Digital Infrastructures and their Impact on Data Acquisition

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In his paper Jeremey Huggett comprehensively explores the intricate relationship between infrastructures, digital data acquisition and knowledge creation in archaeology. As a practitioner deeply engaged in applied digital methods for primary archaeological recording, I am particularly interested in the implications of digital infrastructures for data acquisition and knowledge creation within our field. Rather than counter any of Huggett's points, for they are all important, I will use this space to further develop some of the themes raised and try to offer some practical recommendations for addressing some of the issues raised by this discourse.

The Societal Fabric of Infrastructures

Huggett highlights how archaeological infrastructures, often perceived as technical entities, are dynamic socio-cultural constructs that extend beyond functional utility. This perspective aligns with the understanding that infrastructures are not mere conduits of data; in fact, they possess the agency to shape the very processes of data acquisition. This agency is imbued through

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the standards, protocols and ideological underpinnings that these infrastructures embed. While the paper does shine a light on this crucial aspect, it is perhaps worth emphasizing again that our digital infrastructures are not only shaped by the data that they seek to host or agglomerate, but also the technological considerations which underpin that data and a series of related social, political and ethical dynamics.

There are many examples of this that one could draw upon at various levels, but consider for example LiDAR (Light Detection and Ranging) technology's introduction in archaeological prospection and landscape archaeology. While it emerged as a groundbreaking tool for archaeology, capturing data on large landscape areas quickly in high detail and unveiling previously unseen structures underneath forest canopies, the data gathered is heavily influenced by the choices made in scanning protocols, data processing methods and interpretation frameworks. As Štular and Lozić (2023) recently highlight, all too often these decisions and processes are 'Black Boxed'. Similar critiques can be offered in relation to the now very common use of 3D photogrammetry techniques in archaeology. Despite providing precise and detailed visual reconstructions of artefacts, sites and landscapes, the way this data is collected, processed and interpreted can heavily influence the stories told from these reconstructions. The 'black-box' issue is particularly relevant as emergent 'AI' technologies exhibit the potential to opaquely scrape and re-present the data from our digital infrastructures. As our data find their way into our disciplinary digital infrastructures, what are the implications of this lack of transparency in our contemporary data collection?

Agency, technological determinism, and the digital shift: Reshaping archaeological practice

Another facet of this is the link between agency and technological determinism within the realm of digital archaeology. *To what extent are our primary data collection workflows increasingly influenced by the affordances of digital technologies?*

In fact, digital approaches to archaeology harness the affordances of digital technologies in unique ways, for example: they capitalize on data storage for vast archaeological datasets, leverage multimedia integration for detailed site representations, employ data analysis for pattern recognition in artefact distributions, use virtual reality for reconstructing ancient environments and enhance collaboration across global archaeological teams. However, the full spectrum of these affordances and their implications for the field remain an evolving subject of exploration.

So then, to what extent are our digital infrastructures also influenced by the affordances of digital technologies?

The integration of digital infrastructures and tools into archaeological practice represents not just a supplementary addition, but a fundamental transformation in the very way archaeology is conducted (see for example the discussion presented in Taylor & Dell'Unto 2021). As we navigate through the realms of digital data acquisition and knowledge creation, it becomes evident that these tools and the infrastructures they support, or generate data for, are not mere passive entities. They are agents, actively influencing both the methodologies we employ and the interpretations we derive.

Whilst digital infrastructures empower researchers, they also exert a level of determinism by framing the possibilities and constraints of data acquisition processes and the way that data is curated, queried and ultimately (re-)used. They provide researchers with tools for more efficient data recording, visualization and interpretation. They offer new opportunities for the reuse, combination and analysis of datasets. Moreover, they offer advanced querying capabilities, enabling researchers to draw connections and make interpretations across datasets that would otherwise be isolated or difficult to compare.

At the topmost level, digital infrastructures that play an instrumental role in aggregating, managing and disseminating archaeological data (platforms like The Digital Archaeological Record [tDAR] or Archaeological Data Service [ADS] and above them, for example, ARIADNE Plus) have revolutionized the accessibility and interoperability of archaeological datasets. By amalgamating disparate datasets from various projects across regions, they facilitate studies that would not be feasible with isolated datasets and, by providing access to archaeological reports and publications spanning decades, they enable potential studies on long-term trends. These platforms allow researchers across the globe to engage with vast data repositories, promoting a more democratized and collaborative research environment and fostering a sense of global scholarly community. However, such platforms also necessitate stringent data standards and metadata practices, thereby implicitly influencing the way data is collected, curated and shared.

The standardized data entry fields and metadata criteria used at every level of the discipline, from intra-site, right through to the infrastructural level, being designed largely by practitioners and domain experts, also end up dictating the kind of information researchers prioritize during data entry, or even during primary acquisition of data in the field (*'we don't need to collect metrics and elevations anymore, because they are existentially embedded in our 3D and spatial data!'*; to paraphrase an increasingly common, and not untrue, refrain).

On a more granular scale then, the adoption of digital tools for the data acquisition which feeds into these infrastructures is also profoundly reshaping fieldwork methodologies. The use of drones for aerial surveying, for instance, has made it possible to rapidly document large archaeological sites, providing perspectives that were once limited to time-consuming satellite imaging or costly piloted flights. Similarly, (again!) 3D technologies have offered unprecedented precision in documenting fieldwