 54]. In a similar way, technologies reflect the contexts in which they were designed and engineered. Considering that a critical mass of user-facing technologies has been developed in the Global North, Digital Cultural Heritage practices using these technologies can carry with them biased data cultures and design paradigms.

While the technologies discussed in this report are diverse in their development and uses within Cultural Heritage, many draw on Anglophone, Euro-American design paradigms and perpetuate Western ways of knowing. This takes various forms, for instance: code which is designed to be read and written left-to-right; organisational structures in database categorisation; the privileging of visual information over other forms of information; or the absorption of locally-specific understandings as universal.

These forms of bias have significant implications in terms of who is invited to participate, to co-create and to further develop existing technologies. Examples include etymological bias (e.g. gender binaries being absorbed into the labelling of electric cords); how well a technology works in a specific climate (e.g. most laptops are not built to work efficiently above 27 °C), to sensor accuracy (e.g. facial recognition software not recognising darker skin tones as well as lighter skin tones); data density (e.g. how well mapped different areas of the globe are on Google Maps) and access barriers (e.g. a technology only being available in certain markets, or in certain languages). AI and other technologies which are built on existing datasets compound this bias (e.g. image generation based on photographs does not work equally well across various ethnicities).

> **If we were going to start from scratch and create a new way of holding memories, how would we do that in a digital way?**
>
> **— Chidi Nwaubani, Designer, Artist and Founder of Looty**

Over the past two decades, Digital Cultural Heritage has emerged as a unique space for both the ethical contemplation and innovation around such issues. There has been a significant shift from the development of heritage technologies centralised in Western contexts, representative of Western heritage and data practices, towards more locally produced, controlled and distributed Digital Cultural Heritage. International initiatives have also spearheaded dialogues between international communities to supercharge local responses that are globally interoperable. The Global Indigenous Data Alliance [161], for example, has not only pushed for data management, which is conducive to local ethical standards, but has highlighted the transferability of local solutions for wider cultural application. In a different way, cross-continent initiatives such as the Looty [188], Digital Art network [189] and The Cercle d'Art des Travailleurs de Plantation Congolaise [186] have harnessed technology for digital repatriation, coursing forward international decolonial dialogues.

Considering the complexity of the international interplay between culture, heritage and technology, this report seeks to respect various, hybrid and occasionally contradictory perspectives on Digital Cultural Heritage. For this reason, the international insight of this report is balanced with Digital Cultural Heritage analysis and critical discourse in Egypt, Ethiopia, Iraq and Kenya, thus aiming to contribute to a multi-perspectival, locally-grounded understanding of the future of heritage preservation, [18, 41, 90, 102, 112].

The resulting analysis acknowledges the limitations of Digital Cultural Heritage practices established in Western contexts and the encoded biases in many technologies used to practice Digital Cultural Heritage. However, it also draws attention to the immense potential of Digital Cultural Heritage as a site for addressing these limitations by developing more representative technologies and innovating locally relevant, resilient infrastructure; work which is of value both in the context of heritage preservation and also offers a blueprint for socially beneficial innovation more broadly

Limiting Environmental Impact

No digital tool is a cure-all for the long-standing challenges in heritage preservation. Despite their appeal in terms of ease and speed of use, such technologies are evidenced to have distinct environmental impacts. A major concern in terms of sustainability is the energy demand of Blockchain and many Artificial Intelligence solutions, particularly on already strained local resources which will only be further pressured due to climate change. The democratisation of access to these technologies must be weighed against their power consumption and environmental impacts.

Additionally, sustainability in terms of maintenance and management is a key challenge [1, 2, 47, 117, 140]. In heritage preservation, projects often span years or decades, but technological innovation in the private sector moves at a much faster pace, requiring constant updating and maintenance. Unless there are continuous training initiatives and skilled labour dedicated to maintenance, many technological solutions are not sustainable in the long-term.

Simultaneously, deterioration and destruction through climate change or active conflict sometimes make digital forms of preservation the only viable option. This report aims to balance the potential impacts of technological interventions with the interests of the present and future communities whose heritage they protect.

> **With problems around longevity and sustainability, you have to factor in maintenance.**
>
> **— Seif El Rashidi, Director of the Barakat Trust, Art and Architecture Historian and Heritage Manager**

Addressing the Digital Divide

The Digital Divide manifests at global, regional and local levels in various forms and is an umbrella term which describes nuances of digital access and lack thereof in a variety of cultural settings [38, 40, 87, 99, 148].

It is important to note that whilst the socio-economic divides between the Global South and the Global North are closely intertwined with the Digital Divide, these are not the only lines of exclusion which matter in this context. Other lines of access can include uneven distribution of individual access to web-based services, tech companies separating 'design' and 'building' across the globe in a division that mirrors colonial distributions of labour, or strategic network outages during national elections

> **The uptake of digital technology is not equal everywhere in the world**
>
> — **Kahithe Kiiru, Anthropologist, Production Manager and Choreographer, Bomas of Kenya**

> **A problem I often see in heritage protection is that urban, educated practitioners often don't consider the wishes of the people in the rural countryside where a lot of their projects are located. Fundamentally, there's a lack of understanding, specifically a lack of understanding on what these communities need to survive and thrive**
>
> — **Yenesew Alene Belew, British Council CPF Specialist Assessor; Asst. Professor of Tourism Management; University of Gondar**

Often addressing the Digital Divide is associated with the first of these examples: digital access. However, in regions with high Internet penetration, not everyone has access to all the Web has to offer and official statistics can be misleading. Iraq, one of the countries in which the Cultural Protection Fund (CPF) operates, exemplifies this: with an Internet penetration rate of 75% [163], only 29% of the population living in rural areas [187] and a median age of 22 years within a population of 44.5 million people [171], digital technologies seem within reach for a majority of the population. However, recent studies have suggested that fewer women in Iraq have access to the Internet than men [108] and women's online interactions are often monitored by male family members [124].

This demonstrates that fostering digital adoption is more complicated than simply providing an Internet connection or a device. Instead, digital practices are embedded in social identities. Indirect or 'unintentional' barriers to digital access are equally prevalent: someone's gender, sexuality, age and locality may have multi-layered effects on their access to digital culture beyond regional or national circumstances. An individual may be actively prevented from accessing digital culture based on their age (e.g. with technologies and interface designs which are not suitable for very young or very old people based on motor skills and hand-eye-coordination) [150]; socio-economic status (e.g. when access to digital technologies is too costly or remote) [33, 74, 77]; education level (e.g. when a lack of digital literacy is intentionally used as a tool of exclusion) [2];

gender (e.g. when women are not given access to digital devices as part of misogynistic cultural practices) [1]; disability (e.g. in the case of technologies and interface designs that do not account for different forms of perception) [5, 117] or migration status (e.g. when proofs of identity and residence are needed to access digital services) [47, 76, 140]. Even within a region with relative infrastructural homogeneity, individual experiences of the Digital Divide may vary drastically, compounding existing cultural lines of exclusion.

This report emphasises that any heritage project which seeks to address the Digital Divide should also be aware of, and engage with, the underlying structures which continue to shape how digital exclusion manifests. For example, taking into account technology companies often locate governing bodies in the Global North, whilst production and raw materials are located in the Global South [17, 49, 128], a cultural heritage project in the Global South should consider if there are local, technological alternatives which counteract this dynamic, or could point towards more representative, interconnected programme of technological development.

Similarly, cultural heritage initiatives which seek to address the fact that women are disproportionately affected by digital exclusion, should critically engage with gender-based assumptions in patriarchal cultural structures. One of the biggest promises of digital technologies is to increase access and overcome these existing structures. And yet, without thorough engagement with the underlying dynamics of exclusion and how they compound, digital technologies can just as easily become accelerators of an ever-increasing divide.

> **I think one has to remember that the digital realm is not the same in every place, the challenge of the reality is that not everyone has the same tools**
>
> — **Seif El Rashidi, Director of the Barakat Trust, Art and Architecture Historian and Heritage Manager**

> **We are placing emphasis, not just on new collecting, but on sharing access, and how much that can enrich existing collections. There's so much meaningful stuff we can share with our audiences and we really need to find ways to bring those collections alive**
>
> — **Margaret Maitland, Principal Curator of the Ancient Mediterranean, National Museums Scotland; Partner in Egypt's Dispersed Heritage**

Methodology

For this report, a mixed-methods, qualitative approach was adopted to provide a comprehensive and nuanced understanding of the future of Digital Cultural Heritage in Egypt, Ethiopia, Iraq and Kenya. This methodology leverages the strengths of empirical research to grasp current realities, as well as using more speculative and creative methods to include forward-looking, interdisciplinary perspectives.

Country selection

Four 'spotlight countries' were selected to ground identification of examples, experts and case studies. This focused approach engages with each country's unique conditions and mitigates oversimplification. Countries with preexisting Cultural Protection Fund (CPF) projects and connections formed the basis of selection, to demonstrate how long-standing collaborations may offer insights for future developments. Therefore, in discussion with the British Council Cultural Protection Fund (CPF), Egypt, Ethiopia, Iraq and Kenya were selected as the sample countries for this case study. It is important to note that this selection is not exhaustive but is intended as a starting point for further local research.

Applications review

- **Rationale:** By leveraging the Cultural Protection Fund's (CPF) internal expertise, through a systematic analysis and review of 25 Digital Cultural Heritage proposals (from 2016-2024), we can understand existing standards, widely used technologies and prevailing practices for tech usage in cultural protection and the countries relevant to this report.
- **Limitations:** Applications provide only a 'snapshot' sample of Digital Cultural Heritage projects (only those submitted to British Council's CPF). Applications were not submitted specifically with digitality in mind and digital elements may be 'hidden' in other applications that did not meet the selection criteria.

Desk research

- **Technology-first desk research**
  - *Rationale:* Conducting a horizon-scan allowed us to identify nine key technologies relevant to Digital Cultural Heritage and the standards, practices and emerging trends within their deployment and development. This list is built on the technologies that featured most prevalently in the CPF applications. A broad-scanning approach allowed for maximum ground-coverage, enabling us to include both current Digital Cultural Heritage technologies and technologies that could eventually be developed to inform Digital Cultural Heritage.
  - *Limitations:* Reliance on secondary data sources can introduce bias or outdated

information, compared to on-the-ground evidence and remote-first methods. Technology-first desk research can propagate technological optimism.
  - *Selection of Technologies:* Technologies were chosen based on having proven use-cases in Digital Cultural Heritage, cost operability/interoperability and grassroots accessibility. Software was given preference over hardware.

- **Country-first desk research**
  - *Rationale:* This research method focuses on selected countries to ensure a detailed and locally specific understanding of Digital Cultural Heritage practices. Local language experts translated search terms, ensuring the centrality of region-specific examples, sources and nuances. This method helped detail the unique cultural and technological contexts of specific countries, reducing the risk of universalising and ensuring insights are contextually relevant.
  - *Limitations:* A country-specific focus can overlook broader trends that are not confined to the selected countries. Potential language and translation issues may result in misinterpretations or missed nuances.

Expert interviews with local specialists, tech innovators and Digital Cultural Heritage experts

- **Rationale:** Engaging with 25 global and local experts through one-hour interviews which combined pre-determined questions and open discussion provided real-world insights and perspectives on Digital Cultural Heritage interventions.

- **Breakdown:** Transregional Digital Heritage specialists (8), Iraq (6), Egypt (5), Ethiopia (3), Kenya (3).

- **Selection:** Experts were recruited from previous collaborations with the British Council, including specialist and assessor networks, or approached directly based on their prominence and expertise in respective countries. Interview questions focused on the current usage of digital technologies and projected future use in their specialist fields and countries of expertise. Interviewees detailed practical applications, strategies and potential risks in Digital Cultural Heritage, ensuring the research reflects practical, contextually appropriate realities. Experts' quotations are cited directly throughout the report and their perspectives informed the general findings.

- **Limitations:** The sample size of 25 interviews may not fully capture the diversity of experiences and perspectives across the selected countries. Potential bias in expert selection may influence the findings and the reliance on expert opinions may limit the scope to subjective, individual interpretations. Recruitment and expert interviews were conducted in English, which may have led to a loss of local contextual specialisms.

- **Rationale:** Subjecting the report to local expert review to assess local relevancy and applicability, raise concerns or sensitivities, sense-check the suitability of case studies and provide feedback on the readability and usability of the report.

- **Breakdown:** One peer reviewer for Egypt, Ethiopia, Iraq and Kenya, respectively, who read the report with a focus on their country of expertise.

Peer Review

- **Selection:** Peer Reviewers were recruited from previous collaborations with the British Council, including specialist and assessor networks, or directly based on their prominence and expertise in respective countries. Reviewers were asked to evaluate whether the report accurately reflects the cultural, historical and socio-political contexts of their country of expertise; assess nuance and resonance of these aspects; highlight any language which may improve readability; raise where clarifications are needed; suggest additional local examples where appropriate; evaluate the suitability of the case studies prevailing to their country of expertise; and assess the overall usability of the report.

- **Limitations:** With one peer reviewer per country, the scope of this peer review is limited to subjective, individual interpretations.

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Digital Cultural Heritage: Key Insights

Key Takeaways

Leveraging Immersive Environments

As the Internet becomes increasingly spatial, cultural heritage practitioners are incorporating immersive technologies such as VR (Virtual Reality), AR (Augmented Reality) and 3D printing into their practice to facilitate off-site research and training and reimagine public engagement initiatives.

Decolonising Artificial Intelligence (AI)

With the advancement of AI technologies such as Large Language Models, cultural heritage practitioners are integrating AI across the Digital Cultural Heritage pipeline. Practitioners are increasingly aware that this integration of AI must be developed with diversity and inclusion at its core, to ensure that automated systems do not perpetuate historical biases and that local communities can build and have agency over their own AI models.

Enhancing Archiving

The increasing availability of open-access computer programmes and automated features are enhancing the capture, preservation and accessibility of cultural heritage data, but cultural heritage practitioners require substantial resources to align existing technologies with the heritage sector's needs and to avoid perpetuating non-inclusive practices.

Engaging through User-Generated Content

Building on the growth of user-generated content on social media platforms, cultural heritage practitioners are looking to harness interactive opportunities for engaging audiences in learning about heritage, advocating for heritage and sustaining living heritage, such as intangible practices like language and dance.

Decentralising Curation

The digitisation of cultural heritage offers opportunities for the decentralisation of decision making and data curation traditionally established by museums.

> **Realistically, we cannot sustain our heritage if we are afraid of using technology**
>
> **— Yenesew Alene Belew, British Council CPF Specialist Assessor; Asst. Professor of Tourism Management; University of Gondar**

While each technology holds its own potential and limitations (see 'Technology Deep Dives'), this section points to five future-facing ways in which technologies are transforming and being transformed by Digital Cultural Heritage.

Norms and standards in Digital Cultural Heritage vary as much as places, people and practices. The use of digital tools is inevitably bound up with the cultural contexts in which they are developed, applied and governed. For heritage preservation, it is essential to consider digital technologies not merely as interpretive tools or media for audience engagement, but as novel protection practices and therefore innovation opportunities independently.

Illustrating this point, this section will firstly outline how immersive technologies are opening new avenues for younger audiences to engage spatially in heritage sites, whilst cultural practitioners are innovating in the practices of virtual reconstructions and off-site research. It will then highlight how cultural practitioners are applying Artificial Intelligence not only to increase efficiencies in data analysis and cataloguing, but to develop innovative AI models which better represent diverse languages, cultures and forms of living heritage.

The use of technologies in cultural heritage protection is also decentralising opportunities for the development, archiving and curation of heritage. This section will next demonstrate how cultural heritage practitioners are encouraging audiences to generate their own content on social media to sustain intangible heritage practices and taking advantage of the expanding availability of open-access computer programmes democratising the handling of cultural heritage data. It will then highlight how these technologies are enabling a shift curatorial power towards outside of traditional cultural institutions.

Sustainability and access considerations form the final insights of this section, cutting across Digital Cultural Heritage practices. The environmental toll demanded by technologies and unevenly distributed access to the Internet, technological infrastructure and the literacy required to use them are highlighted as both concerns and opportunities for future innovation.

> **We believe in preserving culture while creating culture… Creation is an important part of preservation**
>
> **— Bryar Bajalan, Project Lead, Mosul Maqam; Filmmaker; Translator; Doctoral Researcher-Management; University of Gondar**

> **Technology is already allowing us to experience history in different ways — the more we experience both past and present cultures, where the tangible and intangible can meet, the more it will resonate with us now**
>
> **—Metasebia Yoseph, Founder and Creative Director of Design Week Addis Ababa; Author of 'A Culture of Coffee'; CEO of D!NK TV; Eastern Africa Arts and Culture Expert**

Leveraging Immersive Technologies

Based on current indications of major investments [107], focus areas of Big Tech [99], research innovations [16], mass market novelties [67] and consumer trends [125] the Internet will become increasingly spatial. ‘Spatial computing’ means reintroducing three-dimensionality into functions which for the past three decades have taken place solely on two-dimensional screens. This means Google Maps is moving from a tool which emulates traditional flat maps to in-camera features which overlay material environments with annotations and directions in real-time [75]. This means instead of Zoom calls with multiple windows, people will start to use Mixed Reality glasses to see their colleagues abroad virtually sitting in the same room with them for conference calls [73]. This means archaeological excavations can involve remote research teams across the globe through Virtual Reality and shared virtual reconstructions of destroyed sites [118, 119, 188]. Heritage is not confined to museums and archaeological sites, however, there is a layer of heritage which permeates the everyday and which is becoming increasingly shareable through immersive technologies. These approaches to on-site and remote engagement with heritage are particularly relevant to research and advocacy [46, 123], but can also be widely applied for training and teaching [79, 151, 189]. 3D printing presents a counterpart to virtual technologies which engage with material environments; born-digital artefacts may be (re) produced in novel ways and made tangible for varied publics [52, 69]. The Spatial Web will change people’s relationships and interactions with material and intangible heritage and heritage experts should consider this trajectory in their long-term projects.

> **Augmented Reality is so normalised for the younger generation. When we incorporate this in our cultural institutions, we can communicate about our shared heritage in their language**
>
> **—Ahmed El Shaer, New Media Artist and Doctoral Researcher**

Decolonising Artificial Intelligence (AI)

At the time of writing, the development and application of Artificial Intelligence is accelerating at unprecedented pace. In this context, AI can be leveraged for Digital Cultural Heritage in a myriad of ways: from the cataloguing of artefacts to enhancing digital restorations. However, there are significant concerns around the transparency of AI processes, data ownership and the potential for AI to reinforce existing inequalities if not carefully managed. For instance, if organisational systems which were created by discriminatory past societies are unquestioningly transferred into automated systems, they are liable to reproduce the prejudices and biases held by those societies, potentially at scale.

Considering this, fostering inclusive AI-facilitated heritage digitisation requires global engagement with decolonial approaches to the information systems, datasets, models and user-facing applications which constitute AI. Whilst there is an urgent need for comprehensive AI policies, data governance and regulation, innovative and ethical approaches to AI also offer the potential to implement decolonial strategies at a large scale, with potentially transformative effect.

This is evidenced in various AI innovations seeking to preserve local culture and heritage. For example, the African grassroots collective Masakhane are delivering research into the representation of African languages in Natural Language Processing (NLP), directly addressing “the tragic past of colonialism [which] has been devastating for African languages in terms of their support, preservation and integration… [resulting in] technological space that does not understand our names, our cultures, our places, our history” [190]. Similarly, platforms such as Somos NLP, or independent artists such as Linda Dounia Rebeiz and Harshit Agrawal who evidence open-source AI, can be leveraged by developers to build new, culturally representative models rather than relying on existing ones [20, 168, 191–193].

Local and Indigenous community-led approaches have also created blueprints for AI governance and licensing of rights. For instance, the Māori Whare Kōrero Kaitiakitanga License [194] is a New Zealand-based initiative for holistic custodianship of heritage data; and the Canadian First Languages AI Reality (FLAIR) initiative [195] is developing Indigenous Voice AI in systems explicitly designed to respect data sovereignty and linguistic self-determination.

> **AI is already in every aspect of our life, even when we aren’t aware of it — but now we are seeing the impacts of what happens when it is not trained in an inclusive way — we are now confronting what should have been dealt with when the technology was developed decades ago.**
>
> **—Joanne Orr, British Council CPF Specialist Assessor; Director of Living Culture Development, UNESCO Expert**

Enhancing Archiving

Digital tools are significantly increasing the volume of capturable cultural heritage data and enhancing its accessibility through measures such as open-access, optimised search functions and automated tagging. Using existing heritage databases by overlaying new tech on top of old tech avoids the need for complete overhauls. This is particularly important in the heritage sector, given the typical constraints of limited budgets and slow adoption rates. In turn, these digital tools increase the types of information being preserved, yielding, for example, greater image resolution, the merging of newer data management systems with existing climatological data and the capture of more diverse histories. Moreover, these tools also expand the remit of who can access heritage data by facilitating instant and rich exchanges through cloud storage, remote teaching tools, digital simulations and 3D printed replicas.

These digital enhancements, however, often demand computers with substantial processing power and specialised skills for operation and maintenance [88]. This can also pose challenges as many tools were not initially designed with the heritage sector's unique needs in mind and therefore risk inadvertently embedding private-sector values. This misalignment can sometimes perpetuate non-inclusive practices or oversimplified historical narratives. Nevertheless the increasing availability of open-access computer programmes and pre-trained AI models is democratising the use of these technologies, allowing heritage professionals without extensive tech training to customise tools to meet their specific requirements.

> **We cannot ensure the survival of cultural heritage by simply just trying to document things and freeze them in time**
>
> **— Kahithe Kiiru, Anthropologist, Production Manager and Choreographer, Bomas of Kenya**

> **I believe there are tools that already do what we need them to do, it's just building awareness and trusting each other, not creating something totally new**
>
> **— Will Korner, Founder of the Cultural Heritage at Risk Database (CHARD); DCH Expert**

Engaging through User-Generated Content

User-Generated Content (UGC) has been on the rise for years on social media and video platforms, but newer apps such as TikTok and BeReal are fundamentally structured around call-and-response interactions (in which one user's posts are complemented by responses from other users, such as comments and reposts). User behaviour which copies formats, filters and sound bites presents new opportunities for institutions. By providing audio-visual formatting elements, such apps can encourage specific interactions with heritage sites both online and onsite. This is particularly relevant as online visitors are growing into a more distinct and diverse target audience [34, 48, 82]. Public participation can be a major avenue of sustaining cultural practices, such as languages or dances which live on through continued replication and adaptation [71, 195, 196]. User-Generated Content is also vital to advocacy initiatives, which increasingly rely on social media strategies to gain attention, funding and community involvement [29, 31, 83].

Decentralising Curation

As digital documentation increases, the selection and organisation of content becomes critical to making it usable and navigable. This introduces a power dynamic around who gets to select what (or who) is included or excluded in the dataset. Since many emerging technologies build on existing databases, they privilege already well-represented information. The increased annotation of digital data, such as in database management and digital classification systems, highlights this issue.

Furthermore, as material spaces become increasingly blended with virtual information, the question of how we can collectively annotate, document and preserve these hybrid spaces becomes crucial. Practitioners are increasingly moving beyond the 'museum voice' to introduce new practices of digital storytelling. Decentralising these decisions and systems can distribute power into the hands of local actors but also risks inhibiting knowledge exchange and data relevance in other contexts. It is therefore essential to foster annotation systems which invite varied contributions.

> **Everyone has something to contribute to digitisation. In this way, we can shift the curatorial power of 'who decides what we need to preserve**
>
> **— Chao Tayiana Maina, Founder of African Digital Heritage; Museum of British Colonialism; Open Restitution Project and Save the Railway**

> **The issues are the same as they've always been: who makes the decisions of what is added to the canon? Who decides what is important to digitise?**
>
> **— Metasebia Yoseph, Founder and Creative Director of Design Week Addis Ababa; Author of 'A Culture of Coffee'; CEO of D!NK TV; Eastern Africa Arts and Culture Expert**

Digital Cultural Heritage in Egypt, Ethiopia, Iraq and Kenya: Key Insights

Key Takeaways

Mitigating Conflict and Destruction

Where political conflicts have led to the intentional and unintentional damage and looting of heritage sites, cultural heritage institutions and community initiatives are harnessing technology to document, report, share and safeguard heritage.

Advocating for Post-colonial Identity Restitution

While advocating for the restoration of cultural artefacts to their origins, practitioners in numerous origin communities are using digital technologies to engage with cultural artworks in their material absence, enhancing cultural cohesion and promoting autonomous ownership.

Enhancing Digital Tourism

Cultural heritage practitioners are engaging digital technologies to promote lesser-known heritage sites and divert traffic from overvisited sites, supporting both economic and conservation efforts.

Tailoring Devices to Local Usage

Cultural heritage practitioners are using digital devices to bypass the slow development of established cultural protection practices and broaden engagement.

Cultivating Home-Grown Heritage Expertise

Locally developed training programmes and startups are emerging, focusing on capacity building and indigenous solutions whilst decreasing dependence on foreign technology, boosting innovation and sustainability.

This section balances global with local insights, detailing five areas in which Digital Cultural Heritage is developing in Egypt, Ethiopia, Iraq and Kenya. While practitioners in each of these countries face distinct challenges, these insights emerged as relevant across the four contexts and introduce a more localised perspective on how technologies are being leveraged to engage with complex cultural histories and on-the-ground technological capabilities.

The first three insights centre on the opportunities for the safeguarding of culture. Community initiatives are harnessing technology to document, report and share cultural heritage where the impacts of political conflicts have damaged cultural heritage and to develop alternatives to traditional repatriation and restitution efforts. Cultural heritage practitioners are also using digital technologies to promote lesser-known heritage sites and divert traffic from overvisited sites, engaging with technology to meet historical and political purposes.

The final two insights focus on technical considerations. Firstly, involving the adaption of technologies across low-resource contexts, especially prioritising mobile engagement and secondly, exploring the opportunities for capacity building initiatives and local innovation, in contrast to foreign technology adoption.

> **We've seen this happen, communities will neglect or abandon their heritage in order to survive or because the heritage, no matter how sacred, is not the priority. We need to consider "what is our role as external practitioners in this situation?**
>
> **— Alia Fares, British Council CPF Specialist Assessor; Archaeologist and Cultural Heritage Manager at the American Society of Overseas Research; Founder of Herigatech Ltd. and the Heritage Education Program**

Mitigating Conflict and Destruction

Political conflicts past and present have led to the intentional and unintentional destruction, damage and looting of heritage sites in Egypt, Ethiopia, Iraq and Kenya. Institutions and community initiatives have been adaptive and creative in employing technologies to support the preservation of material heritage in virtual realms.

Where artefacts and sites have been destroyed from conflict, cultural heritage practitioners are using technologies to reconstruct replicas. The creation of the five-metre tall Bull of Nimrud 3D replica [28] is a prime example. Following the 2015 destruction of the statue, a symbol of the Assyrian civilisation near modern day Mosul, restoration specialists based in Italy developed a digital model from images and video footage before fabricating a large fiberglass copy using 3D printing. Initially exhibited at the Colosseum in Rome, the replica now stands outside the entrance of the Museum of Basrah in Iraq, gifted by the Italian Government in an act of international collaboration for the 'enhancement of the heritage of humanity'[130]. Google Arts and Culture similarly recreated the Lion of Mosul, using crowd-sourced pictures and 3D printing.

Technologies are also important for preventative preservation of cultural heritage at risk of destruction due to conflict or climate change. HeritageWatch.AI, an independent, non-commercial body formed of four organisations, collects real-time information for the heritage sector drawn from satellite imagery from Planet Labs PBC, which is then used by Iconem to create 3D models of heritage sites and analysed by Microsoft using AI to identify vulnerable communities at risk of extreme heat, flooding and rising sea levels [103]. Partner, Aliph Foundation, then used the information to provide grants, as they did for Beirut's Sursock Museum to protect its structural integrity following the devastation of the 2020 port explosion.

Cultural heritage practitioners are also leveraging user-generated content. The cross-regional initiative, AMAL in Heritage [197], for example, encourages community and visitor participation in the preservation of material heritage sites. AMAL is a mobile and web application which invites everyday users to document at-risk cultural heritage, assess the

> **I advocate for preventative preservation in the sense that I don't think there has to be a direct threat for something to be worth preserving**
>
> **—Chao Tayiana Maina, Founder of African Digital Heritage; Museum of British Colonialism; Open Restitution Project and Save the Railway**

risk of damage and report it. By engaging and training local people with mobiles at hand, the data collected in the immediate aftermath of damage, can also be used to repair or reconstruct damaged heritage. In a similar way, online digital archives, like Vox Populi, also offer spaces for the documentation and archiving of global social movements in both online and in physical spaces as they evolve [138]. Together, these examples highlight that where heritage challenges are faced by multiple governments, institutions and communities, technologies can provide opportunities for mitigation and preservation.

> **Often they focus on preserving the physical space but not thinking about creating a digital copy or the stories associated with that space. If there's a future conflict the site is still vulnerable, so without the digital it is futile.**
>
> **—Daniel Getachew, Founder and CEO of Guzo Technologies**

Advocating for Post-Colonial Restitution

Grappling with the ongoing aftermath of modern colonialism is a legacy the countries highlighted in this report all share, whether directly or indirectly. Each country has their own set of challenges in relation to the return of looted artworks in the context of post-colonial restitution and their individual reckoning with cultural reverberations of colonial histories. Yet the restitution discourse is remarkably similar across global efforts, often prioritising who gets to profit from an artefact or artwork and who is best placed to maintain it in its material form [3, 19, 62, 93], with less regard for the spiritual and non-material dimensions of returning an artwork or entity to its origin community [15, 43, 106, 131].

> **Digital technologies can remove us from the normal practices of the Western Museum – there are new ways of creating memories by digital means and this is incredibly exciting**
>
> **— Chidi Nwaubani, Designer, Artist and Founder of Looty**

Communities are increasingly looking toward alternatives which can enable engagement with the stolen artworks in their material absence. As an extension of this development, numerous origin communities utilise digital technologies to engage with artefacts that remain in overseas collections, or cultural practices. As one of the first global examples of digital restitution, The Congolese Plantation Workers Art League (CATPC) initiated the Balot NFT initiative. They minted and sold 306 unique Non-Fungible Tokens (NFTs) of a sculpture currently held in the Virginia Museum of Fine Arts, which was carved during a Pende uprising against Belgian colonial agents and the Unilever plantation system (for more information on NFTs see 'Technology Deep Dive: Blockchain'). CATPC are using the funds generated to buy back local land, thus leveraging Digital Cultural Heritage to trial locally-led approaches to governance, land-use and community building [198].

Digital Cultural Heritage practitioners also highlight how technology can place the power of cultural narratives back in the hands of local owners. Games and other experiences enhanced by immersive technologies are seen to provide potential opportunities to counteract 'official' histories with lived experiences, engaging communities in their ancestors hopes, triumphs and spiritual practices. While digital practices are not replacements for restitution and repatriation, cultural practitioners highlight how they are important tools to build dialogues between countries whilst drawing attention to cultural reverberations of colonial violence.

Enhancing Digital Tourism

Regional and foreign tourism in Egypt, Ethiopia, Iraq and Kenya is currently concentrated in certain areas, with a few sites accounting for the majority of international tourism. Many heritage sites seek to attract more visitors – and boost the economic footprint of the surrounding region – whilst others aim to divert tourists from the most frequented hotspots to less popular sites. Digital technologies can support both aims. They can be used as a means of advertising, reputation-building and visitor engagement, but also as strategic tools to divert tourists from overvisited sites to more niche destinations. This is particularly relevant for heritage protection initiatives which seek to preserve enormously popular sites which are negatively affected by tourism. Similarly, heritage sites which are threatened by climate change or deterioration can be made accessible through digital engagements and can use increased tourist attention to raise awareness and funds for mitigating these challenges.

> **Community engagement with cultural heritage tends to be positive, unless a place is spoilt by tourism. In those cases, it can become difficult to build trust**
>
> **— Laura Melpomeni Tapini, Founder, Managing Director and Head Conservator at Diadrasis**

> **As a tech company, we leverage cutting-edge technologies like VR, AR, AI, IoT, and robotics to empower sectors like tourism**
>
> **— Daniel Getachew, Founder and CEO of Guzo Technologies**

Tailoring Devices to Local Usage

Heritage institutions with a digital presence must account for people navigating different digital formats. A website, for instance, must be desktop-, tablet- and phone-friendly for people to reliably access it. In a region where most people access the Internet through smartphones, priority may be given to mobile interactions. For instance, The Arches Project is an open-source data management platform which can be used by organisations to create heritage inventories, heritage science databases and to manage infrastructure and construction projects. The platform's adaptation of smartphone-first approaches connects a wider range of organisations, users and functionalities to critical resources. Within the countries highlighted in this report, understanding the device usage patterns of local communities and finding the right balance between mobile and desktop access is particularly relevant for community involvement in heritage preservation.

> **Phones are really important technology because of their accessibility. Most people already have them, and they're brilliant for rapid data capture**
>
> **— Rob Woodside, British Council CPF Specialist Assessor; Conservation and Estates Director, English Heritage**

> **Anything like WhatsApp, instant messaging, really the most basic things that put engagement and communication at the forefront… not only [are] affordable and easy to do, but actually have some of the biggest impact**
>
> **— Margaret Maitland, Principal Curator of the Ancient Mediterranean, National Museums Scotland; Partner in Egypt's Dispersed Heritage**

Home-grown Expertise for Heritage

The tech industries in Egypt, Ethiopia, Iraq and Kenya currently largely rely on foreign software and digital skills, but this is beginning to change. In Kenya, for instance, training programmes and local start-ups have already created a digital landscape with a uniquely Kenyan character, contrasting both with tech ecosystems in neighbouring countries and globally dominant Western technological conventions [164]. Developing this local character is important, as it drives research, development and experimentation towards technologies rich in local nuance and culture. Experimental uses of emerging technologies are one of the most vital drivers of innovation and the foundation for the long-term establishment of new tech markets. In the context of heritage protection, this presents an important argument to support the prioritising of local training programmes for tech skills and equipment maintenance [98, 105, 136]. Considering the long-term sustainability of digital approaches, it is essential that local stakeholders know how to use, maintain and experiment with digital tools independent of foreign intervention.

> **We have had a lot of engagement from people and practitioners who have come to us for training on digitisation... so we have built a substantial community of cultural practitioners here in Kenya, both at a grassroots level and at a national level through training opportunitiest**
>
> **— Chao Tayiana Maina, Founder of African Digital Heritage; Museum of British Colonialism; Open Restitution Project and Save the Railway**

Digital Cultural Heritage Technology Deep Dives

This section introduces key technologies used in Digital Cultural Heritage, covering a wide range of applications and use cases. Based on previous Cultural Protection Fund applications, desk and expert-led research, we selected 3D printing, Anti-theft Technologies, Artificial Intelligence (AI), Blockchain, Databases, Digitising, Extended Reality (XR), Gaming and Social Media. Each deep dive details a technology's applications, benefits and challenges in preserving, protecting and engaging with cultural heritage.

3D Printing

Key Takeaways

Overview

3D printing can be used in Digital Cultural Heritage to create physical replicas of artefacts for educational purposes, exhibitions and preservation, allowing for hands-on interaction with historical objects.

Pros

Enables the accurate reproduction of artefacts, supports conservation efforts and enhances accessibility for education and exhibition.

Cons

High costs and technical barriers limit widespread adoption and it requires significant maintenance and specialised skills to operate.

Ethical Risks & Considerations

Issues of copyright, cultural appropriation and the potential displacement of traditional artisans need careful management.

Possible Future Deployments

Locally developed training programmes and startups are emerging, focusing on capacity building and indigenous solutions whilst decreasing dependence on foreign technology, boosting innovation and sustainability.

Examples

Reproduction of the Bull of Nimrud at the Museum of Basrah [179], replication of the Natural History Museum's much-loved Diplodocus [180] and creation of tactile exhibits for visually impaired visitors at the Victoria and Albert Museum [43].

What is 3D Printing?

3D printing is an umbrella term for a variety of manufacturing processes that build physical structures from three-dimensional digital models by layering material planes in succession.

3D printers range from household devices which can be used by laypeople – mostly using bio-degradable, corn-based plastics as their printing material – to industrial concrete 3D printers, used by professionals, which can build entire houses. 3D bio-printing, an approach which uses cells and other biological base materials to print, is particularly cutting-edge in this field. 3D bio-printers have the potential to fundamentally change cultural practices, since they can print, among other things, food, insects and organs.

In heritage protection contexts, the uses of 3D printing are varied. Smaller printers can be used to create precise replicas of missing or damaged parts of artefacts and monuments, enabling accurate restoration. These replicas can be used in visitor engagement and teaching, with individuals handling the shapes and textures of historical artefacts without risking damage to the originals. Larger 3D prints may support the reconstruction of deteriorated or endangered heritage sites or provide bespoke support structures.

In addition to material outputs, the virtual models, 3D modelling software and online repositories upon which 3D printing relies are also valuable resources for digital forms of heritage preservation. Thus, 3D printing is closely interwoven with other digital technologies which connect virtual and material dimensions of heritage preservation, such as Extended Reality (XR) technologies and object-oriented online databases. One of its greatest strengths, however, is its wide range of applications in heritage protection and restoration, spanning both public-facing, industry-specific and research functions.

How is 3D Printing being used for cultural heritage?

Artefact Replication and Restoration

3D printing technologies can replicate and restore historical artefacts and cultural heritage items. By producing accurate and detailed replicas, 3D printing allows museums and heritage institutions to preserve and display fragile or damaged items with minimal handling, thereby reducing the risk of damage to the originals.

This technology extends to specialised forms such as concrete 3D printing which holds transformative potential for the replication and restoration of historic structures. It can capture intricate architectural details and textures, such as ornate facades or decorative elements, producing faithful replicas of heritage buildings and artefacts. Moreover, it enables the creation of customised restoration solutions tailored to the specific needs of a heritage site. This includes replacing deteriorated elements or reinforcing fragile components with precise and durable structures that integrate seamlessly with existing architecture.

Concrete 3D printing is a relatively new innovation in the construction and restoration industry, allowing for the creationn of complex structures that were previously difficult or impossible to achieve with traditional methods. This technology offers reduced costs, shorter construction times and enhanced sustainability. However, being a novel technology, it is still subject to evolving regulations. The ongoing development and acceptance of concrete 3D printing in heritage construction and restoration are dependent on regulatory bodies establishing and enforcing safety standards for 3D printed buildings and structures.

Archaeological Reconstruction and Visualisation

3D printing offers a powerful tool to reconstruct and visualise archaeological sites, structures and artefacts with unprecedented detail and accuracy, providing valuable insights into past civilisations and historical events. 3D printing can also enable the reconstruction of ancient biological structures, such as facial reconstructions based on skeletal remains [199]. Through these processes, researchers can gain insights into the social and cultural aspects of ancient populations' health, diet and lifestyle, contributing to bioarchaeological understandings of cultural heritage. Additionally, another 3D printing technology, Metal 3D printing, can be utilised for non-invasive restoration, creating bespoke structures that would not risk damaging or alteration of original materials, allowing heritage sites to be restored without compromising their authenticity or integrity.

Accessible Heritage Experiences & Education

3D printing technologies can enhance the accessibility of museum collections for diverse audiences, including individuals with disabilities. Tactile replicas and interactive exhibits created through 3D printing allow visitors to engage with cultural heritage items through touch, fostering greater inclusivity and engagement in museum experiences. Additionally, 3D-printed replicas and models serve as powerful educational tools for teaching history, archaeology and cultural heritage. Educational institutions and heritage organisations can use 3D printing to develop immersive learning experiences, interactive exhibits and educational resources which engage students and the public in the study and appreciation of cultural heritage

Conservation and Preservation

3D printing technology supports conservation efforts by providing tools for the preservation, repair and replication of heritage assets. Conservationists can use 3D scanning and printing to document and analyse deteriorating artefacts, create custom-fit supports and replicas for restoration and develop innovative conservation solutions to protect cultural heritage for future generations. 3D bio-printing, for example, could become an enormous contributor to environmental conservation efforts by replicating endangered or extinct species' biological structures. These replicas of extinct animal bones or tissue could enable researchers to study their morphology and contribute to biodiversity conservation initiatives. Simultaneously, bio-printing could be utilised to preserve and protect living cultural heritage, such as ancient trees or heritage gardens. By reproducing plant tissues or entire organisms, bio-printing could help maintain biodiversity in cultural landscapes and protect endangered species. Generally, the integration of advanced materials in 3D printing can help mitigate environmental degradation and prolong the lifespan of restored buildings, structures and artefacts.

Remote Access and Digital Archives

Like immersive technologies, the digital modelling side of 3D printing enables the creation of digital archives and repositories of cultural heritage assets, facilitating remote access and research opportunities for scholars, students and the public. Digital models generated through 3D scanning and printing preserve the physical characteristics and historical context of material heritage, allowing for virtual interaction from anywhere in the world. A crucial benefit of 3D printing in relation to these repositories is that they do not only facilitate virtual engagement but rather enable a re-translation of digital spaces into tangible replicas. This aspect of 3D printing has widespread potential for enhancing embodied engagement. While an AR (Augmented Reality) experience may enable someone to examine the Rosetta Stone from within the walls of their classroom, 3D printing allows for them to produce their own tangible replica.

Crowdsourced Conservation and Reconstruction

In addition to being usable by specialists, 3D printing technology empowers communities to participate in the conservation and reconstruction of cultural heritage sites and artefacts through crowdsourcing initiatives. While 3D printing has relatively high skill requirements to conduct a replication process end-to-end, many elements of the process are

easy to share and utilise in collective settings. By sharing digital models and collaborating on 3D printing projects, community members can contribute to the preservation and interpretation of their cultural heritage, fostering collective stewardship and appreciation of shared heritage resources [200]. This is particularly relevant for initiatives which aim to shift existing power dynamics within heritage preservation from institutions and towards community stakeholders [159]. Training programmes for 3D printing skills for heritage preservation conveniently provide skills for broader applications in the tech industry, potentially attracting a different range of community involvement than other heritage protection approaches.

Conservation and Preservation

3D printing technology supports conservation efforts by providing tools for the preservation, repair and replication of heritage assets. Conservationists can use 3D scanning and printing to document and analyse deteriorating artefacts, create custom-fit supports and replicas for restoration and develop innovative conservation solutions to protect cultural heritage for future generations. 3D bio-printing, for example, could become an enormous contributor to environmental conservation efforts by replicating endangered or extinct

Further Case Studies

- 3D mapping and reconstruction of Mau Mau detention camps by African Digital Heritage [201]
- The Zamani Project—3D models of the Great Mosque of Gede and the Swahili house museum in Lamu [202]
- 3D scanned digital bust of Nefertiti (Neues Museum, Berlin) [23]
- 3D scanning of Ramses II statue and collection of artefacts from King Tutankhamun's tomb (Grand Egyptian Museum) [203]
- The reconstruction of the Palmyra Arch by the Institute for Digital Archaeology and their replication of the Elgin Marbles, are examples of 3D manufacturing being used in a subtractive process, where material is removed or chiselled away [166]

What are the risks and ethics of 3D Printing in cultural heritage?

- **Health Risks:** Potential health risks from fumes (e.g. materials like ABS emit styrene), liquid resins (which are toxic and can cause skin irritation or allergic reactions), fine powder particles (which pose respiratory hazards if inhaled and skin irritation if not handled properly), metal powders (highly reactive and hazardous if inhaled or improperly handled, posing significant respiratory and contact hazards), photopolymer resins and UV light, biologically active materials (which require stringent sterility and safety protocols to prevent contamination and ensure operator safety) and concrete dust exposure.

- **Pollution:** Non-biodegradable materials contribute to plastic waste, posing environmental and sustainability challenges.

- **High Costs:** While some 3D printers are increasingly affordable and accessible, many still represent a significant investment for individuals or small businesses. Additionally, the operation and maintenance of these machines require technical knowledge and skills, which can be a barrier for novices and may increase labour costs.

- **Copyright & Data:** The use of 3D scanning/printing technologies raises ethical concerns regarding the replication of copyrighted or patented artefacts without permission, leading to intellectual property disputes and potential legal issues. There is also a potential risk of hacking and unauthorised access to proprietary or sensitive design files, which could lead to theft of designs or compromised product integrity.

- **Cultural Appropriation:** The use of concrete 3D printing technology may lead to debates over the aesthetics and cultural appropriateness of new structures in historic or sensitive areas, potentially leading to disputes over urban and architectural heritage.

- **Bioethics:** 3D bio-printing raises ethical concerns about the manipulation of biological tissues and the potential creation of living organisms, which can give rise to debates about medical ethics, consent and the meaning and advisability of human enhancement.

- **Statics risks:** 3D-printed architectural structures bear similar risks in terms of statics and load bearing as do other forms of architecture.

- **Labour Rights:** Concrete 3D printing raises ethical concerns regarding the displacement of traditional construction jobs, potentially leading to economic and social impacts on communities accustomed to conventional building practices.

What could be the future of 3D printing in cultural heritage?

- **Artefact Replication:** 3D printing creates detailed replicas of fragile or damaged artefacts, allowing museums to preserve and display items whilst minimising damage to originals — for example, the 3D-scanned digital bust of Nefertiti (Berlin Neues Museum) [144].

- **Archaeological Reconstruction:** 3D printing helps archaeologists reconstruct and visualise sites and artefacts with accuracy, providing insights into past civilisations and historical events, such as Wessex Archaeology's visualisations of archaeological and historical locations [204].

- **Accessible Museum Experiences:** 3D-printed tactile replicas and interactive exhibits enhance accessibility for diverse audiences, including those with disabilities, fostering greater engagement with cultural heritage. Cambridge's Fitzwilliam Museum [116], for example, has conducted research into the potential of using 3D printed artefacts to provide tactile viewing experiences for visitors and to limit the touching of real artworks on display.

- **Educational Outreach:** Educational institutions use 3D-printed models as immersive tools to teach history and cultural heritage in immersive and interactive ways, as exemplified by the Science Museum Group [205].

- **Conservation:** 3D printing aids conservation efforts by documenting, analysing and replicating deteriorating artefacts, supporting innovative solutions for protecting cultural heritage [32].

- **3D Bioprinting:** While still in its infancy of development and utilisation for the museum and cultural heritage sectors, with pointed investments into specialised techniques and technologies, 3D bioprinting could be used to replicate and restore delicate biological artefacts like ancient bones, fossils, or organic materials including leather or textiles, by precisely recreating missing or damaged parts using compatible organic materials, offering a non-invasive and sustainable conservation method.

> **Careful planning in 3D data capture is crucial — ensuring you've considered all facets of the capture, throughout the pipeline all the way to data accessibility and data archiving.**
>
> **— Lyn Wilson, British Council CPF Specialist Assessor; Head of Research & Climate Change, Historic Environment Scotland**

Case Study:

Restituting Kenyan Heritage – the 3D-Printed Kamba Belt

Kenya currently has the foundation for most, if not all, of the infrastructure for broad applications of 3D printing, but the tech is still in the early stages of adoption. Various forms of 3D printing are beginning to find their way into diverse sectors, including education, healthcare and cultural preservation. The University of Nairobi's Science and Technology Park opened a Fab Lab in 2009 [206] and local initiatives are increasingly employing 3D printing to create medical supplies, educational tools and replicas of cultural artefacts. The Kenyan Government's National Assembly also passed the ambitious Affordable Housing Bill 2023/2024 [58], banking heavily on advancements in large-scale 3D printing to help meet their construction goals. This is not necessarily specific to Kenya: the technology itself is still finding its niches in the global manufacturing ecosystem and its potential applications vastly exceed its current use.

The 3D-Printed Kamba Belt [179] is a project arising from the International Inventories Programme (IIP) [207], which questions Kenyan collections' presence in Western museums. The IIP is a collaborative research and database initiative focused on documenting Kenyan cultural objects held in institutions worldwide. Its aims are to build relationships between the National Museums of Kenya and global cultural institutions, create a comprehensive inventory of Kenyan artefacts abroad and improve the identification, labelling, storage and display of these artefacts.

Dennis Poriot and Steve Onyiro are part of a team of Kenyan and German anthropologists who are 3D-printing replicas and bringing them to their communities of origin. Since 2022, the team has been working towards cataloguing every artefact from Kenya which remains outside the country. So far, they have identified more than 32,000 artefacts in 30 museums across seven countries.

Image Courtsey of Fablab Nairobi.
Copyright Ken Abwao.

The 3D printed Kamba Belt offers us a unique and innovative approach to cultural restitution using 3D printing. It is relevant to global conversations on historical injustices and the decolonisation of museum collections. Kenya, like many postcolonial countries, is seeking the return of artefacts taken during colonialism, now housed abroad. The use of 3D printing to create faithful replicas is a mitigating option for Kenyan communities to reclaim and share their cultural legacy domestically whilst the return of the originals is still being negotiated. This project exemplifies how the 3D printing of highly accurate replicas of cultural artefacts, which preserve intricate details that might be lost with other replication methods, can contribute to restitution. Apart from symbolic value, these high-quality replicas can also be used in educational settings and exhibitions, making these artefacts accessible to broader audiences in the absence of the originals. Additionally, this project questions the cultural significance and ownership of the original artefacts, fostering ongoing conversations about materiality, historical injustices and decolonisation.

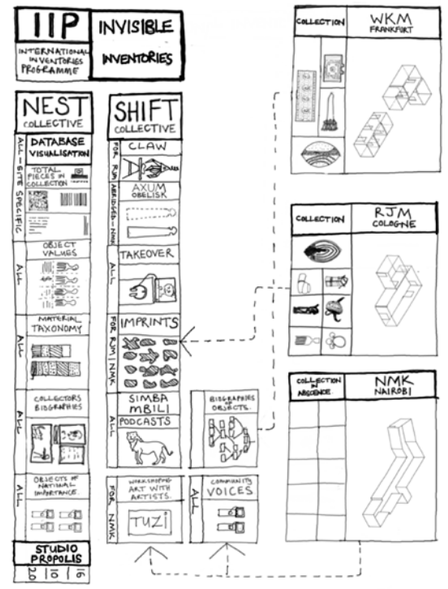


Image Courtsey of Fablab Nairobi.
Copyright Ken Abwao.

> **Handing over the 3D recreated version of a museum artefact to the original communities is not an ideal solution. But we feel it starts the conversation and can lead to other resolutions.**
>
> **— Terry Little, British Council CPF Specialist Assessor; Lecturer, Dept. of Archaeology and Heritage Studies, Ahmadu Bello University**

Anti-theft Tech

Key Takeaways

Overview

Anti-theft technology in Digital Cultural Heritage can be applied to protect valuable artefacts from theft and loss by integrating tracking and security measures into both physical and digital collections.

Pros

Enhances the security of cultural assets and aids in the recovery of stolen items through advanced tracking and identification technologies.

Cons

High implementation and operational costs can limit its use, particularly in regions with fewer digital and personnel resources.

Ethical Risks & Considerations

The use of tracking technologies raises privacy concerns, particularly in how data is managed and protected and there is a risk of these technologies being misused for purposes other than heritage protection.

Possible Future Deployments

Future advancements might involve the integration of IoT with Anti-theft systems to improve the predictive capabilities of these technologies and the development of more affordable and accessible systems that can be widely adopted in various settings, including at-risk conflict zones.

Examples

SmartWater fingerprinting in Iraqi museums [212], GPS trackers to reveal ivory smuggling routes [44], GlobalXplorer monitoring looter holes [160] and Rashid International's satellite monitoring of Iraqi archaeological sites [213] [43].

What is Anti-theft Tech?

In recent years, the rise of sophisticated Anti-theft technologies has significantly enhanced the ability of museums, galleries and heritage sites to safeguard material cultural heritage.

These technologies, ranging from SmartWater fingerprinting and Global Positioning Systems (GPS) tracking to digital inventory management, provide promising defence mechanisms against theft and looting. Their potential, however, is yet to be fully harnessed in cultural heritage protection, largely due to the cost of their implementation.

Digital fingerprinting is a particularly apt example of this dilemma. This technology involves creating a unique digital identifier for each artefact, artwork, or historical document, capturing its specific characteristics and details. These identifiers are based on high-resolution imaging and advanced algorithms which analyse unique features in texture, colour and microscopic surface variations. By generating a digital fingerprint, institutions can maintain an accurate and unalterable record of each item, which serves as a benchmark for verifying authenticity and detecting forgeries. This process is particularly valuable for items which are frequently loaned out or displayed in various locations, as it allows for quick and reliable verification upon their return.

Beyond authentication, Digital Fingerprinting can be integrated with global databases and tracking systems, facilitating international cooperation in the fight against heritage artefact theft and illicit trafficking. Additionally, Digital Fingerprinting supports conservation efforts by documenting the condition of artefacts over time, allowing conservators to monitor changes and implement timely interventions. As a result, Digital Fingerprinting not only protects the integrity and provenance of cultural heritage items but also contributes to their long-term preservation and accessibility. While entire archaeological sites could hypothetically be protected in this way, the cost of such an endeavour is prohibitive to most heritage sites, especially those most at risk of destruction. Thus, reducing costs is one of the core challenges faced by proponents of cutting-edge Anti-theft technologies.

> **Many resources are being lost, with artefacts often smuggled out as souvenirs. Without even digital copies or knowledge of their stories, we risk losing our heritage entirely**
>
> — **Daniel Getachew, Founder and CEO of Guzo Technologies**

How is Anti-theft Tech being used in Cultural Heritage?

Law Enforcement

Anti-theft Technologies have become integral to law enforcement settings in the Global North, where they are used extensively for asset-tracing and recovery. Technologies including GPS trackers and Smartwater enhance the ability of law enforcement agencies to track stolen goods and recover them efficiently. By embedding tracking devices and using advanced identification methods including tagging with unique chemical signatures, law enforcement can significantly reduce the incidence of theft and ensure the swift return of stolen assets. In the fight against illegal trafficking, Anti-theft technologies have proven invaluable. In Iraq, Yemen and Syria, for instance, SmartWater is employed to combat illicit trading of antiquities [9]. Similarly, in Benin, SmartWater and GPS tech are used to prevent the illegal ivory trade [39].

Museums & Archives

Museums and archives rely heavily on Anti-theft technologies for various purposes. Passive RFID tags (Radio Frequency Identification tags) contain tiny microchips or antennas which use radio waves to wirelessly identify and track objects [208]. Alongside SmartWater fingerprinting [39], RFID tags help to identify and associate objects, which is crucial for storage, cataloguing and exhibition support. By implementing sophisticated tracking and identification systems, museums can better manage their collections, ensuring that each item is accurately documented and protected from theft or loss.

Humanitarian Aid

Innovative uses of Anti-theft Technologies have also been applied in humanitarian aid, particularly in active conflict zones. Technologies like RFID-enabled GeoSeals have been used to track aid shipments in Ethiopia [14] and monitor their stock levels, ensuring that resources reach their intended destinations and are not diverted or stolen. This enhances the efficiency and effectiveness of humanitarian efforts in areas where security and resource management are critical. This can easily be translated to heritage protection contexts: beyond tracking an object, institutions can also use Anti-theft Technologies to ensure sealed packages were not opened or tampered with.

Counterfeits

In industries such as pharmaceuticals and luxury goods, Anti-theft Technologies are already being used to ensure the authenticity of products. Pharmaceutical production and storage facilities in the USA, for example, depend on real time location systems (RTLS) [111] which leverage Wi-Fi infrastructure and harness wireless technologies such as Bluetooth to monitor progression of inventory along a supply chain. The implementation of RTLS early in supply chains allows handlers to confirm the provenance of products by the information on their covert tags. This makes the insertion of counterfeit goods along the supply chain easy to notice due to the inaccurate information on their tags [100]. Heritage institutions can leverage the same technological tools to identify and prevent counterfeiting and illicit replication of protected heritage artefacts.

Further Case Studies

- Rashid International's use of satellite technology to monitor Iraqi archaeological sites [169]
- GPS trackers being implanted in elephant tusks to trace ivory trafficking routes [44]3D scanned digital bust of Nefertiti (Neues Museum, Berlin) [23]
- RFID tags (GeoSeals) being attached to boxes of humanitarian aid to safeguard during transit and monitor stock levels [14]
- FLIR thermal imaging/infrared cameras allowing rangers to find and catch poachers or looters in deep darkness [113]

What are the risks and ethics of Anti-theft Tech in Cultural Heritage?

- **Cultural Sensitivity:** Some may be resistant to tagging certain articles of sensitive religious or cultural significance, such as religious texts or relics. Furthermore, museum staff and visitors may be offended by the implication that precious artefacts are at risk of being looted by them.

- **Systems Vulnerabilities:** As with any radio technology, RFIDs run the risk of having signals blocked. If the middleware were hacked, the whole system might be vulnerable.

- **Damage to Artefacts:** Attaching GPS trackers to objects could potentially cause damage. Additionally, they are battery-reliant and more easily detectable than discreet RFID tags or SmartWater and can therefore be easily removed by looters or thieves. Microdots (description below) cannot be removed so the item will be indelibly marked with the same number for a long time and additionally, the number record cannot be updated or easily overwritten.

- **Privacy Concerns:** There may also be privacy concerns about using GPS technology, particularly in countries or regions with a history of enhanced government or foreign surveillance.

- **Ethical Concerns:** SmartWater could be used as a surveillance tool. Indeed, ideas like the 'SmartWater Cannon' have provoked ethical debate (see Anti-theft Tech Case Study).

What could be the future of Anti-theft Tech in Cultural Heritage?

- **Law Enforcement:** After a successful pilot project in Iraq, SmartWater has been applied to at-risk artworks in other countries such as Yemen and Syria. It has been suggested the liquid could be used to cover large areas such as archaeological sites, through distribution by drones or crop-duster aircraft [9]. These methods are currently in their trial stages.

- **IoT**: Low-cost RFID technology is being trialled for the tracking and monitoring of humanitarian aid shipments in conflict regions, such as Tigray [12]. RFID tech is increasingly being integrated with Internet of Things (IoT) technologies to improve real-time data collection and analysis.

- **Networks:** GPS has been used in conjunction with RFIDs—such as in the Orion Network [165]—to provide sophisticated and accurate security solutions for museums and galleries. In terms of asset tracking in industry, cloud-based solutions such as the Pozyx platform [209] are commonplace for asset visibility.

- **Personal asset tagging:** A growing trend in the consumer market is towards attaching small GPS or Bluetooth trackers to personal items such as luxury handbags to allow them to be traced if lost or stolen. A cutting-edge example of this technology is the Apple AirTag [173], which allows precise tracking and integration with other Apple technologies such as iCloud and the 'Find My' app.

- **Microdots:** Microdot tagging is growing in popularity as a method for reducing high value asset loss, for example of vehicles, luxury good shipments and valuable construction materials such as copper wire and metal components. DataDot has developed a web-based asset upload platform [174] where all items marked with DataDot microdots can be recorded, for an annual fee. This has the potential to function as a centralised register for all micro-dot marked items across a country or region.

> **Trying to convince people to do checks is the real challenge because these checks suggest you are looking for a problem. People see it as having to prove a negative. Take SmartWater: people have to know they should be looking for it.**
>
> **— Will Korner, Founder of the Cultural Heritage at Risk Database (CHARD); DCH Expert**

Case Study:

SmartWater – Fingerprinting atrisk artworks in Iraqi Museums

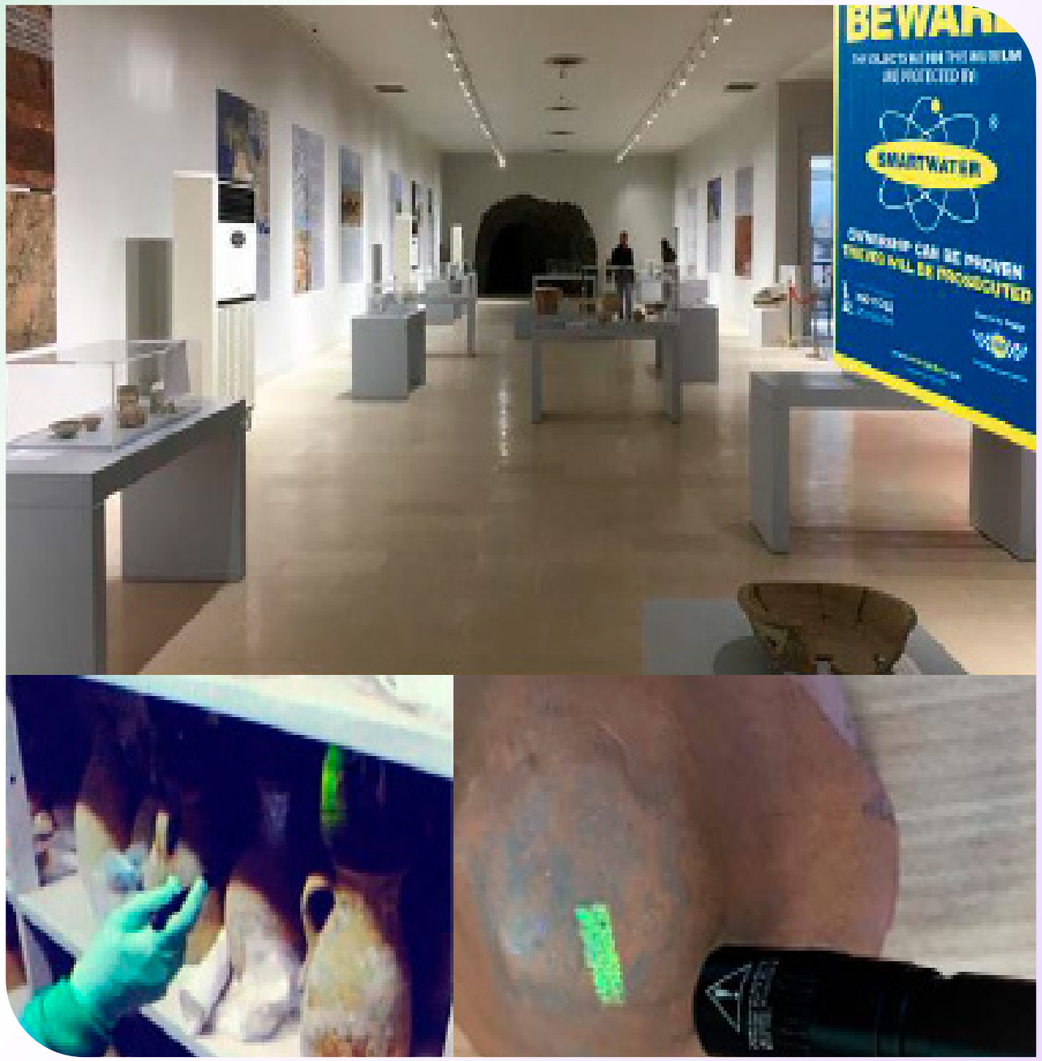
Iraq has experienced several significant waves of looting during national conflicts and political crises. The most notable of these was the 2003 looting of the Iraq Museum which saw the theft of thousands of artefacts during a period of US-Iraqi military action. In the late 2010s, the widespread destruction and theft of cultural heritage witnessed during the Daesh Insurgency (c.2014—2019) [26] demonstrated the continued need for innovative Anti-theft measures in Iraq. In response, international NGOs and funders, Iraqi state institutions and museum professionals have piloted innovative applications of Anti-theft technologies.

In 2020, a collaboration between British Council CPF, the SmartWater Foundation, the University of Reading and Iraq's State Board of Antiquities and Heritage supported the tagging of thousands of artworks in Iraqi Museums with SmartWater's patented forensic liquid. Artworks tagged with forensic liquid are unappealing to illicit antiquities dealers and buyers since their stolen provenance is easily identifiable by law enforcement agencies. The project introduced a long-established law enforcement method of deterring theft into cultural heritage contexts, safeguarding at-risk artefacts and increasing their chances of recovery and restitution in the case of looting.

Researchers at the University of Reading first tested the safety and durability of SmartWater liquid before it was implemented in a real-life cultural heritage protection scenario. Each bottle of SmartWater heritage liquid contains a unique chemical code. Once applied to an inorganic object such as a potsherd or stone tablet, SmartWater is indelible and invisible, only appearing under black UV light. Funding from the British Council's Cultural Protection Fund alongside generous discounts on the liquid and application tools from the SmartWater Foundation enabled this project to succeed. 273,000 artworks were tagged and catalogued over the course of the pilot project, exceeding the initial target of 265,000, demonstrating the scalability and effectiveness of this method.

Apart from tagging and thereby protecting the thousands of cultural valuables mentioned above, the project enabled the continuation of SmartWater tagging in Iraqi institutions by training 43 Iraqi museum professionals, including underrepresented groups, such as women, in digital fingerprinting, well above the planned target of just 18 trainees. Moreover, the SmartWater Foundation has established best practices for the protection of mobile at-risk cultural property in other countries as well, with SmartWater liquid subsequently being applied in Yemen [156] and Syria [181]. Increased training opportunities resulted in the wider spread of knowledge on the technique, which has, in turn, accelerated the use of SmartWater in multiple localities. Other potential uses of anti-theft tech in Iraq include widespread coverage of archaeological sites with SmartWater using crop-duster aircrafts, 'SmartWater cannons' aimed at looters and utilising SmartWater in litigation processes for restitution cases [170].

Image Courtesy of Smartwater.
Copyright Roger Matthews.



Artificial Intelligence (AI)

Key Takeaways

Overview

AI can be applied to Digital Cultural Heritage by automating the cataloguing of artefacts, enhancing digital restorations and creating interactive virtual experiences that engage with historical data in new ways.

Pros

Enhances the security of cultural assets and aids in the recovery of stolen items through advanced tracking and identification technologies.

Cons

Enhances the security of cultural assets and aids in the recovery of stolen items through advanced tracking and identification technologies.

Ethical Risks & Considerations

There are significant concerns around the transparency of AI processes, data ownership and the potential for AI to reinforce existing inequalities if not carefully managed. Additionally, there are concerns about intellectual property rights and the authenticity of AI-generated reconstructions.

Possible Future Deployments

AI could evolve to support more local and culturally sensitive heritage projects, particularly in language translation and the integration of AI with other digital tools to create more dynamic and accessible cultural databases at-scale.

Examples

The Alan Turing Institute's 'Living with Machines' project [191], The British Museum's 'Curatorial Assistant' AI [192] and the 'Transkribus' project for historical handwritten text recognition [210]

What is Artificial Intelligence (AI)?

Artificial Intelligence (AI) is a broad field enabling machines to undertake tasks traditionally requiring human intelligence.

Within this sphere, Natural Language Processing (NLP) concentrates on interpreting and generating human language, Computer Vision analyses visual data and Large Language Models (LLMs) employ extensive datasets to produce complex text. According to the Future Art Ecosystems Public AI / ATI framework, a typical AI workflow spans data collection, preprocessing, model selection, training, validation, deployment and ongoing monitoring. Applied to cultural heritage, these technologies can streamline efforts such as detecting damage in artefacts, translating ancient scripts and offering immersive digital experiences, ultimately safeguarding these treasures for generations to come. NLP, for instance, is increasingly employed to analyse and interpret vast amounts of historical texts and documents, aiding researchers in uncovering insights and connections which would be time-consuming or impossible to detect manually. Simultaneously, NLP may help digitise and translate artefacts bearing ancient scripts, making historical knowledge more accessible and preserving it for future generations. Computer Vision, on the other hand, may be used to catalogue visual data from artefacts, artworks and archaeological sites, detect and track changes over time, identify patterns of deterioration and assist in restoration processes by providing detailed visual analyses.

How is Artificial Intelligence being used in cultural heritage?

Data Collection and Acquisition

Consistency and comparability across diverse cultural heritage datasets can be achieved by using AI to make the data easier to work with. Machine Learning algorithms can automate this 'normalisation' process by learning how to best convert a variety of data types into a standard one, ensuring that all data inputs are consistent and analytically comparable. This adjusts contrasting data forms to a standard, usable format, to facilitate more effective processing. Foundation Models are adaptable to changes in data and can be retrained as new information becomes available, ensuring that cultural heritage data systems remain up-to-date and reflective of best practices. By periodically recalibrating their parameters, these models also maintain consistent data normalisation processes and update underlying algorithms to reflect ongoing research, thereby preserving integrity and accuracy in cultural heritage datasets.

Data Normalisation and Algorithm Updates

AI can play a role in extensive data collection. The acquisition of digital records such as images, texts, or sensor data relevant to cultural artefacts, historical sites, or archives, can set the stage for rich, in-depth analysis. NLP and LLMs are instrumental in distilling and interpreting complex data from textual records, such as historical documents or archival materials like the Brookside Museum and Saratoga County Historical Society's Digital Docent [210]. They can process and understand vast amounts of text to uncover patterns, themes, or historical facts that would take humans much longer to identify.

Ranking and Predictive Analysis

AI algorithms can rank cultural heritage items within databases based on specified metrics. Machine Learning and Predictive Analytics could help rank cultural heritage items by significance or risk level, based on patterns learned from historical data, helping to predict future trends in heritage conservation needs. By generating data-driven risk assessments, these tools enable cultural institutions to prioritise preservation efforts and allocate resources more effectively, reducing the likelihood of irreversible damage and safeguarding the most vulnerable assets. Generative AI could then simulate potential future scenarios based on past data, helping professionals in cultural heritage to plan effectively for preservation efforts.

Image Acquisition and Data Annotation

Employing high-resolution and multispectral imaging techniques, Computer Vision can capture high-quality images and provide automatic annotations. (A clear example of Computer Vision being used like this is Europeana's Automated Metadata Tagging [211].) Each image or video is then annotated with metadata, which, given the right dataset, can detail elements from artefact's origin and age to its material and historical context. Furthermore, Deep Learning models could detect finer details in images, invisible to the naked eye, critical for assessing the condition of heritage items or for authenticating them.

Visualisation and Interpretation

AI systems can be deployed in the visualisation and interpretation of cultural heritage, enhancing how historical data is presented and experienced. Generative AI and Diffusion Models can offer detailed visual reconstructions of damaged or degraded heritage sites and artefacts (such as Europeana's AI-enhanced image restoration for digital archives [4] or Smithsonian Museum's AI-driven enhancement of historical photographs [64]). Applying complex academic research to engaging, interactive experiences, such as an AI reconstruction of a historical site, can broaden the reach of cultural heritage.

Addressing the Digital Divide

To bridge the digital divide, it is essential to promote inclusive AI development that considers diverse cultural perspectives from the outset. This includes providing resources and platforms for local initiatives, facilitating global collaboration and sharing best practices between Western and non-Western institutions. By doing so, AI can be leveraged to enhance the preservation and interpretation of cultural heritage in a way that is inclusive and respectful of all cultures, ensuring that technological advancements benefit a wide array of communities and contribute to a more equitable digital future. Current practices, such as Forensic Architecture's analysis of Yazidi cultural heritage destruction [212] and Morehshin Allahyari's 3D recreations of lost artefacts [7], highlight the potential of AI for preserving and interpreting cultural assets. However, there is a significant risk that AI applications developed in the West may not align with or respect the cultural contexts of the regions where they are implemented. This misalignment can worsen existing inequalities, since AI technologies may fail to adequately represent or preserve local cultural nuances and knowledge. Local initiatives play a crucial role in addressing these challenges by ensuring AI applications are culturally representative and inclusive. For instance, Masakhane's work on incorporating African languages into natural language processing and indigenous language preservation projects in the Americas [196] demonstrates how local contexts can be integrated into AI development. These initiatives highlight the importance of supporting and promoting region-specific AI projects that respect and preserve local cultures.

> **Now with AI and Machine Learning we have a lot of potentials, but only if we have captured good data from the outset.**
>
> **— Assaad Seif, British Council CPF Specialist Assessor; Archaeologist and University Professor, Lebanese University; UNESCO & ICOMOS Heritage Expert**

Further Case Studies

- Masakhane's grassroots organisation strengthening and spuring NLP research in African languages, for Africans, by Africans [213].
- Morehshin Allahyari's AI-driven practice merging activism and digital technologies to reimagine cultural narratives and mythologies [214].
- Nora Al-Badri's AI practice harnesses data appropriation and digital technologies to interrogate institutional power structures and decolonise cultural narratives [215].
- "Deep Learning in Archaeological Remote Sensing: Automated Qanat Detection in the Kurdistan Region of Iraq" uses remote sensing data and advanced machine learning to generate multi-resolution 3D reconstructions for cultural heritage sites [132].
- Forensic Architecture's applied satellite imagery and computational analysis to document and investigate the destruction of Yazidi cultural heritage [216].
- The Nairobi Art Centre's AI-powered tools provide interactive and engaging art education programmes [95]
- British Library's OCR (Optical Character Recognition) for Historical Texts (machine learning) [217]
- The Louvre's 'Beyond the Glass' app (computer vision) [218]
- Europeana's Automated Metadata Tagging (natural language processing) [211]
- The Smithsonian Institution's Digital Docent (deep learning) [65]
- The V&A Museum's persoalised virtual tours (foundation model) [219]
- The British Museum's AI-based reconstruction of ancient artefacts (diffusion model) [114]

What are the risks and ethics of Artificial Intelligence in cultural heritage?

- **Bias and Representation:** AI systems can inherit biases present in the data they are trained on, potentially leading to misrepresentation or underrepresentation of certain cultures or historical narratives. This can perpetuate existing biases and inequalities.

- **Data Privacy and Security:** The collection and storage of large amounts of data, including sensitive historical and cultural information, raise concerns about data privacy and security. Unauthorized access or data breaches could result in the misuse of cultural information.

- **Authenticity and Integrity:** The use of AI in recreating or restoring artefacts and sites might blur the lines between original and reconstructed elements, raising questions about the authenticity and integrity of cultural heritage.

- **Intellectual Property Rights:** The digitisation and reproduction of cultural artefacts using AI may infringe on intellectual property rights, especially if proper permissions are not obtained from rightful owners or custodians of cultural heritage.

- **Consent and Agency:** The communities to which cultural heritage belongs should have a say in how AI technologies are used to document, preserve, or recreate their heritage. Lack of consent and agency can lead to exploitation and cultural erasure.

- **Accuracy and Reliability:** AI-generated reconstructions and analyses might contain inaccuracies due to limitations in the technology or the quality of the input data. Reliance on such outputs without proper validation could lead to incorrect interpretations and decisions.

- **Accessibility and Equity:** There is a risk that AI technologies could widen the gap between well-funded institutions and those with fewer resources. Ensuring equitable access to AI tools and benefits is crucial to prevent disparities in cultural heritage preservation efforts.

- **Long-term Sustainability:** The use of AI requires significant resources, including computational power and technical expertise. Ensuring the long-term sustainability of AI-based heritage protection projects is essential to avoid the abandonment or degradation of digital assets over time.

- **Transparency:** The lack of transparency in the development of AI, the inner working of which are often black-boxed, is an ongoing concern. Even open source AI provides very little transparency and openness to adaptation [81].
  Production vs. Consumption: There exists a skills gap between a handful of global industry giants and the rest of the world. This gap creates challenges for local development capabilities and can result in dependence on technologies which were not developed with the needs and interests of people at global margins in mind. Examples of initiatives to counter this skills hap include SomosNLP [191] and BigScience projects [192].

What could be the future of Artificial Intelligence in cultural heritage?

- **Exponential Scale:** AI models are becoming bigger and more capable. For example, OpenAI's GPT-1, introduced in June 2018, consisted of around 117 million parameters. GPT-3, launched in June 2020, was trained on 175 billion parameters [109].

- **Increasing Specialisation:** Fine-tuned models are becoming increasingly specialised, such as in the healthcare context, where robot-assisted surgeries are projected to generate a market worth over 40 billion USD by 2026.

- **Localisation:** There are many localised use cases, for example in language translation models such as Wordly [220], where smaller models are both accurate and considerably more resource efficient than bigger models. This indicates the future potential of local AI model development and deployment.

- **Integration:** Integration is increasing, with models likely to gain more widespread access to the Internet in real time, which may improve the accuracy and relevance of their outputs. Better ways of linking LLMs with other tools that augment their capacities (for example, calculators) and with other real-world systems (for example, email, web search, or internal business processes) are expected

- **Collaboration:** Collaborative AI, where multiple AI systems work together to solve complex problems, is emerging as a new area of development. This is evidenced in business where multi-agent systems and federated learning are combined to streamline complex decision-making processes.

- **Hardware developments:** Investment in AI hardware, such as specialised chips and quantum computing, is likely to accelerate, to support the growing computational demands of advanced AI models.

- **Responsible AI:** AI ethics and governance continue to emerge as a major focus in policy and governance, with investments in developing frameworks and tools to ensure the responsible and fair use of AI technologies. Notable examples of regulatory bodies focusing on AI and algorithms include the UK's Office of Communications (OFCOM) and the U.S. Federal Trade Commission's (FTC) Office of Technology [221].

> **I think AI is very useful and important to our work, but it is important to support AI with the correct information and methodology.**
>
> **— Moaaz Lafi, Researcher of Islamic Architecture and Archaeology**

Case Study:

Deep Learning in Archaeological Remote Sensing – Automated Qanat Detection in the Kurdistan Region of Iraq

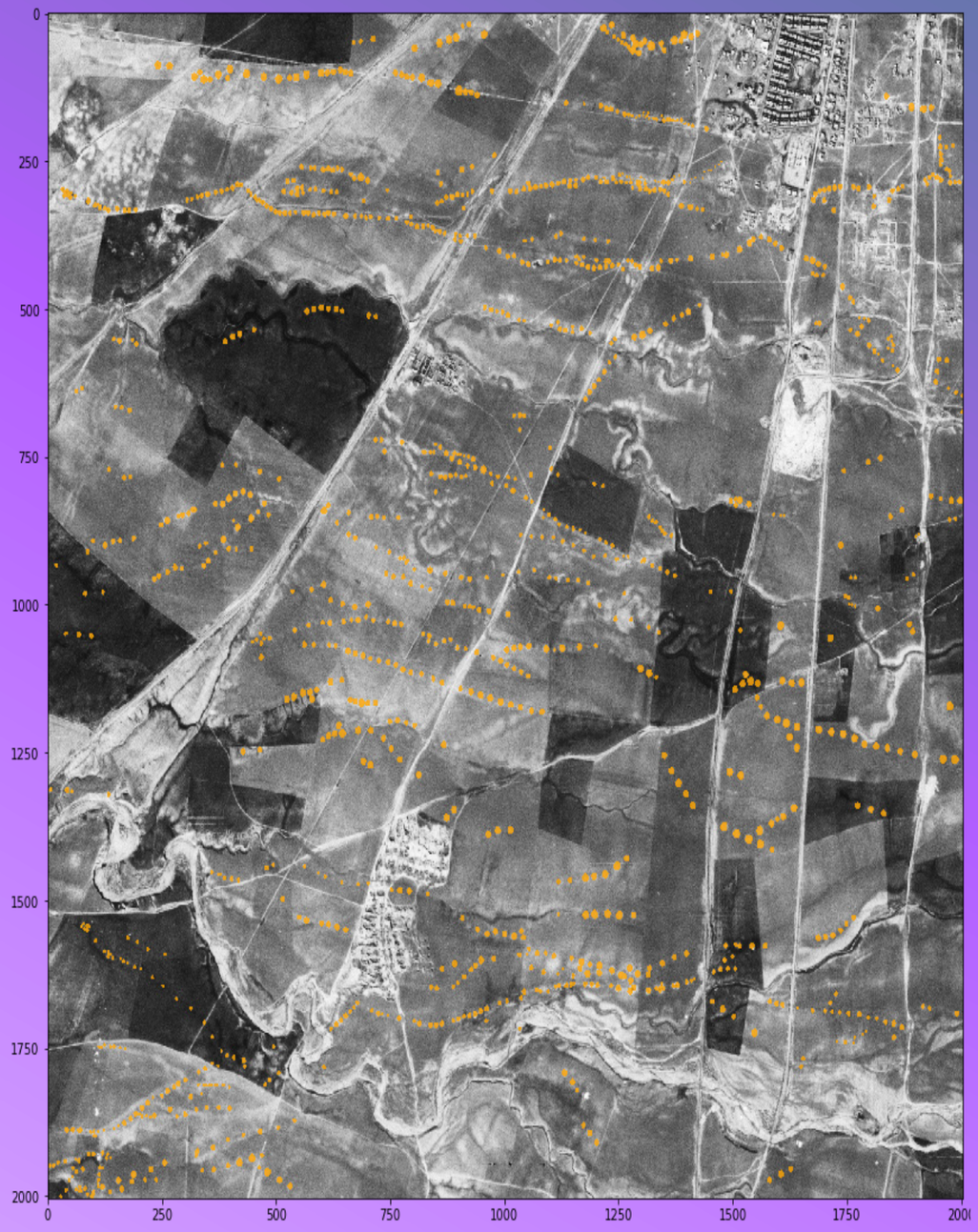
The Iraqi government is implementing significant economic reforms to attract foreign investments, particularly in the technology sector. These reforms include modernising laws to allow greater foreign ownership of businesses and fostering a more transparent business environment for AI projects. Additionally, Iraq is investing in renewable energy projects that heavily utilise AI for optimisation and management. These initiatives are part of a broader strategy to reduce the country's carbon footprint and address power shortages, with AI playing a critical role in managing these complex systems. In the heritage sector, AI is employed in varied capacities, including archaeological remote sensing.

A project exemplifying this use case is a 2020 research project which employed deep convolutional neural networks (CNNs) to detect qanat systems in the Erbil Plain, Kurdistan Region of Iraq, using declassified CORONA satellite imagery from the Cold War era. Qanats are ancient underground irrigation channels that transport water from aquifers in hillsides to arid areas, crucial for agriculture and settlement sustainability in historical contexts. They are vital for cultural heritage as they represent sophisticated engineering and the adaptation of communities to their environment over millennia.

Researchers developed a model trained on eleven image patches to identify semi-circular qanat shaft openings, creating a detailed map that digitally preserves these ancient irrigation systems, which may be lost to modern development. The study showcases the use of deep learning to automate the identification of qanat shafts from historical satellite imagery, addressing the challenge of processing vast remote sensing data manually, especially in areas significantly altered by modern development. The methodology included gathering data using CORONA satellite imagery with a resolution of 1.8 metres to capture pre-modern alterations. Pre-processing involved annotating images and performing exploratory data analysis to ensure training data quality. Model training was completed by developing a fully convolutional neural network (FCN) inspired by the U-Net model to segment and identify qanat shafts. Post-processing applied a sliding window approach and thresholding to create the final binary mask of qanat detections.

This project, partially funded by the US National Science Foundation, demonstrates the potential of deep learning to accelerate the documentation of archaeological features across large areas. The automated method reduces false positives compared to traditional pattern recognition techniques, enhancing reliability and efficiency. This project in indicative of the potential of other AI-based projects in Iraq. The successful use of deep learning for qanat detection suggests that similar technologies could be applied to other archaeological features, enabling comprehensive documentation and preservation of heritage sites. Deep learning models can also be adapted and scaled to process vast amounts of remote sensing data across different regions and periods. Moreover, the integration of deep learning with other emerging technologies, such as drones and XR, can provide real-time updates and monitoring of archaeological sites and create immersive educational experiences for the public fostering global awareness and appreciation of historical sites in Iraq.

Image Courtsey of Deep Learning in Archaeological Remote Sensing.



Blockchain

Key Takeaways

Overview

Blockchain can be used to create unchangeable records of provenance and ownership for digital artefacts, ensuring degrees of authenticity and traceability that are helpful for Digital Cultural Heritage.

Pros

Provides a secure, unalterable and transparent system for tracking cultural artefacts, with the potential to reduce the risk of fraud, corruption and theft.

Cons

High energy consumption, technical complexity and the high f inancial volatility of cryptocurrencies.

Ethical Risks & Considerations

The environmental impact of blockchain technologies is a major concern, as is the lack of regulation that is built into the technology, which can perpetuate misinformation.

Possible Future Deployments

Blockchain could be used to secure digital records of heritage sites in conflict zones, support digital restitution efforts and enhance the traceability and storytelling of intangible cultural heritage.

Examples

Salsal blockchain for vetting potential unethical or illegal objects in collections, Looty NFTs for digital restitution [165], Yatreda digital artworks (as NFTs) for sharing Ethiopian heritage [204].

What is Blockchain?

Blockchain technologies can serve both back-end and front-end roles in the preservation, management and promotion of cultural heritage.

Blockchain functions as an immutable digital ledger, distributed across multiple ‘nodes’ (computers) within a network. This distribution allows for long-term preservation of data related to cultural artefacts, which is resistant to tampering. The network of computers collaboratively validates each transaction recorded on the blockchain through complex cryptography, enhancing security and eliminating any single point of failure in case of a disaster. The blockchain’s digital ledger is exceptionally useful in establishing a provenance chain and authenticity for cultural heritage artefacts, assuming the information logged is initially verified. This proves beneficial in contexts such as combating the theft of cultural heritage artefacts, providing reliable databases in conflict zones, or ensuring fiscal transparency within government agencies.

Several technologies developed atop the blockchain, such as Non-Fungible Tokens (NFTs) and Smart Contracts, have also shown utility in cultural heritage. NFTs, often linked to ‘real-world’ artefacts, offer unique digital identifiers that can be owned or traded online, providing a way to authenticate and transact digital objects traditionally challenging to commodify. Smart Contracts, frequently associated with NFTs, can automate the terms of an agreement – like ownership, licensing, or resale rights – without needing an intermediary. When used together, NFTs and Smart Contracts can replicate cultural assets digitally, enabling restitution or trading whilst allowing original creators to control their works in the digital realm and receive appropriate recognition and remuneration.

Other blockchain innovations such as Cryptocurrencies, Decentralised Autonomous Organisations (DAOs) and Decentralised Apps (dApps) are also being developed, though their impact on cultural heritage has been minimal so far.

How is Blockchain being used in cultural heritage?

Blockchain for Digital Storage of Cultural Heritage

Blockchain’s primary role in cultural heritage has been as an extension of database technology, enhancing security through cryptography and decentralised authentication systems. Blockchain ledgers are employed to record and store digital copies of heritage artefacts, such as those from museum collections or live heritage sites, exemplified by the Salsal blockchain designed for preventative preservation in the West Asia. Additionally, blockchain can store born-Digital Cultural Heritage artefacts, like oral history audio files, which can be hyperlinked directly to the blockchain using decentralised file storage systems like IPFS. A notable instance of born-digital storage is the Ukraine Ministry of Culture’ ‘Meta Museum: History of War’, which logged digital content including newsreels and social media posts to create a live, authenticated and transparent record of the early days of Russia’s full-scale 2022 invasion of Ukraine to counter disinformation.

Blockchain for Showcasing Cultural Heritage

Due to its storage capabilities and transparency, numerous projects have uploaded their cultural heritage to the blockchain to ensure digital accessibility as well as secure storage and authentication. For example, the ‘Digital Library of Italian Culture’ focuses on preserving at-risk Puglian cultural heritage. Once recorded on the blockchain, due to the decentralised and immutable nature, these digital copies are arguably more resistant to data degradation or hardware failure, common concerns in traditional storage systems. Some blockchain-showcasing projects also incorporate a transaction element, whereby digital artefacts are traded like baseball cards, often as Non-Fungible Tokens (NFTs).

Non-Fungible Tokens

Non-Fungible Tokens (NFTs) are unique digital identifiers that attach to a real-world or digital artefacts logged on the blockchain. Unlike mere logging (known as a hash function) to a blockchain, NFTs have tradability embedded in their code, allowing them to be transferred from one digital wallet to another—with or without payment—conveying ownership within the blockchain ecosystem. They have been used for fundraising and awareness raising projects, as seen in the case of the Yawanawá indigenous community, who used NFTs to fund their long-term initiatives to protect their land and cultural heritage [149]. NFTs have also played a role in digital restitution projects like Looty, which 'reclaims' stolen artworks by creating digital records, rendering them in 3D and tokenizing them on the blockchain as NFTs. This not only provides decentralised access and visibility to the stolen artefacts but also generates royalties. Specifically, sales from these NFTs contribute 20% to the Looty Fund, which awards grants to young artists from Africa [222]. While the legality of NFTs regarding real-world ownership and copyright is still evolving, they mark progress toward a more accountable system of digital ownership.

Smart Contracts

Smart contracts provide a layer of legal accountability within the blockchain ecosystem by automatically executing algorithmically coded functions. For example, a smart contract embedded in an NFT could ensure continuous remuneration to the original creator each time the NFT is sold, as with the Looty Fund or Tune.fm [198], which uses smart contracts to instantly pay musical artists for every stream. Additionally, a smart contract could limit the use or licensing of an NFT in certain digital contexts by scanning the web and issuing automatic takedown orders under intellectual property claims. This could be particularly significant for indigenous communities, whose designs could be digitally plagiarised or used without credit [167], as has been evidenced in the IndigiLedger, which deploys 'smart labels' to verify and authenticate Aboriginal and Torres Strait Islander artworks, designs and souvenirs at point of sale [223], ANU School of Law/ANU First Nations Innovation Hub's Evernode Project [61].

> **We can embed utility into digital artefacts so that the originating community benefits f inancially. A portion of the proceeds, perhaps from ticket sales at exhibitions or museums, could be integrated into the artefact and distributed via NFTs... Creativity is essential in this approach. However, if we're talking about digital replication having the same impact as physically repatriating items, I don't believe we're there yet.y.**
>
> — **Chidi Nwaubani, Designer, Artist and Founder of Looty**

Further Case Studies

- Rich Allela's NFT Collection showcasing traditions of Kenyan history and tribal communities [157]
- Blockchain Kimono [224], a textilebased project which uses smarttagging and blockchain to tell the stories of children in the oncology ward of the Black Lion Hospital in Addis Ababa
- Balot NFT, a Congolese digital restitution initiative which utilises NFTs as a decolonial tool [198]
- Mara Wildlife NFT digital avatars, based on live data from nature reservations raised $76k for the Wildlife Trust [225] • Aya Tarek x B'sarya For Arts, Alexandria x NFTY Arabia 'Token' exhibition [226]

What are the risks and ethics of Blockchain in cultural heritage?

• **Lack of regulation:** Blockchain's decentralised promise means at its core that content goes unchecked, since there is no centralised authority (like a museum, university) to carry out the checking. False or inaccurate input is common, particularly if the blockchain is not privatised or accessrestricted — this can lead to false records that can have severe knock-on effects with future records.

• **Ambiguous legal positioning:** A lack of clarity about the scope of IP protection means that for many digital-borne artworks, plagiarism is rife. Artists and creators often f ind their work being minted and sold without their permission. Changes in privacy laws would impose new regulations on what can be minted and distributed on the blockchain, significantly limiting the types of content that can be shared.

• **High computing power required:** The sheer amount of computing power required to validate the consensus mechanisms results in significant cost and sustainability issues for blockchain technologies. The power required is reflected in the cost of GAS fees for minting but also in the prohibitively slow pace at which legacy systems can utilise blockchain services. With high computing power also comes significant environmental costs, however newer chains and developments, such as Cardano, Avalanche and Ethereum 2.0 are trying to mitigate the resource intensive process of Proof-of-Work (PoW) consensus mechanisms by switching to Proof-of-Stake (PoS) protocols to approve transactions.

• **High cybersecurity risk:** Scams are rife in the realm of NFTs, particularly phishing scams. Due to a lack of regulation, scammers often pose as legitimate actors to trick users into revealing their private keys or transferring their NFTs or cryptocurrencies.

• **Technological obsolescence:** Changes to systems and migrations pose a significant risk to blockchain technology. As blockchain platforms evolve, older systems will become outdated and can result in the loss of data, increased costs and operational disruptions. Quantum computing developments, for instance, could theoretically break the cryptographic framework, rendering this supposed security fragile.

• **High on-ramp / unfriendly UI:** Difficulty in accessing the technology when not using an intermediary platform (which ultimately defeats the decentralised principle of the blockchain), could lead to abandonment of projects.

• **Volatility:** The extreme volatility of NFTs and cryptocurrencies means that artists and buyers can suffer large losses during socalled 'bear markets', a period of a prolonged drop in cryptocurrency values, especially if they are using these technologies to finance their projects.

What could be the future of Blockchain in cultural heritage?

• **AI Optimisation:** Integrating existing blockchain tools with AI features can supercharge data management and analysis. For example, by using distributed ledger technologies to track the provenance of music across immutable blockchains, AIgenerated music can be more effectively identified.

• **User-friendly layers:** Accessing the blockchain directly is technologically complex; the development of user interfaces, like marketplaces or search engines, is critical to expanding usage.

• **Tokenisation beyond financialisation:** Utilising the potential of blockchain's ownership layer (NFTs) beyond just cryptocurrencies and speculative assets can create authenticated, traceable ownership in the digital realm. This has occurred when NFTs have been used in restitution projects to create digital copies of stolen artefacts, providing a record of the original and a remuneration source to original community.

• **Smart Contracts:** Algorithmically automated contracts CAN carry out actions without the need of an external agent. As the legal framework develops around blockchain, smart contracts will play a key role.

• **Digital Museums:** Showcase blockchains are increasingly integrated with digital museums, such as the Digital Library of Italian Culture, which leverage XR to enhance user engagement with digital objects. The seeming infinity of the digital realm allows museums to showcase a greater volume of otherwise dormant artefacts.

Image courtesy of Blockchain Kimono. Copyright Dominik Gigler.

Case Study:

Yatreda – NFTs for Ethiopian heritage awareness and ownership

Ethiopia is actively integrating blockchain technology across various sectors as part of its Digital Transformation Strategy 2025. The country has already established the world's largest government blockchain deal with software giant IOHK, implementing blockchain within the public education system. Plans are underway for a digital identity rollout, supported by a $350 million fund from the World Bank and to enhance financial inclusion using blockchain.

On a smaller scale, blockchain is being applied to heritage preservation projects. The Addis Ababa art collective Yatreda [227], led by photographer Kiya Tadele, has harnessed the power of Non-Fungible Tokens (NFTs) to address the lack of representation and visibility of Ethiopian cultural heritage. These digital portraits, released on the Foundation NFT marketplace in 2022, have not only generated crucial funds for the collective but also play a vital role in preserving Ethiopia's intangible cultural heritage. Blending emergent technologies with ancient themes, Yatreda has adopted NFTs over other visual mediums for three reasons: documentation, remuneration and ownership.

Yatreda deploy the concept of tizita — an Amharic term embodying nostalgia, memory and soul — to document the rich historical and cultural narratives of Ethiopia. Their project, "Strong Hair", consists of one-hundred motion portraits which celebrate Ethiopian hair art, each portrait highlighting the unique cultural expressions embedded in traditional hairstyles. This initiative was recognised by Prix Ars Electronica [228] for its significant contribution to documenting intangible cultural heritage. Prix Arts Electronica comments on the urgency of Yatreda's project: "When we lose a hairstyle, we lose a visual language, an expression that has been created in over thousands of years that may never be repeated again."

In their subsequent project, Movement of the Ancestors, Yatreda forged dynamic, multisensory, cultural expressions: "We are recording what we can't capture in a still photo, what we can't print into a book", Tadele told Vogue [104]. One such portrait, 'Masenqo Nostalgia', features a man playing the Masenqo—a bowed lute that is significant in Ethiopian and Eritrean religious and secular ceremonies—which highlighting the rich auditory and visual heritage that static images cannot convey.

Tadele selected NFT technology because it allowed her greater autonomy from traditional gallery models, which often favour artists from the Global North. The technology not only allowed her to sidestep gatekeepers but also to maintain complete creative ownership. Tadele highlighted the benefits of using blockchain technology over mainstream, user-generated media platforms: "if we simply uploaded it to YouTube, or Instagram, maybe it would be appreciated with likes. Those likes benefit only large companies, who give very little back to the actual creators who are the soil of their platform. Using web3, our audience is much smaller, but we are more direct." [229]

Other applications of blockchain technologies in Ethiopia could involve the securing of cultural heritage through digital twins and records of monuments, digital restitution of displaced artworks and the promotion on intangible cultural heritage (e.g. through verifying provenance and quality of coffee products).

Databases

Key Takeaways

Overview

In Digital Cultural Heritage, databases are essential for storing and managing vast amounts of digitised artefacts, plus associated metadata and research data.

Pros

Facilitates the organisation, retrieval and analysis of large cultural datasets, enhancing preservation and accessibility.

Cons

Managing large databases requires ongoing maintenance and significant technical expertise, they are often built on legacy systems which can perpetuate historic, biased classification and selection systems.

Ethical Risks & Considerations

Key concerns include data ownership, particularly for Indigenous and marginalised communities and the potential for data colonialism where external entities control or exploit cultural data.

Possible Future Deployments

Databases might integrate more sophisticated automation tools for data categorisation, management and metadata linkage at a larger scale.

Examples

Mapping Africa's Endangered Archaeological Sites and Museums (MAEASaM) [237], the Library of Congress [238], Europeana [239], JSTOR [240], Art Loss Register of Cultural Heritage at Risk Database [241], Spatial Monitoring and Reporting Tool (SMART) for wildlife conservation [242].

What are databases?

Databases play a crucial role in the preservation and management of cultural heritage by providing a systematic way to store, organise and exchange information about artefacts, artworks, historical documents and sites.

These digital repositories enable institutions to catalogue detailed descriptions, provenance, condition reports and high-resolution images of their collections, ensuring comprehensive documentation. Digital databases facilitate effective inventory management, allowing the tracking of items and reducing the risk of loss or misplacement. Moreover, databases support the creation of digital archives, preserving vital information for future research and reference, which is essential in cases of damage or theft where original records might be compromised.

In addition to preservation and management, databases enhance accessibility and research in the cultural heritage sector [146]. Scholars, historians and the public can access vast amounts of data remotely, fostering greater engagement and collaboration across the globe [230]. Advanced search functionalities and metadata tagging allow users to quickly locate specific items or information, streamlining research processes and enabling new insights into historical contexts and cultural connections. Furthermore, databases can integrate with other digital tools, such as 3D modelling and XR functions, to create interactive educational experiences and virtual exhibits. This democratisation of access ensures that cultural heritage is not only protected but also actively shared and appreciated by a wider audience.

How are databases being used in cultural heritage?

Cataloguing Data

Databases streamline the cataloguing process, enhancing the accessibility and searchability of cultural artefacts. General-purpose databases like Oracle facilitate the cataloguing of artefacts through robust capabilities adaptable across various operating systems. These databases support a range of programming languages and interfaces, such as Structured Query Language (SQL) and Java, making them ideal for cataloguing artefacts, managing museum collections and maintaining extensive archival records.

Managing Data

Databases enhance the management of cultural heritage by organising and securing complex data types. Object-Oriented Database Management Systems (OODBMS) such as ObjectDatabase++ effectively manage complex data types, particularly suited for unique objects like photographs, audio clips and video footage. This aids in managing digital representations of artefacts and supports rich, multimedia educational content. Secure storage facilities and comprehensive inventory databases ensure that artefacts are safeguarded and that information is organised and retrievable.

Querying Data

Databases improve the efficiency and precision of data retrieval, facilitating detailed analysis and research in cultural heritage. Relational Database Systems (RDBs) excel in environments where relationships between various data entities need to be efficiently organised and queried. They allow complex searches and relationships to be maintained through SQL, which is useful for managing large collections of digitised documents and cultural records.

Registration Processes

Databases are vital in streamlining registration processes, enhancing traceability and accountability in cultural heritage management. RDBs are crucial in registration processes within cultural heritage, managing extensive data related to artefact registration and provenance details. Collections such as the Art Loss Register and Cultural Heritage at Risk Database [231] ensure that all information is traceable and verifiable, which is crucial for documenting the provenance of looted or at-risk items.

Accessibility

Databases play a key role in making cultural heritage accessible to a global audience, breaking geographical and logistical barriers. Both Oracle and OODBMS can be adapted to create digital archives that not only store data but also make it accessible worldwide. This global accessibility is important for making cultural heritage available to broader audiences and for educational purposes.

Further Case Studies

- Mapping Africa's Endangered Archaeological Sites and Museums (MAEASaM) [175]
- SMART (Spatial Monitoring and Reporting Tool) for wildlife conservation [232]
- The Cultural Heritage at Risk Database (CHARD) [233]

Image courtesy of MAEASaM.
Copyright Paul Lane.

What are the risks and ethics of databases in cultural heritage?

- **Data Ownership Ethics:** Ethical concerns arise when external entities attempt to own or monetise data that belongs to a community or individual, potentially leading to cultural exploitation.
- **Data colonialism:** The value-based decisions around which data are selected and categorised when not made locally can replicate imperialist practices whereby data collection was used as an extension of colonial administration [25].
- **Data Privacy Risks:** Privacy regulations vary by jurisdiction, significantly affecting how data is secured and shared. Databases must navigate these laws to ensure consistent protection of sensitive information.
- **Editing and Authorship Rights:** Decisions about database content and classification carry significant ethical implications, influencing cultural narratives. Editorial authority should align closely with those who have a legitimate stake in the cultural heritage.
- **Accessibility:** Access to databases need to balance data protection with public educational benefits, ensuring that access decisions promote fairness and inclusivity without compromising cultural sensitivity.

> **Some of the greatest challenges we have are actually nuts and bolts stuff: data storage, discipline about where you keep stuff and how you file it.**
>
> **— Rob Woodside, British Council CPF Specialist Assessor; Conservation and Estates Director, English Heritage**

What could be the future of databases in cultural heritage?

Inventory management: Retailers often use RDBMS to store and manage product information, including information about the product, stock levels, suppliers and transaction figures. AI is increasingly being leveraged in industrial contexts, such as the telecommunications industry, to advance the efficiency of large-scale data processing and storage [234].

Social Media: Social media platforms rely on relational databases to manage and interrogate user data, often aiding recommendation systems. Repositories of user data are continuously expanding and developers are more and more relying on cutting-edge algorithmic tools to moderate content management [235].

Gaming: OODBs can be used in gaming applications to help store and access data about game objects such as characters and weapons. With game-play and world-building becoming increasingly more nuanced and sophisticated, gaming is one of the OODBMS's fastest growing applications [146].

Healthcare: OODBs can assist with the storage and retrieval of patient data and associated data such as test results and MRI scans. A growing number of public and private healthcare systems are adopting the technology to improve integration and operational efficiency.

Spatial Digital Asset Management: OODBs can handle complex sets of structured, semi-structured and unstructured data types including photos, videos, audio and text. As such, OODBs are a continuously preferred software choice for contexts in which heterogeneous datasets need to be managed, such as computer-aided design and digital asset management [133].

> **Data accessibility and data storage have always been a challenge—particularly given the exponentially increasing size of these datasets. But making these datasets available and usable to practitioners is critical if they're going to be directly of use in monitoring the condition of heritage assets.**
>
> **— Lyn Wilson, British Council CPF Specialist Assessor; Head of Research & Climate Change, Historic Environment Scotland**

Image courtesy of SMART Implementation Laikipia.
Copyright Space for Giants.

Case Study:

The Ethiopian Heritage Digital Atlas – web-based documentation of Ethiopia's cultural monuments

The Ethiopian Heritage Digital Atlas (EDHA) is a collaborative initiative which emerged as a response to an ongoing violent conflict in Tigray. Scholars and researchers from a cross-institutional and international team from the Mekelle University (Ethiopia) and Ghent University (Belgium) had previously mapped qualitative and quantitative data to provide a priority-driven humanitarian outlook on issues such as internal displacement, war crimes and population loss in the region [13]. The EDHA adds to this data infrastructure by compiling and storing information on direct damages caused to heritage sites by ordnance or vandalism during the conflict. It also logs threats to landmarks through decay or natural disasters such as mudslides. As these are issues faced by built heritage around the world, the EDHA is particularly instructive in how databases can be used to document these threats.

Data management in Ethiopia has been a topic of debate in recent years, particularly around the proposed implementation of a controversial blockchain-based national identity scheme [127]. Commentators have voiced concern about this project's perceived overcentralisation of sensitive data and the amplified role of offshore actors in the management of an Ethiopian digital institution [229]. The EHDA provides a positive counterexample in that the software components used to build the database have been specifically adapted to Ethiopia's specific requirements for data handling, with much of the agency for data stewardship in the project being afforded to the Ethiopian partners, rather than an international actor. Specifically, the Ethiopian Antiquities Authority and Addis Ababa University are developing the EHDA in collaboration with the German Archaeological Institute, funded by the Gerda Henkel Foundation. Since 2022, the project team has documented around 1,700 sites of cultural heritage significance in Northern Ethiopia, enabling their long-term monitoring

The EHDA is built on a Geographic Information System (GIS), a spatially enabled relational database. A press release describes the Atlas as a 'comprehensive register of regional cultural sites' [141], which records archaeological sites and historical monuments and links them to data gleaned from additional research into museum and art databases, as well as photographs and satellite images. Researchers also consulted local communities about notable finds such as ancient inscriptions in residential or commercial buildings, allowing for a layered depiction of the archaeological wealth of the region and better informed protection recommendations.

Digitising

Key Takeaways

Overview

Digitising processes in Digital Cultural Heritage involve converting physical artefacts, texts, audio and images into digital formats, in a way that ensures their preservation, widens access to them and facilitates research into them.

Pros

Expands access to and visibility of cultural heritage, enhances preservation by reducing handling of fragile materials and supports research and educational efforts globally.

Cons

High costs and technical demands for high-fidelity data and storage, as well as potential issues with the loss of context or nuance in the digitisation process, can be significant drawbacks.

Ethical Risks & Considerations

The digitisation process must navigate issues related to the cultural sensitivity of certain items, potential intellectual property disputes and the ethical handling of sacred or restricted materials.

Possible Future Deployments

Expanding the possibility of input sources for digitisation (e.g. 2D, 3D, geospatial) to make output more immersive and interactive; also, extending on-the-ground or emergency data collection via lo-fi scanning and access devices like smartphones.

Examples

CyArk Tomb of Tanwetamani (3D) [243], Zamani Project [211] and Mapping Africa's Endangered Archaeological Sites and Monuments [184].

What is digitising?

Digitising technologies have become indispensable tools in cultural heritage protection, offering advanced methods for documenting, preserving and sharing historical artefacts and sites.

High-resolution photography allows for the detailed capture of artefacts, artworks and documents, preserving their visual details with exceptional clarity. Complimentarily, Geographic Information System (GIS) mapping enables precise spatial analysis and visualisations, helping researchers understand the geographical context and historical significance of existing and former heritage sites. Both can be used to track changes over time, assess environmental impacts and develop targeted conservation strategies. While these technologies exist in non-digital capacities, their adaptation into interconnected databases and online spaces has massively expanded the reach of digitised heritage information.

A central component in this translation is scanning technology–both traditional 2D scanning and 3D scanning tools like LiDAR (Light Detection and Ranging). Many software programmes which allow for the virtual handling of 3D models work with 2D information. Regard3D, for instance, is a popular tool which assembles two-dimensional photographs into a three-dimensional model. This is a crucial connection point between communities, institutions and individuals who have access to relatively high-tech solutions like LiDAR (including in the latest iPhone models) and those who work with low-tech equipment, such as a digicam.

Outside of heritage contexts, the 3D modelling community is large and resourceful, which results in an abundance of freeware available online to bridge the existing gaps in hardware. The value of these low-to-high-tech translations is also evident in creative adaptations of audio equipment: initiatives which use phone recordings together with professionally recorded music to capture variations of musical practices across a region, for instance, show the efficacy of such approaches. Collectively, digitising technologies expand on how cultural heritage may be protected and preserved, interacted with and shared across communities and borders.

How is digitising being used in cultural heritage?

Archiving & Recording

Academic institutions and libraries frequently employ digitisation to make valuable or highly demanded books and manuscripts more accessible. A key example of this is the British Library's Digitised Manuscripts collection [236]. This method not only protects the physical condition of these items but also extends their reach to a broader audience, who can consult these digital copies without the risk of damage to the original materials. Organisations like The Memorist [60] specialise in on-site digitisation services, catering particularly to clients with substantial collections of 2D materials, such as textual documents and photographs. Additionally, governing bodies such as the Federal Agencies Digital Guidelines Initiative [8] can provide comprehensive technical guidelines to standardise and optimise the digitisation processes of cultural heritage materials.

Documentation & Restoration

2D and 3D scanning can create highly accurate digital replicas of artefacts, monuments and sites. These digital models preserve intricate details and can be stored in digital archives, providing a permanent record that can be referenced for research, restoration and educational purposes, even if the physical objects are damaged or lost. 3D scanning specifically can aid in the restoration of damaged artefacts and sites by providing precise measurements and detailed models that conservators can use to design and create replacement parts or supports.

Geographic Information Systems

GIS mapping is crucial for creating comprehensive spatial databases of cultural sites. These databases can include detailed maps that pinpoint the exact location of archaeological finds, historical ruins and other culturally significant sites. The spatial data can be layered with historical maps, images and other relevant data, providing a rich, multidimensional view of heritage sites. In cases where sites have been damaged or are inaccessible, GIS can also be used to create accurate reconstructions. GIS mapping can be used for interactive museum displays, bringing to life inaccessible archaeological sites (such as those that are underwater, or located in conflict zones, or have been destroyed due to conflict). GIS data supports legal protection efforts by accurately documenting the boundaries and details of heritage sites, which is crucial for enforcing heritage protection laws.

> **A big challenge of heritage preservation is that it's a costly endeavour: it requires knowledge, commitment, investment and people who will develop the skills to preserve it".**
>
> **— Seif El Rashidi, Director of the Barakat Trust, Art and Architecture Historian and Heritage Manager**

Further Case Studies

- Coptic Heritage Village YouTube Videos [145]
- Photo-documentation of coffins in the Egyptian Museum [237]
- Scanning Arabic and Coptic manuscripts in the Deir al Surian Monastery [238]
- Egyptian Film Restoration Centre [239]
- Digitising audio from the Cairo Opera House [240]
- The Sabaic Online Dictionary [241]

What are the risks and ethics of digitising in cultural heritage?

- **Prohibitive Costs:** the price of high-fidelity equipment may be prohibitive in less-developed regions with low technology penetration. Furthermore, there are significant labour costs associated with digitising large quantities of data.
- **Data Stewardship:** Disputes may arise over the data ownership and stewardship of digitised materials. The ownership of language training data may be extractive. Informed consent needs to be obtained from all those being recorded.
- **Cultural Sensitivity:** The scanning of sacred documents has posed problems in previous projects, such as when documents can only be handled by certain people or cannot be removed from a specific location. Some images or texts may also have restrictions relating to reproduction and dissemination. Recording only sections of oral traditions and removing them from their cultural contexts could result in a form of digital isolation of the original.
- **Digital Privilege:** Potential for over-reliance on, or over investment in, digitising may reduce interest in preserving original documents or artefacts.
- **Access to High-Quality Raw Data:** The effectiveness of building a GIS is contingent on high quality and available spatial and attribute data, which in many cases may be out of date, poor quality, or inaccessible without significant cost and risk (such as when gathering data underwater or in an area at severe risk of armed conflict).

Image Courtesy of Middle East Culture Conservation Collective. Copyright Fady

What could be the future of digitising in cultural heritage?

- **Advanced Photography:** The increasing sophistication of smartphone cameras, as well as wearable cameras such as OhO Sunshine glasses and GoPros, enables wider participation in photography-based digitisation, whilst hyperspectral imaging (light capture beyond the visible spectrum) is an area of considerable innovation in professional photography. On the database side of using photography as a digitising tool, the Flickr Foundation is developing “data lifeboats” which are discrete packages of digitised photographic data which can be salvaged in the event of catastrophic loss [242].
- **2D Scanning:** Mobile solutions to 2D scanning needs, such as MS Office Lens, are increasing in popularity whilst machine learning models are being trained in “noise reduction” for textual documents, diminishing the need for manual editing. These innovations make 2D scanning more versatile and easily accessible by a larger number of lay users.
- **3D Scanning:** LiDAR technology being integrated in mass market smartphones is a major step towards broad adaptation of high-res scanning technologies. The adaptation of LiDAR in drone usage is equally relevant for archaeological research and site scanning. The more 3D scanning is democratised by including a wide array of low-tech solutions, the more people can participate in the building of 3D model repositories, enabling knowledge exchange and diasporic community involvement in heritage preservation. Initiatives like [176] Scan the World push global collaboration and accessibility to virtual engagements with material spaces across various skill and tech literacy levels. Additionally, micro-photogrammetry has the potential to support investigations of archaeological questions at a cellular level.
- **GIS/mapping:** GIS (Graphic Information Systems) mapping is increasingly used in museum settings to create interactive maps which can assist visitor experience as a form of AR. GIS is also progressively being integrated with relational database software to ensure data integrity and security across platforms [243].
- **Audio:** The Endangered Languages Documentation Programme [175] is a global leader in providing grants and training for teams seeking to document endangered language heritage. Their projects demonstrate a varied use of audio tech, including spatial sound and annotation tools, to further heritage protection.

> **“As humans we have always tried to capture Intangible Cultural Heritage by writing, photographing, performing… Digital technologies, in particular, offer excellent advanced tools for documenting Intangible Cultural Heritage, as well as transforming the old analogue related documents into digital format.**
>
> **— Assaad Seif, British Council CPF Specialist Assessor; Archaeologist and University Professor, Lebanese University; UNESCO & ICOMOS Heritage Expert**

Case Study:

Scanning and documenting ElKadi House in Historic Cairo

The infrastructure for digitising technologies in Egypt is advanced, ranging from photography [244], which has been a feature of Egyptian cultural documentation since the 19th century, to more modern and innovative methods, such as GIS mapping. Digitisation in Egypt concerns both tangible and intangible heritage and can aid in the conservation of historic structures [177]. The documentation of El-Kadi House in Cairo using terrestrial laser scanners is an example of the latter purpose [45].

An important archaeological site in the heart of Historic Cairo, El-Kadi House ('The Judge's House') is structurally threatened by underground water. A team of Egyptian researchers and scientists from the National Research Institute of Astronomy and Geophysics in Cairo used modern surveying technologies to produce a digitised reconstruction of the house in its current state, with the aim of informing future conservation efforts [45].

The team utilised a Trimble TX6 laser scanner, a cost-effective model which can record the three-dimensional data of large objects with a high degree of accuracy. The researchers planned the study area's survey before using the laser Trimble TX6 to scan the house from different heights. A 3D model of the building, including plan, section and elevation, was produced by their efforts to gather and process the data, providing a digital representation of the existing structure accurate down to its colour.

With an accurate digital reconstruction of the building, conservators are better positioned to recognise changes or degradations in its condition, such as listing caused by underground water shifting the ground on which it rests. The digitisation of El-Kadi House and similar projects on other examples of built heritage can therefore help to protect structures from excessive damage and pre-empt further deterioration of already restored buildings, preserving key cultural heritage in historic locales such as Cairo. This is just one example in a wide range of digitising initiatives in Egypt, many of which focus on advocacy and education, enhancing conservation and the support of restitution initiatives for displaced Egyptian artworks.

Extended Reality (XR)

Key Takeaways

Overview

XR technologies can be used in Digital Cultural Heritage to create immersive tours of historical sites, virtual reconstructions of ancient buildings and interactive educational experiences that bring history to life.

Pros

Enhances engagement with cultural heritage, making it more accessible and interactive for diverse audiences and supports innovative educational and research initiatives.

Cons

The high cost of XR technology and the need for specialised skills can limit its accessibility and use, furthering perpetuating global digital divides.

Ethical Risks & Considerations

Care must be taken to ensure that XR experiences are accurate and respectful of cultural contexts, avoiding the risks of misrepresentation, oversimplification or trivialisation.

Possible Future Deployments

XR developments may further increase fidelity to be virtual reconstructions of endangered or lost heritage sites, allowing global audiences to engage with them in multisensory detail; XR is also increasingly being used in training and remote operations.

Examples

Looty's Digital Heist [165], The Unfiltered History Tour [117] and HistoryCity [214].

Image courtesy of Co(X)ist. Copyright Mahder Getaneh.

What is Extended Reality?

XR (Extended Reality) is an umbrella term for different immersive technologies, encompassing Virtual Reality (VR), Augmented Reality (AR), Mixed Reality (MR), holograms, responsive projection mapping and different types of digital 3D modelling, amongst others.

The differences between these technologies mostly manifest in the modes of immersion on side of the user (for instance, VR uses goggles which create an entirely virtual environment, whereas AR can use phone screens to add information to existing material environments and holograms allow for audiences to collectively consume content in 3D) and whether they can be used remotely or in-situ. On the production side, all XR technologies use similar programmes to scan, create and export 3-dimensional models or animations.

During the COVID-19 pandemic, the potential of XR applications became visible within the heritage sector, both in the creation of remote audience engagement (as seen in VR tours of a site) and on-site interactions that utilised visitors' own devices (as in the use of AR phone applications rather than shared audio-guides). With Big Tech companies investing significantly into the future of these technologies, XR's capabilities to be used in cultural heritage contexts are vast and varied. They can increase accessibility [37, 92, 97, 120] and critical knowledge exchange [42, 51], mitigate language and attention barriers [21, 30, 56, 59, 70, 78, 110, 121] and invite new forms of interaction with heritage sites [51, 57, 71, 137]. For heritage preservation, XR repositories form interactive platforms for the documentation of sites and objects, as well as the basis of ongoing transnational discourse regarding specific endangered sites.

> **With VR, we can recreate the actual heritage site, or the culture itself. We can apply a volumetric capture of music, of dancers, create 3D representations of celebrations to explain the joy**
>
> **— Daniel Getachew, Founder and CEO of Guzo Technologies**

How is Extended Reality being used in cultural heritage?

3D Repositories

With the increasing digitisation of heritage sites and artefacts through 3D scanning, photogrammetry and drone photography, virtual repositories of heritage-related 3D models are expanding. This opens new avenues of access both remotely and on-site, as virtual models can be replicated, rotated, zoomed into, annotated and animated in ways that material spaces often cannot. These functions allow for new dimensions of research collaboration: for instance, through VR, researchers and practitioners in various locations can examine the same site together in an embodied way. Virtual access is often easier and cheaper to manage than physical access and with long-term sustainability in mind, immersive technologies mitigate the need for research teams to travel to a site together from around the world. Especially in regions with significant risks attached to in-person visits, remote access can facilitate the continuation of research projects despite the precarities involved.

Teaching & Training

Virtual access can be used to customise teaching and training programmes, too. While a material artefact may have to be kept in a safe, temperature-controlled environment, a virtual 3D model – or a 3D printed replica based on that model – can be handled, annotated and altered by as many people as desired. This can mitigate sight-related access barriers, help learners with dyslexia or dyspraxia, or provide translations of contextual information into as many languages as needed. While current mass-market XR technologies are not quite advanced yet to facilitate this form of immersion to most heritage site visitors, the seeds of this development are already visible. AR-based teaching tools mostly use smartphones, which have a limited interactional reach in terms of their spatial embodiment due to screen size and functions, but as MR goggles become more common to facilitate teaching experiences, the interactional range of XR teaching tools will expand. It is particularly the appropriation of smartphones for spatial interaction, however, which is crucial for the widespread adoption of XR experiences in heritage sites. In localities where a majority of users access the Internet through mobile devices, light AR applications for smartphones offer one of the most robust routes to disseminating XR interactions.

Gamification

While some aspects of XR are more likely to be used in research and professional environments for the foreseeable future, user-oriented interpretations of heritage sites and objects are the most prominent short-term use case of immersive technologies. This comes within a larger context of gamification in heritage sites, where audiences are encouraged to interact with cultural heritage in inquisitive, playful ways. While gamification does not have to be digital, AR offers a variety of options in adding gamified elements to existing exhibitions, sites and artefacts on-site. These interactions often target digital native age groups, but also offer increased accessibility for people who struggle with traditional didactics in heritage sites (for instance, because they involve a lot of reading, sometimes in foreign languages). Moreover, they can lead people to interact with less-visited parts of a museum or encourage visitors to veer away from over-touristed hotspots to less popular sites and artefacts.

Community-based adaptability

Immersive technologies offer excellent support to community-based heritage projects, not only in their capacity of making materials accessible to a wide range of people and needs or their ability to make complex content interactive but in their adaptability and potential for polyvocality. This means they can represent a wide range of voices and perspectives without creating hierarchies between these potentially contradictory viewpoints. Additionally, they can easily be changed and adapted, reflecting changing practices, attitudes, or priorities within communities of shared cultural practice.

> **When people have lost the connection between themselves and their heritage, we can use Extended Reality to close this gap between what is truly our experience and narrative, and what is represented back to us through our "official" institutions.**
>
> **— Ahmed El Shaer, New Media Artist and Doctoral Researcher**

User-Generated Content (UGC)

The UGC potential of immersive technologies is one of its main assets in relation to advocacy: AR is deeply ingrained in the popular Social media platforms and is thus an enticing choice to draw attention to a heritage site or object. Several museums have used AI-enabled AR face filters to draw attention to their lesser-known artworks by matching people's features with one of their paintings or by overlaying their faces with a specific artistic style. Restitution activist art (like Looty's 'Digital Heist') has utilised AR to draw attention to looted artefacts being held in Western museums, which demonstrates the potential of XR technologies being used to support the agendas of heritage institutions or challenge their authority over heritage curation. With the increasing availability of tools which allow for lay creation of XR interactions with little to no prior knowledge of 3D modelling or coding, varied uses of XR in advocacy, Social media campaigns and on-site interactions are likely to diversify further. Especially in cultural contexts where concerted efforts to heritage protection are complicated by administrative hurdles, XR offers varied opportunities for communities to take charge of the narratives which engulf their heritage and encourage participation with their cultural legacies on their own terms.

Further Case Studies

- If Objects Could Speak [245], an AR installation and documentary taking virtual replicas of displaced Kenyan art across communities in Kenya
- Maison Interactive [246], a Nairobibased design and tech studio producing XR heritage experiences and interactions
- Co(X)ist [247], a virtual reality game that builds peaceful coexistence through immersive role-playing programs that amplify cultural awareness and social tolerance in Ethiopia
- Fallohide Africa [158], an XR studio creating immersive experiences
- GuzoMap XR [248], a branch of Guzo Technologies, an Ethiopian Internet of Things (IoT) and XR prototyping startup
- Tutankhamun Immersive Experience at the Grand Egyptian Museum (GEM) [249]
- Home After War [250], an Iraqi VR experience focusing on destruction through improvised explosives

What are the risks and ethics of Extended Reality in cultural heritage?

- **Real-world Impact:** Virtual interactions do not replace material change. In creating XR interventions to heritage sites, there is a risk of forgoing material engagement and impact.
- **Gamification:** Gamifying sensitive topics can easily become problematic and should thus always be conducted with the most sensitive audience member in mind.
- **Ephemerality:** XR's adaptability is one of its advantages, but it also means there is less permanence to the context created by its interventions.
- **Editorial Power in Co-creation:** In UGC contexts, there need to be editorial practices in place which ensure minimum standards of information creation. Who holds this editorial power is unclear and without transparency about this aspect, there is a risk of presenting XR experiences as more inclusive than they are (a similar issue is raised by content-editing issues on social media platforms).
- **Data Management:** The scanning, retention and alteration of 3D spaces is currently barely regulated and how data is managed and kept secure is a major concern, especially as XR is becoming increasingly UGC-oriented.
- **Geo-tracking:** Location-specific XR applications require geo-tracking to be enabled, which usually creates an array of data tracking commitments which most users are not aware of.
- **Non-Consensual 'resurrections':** Holograms of famous people who have passed away have received criticism for their embodied depictions of people who did not consent to their bodies being displayed in this way.
- **IP in 3D databases:** The currently most popular 3D model databases retain (part of) the IP of models users create on free subscriptions, which can lead to ownership issues in commercial use.
- **Content Risks:** Embodied experiences through XR might have a more immediate effect on users than, for instance, reading a didactic, which needs to be navigated with care.
- **Attention Hazards:** As the popular AR game Pokémon Go demonstrated, people can lose their attention for hazards around them when interacting with an XR application, leading to accidents (particularly relevant for on-site AR in big or perilous heritage sites).
- **Health Risks:** VR and MR can cause motion sickness and nausea, by which women are disproportionately affected. Holograms and responsive projection mapping can be epilepsy triggers.

> **VR will develop into more multi-sensory experiences around cultural heritage. Allowing users to touch, hear, maybe in the future even smell and taste**
>
> **— Metasebia Yoseph, Founder and Creative Director of Design Week Addis Ababa; Author of 'A Culture of Coffee'; CEO of D!NK TV; Eastern Africa Arts and Culture Expert**

What could be the future of Extended Reality in cultural heritage?

- **Mapping:** XR functions are increasingly being integrated into existing mapping technologies (like GoogleMaps) and in the next 5-10 years, connecting geo-located information and immersive XR experiences is presenting a wide area of innovation potential.
- **Video Gaming:** The gaming industry is continuously expanding and adopting XR functions, presenting a commercially significant field of innovation. Beat Saber, a popular and accessible VR rhythm game, is a useful example of XR's gaming applications.
- **Cultural Heritage:** Heritage sites and museums are using XR to extend their repertoire of audience engagement, notably with holographic displays, which are in their infancy of wide-spread use.
- **Training and Teaching:** XR offers innovation opportunities for virtual, embodied training programmes (as seen in the flight attendant training at Lufthansa, woodworking VR programmes, medical surgery training and school education.)
- **Decentralised Co-creation:** User-generated content is becoming increasingly popular in creating XR experiences, diversifying the range of available XR experiences.

Image courtesy of If Objects Could Speak. Copyright Saitabao Kaiyare.

Case Study:

MediAR – Kenyan innovation for XR co-creation

Image courtesy of Co(X)ist. Copyright Mahder Getaneh.

BlackRhino's MediAR sits against the backdrop of the Kenyan government's push to support digital industries, leading to a rapid expansion of private companies using XR in both audience-facing capacities and training (e.g., 'Toolkit Skills'). Kenyan examples of immersive technologies illustrate how an economy building towards a region-leading digital industry in the next five to ten years sees the broader infrastructures of the Spatial Web taking shape. Projects in Kenya are not purely focused on audience engagement or specific site-responsive work but are considering how XR can be created, shared and utilised as a training tool in varied contexts. However, obstacles remain, particularly regarding reliable Wi-Fi coverage, especially in rural areas.

In 2023, BlackRhino VR [251], a Kenyan XR company, launched MediAR, a no-code platform for AR content creation. While XR experiences, especially mobile AR, are very accessible to users, creating XR content is not. Industry-standard XR editing software requires significant levels of specialist skills, including digital 3D modelling and coding. BlackRhino's platform seeks to overcome these lines of exclusion with a user-friendly interface that requires no specialised prior knowledge. Their innovation mirrors website-building platforms like Squarespace or Wix, which have democratised website creation for a broader audience. MediAR promises to have a similar impact on Kenyan AR creation: their cloud-based editor provides templates and design guidelines whilst allowing their users to share and monetise their designs and prototypes. Therefore, MediAR addresses two aspects which are crucial to XR futures in Kenya and beyond.

Firstly, MediAR foregrounds user-generated content (UGC), enabling grassroots content creation in XR. While this is a wider trend within web-based platforms, the spatial nature of XR and its easy deployment via mobile devices is particularly appealing for engagements with material and intangible heritage.

Secondly, MediAR's revenue share model creates monetary incentives for its users, avoiding precedents set by other commercial content-sharing platforms. While there are 3D model repositories where users can sell their creations or share them for free, this is usually within a specialised context, as seen in the 3D models for sale for people who have a 3D printer and the skills to alter the model to their needs. MediAR, by contrast, offers pay-per-view monetisation which is more in line with film-based platforms. This makes sense in the context of BlackRhino's other services, which include several award-winning films and media productions. Their translation of one industry's approach to content management and monetisation into XR is an excellent example of how multifaceted companies and initiatives can draw on interdisciplinarity for innovative solutions.

BlackRhino, led by Michael Ilako and Brian Afande, developed MediAR on a budget of £150,000, with funding from the Ignite Culture Programme, an initiative by the British Council and the HEVA Fund. As part of their monetisation model, they provide their users with valuable metadata: they track the total views of a project, clicks on external links and the duration of each view. 20% of the view price goes to BlackRhino and the rest goes to the content creators, who are fully in charge of managing projects and licenses. Beyond this trailblazing project, Kenya has a diverse landscape of XR potential. This involves user-generated XR content, content sharing networks (e.g. MediAR) and low-code/no-code platforms for training and upskilling.

Gaming

Key Takeaways

Overview

Gaming is the act of engaging in interactive activities, typically involving video or computer games, for entertainment, competition, or skill development.

Pros

Offers a captivating tool for engaging especially younger audiences with cultural heritage, making heritage more accessible and interactive.

Cons

Game development is costly and predominantly conducted in the Global North; it is difficult for bespoke and educational games to break through to new users.

Ethical Risks & Considerations

Game developers must carefully navigate the balance between creating entertaining content and ensuring historical and cultural accuracy, avoiding the perpetuation of stereotypes or inaccuracies.

Possible Future Deployments

The rise of mobile gaming and crowdsourced development tools, such as user-generated content, can support more local and accurate simulations of cultural heritage in games.

Examples

‘878 AD Experience’ (leverages ‘Assassin’s Creed: Valhalla’), Dunhuang Civilisation in ‘Clash of Kings’, ‘Voices of the Forgotten’ Museum in Fortnite, ‘Heritage Immortalised Championship’ in Minecraft.

What is gaming?

In cultural heritage contexts, the difference between gaming and gamification is crucial to distinguish: gaming refers to interactions with video games, digital games, computer games and mobile games, whereas gamification describes the process of taking elements of games (such as leaderboards, streaks, etc.) and applying them to other products.

Gamification is widely used within cultural heritage interpretation and presentation and does not necessarily have to involve digital technologies. ‘Serious Games’ is the industry term for custom-built games made for an explicit (often learning) outcome besides entertainment. These can include skills training, knowledge transfer, or behavioural changes. Serious Games can include educational games, which are games developed for specific educational outcomes, such as teaching specific skills or concepts.

Heritage-related gaming does not necessarily need to precisely represent or interact with a real heritage site or object. There is significant potential for authentic adaptation: video games and Serious Games designed around historical themes or cultural sites allow players to immerse themselves in different time periods, interacting with virtual recreations of ancient cities, monuments and artefacts. Such games can serve as educational platforms that inspire a deeper appreciation for cultural heritage and motivate players to support conservation efforts. Gaming facilitates digital representations of both tangible and intangible heritage objects, allowing interaction with items that may not be accessible in the physical world due to their fragility or because they no longer physically exist. These experiences can be tailored to different age groups and learning levels, making cultural education more inclusive and effective.

By integrating gaming experiences, heritage initiatives can foster a sense of curiosity and involvement, encouraging individuals to learn about, respect and actively participate in the preservation of cultural heritage [37]. However, these opportunities come with the caveat of cultural sensitivity: difficult histories should be treated with care in relation to games, as should topics which relate to the continuous oppression of peoples and cultures [11, 24, 35, 142]. An important aspect to navigate in this regard is determining who is being represented, depicted and affected by the narratives which heritage-related games depict [71].

How is gaming being used in cultural heritage?

Educational Tools

Video games can serve as educational tools, both through commercial games and specially designed educational and Serious Games. Educational and Serious Games are designed to teach players specific skills, events, or other forms of knowledge. When considering cultural heritage, such games can teach players about historical events, cultures and heritage sites. They leverage the interactive nature of games, including enhanced 3D graphics and immersive storytelling, to foster educational outcomes. At the same time, some commercial games are incorporating historical content and narratives to provide players with accurate learning opportunities.

Virtual Reconstructions

Video games are digital experiences, often 3D (though they can also be 2D). They are filled with a range of 3D objects that players can observe, interact with and sometimes transform. Video games provide an opportunity to recreate historical sites and artefacts in the digital world. Such digital artefacts offer more than just passive observation; players can immerse themselves in these digital artefacts in ways potentially inaccessible in the physical world. For example, we often cannot physically hold, rotate and examine tangible heritage artefacts. Sometimes, we no longer have access to the physical artefact — there may only be notes or images of it remaining. Gaming provides a space to bring lost artefacts back to life. It offers opportunities to interact with virtual reconstructions of tangible objects, merging the past with the present in a way that is both exciting and accessible. This includes everything from ancient architecture to artefacts that have been painstakingly recreated in digital form.

Public Engagement

Gaming is a popular cultural activity. By giving people the opportunity to engage with Digital Cultural Heritage through gaming, we can meet people in the spaces they currently enjoy occupying. The interactive and playful nature of games can capture the attention of younger generations especially. By turning learning about heritage into an experience, gaming can foster an inclusive environment that promotes cultural understanding and appreciation.

> **If we really want to make cultural heritage survive, we need to bring it into the present, and make it part of people's lives today. For that to be possible, it has to be informative in a way that speaks to today's world.**
>
> **— Kahithe Kiiru, Anthropologist, Production Manager and Choreographer, Bomas of Kenya**

Crowdsourced Archaeology

Gaming presents an enriching opportunity to engage and involve people in the world of archaeology. The concept of crowdsourcing, which has proved notably impactful in various fields, is one such example. Numerous platforms have utilised crowdsourcing to great effect, such as Zooniverse [252], where the power of collective intelligence has brought about significant real-world impacts. In the realm of gaming, players can be actively encouraged to identify and catalogue in-game artefacts or features. This not only enhances the immersive experience of the game but also serves as an educational tool, teaching players about historical artefacts and their significance. By integrating these elements into the gaming environment, we can effectively apply crowdsourcing approaches to archaeological research and conservation efforts. It offers the potential to gather vast amounts of data and insights, which may otherwise be difficult to achieve. This innovative approach could revolutionise the way we conduct archaeological research, making it more interactive, accessible and engaging for a wider audience.

Further Case Studies

- Assassin's Creed: Mirage (Ubisoft) [253], a game set in medieval Baghdad, inviting gamers to interact with the city at the height of its power.
- 1979 Revolution: Black Friday (iNK Stories) [254], a game set during the Iranian Revolution allowing players to experience events from the perspective of a photojournalist.
- Unearthed: Trail of Ibn Battuta (Semaphore) [255], an episodic actionadventure game inspired by the travels of the 14th Century Moroccan explorer, Ibn Battuta.
- Quraish (Afkar Media) [256], Syrian strategy game focuses set around the early Islamic conquests where players can control different factions and relive historic battles

What are the risks and ethics of gaming in cultural heritage?

- **High Development Costs**: Often, bespoke Serious Games are built without the knowledge, expertise, time and financial means of a large video game studio. As such, they often — but not always — have noticeably different graphics, performance and narrative quality.
- **Underperformance**: Poor quality 'Serious Games' run the risk of underperforming. As these are often bespoke games, they have higher costs than just implementing elements of an already existing video game.
- **Physical Health Risks**: Playing video games might have health risks. The lighting in games can trigger people suffering from epilepsy, for example and excessive gaming can lead to physical health issues such as eye strain, carpal tunnel syndrome, poor posture and sleep disturbances.
- **Social and Mental Health Risks**: Playing online with others also involves potential risks of harassment and bullying.
- **Oversimplification**: Gamifying serious issues bears significant risk to trivialising or appropriating these issues in an insensitive way.
- **Cybersecurity Risks:** Unregulated online gaming platforms can be targets for cyberattacks, including phishing scams, malware, or identity theft, especially if personal or financial information is shared.

What could be the future of Gaming in cultural heritage?

- **Mobile Gaming:** Mobile gaming is the fastest current segment of the games industry. As more people have access to mobile devices than other gaming devices (computers and consoles), there is great opportunity for more diverse audiences.
- **More detailed graphics:** The quality and expansiveness of gaming graphics continues to improve [126]. This means that the expectations for the quality of games is increasing and game design is becoming more expensive.
- **Increased education and tools:** With the rising prominence of gaming comes an increased focus on improving the processes of game design. There is more attention paid to improving the quality and access to education and more game development tools are becoming accessible to broader audiences.
- **XR Gaming:** The XR gaming market is growing rapidly, with every major tech company investing significantly and new populations becoming players [148].
- **Heritage Site Collaborations:** Popular games like Assassin's Creed as pushing for collaborations with heritage sites to promote their game and to draw attention to the cultural research they do as part of their game design.
- **Inclusive Gaming:** There is a growing trend in game design and research which seeks to make gaming more accessible, diverse and multi-perspectival [178].

Case Study:

Depicting Ptolemaic Egypt in Assassin's Creed: Origins

The gaming industry in Egypt is witnessing significant growth and transformation. According to market forecasts, the video games market in Egypt is projected to reach a revenue of $1,097 million in 2024, with an annual growth rate of 7.98% from 2024 to 2027 [129]. This growth is fuelled by a young and increasingly connected population, as well as home-grown studios such as Rumbling Games, Appsinovate and Instinct Games, which coalesce around industry events such as the Insomnia Egypt Gaming Festival. Mobile gaming have played a particularly pivotal role in this expansion due to ease of access and adaptability, with 87% of gamers prioritising this device, as well as the highest average hours played each week (8.7 hours) [129].

Egypt also boasts an extensive network of museums with famed historic artefacts, which are seeking to extend use of immersive and gamified digital technologies into their exhibits. The Grand Egyptian Museum at Giza is set to be a flagship display of such experiments. It is worth noting however, that some of the most prominent digital projects involving Egyptian heritage are based in other countries under the authorship of foreign researchers and museums, a phenomenon in part tied to the concentration of Egyptian heritage artefacts overseas following extensive looting in the 19th and 20th century. Similarly, in Egypt's gaming industry, a majority of games which incorporate Egypt's cultural heritage is being developed by overseas companies, such as Core Design's 'Tomb Raider', Firaxis Games' and 'Sid Meyer's Civilization V'.

Assassin's Creed: Origins (AC Origins) is a video game in Ubisoft's Assassin's Creed franchise in which the player assumes the role of Bayek of Siwa, a Medjay and his wife Aya, in Ptolemaic Egypt. The game was designed by game developers, but informed by historical research. It simultaneously depicts contemporary Egypt and an Egypt of the past, moving between 49 BC (where a majority of the gameplay resides) and modern day, where players embody Layla Hassan, an Egyptian-American. AC Origins allows players to enter large cities and hidden areas where they can interact directly with a range of heritage artefacts, from a reconstruction of the Memphis Temple to everyday objects. The design team worked alongside historical researchers to recreate the physicality of Ancient Egypt.

AC Origins does not only facilitate an engagement with tangible heritage, it allows players to immerse themselves in the intangible dimensions of Ptolemaic Egypt. 'It gave me a sense not only of the myth, but of the people's everyday existence... I could find the people fishing, witness the irrigation systems they used to pull water from the Nile and see how pressures from the Roman Empire drove them to seek assimilation. There's a real sense of society', game reviewer Amr Al-Aaser states [6].

The game also includes an educational virtual museum, "Discovery Tour Mode" and has also been featured in museum exhibits. For instance, The National Geographic Museum, in Washington DC, USA, used gameplay from Origins in their exhibit: "Queens of Egypt." In it, footage from the game was paired alongside tangible artefacts. Ubisoft has repeatedly partnered with other museums and cultural heritage institutions. In doing so, they are able to bring the gameworld into conversation with heritage. After the game's release, Ubisoft developed the "Discovery Tour mode", additional downloadable content, explicitly designed to be an educational resource for players, without the combat and levelling mechanisms.

Games like AC Origins, in particular, are designed to be played and enjoyed. While games may have informational value based on historical facts, they also include storylines or quests which can be fictional - such as fighting gods. They can also condense maps and alter the size and structure of buildings to allow the player to traverse with speed and climb architecture. These features highlight that a good game is not a perfect representation of history and that game producers, like Ubisoft, are not educational institutions. In Egypt, there is a wide range of other possible futures for gaming in heritage contexts. This encompasses engagements with intangible cultural heritage, the fostering of local game design studios, using gaming to attract a new generation of heritage site visitors and encourage user-generated content in virtual representations of Egyptian heritage.

> **"By employing game design and environments, we can resonate closer with the cultural language of the new generations. So we're more likely to succeed in representing their interpretation of cultural heritage."**
>
> **— Ahmed El Shaer, New Media Artist and Doctoral ResearcherHeritage Studies, Ahmadu Bello University**

Social Media

Key Takeaways

Overview

Social media can be used to promote awareness, engage the public with historical and cultural content and crowdsource information or funding for heritage projects.

Pros

Amplifies reach and engagement, making cultural heritage more accessible to a distributed, online audience and supports collaborative and community-driven heritage initiatives.

Cons

The spread of misinformation, data ownership (by platforms) and maintaining the authenticity and cultural ownership of shared content are significant concerns.

Ethical Risks & Considerations

The spread of misinformation, data ownership (by platforms) and maintaining the authenticity and cultural ownership of shared content are significant concerns.

Possible Future Deployments

The spread of misinformation, data ownership (by platforms) and maintaining the authenticity and cultural ownership of shared content are significant concerns.

Examples

The spread of misinformation, data ownership (by platforms) and maintaining the authenticity and cultural ownership of shared content are significant concerns.

What is Social Media?

While the use of social media apps and platforms to engage the public, raise awareness and promote conservation efforts in cultural heritage contexts is their most visible function, the enormous accessibility of social media has led to an incredibly varied array of applications.

For many people, social media platforms are a first port of access to the Internet and a main source of information and community engagement. Often, social media is used to subvert existing power hierarchies regarding engagement with cultural heritage: during the COVID-19 pandemic, for instance, a few privileged users who could access private museums in the US gave people free virtual tours of those museums via the short-form video platform, TikTok. This propelled an avid online debate about whether museums should charge people to begin with, questioning who holds claim over heritage objects and how they are presented to the public.

Museums and heritage institutions actively engage in this discourse, albeit from a different position: they tend to utilise social media platforms to share information and stories that highlight the significance and history of the cultural heritage items in their custody. There have been enormously successful social media campaigns conducted by individual heritage institutions, but as a tendency, the pace of social media discourse stands in contrast to the speed at which heritage institutions normally operate. Regardless, the widespread use of social media opens exciting opportunities for community engagement, both virtually and on-site. By leveraging hashtags, live streaming and interactive content, these platforms create virtual communities where individuals can learn about and appreciate cultural heritage, fostering a collective sense of responsibility for its preservation.

Globally used messaging applications like WhatsApp, Telegram and Signal, along with regional platforms such as Yalla, can play a crucial role in cultural heritage protection by facilitating secure and real-time communication among researchers, activists and local communities. These apps' end-to-end encryption features ensures that sensitive information, such as activist networks, remains protected from unauthorised access and surveillance. Additionally, the group-chat features of these apps can be used to organise volunteer efforts and engage the public in protection initiatives through educational broadcasts and updates.

In addition to public engagement, social media also facilitates collaboration and information sharing among heritage professionals. Platforms like LinkedIn and specialised forums allow conservators, archaeologists and historians to connect, share best practices and discuss the latest research and technologies in heritage protection. social media campaigns can also mobilise public support and funding for conservation projects, as seen in numerous successful crowdfunding initiatives. Furthermore, these platforms play a critical role in rapid response efforts, such as during natural disasters or conflicts, where real-time updates and calls for assistance can help protect endangered heritage sites and artefacts. Overall, social media enhances the visibility, accessibility and collaborative efforts necessary for effective cultural heritage protection. Crucially, they present low-tech tools to engage communities with and effectively communicate with stakeholders.

> **Social Media is a place where we're enacting our own Digital Cultural Heritage, we're our own curators — we all select what we share online, it's personal curation.**
>
> **— Terry Little, British Council CPF Specialist Assessor; Lecturer, Dept. of Archaeology and Heritage Studies, Ahmadu Bello University**

How is Social Media Educational Content being used in cultural heritage?

Raising Awareness

Social media platforms can be used to raise awareness about endangered heritage sites and artefacts. For example, The National Trust for Historic Preservation [257] has launched awareness campaigns on Twitter, using hashtags like #ThisPlaceMatters to encourage people to share photos and stories of historic places that matter to them. This campaign raises awareness of cultural heritage sites and encourages community involvement in preservation efforts. By sharing stories, images and videos, organisations can highlight the importance of these cultural assets and the threats they face, garnering public support and attention. The Museum of Fine Arts, Boston, has embraced TikTok to reach younger audiences by sharing short, engaging videos that highlight interesting facts about their collections, behind-the-scenes looks at museum operations and creative challenges.

Community Engagement

Social media enables heritage organisations to engage with local and global communities. Platforms like Facebook, X and Instagram can be used to create interactive campaigns, polls and discussions that involve the public in heritage protection efforts and foster a sense of collective responsibility. For instance, The British Museum has used Instagram to host virtual exhibitions, sharing high-quality images and stories behind artefacts. This approach allows users worldwide to engage with the museum's collections and learn about historical artefacts through visually appealing posts and interactive content.

Educational Content

Social media are powerful tools to disseminating educational content on a wide scale and to targeted or tailored groups. For instance, the Smithsonian Institution has created educational video content on YouTube, featuring in-depth engagements with historical artefacts, interviews with historians and virtual tours of exhibitions. These videos serve as valuable educational resources and enhance public understanding of cultural heritage.

Crowdsourcing & Social Monitoring

Social media can be utilised to crowdsource information about heritage sites and artefacts. Platforms can be used to gather historical data, photographs and personal stories from the public, which can be valuable for research and conservation projects. Monitoring social media trends and discussions can also help heritage organisations predict and respond to emerging issues or interests. For instance, if there is a sudden spike in interest in a particular artefact or site, organisations can tailor their engagement strategies accordingly.

> **Social media is very important to share events and works to many people**
>
> — **Moaaz Lafi, Researcher of Islamic Architecture and Archaeology**

Rapid Response and Reporting

In cases of emergencies, such as natural disasters or conflicts, social media can be used for rapid response and reporting. Heritage organisations can quickly disseminate information about the status of heritage sites, call for immediate assistance and coordinate rescue efforts with volunteers and professionals. For example, numerous Facebook groups have emerged organically to virtually reconstruct and document the cultural heritage of cities like Aleppo, such as The Encyclopaedia of Aleppo Folk Proverbs [180].

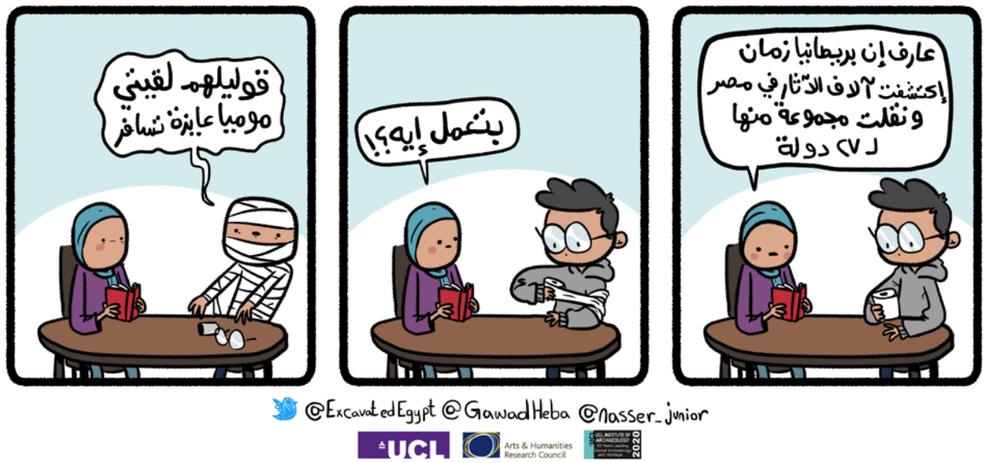
Fundraising Campaigns

Crowdfunding platforms integrated with social media can help reach a wider audience and encourage donations from individuals and communities interested in preserving cultural heritage. An example of this in the UK is the National Lottery Heritage Fund's use of the #HeritageIsOpen hashtag to advertise and promote the fund and its summer openings and events. Further afield, organisations such as the Sisonke ZW Family Trust in Zimbabwe use Facebook to increase exposure for their educationalazly targeted fundraising, particularly among prospective diasporic givers. A recent report [50] on digital philanthropy in Eastern Africa has also found that using social media and online giving platforms such as GoFundMe and JustGiving for outreach has reinforced longstanding traditions of community and giving in Kenya ("Harambee").

> **"I think swiping [on social media] has changed our general mode of consumption, and our focus. But social media can only produce what is consumed, which means there's an interest in it."**
>
> — **Kahithe Kiiru, Anthropologist, Production Manager and Choreographer, Bomas of Kenya**

Further Case Studies

- Instagram influencers sharing photography of authentic Orthodox culture in Ethiopia.
- Hashtag campaigns on X/ Twitter for cultural heritage protection in conflict zones such as Tigray, Ethiopia.
- Instagram AR filters celebrating the cultural heritage of Egypt [160].
- Museum collaboration with artists re-Egyptianizing ancient Egypt on X/ Twitter, such as Egypt's Dispersed Heritage [258].



Images courtesy of Egypt's Dispersed Heritage.
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What are the risks and ethics of gaming in cultural heritage?

Censorship: Censorship is an issue across several platforms, both from the platform providers and governmental intervention.

Misinformation: Many social media platforms are subject to rampant misinformation, as users treat unverified information as factual. Sophisticated AI-generated images accelerate this issue, as does the intentional weaponising of misinformation campaigns by political actors.

Conflation of identities: Social media platforms carry a notion of depicting a real person or identity, even though these presences are highly edited and often fake. Politicians, for instance, use social media as part of their press work, but might have been private users of the platform previously.

Information Siloes: a small number of topics get algorithmic preference on social media platforms, which can lead to information siloes. For heritage preservation, this is for instance problematic in relation to over-touristed areas which keep getting recommended to people through social media.

Data security: Social media companies trade with the data of their users and every major company has had at least one large data breach.

> **There are risks with profit-oriented platforms: what if they no longer make profit and close, what happens to our archive?**
>
> **— Bryar Bajalan, Project Lead, Mosul Maqam; Filmmaker; Translator; Doctoral Researcher**

What could be the future of Social Media in cultural heritage?

> **Where is upskilling or strategic help needed within the digital heritage area for us? I think some social media training or support with how to do it more strategically, and how to navigate all the different kinds of social media successfully for our audiences would be a helpful thing**
>
> **— Hannah Lewis, Programme Manager, Safina Projects**

Algorithm Tailoring: On the user side, people are increasingly influencing Social Media algorithms to tailor content to their preferences, furthering the threat of information siloes [235].

Oral Histories: Messaging apps like WhatsApp are increasingly used in community-led heritage projects to capture oral histories, languages, music, soundscapes and other audio materials.

Enhanced privacy: Signal and Telegram are pioneering privacy protection in messaging apps, with end to end encryption, self-destroying messages and secret chats [40].

Augmented Reality: Interactive social media platforms like TikTok, Instagram and Snapchat are pioneering AR applications in the forms of filters, interactive prompts and video effects. Snap Lenses are an extension of this trend, hinting that many social media platforms will likely produce their own XR products soon – Meta's massive investment in VR is another indicator of this [122].

E-sales and Influencer Marketing: East Asian social media platforms are spearheading the integration of sales events and influencer marketing, with enormous success. This is likely to be adopted at a global level in the coming decade.

Case Study:

The Singing Wells Project – Safeguarding Kenyan musical traditions online

Kenya remains a digitally developing country, with a significant disparity between Internet and mobile penetration rates. The Internet penetration rate in 2023 was recorded at just 32.7%, reflecting the disparities between urban and rural Kenyans. In contrast, however, the mobile penetration rate stands at an impressive 131.3%, which indicates that many Kenyans own multiple SIM cards to take advantage of different network offers. This suggests that whilst social media access is relatively widespread, network consistency remains an issue.

A project which leverages social media innovatively is the Singing Wells Project, a collaborative initiative between two organisations: the Kenyan music studio Ketebul and the London-based Abubilla Music Foundation. The project's goal is to capture and preserve Kenyan and broader Eastern African musical heritage in a permanent online form. It leverages social media platforms like YouTube and SoundCloud (an audio streaming service with 76 million active monthly users) to reach as wide an audience as possible.

Singing Wells' use of technology for cultural heritage preservation lies at the crossroads of digitisation and effective social media use. Since 2011, an evolving team of local Kenyans has travelled between rural communities with a "mobile recording studio to capture sounds in their proper context. The team then gives these recordings a digital afterlife by uploading them to various social media channels. The project's aim is not simply to archive the sounds, which could be done in a closed database system, but to ensure their continued relevance and advocate on behalf of the music's creators. For example, a video [155] posted to YouTube by the project which documented the restitution of recordings taken by a British ethnomusicologist to local communities garnered over 28,000 views and was featured in a New Yorker article [115]. This evidences the project's effective use of social media platforms for cultural heritage advocacy, reaching audiences even beyond the channel's respectable 82,000 YouTube subscribers.

Notably, the project is conscientious about obtaining consent from participants. The organisers stress that the ownership of the original songs remains with the performers, who are paid a gratuity for their participation. Consent is secured before the songs are uploaded to digital platforms such as YouTube. This project indicates a future landscape of social media use in Digital Cultural Heritage in Kenya, including the digitising of intangible heritage, virtual tourism and diverse community engagement.

> **In Mosul, we don't have great internet. So we use our phones, for Facebook, Instagram and YouTube to post our projects and let people know what is happening. These platforms are easy to use in Mosul.**
>
> — Tahany Saleh, Researcher, Mosul Maqam

Recommendations

Key Takeaways

1. **Infrastructure**
   Digital Cultural Heritage infrastructure should be approached from a holistic perspective that considers interconnected social, ecological and technological systems. For example, if a project is investing in reliable Internet access, it should also consider clean, stable energy supply for servers and harnessing community engagement and local knowledge.

2. **Data Collection**
   Cultural heritage data collection processes should be designed to engage community stakeholders in data collection and management, including decisions about which data to preserve and why.

3. **Data Stewardship**
   Investment in clear and robust data stewardship models are required at all levels of Digital Cultural Heritage preservation to ensure that culturally informed and transparent practices are followed. Projects that support long-term communities of practice, sustained learning and critical thinking about technologies, or small-scale, community-led models of data ownership are key

4. **Possible Future Deployments**
   Creative applications of technologies can engage new audiences in cultural heritage, particularly young audiences or those without pre-existing access to or interest in heritage. This is often particularly relevant in the context of protecting living heritage and can incorporate approaches such as user-generated content, distribution via social media, or gamification.

5. **Long-term Maintenance**
   Digital Cultural Heritage maintenance models need to prioritise sustainability and resilience over continuous innovation to ensure that existing, previously funded, projects remain functional. Technical maintenance should be combined with holistic processes that enable institutional or community agility, responsiveness and ability to adapt in the face of change.

This report evidences Digital Cultural Heritage as a site of innovation, creativity and community engagement.

Digital Cultural Heritage contributes to the novel archiving of complex histories such as the Ethiopian Heritage Digital Atlas, the detection of important sites such as the Qanats in Iraq, the restitution of objects such as Kenya's Kazba Belts and the engagement of new audiences in games such as Assassin's Creed: Origins.

The impact of Digital Cultural Heritage is not only confined to cultural heritage preservation, however. Innovation grounded in a desire to represent and preserve diverse histories drives new enterprise such as MediAR or Lelapa AI, equitable economic models such as Yatreda and Looty, novel security solutions such as SmartWater and fair ownership and accreditation as in Singing Wells.

Leveraging the technologies detailed in this report maximises the potential of heritage innovation, whilst ensuring that technological foundations being laid are fair, representative and sustainable requires focused and sustained investment.

This section outlines key areas where increased support is needed for Digital Cultural Heritage based on the examples from Egypt, Ethiopia, Iraq and Kenya. It outlines five distinct elements of the Digital Cultural Heritage pipeline: infrastructure, data collection, data stewardship, audience engagement and maintenance as critical interventions in ensuring long-term sustainability and adaptability.

1. Infrastructure

> **As much as we say ‘yes, let’s leverage data technology’, let’s not forget about the discrepancies in the uptake of digital technology across regions and socio-economic groups.**
>
> **— Kahithe Kiiru, Anthropologist, Production Manager and Choreographer, Bomas of Kenya**

Digital Cultural Heritage projects crucially rely on baseline infrastructure such as high-speed Internet access, mobile data connectivity and consistent energy generation. However, in Egypt, Ethiopia, Iraq and Kenya, this infrastructure is often inconsistent and at-risk. The application of Western-developed technologies in these contexts is sometimes incompatible with local infrastructure conditions. This both compromises the effectiveness and long-term potential of Digital Cultural Heritage and limits the interoperability of technologies at a global scale. Digital Cultural Heritage projects often must also adapt to exceptional circumstances such as Internet shutdowns during tumultuous elections and damage to power and mobile networks from annual floods, which requires flexible, agile digital solutions. More robust infrastructure for Digital Cultural Heritage, that learns from the best practices of existing technologies whilst innovating to address their current limitations in diverse contexts, both increases long-term sustainability of Digital Cultural Heritage and affords the development of novel solutions to adaptable technologies. In an increasingly changeable international landscape facing global challenges, these solutions are of immense value, both in the countries highlighted in this report and beyond them.

> **Importing equipment is a major challenge, often costing us four to five times its original price**
>
> **— Daniel Getachew, Founder and CEO of Guzo Technologies**

Recommendation:

When planning infrastructure for Digital Cultural Heritage projects, it is crucial to adopt a holistic approach that considers interconnected social, ecological and technological systems. This involves ensuring not only reliable Internet access but also stable energy supply for servers and adequate support for personnel. ‘The Singing Wells’ project, for instance, considers not only the cultural dimension of Eastern African music, but also its social dimension, through educational engagement; its ecological dimension, by using low-power recording equipment; and its technological dimension, by opting for accessible cloud storage [259].

Utilising lo-fi solutions, like mobile phones or audio recorders, for Digital Cultural Heritage projects can significantly lower infrastructural costs without increasing local energy demands. These technologies offer a sustainable choice, allowing resources to be allocated to other critical projects without compromising the effectiveness of Digital Cultural Heritage initiatives. Establishing robust backup systems such as offline storage, content delivery networks and decentralised networks safeguards Digital Cultural Heritage projects against disruptions like power outages and cyber-attacks. Determining minimum viable service options can ensure that continued access remains possible during system failures.

Finally, thinking beyond traditional hard infrastructure (the fundamental, physical components that support functioning) and consider soft infrastructure, such as community engagement and local knowledge, is essential to ensure the long-term sustainability of Digital Cultural Heritage projects.

> **We need to be thinking about the entire Digital Cultural Heritage pipeline… what does it take to sustain it?**
>
> **— Chao Tayiana Maina, Founder of African Digital Heritage; Museum of British Colonialism; Open Restitution Project and Save the Railway**

2. Data Collection

“

Documentation is not an end goal in itself, it’s just the tip of the iceberg. If the data is just sitting in someone’s hard drive, it’s not contextualised… The purpose of this data should be to enrich it, to expand upon it, to recontextualise it and use it in different ways to tell stories, increase awareness and build cohesion.

— Chao Tayiana Maina, Founder of African Digital Heritage; Museum of British Colonialism; Open Restitution Project and Save the Railway

In Digital Cultural Heritage, there is often an accumulation of digital documentation collected without a clear end goal. This suggests a risk of backlog that is not only resource-intensive to maintain but also lacks strategic value. Inviting more careful curation and management of data not only addresses this backlog but also offers an opportunity to tell focused, meaningful and easily navigable stories through archives, about the communities they represent.

Furthermore, careful curation of digitisation offers more sustainable approach to Digital Cultural Heritage, particularly in light of the evidenced ecological cost of technologies like blockchains or AI and the challenges of maintaining servers in hot regions.

Recommendation:

When planning infrastructure for Digital Cultural It is important to acknowledge that datafication cannot and should not be infinite. It is crucial to discern which data is truly meaningful, rather than indiscriminately saving everything for a proverbial rainy day.

Engaging community stakeholders in deciding what data to preserve ensures that the data retained has genuine cultural and historical value. Prioritising the use of emerging tools such as large language models and vector embeddings can help treat and reinterpret existing databases to create new meanings. This approach shifts the focus from merely gathering more data to deepening the value and understanding of existing data sets.

In the context of often-over looked recent histories, or digital-born heritage, digital documentation tools provide open-source, cost- effective and easily accessible resources for both experts and non-experts to preserve their local tangible and intangible cultural heritage. Adding context through user-generated tagging, descriptions and links (more feasible with history in living memory) enhances the richness of the digital archives.

“

For me, it’s about creating the data that you can really use to tangibly monitor condition and safeguard heritage for the future.

— Lyn Wilson, British Council CPF Specialist Assessor; Head of Research & Climate Change, Historic Environment Scotland

3. Data Stewardship

Maintaining robust data stewardship is a central challenge, particularly in regions where data protection laws are developing with inconsistent implementation. The stakes in Egypt, Ethiopia, Iraq and Kenya are particularly high as data controllers and brokers are often based overseas, which can reinstate uneven power dynamics.

“

If data stewardship is not a priority from the start of the project, it can’t be a conversation tacked onto the end

— Chao Tayiana Maina, Founder of African Digital Heritage; Museum of British Colonialism; Open Restitution Project and Save the Railway

One significant risk of unclear or inconsistent data stewardship of Digital Cultural Heritage is the granting of third-party rights over the digital assets, which could lead to cultural heritage being used in commercial ventures. For instance, it is difficult to see the extent and origin of what is included in the seismically large training sets for Artificial Intelligence (AI) models. This has been evident in OpenAI’s Whisper, a speech recognition model trained on audio data scraped from the Web, recently critiqued for its unauthorised scraping of Māori language data from YouTube [162]. Perhaps more concerning is when this data is used to train generative models, such as Dall-E, where indigenous artworks or textile patterns could be synthetically reproduced without author accreditation or cultural or spiritual context. A transparent, resilient and clearly defined data stewardship model is particularly important in unstable political climates, where unguarded data can be repurposed for use in surveillance or persecution as government priorities shift.

At a moment when the relationship between advanced technology and intellectual property is of widespread public debate [182], developing Digital Cultural Heritage stewardship solutions has relevance within and beyond heritage protection and offers a valuable site for trialling alternative models to data and protection.

“

When it comes to Digital Cultural Heritage there is a tension between Open Access and content that shouldn’t be shared in the public domain… but the key question is, how do you ensure recognition and ownership of data are granted back to the original community who produced it?

— Joanne Orr, British Council CPF Specialist Assessor; Director of Living Culture Development, UNESCO Expert

Recommendation:

Working with communities to raise awareness about the importance of clear and robust data stewardship of Digital Cultural Heritage data is critical, as is ensuring that data stewardship models meaningfully engage community stakeholders.

As part of this process, revisiting the definition of stakeholders regularly is essential — especially after generational shifts, leadership changes, or when new custodians, like environmental stewards, emerge. It is important to acknowledge that what constitutes standard practice today might be fundamentally different tomorrow, therefore supporting long-term communities of practice, sustained learning and critical thinking in engaging with technologies is essential.

Furthermore, international teams should recognise that concepts of privacy are culturally informed [20] and may differ across communities, thus discussions should be held to accommodate this difference. Experimenting with small-scale, community-led models of data ownership, , could offer a grassroots approaches to data stewardship [260] that enable cultural heritage practitioners to trial models by which communities directly influence and benefit from their digitised cultural heritage. Experimenting with small-scale, community-led models of data ownership, could offer a grassroots approaches to data stewardship [260] that enable cultural heritage practitioners to trial models by which communities directly influence and benefit from their digitised cultural heritage.

Finally, careful consideration should be given to technical solutions for protecting community knowledge considered secret and sacred. Techniques like digital encryption or cryptography could be deployed to maintain the confidentiality of communal rites, gender-based practices, or secret recipes.

> **If you don't have a template, if you don't have a method or system for how you're going to describe and define things, digital resources become far less easy to navigate.**
>
> **— Seif El Rashidi, Director of the Barakat Trust, Art and Architecture Historian and Heritage Manager**

> **You have to start with the local communities, wherever you are in the world. They're the protectors. They're the ambassadors of the heritage and without them, you can't do anything.**
>
> **— Alia Fares, British Council CPF Specialist Assessor; Archaeologist and Cultural Heritage Manager at the American Society of Overseas Research; Founder of Herigatech Ltd. and the Heritage Education Program**

4. Audience Engagement

Digital Cultural Heritage projects are primarily focused on applying digital tools to preserve well-established tangible and intangible cultural heritage. However, there is a notable oversight in the preservation of recent history and audience engagement with said history. Significant social and political shifts in the last three decades have fundamentally altered material, ecological, social and aural landscapes, leading to the loss of tangible and intangible cultural heritage from recent centuries. Simultaneously, relying on conventional ways of engagement can hold back the involvement of new audiences. Audience engagement, involving technologies or not, cannot only bridge gaps between the past and present, but also between communities and institutions.

Moving beyond the traditional museum context, we could embrace user-generated content, distribution via social media, or even gamification, which might resonate more naturally with younger audiences. Additionally, the rise of curated personal digital spaces, such as Pinterest or Are.na, offer new ways for individuals or communities to represent Digital Cultural Heritage on their own terms. As Assassin's Creed: Origins demonstrates there is significant potential to engage audiences on their own terms using media that feels natural and intuitive to the individual. This kind of audience engagement offers a new kind of living heritage that exists in virtual spaces or experiences and is integrated into the Internet or digital culture.

> **Heritage that is actively used by the community is always the best preserved.**
>
> **— Terry Little, British Council CPF Specialist Assessor; Lecturer, Dept. of Archaeology and Heritage Studies, Ahmadu Bello University**

Recommendation:

Acknowledging layers of recent history present even in ancient artefacts can deepen audiences' cultural appreciation and preservation efforts. Digital documentation tools provide open-source,

cost-effective and easily accessible resources for both experts and non-experts to preserve their local tangible and intangible cultural heritage. Adding context through user-generated tagging, descriptions and links (which is more feasible when working with history within living memory) enhances the richness of the digital archives and fosters audience engagement. Making existing data usable and valuable through technologies such as data visualisations or immersive experiences can transform how cultural heritage data is understood, interacted with and appreciated, potentially broadening reach and impact.

> **How do you ensure that communities benefit? How do you ensure any income or commercial aspect goes back to the regional practitioners in the communities?**
>
> **— Kahithe Kiiru, Anthropologist, Production Manager and Choreographer, Bomas of Keny**

5. Long-Term Maintenance

> **Sustainability is a big thing to consider in DCH projects—you can't spend thousands of pounds on a machine and not think about who's going to fix it, or at least maintain it**
>
> **— Assaad Seif, British Council CPF Specialist Assessor; Archaeologist and University Professor, Lebanese University; UNESCO & ICOMOS Heritage Expert**

Maintaining the lifespan of a Digital Cultural Heritage project is a major challenge. Once foreign investment exits, many projects struggle to sustain themselves — not due to a lack of will or ambition, but because of a lack of foundational support or infrastructure [87]. This manifests as siloed skills capacities which can lead to maintenance issues (e.g. updating obsolete technology in-house) and inconsistencies in long-term maintenance strategies. The principles of analogue storage cannot be easily applied to Digital Cultural Heritage, which is often vast in scale, user-generated and resistant to clear classification. File format obsolescence, data corruption and cybersecurity threats are all critical maintenance issues that receive scant attention in heritage conversations.

Addressing these challenges is a significant task but has widespread relevance beyond Digital Cultural Heritage. This, combined with the proclivity in cultural heritage to understand data preservation in terms of long time scales, requires exceptionally future-facing approaches to data infrastructure and maintenance. Again, Digital Cultural Heritage presents an opportunity to innovate solutions that have applicability both within and far beyond preservation of cultural heritage.

Recommendation:

Technologies that aid or even automate the maintenance of Digital Cultural Heritage projects during and after their funding periods offer significant opportunities for sustainability. Prioritising the valorisation of maintenance over continuous innovation ensures that existing, previously funded, projects remain functional. Emphasising the value of digital data by including robust digital documentation of each layer of the process is essential even to tangible heritage projects. Data should not become a mere appendage but rather should operate at the heart of each project. Maintenance and technological skills-transference are essential, but attention should also be placed on soft skills such as agility, responsiveness and the ability to adapt. This helps mitigate the risks of technological obsolescence and ensures that personnel can effectively manage and maintain Digital Cultural Heritage projects in the long-term.

> **Funders really ought to insist on and support a long-term plan—especially for data management... I've seen projects where money comes into an institution, they buy the cameras, they do the digitisation work, but three years later no one knows where the data is.**
>
> **— Chao Tayiana Maina, Founder of African Digital Heritage; Museum of British Colonialism; Open Restitution Project and Save the Railway**

Conclusion

Key Takeaways

Digital Cultural Heritage Challenges:

DCH leverages digital technologies to preserve cultural narratives and heritage, fostering new discussions on ownership and preservation. However, there are challenges in balancing local needs, engagement, and the evolving technological landscape.

Communities and Collaboration:

Successful heritage preservation requires local stakeholder engagement, grassroots involvement, and collaboration across various sectors (e.g., institutions, startups, governments).

Risks and Ethical Considerations:

While digital technologies have significant potential, they also present risks, including issues of accessibility, power dynamics, and the Digital Divide. Ethical data management, sustainability, and community-driven approaches are essential for ensuring the long-term success and relevance of digital heritage projects.

Digital Cultural Heritage (DCH) plays a central role in preserving and engaging with cultural narratives, past and present. The technologies outlined in this report offer unprecedented opportunities for polyvocality in the stewardship and maintenance of cultural heritage. They invite new discussions on **what heritage is, who it belongs to, and how we may preserve it for future generations.** However, our findings also underline that there are significant risks inherent to utilising these technologies. Striking a balance between local needs, critical engagement, and a constantly evolving technological landscape is as challenging as it can be rewarding. Considering are key factors in ensuring the long-term success, sustainability, and relevance to stakeholder communities.

This requires solution-oriented approaches which position **digital tools alongside diverse preservation practices.** For instance, climate change is a risk factor faced by numerous nations around the world, and no single technology will be able to mitigate that risk alone. In learning from other projects and experimenting with existing technological solutions, new mitigation approaches may be developed collectively and dialogically. This report underlines how **local specificity supports knowledge exchange between different communities, but also different realms of technology.** A locally produced GIS map recording environmental data can create open-source records of climatological data which inform research in other localities or build the basis of a community-based 3D printing project to raise climate change awareness. A shared understanding of the limitations and potentials of specific technologies is essential to creating these connections, and to learn from one another.

Prioritising local stakeholders, grassroots involvement, and inclusive practices ensures that the use of digital technologies is rooted in specific cultural heritage needs. A key challenge is how we identify and communicate these needs, and who has the authority to make these decisions. While this is not a new challenge in heritage preservation, emerging technologies amplify these power dynamics. Along the arbitrary lines of the Digital Divide, questions of who has access and who holds power are being renegotiated. Therefore, it is all the more vital to develop a **shared understanding of the potentials and risks of digital technologies.** Interoperability and established workflows are crucial to this understanding: knowing how specific technologies connect and overlap is key to utilising their full potential. This means collaboration at every level – between institutions, labs, start ups, governments, local and virtual communities.

The examples in this report demonstrate that these intersections can be fruitful areas of innovation and experimentation, leading to preservation approaches which could not have been developed by any single stakeholder. We emphasise the importance of collaboration and knowledge sharing across different regions and technological fields in this context. Heritage is based on shared histories, presents, and futures, and only collective approaches to preserving heritage are feasible to be sustained long-term. Digital technologies can help in this endeavour, but only if they are accessible to diverse publics and employed sustainably, with ethical data management and stewardship.

This report explores the promise digital technologies hold for cultural heritage preservation, while also acknowledging the challenges and risks they present. By showcasing initiatives that blend technological innovation with traditional knowledge and local cultural practices, it seeks to challenge dominant narratives that position technology as neutral or universally applicable. Central to this approach is the belief that technology should not only be applied to cultural heritage but also influenced by it. When the development of technology is guided by cultural context and community values, it becomes more inclusive, durable, and meaningful, capable of impact and relevance both within the preservation of cultural heritage and beyond it.

Cultural practitioners working in Egypt, Ethiopia, Iraq, and Kenya highlight opportunities and considerations for the development and application of technologies in their specific contexts. While practitioners in each of these countries face distinct challenges, this section aims to articulate key insights relevant across the four contexts, introducing a multi-perspectival viewpoint for how technology is being leveraged to engage with complex cultural histories and on-the-ground technological capabilities.

Mitigating Conflict and Destruction: Where political conflicts have led to the intentional and unintentional damage and looting of heritage sites, cultural heritage institutions and community initiatives are harnessing technology to document, report, share and safeguard heritage

Advocating for Post-colonial Identity Restitution: While advocating for the restoration of cultural artefacts to their origins, practitioners in numerous origin communities are using digital technologies to engage with cultural artworks in their material absence, enhancing cultural cohesion, and promoting autonomous ownership.

Enhancing Digital Tourism: Cultural heritage practitioners are engaging digital technologies to promote lesser-known heritage sites and divert traffic from overvisited sites, supporting both economic and conservation efforts.

Tailoring Devices to Local Usage: Cultural heritage practitioners are using digital devices to bypass the slow development of established cultural protection practices and broaden engagement.

Cultivating Home-Grown Heritage Expertise: Local grown training programmes and startups are emerging, focusing on capacity building and indigenous solutions while decreasing dependence on foreign technology, boosting innovation and sustainability.

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Appendix:

Technology Definitions and Infrastructure Requirements

1. 3D Printing

Definition: 3D printing is an additive manufacturing process that creates a physical object from a digital design by laying down successive layers of material. It is used in various fields, from prototyping to production.

- Examples include 3D printed rotor blades for wind turbines, satellite hardware, fabricating rocket engines and building concrete houses.

Infrastructure:

- **Computer-Aided Design (CAD) Software:** essential for creating the digital models of objects from which 3D prints are created. These software packages allow users to design and manipulate 3D models with precision.
- **3D Printing Software/Slicers:** Slicer software converts the digital 3D model into a series of thin slices and generates the instructions (G-code) for the 3D printer to follow layer by layer. It is a crucial link between the digital design and the physical printing process.
- **3D Printer:** ranging from desktop models for personal use to industrial-scale machines for manufacturing. The printers come in various types, each with its own requirements and capabilities.
- **Material Inputs:** A wide range of materials can be used for 3D printing, including plastics, metals, ceramics and even bio-materials. The availability and quality of these materials are essential for achieving desired properties in the printed objects.
- **Networking Infrastructure:** For large-scale 3D printing operations or those involving remote collaboration, networking infrastructure is crucial. This includes high-speed Internet connections, networked printers and collaboration tools for sharing and managing design files.

2. Anti-theft Tech

Definition: Anti-theft technology refers to various systems and devices designed to prevent or deter theft or track down stolen items.

- Examples include electronic tags (such as RFID technology), alarms and GPS tracking.

Infrastructure:

- **Secure, Stable Storage Facilities:** Essential to prevent Anti-theft devices being deliberately interfered with or accidentally damaged before deployment. For example, SmartWater liquid is best stored at room temperature and the storage facility should be secured against potential theft or tampering, for example with locks and CCTV.
- **Deployment Tools:** Various deployment tools, such as brushes and aerosols, are used to apply across Anti-theft tech. Black UV lights are needed to detect marked items and printing facilities are required for signage unless pre-printed signs are provided by SmartWater.
- **Databases for Inventory Management:** To maintain a comprehensive inventory database for all marked items.
- **RFID Tags and Readers:** both passive and active and RFID readers with antennae are used for tracking items. Middleware facilitates communication between tagged items and backend systems, such as BLE beacons.
- **Middleware, Ground Stations and Communications:** Middleware is required to manage communication between tagged items and backend systems (e.g., BLE beacon). GPS trackers, mobile or satellite networks and ground stations ensure data transmission. Secure storage for microdots and microdot cameras are necessary for viewing and verification.
- Reliable power supplies: Vital for maintaining communication between these systems.

3. Artificial Intelligence (AI)

Definition: Artificial Intelligence (AI) is an umbrella-term for a range of algorithm-based technologies that simulate forms of human intelligence and complex problem-solving, either on its own or combined with other technologies.

- Examples include digital assistants (Amazon's Alexa), image generators (Midjourney), chatbots (OpenAI's ChatGPT) and autonomous vehicles (Waymo).

Infrastructure:

- **Deep Learning Frameworks:** TensorFlow, PyTorch and Keras are crucial for developing deep learning applications. These frameworks provide advanced capabilities for building, training and deploying complex neural networks.
- **Training Data:** the core of deep learning, large, often multi-modal datasets are used to train neural networks. This might include immense collections of images, videos, text and audio.
- **Computational Hardware:** GPUs (Graphic Processing Units) are essential for training deep learning models due to their superior processing power and ability to perform parallel computations, drastically reducing the time required to train complex models.
- **Tensor Processing Units:** TPUs are highly specialised hardware designed specifically for deep learning tasks by Google, offering even faster processing than GPUs for particular types of calculations in large-scale training environments.
- **Software Development Kits (SDKs) and APIs:** These tools allow developers to integrate AI functionalities into various applications easily. SDKs and APIs help bridge different technologies and platforms, making it easier to incorporate AI into existing systems and workflows.
- **Human-in-the-loop (HITL) Systems:** Infrastructure to allow for human oversight and intervention in AI processes is critical, especially in scenarios where decision-making requires nuanced understanding or ethical considerations.
- **Data Centres:** to store large datasets and provide the computational power to perform intensive training sessions of deep learning models.
- **Cloud platforms:** such as AWS, Google Cloud and Microsoft Azure play a pivotal role in offering scalable computing resources and the deployment of models globally.
- **High-Speed Internet Connectivity:** Essential for accessing cloud platforms, collaborating with remote teams and transferring large volumes of data quickly and reliably.

4. Blockchain

Definition: Blockchain is digital ledger where transactions are logged and stored across multiple computers in a decentralised network. The network uses complex cryptography to ensure security and integrity and once logged, the ledger cannot be changed retroactively. Blockchains vary by degrees of transparency, cost and energy efficiency.

- Examples include IBM blockchain, Everledger, as well as technologies built on-top of blockchains, such as cryptocurrencies (e.g. Bitcoin and Ethereum), Non-fungible tokens (NFTs e.g. CryptoPunks), smart contracts and decentralised autonomous organisations (DAOs).

Infrastructure:

- **Internet Connectivity:** to access the blockchain and its constituent parts.
- **Blockchain Network:** access to an existing blockchain network (e.g. Ethereum, Tezos, Solana) or the establishment of a new blockchain.
- **Software to Interface with Blockchain:** to log the transaction, scan (e.g. EtherScan), or trade (e.g. Foundation).
- **Storage Capacity:** either on-chain or off-chain e.g. IPFS, AWS.
- **Funds in Cryptocurrencies:** required to 'mint' (upload) data on the blockchain.
- **Digital Wallets:** if trading, a digital wallet capable of storing cryptocurrencies and Non-Fungible Tokens.
- **Display Layer:** if moving beyond hashes (transaction IDs), an externally hyperlinked visual layer for display and exhibition of the blockchain's content (e.g. Spatial.io, Art Korner, Decentraland).

5. Databases

Definition: A database is an organised collection of structured information or data, typically stored electronically either on local, cloud or distributed systems. Databases are often managed by Database Management Systems (DBMS) and can be used to store, retrieve and manage data efficiently.

- Examples include Oracle Database, MySQL, Amazon Aurora.

Infrastructure:

- **Server Infrastructure:** High-performance servers essential for handling large volumes of data and complex queries with efficiency. It is crucial these servers have sufficient RAM to support large-scale data processing and ensuring smooth operations
- **Storage Solutions:** HDDs and SSDs provide physical storage options for databases with SSDs offering faster access and better performance. Alternatively, cloud storage can offer scalable and flexible storage solutions without the limitations of physical hardware.
- **Database Management Systems (DBMS):** robust systems like MySQL and MS SQL Server are fundamental for creating, managing and manipulating data structures.
- **Security Apparatus:** Encryption and security infrastructure is essential for protecting data from unauthorised access and ensuring data integrity. Clustering and replication strategies ought to be used to ensure data is not lost and can be recovered in case of system failure.
- **Networking Infrastructure:** Comprising cables, routers and other networking hardware necessary for ensuring stable and secure data transmission between database components.

6. Digitising

Definition: Digitising is the process of converting information into a digital format. This can involve manual methods, but increasingly adapting to volume conversion (e.g. Automated Document Feeders) and mobile methods. 3D scanning technology captures detailed digital models of objects, preserving their spatial characteristics.

- Examples include Adobe Scan, PolyCam, digital photography.

Infrastructure:

- **Recording Equipment:** High-quality cameras, 2D scanners and LiDAR-equipped smartphones, as well as supporting equipment such as tripods and lighting rigs.
- **Databases and Data Storage:** To manage and preserve the vast amounts of digital data generated, onsite storage or offsite (such as cloud) storage.
- **Reliable Power and Internet Access:** Continuous access to electricity is crucial for operating digital equipment. Similarly, reliable and fast Internet access is essential for uploading large files to databases, sharing data with collaborators and accessing cloud storage.
- **Backup and Recovery Systems:** Critical to protect digital heritage data against data loss due to hardware failure, cyber-attacks, or natural disasters.
- **Staff Training:** Specialised staff trained in digitisation equipment, software and classification systems.

7. Extended Reality (XR)

Definition: Extended Reality (XR) is an umbrella term for immersive technologies which merge material and digital worlds to create multi-sensory experiences.

- Examples include Tupac hologram at Coachella (2012), Pokemon Go!, Beat Saber VR.

Infrastructure:

- **Network Connectivity:** Essential for running most XR applications, allowing for streaming of complex data and real-time interaction with virtual content. Although some XR applications can be downloaded and run offline.
- **Enhanced Computer Power:** Powerful computing resources, with high-performance CPUs and GPUs, are required to handle the heavy processing loads of XR applications, especially those that involve complex simulations.
- **Interactivity Hardware:** Devices such as motion trackers, haptic feedback systems and advanced controllers enhance interactivity in XR experiences.
- **Mobile or Wearable Devices:** Phones, tablets and XR headsets equipped with cameras and sensors are necessary to access VR, MR and AR. These devices capture and process the user's physical environment to overlay digital information. VR and MR Goggles are specifically designed for a fully immersive experience.
- **Project and Display Technology:** Specialised projectors are needed for creating holograms and conducting responsive projection mapping. These projectors are used, for instance, to display 3D holograms and interactive maps on physical surfaces.
- **Content Creation Software:** While professional-grade software, such as Unity and Blender, may be required for complex content creation, there are also freeware and web-based options available that can suffice for simpler projects.

8. Gaming

Definition: Gaming refers to interactions bween players and an electronic device, including computers, gaming consoles, XR headsets and mobile devices, in which the player (or group of players) control some element of the electronic device.

- Examples include the 'Assassin's Creed' franchise, 'Grand Theft Auto' franchise, 'Clash of Clans' and 'Candy Crush'.

Infrastructure:

- **Devices:** Games require a device such as a video game console, a computer with high RAM and a robust graphics card, mobile devices for mobile games, or an AR/VR headset for immersive experiences.
- **Reliable Internet Connection:** For online gaming, a stable and fast Internet connection is critical to ensure smooth gameplay and to handle real-time data transmission without lags that can cause interruptions.
- **Access to Game Software:** Gamers need either a physical disk or a digital copy of the game, dependent upon the game's distribution model.
- **Enhanced Display Technology:** Advanced display technologies like 4K monitors or specialised VR headsets might be necessary for high-resolution and immersive gaming experiences. Also, possibly, high-quality audio systems
- **Adequate Storage Solutions:** Especially important for games with extensive graphics and large worlds, solid-state drives (SSDs) provide faster load times and smoother gameplay.
- **Development Tools:** Software Development Kits (SDKs) and game development tools like physics engines and animation software are essential for developers to create sophisticated games.
- **Community and Support Platforms:** Forums, in-game chat functionalities and support can enhance for community engagement and player support.

9. Social Media

Definition: Social media refers to Internet-based platforms that allow users to create, share and interact with content and other users.

- Examples include Facebook, TikTok, WeChat, X and Telegram.

Infrastructure:

- **Internet-Connected Device:** smartphone or laptop / desktop, suitable for capturing, sharing digital content and accessing Social media sites.
- **Internet Connectivity:** Reliable Internet access is crucial for uploading and downloading content, live streaming and real-time interaction.
- **Virtual Private Network (VPN):** used to circumvent regional censorship, VPNs allow access to social media platforms in restricted areas. Note: Using a VPN may be illegal in some countries and should be approached with caution.
- **Identification for Set-Up:** a phone number or email account are required for signing up and verifying social media accounts.
- **Social Media Management Tools:** Software like Hootsuite or Buffer can help schedule posts, manage multiple accounts and track engagement.
- **Analytical Tools:** Platforms like Google Analytics or social media-specific analytics tools can track performance and engagement metrics.

The British Council is the UK's international organisation for cultural relations and educational opportunities. We support peace and prosperity by building connections, understanding and trust between people in the UK and countries worldwide.

At the core of the British Council's approach to arts, cultural relations and digital innovation is the recognition that:

- Arts, Cultural Sector and Creative Industries are critical drivers of innovation and key contributors to the UK and international innovation agendas
- Interdisciplinary, international creative collaboration facilitates the development of diverse, representative and resilient technologies.

The Cultural Protection Fund was founded in 2016 and is led by the British Council in partnership with the Department for Culture, Media and Sport.

The Cultural Protection Fund is the UK's main response to international cultural heritage protection. Its role is to safeguard cultural heritage at risk due to conflict and/or climate change and to contribute to sustainable social stability and economic prosperity. Putting people at the heart of cultural heritage protection, the fund supports organisations to safeguard cultural heritage whilst seeking to strengthen individual, community and societal identity.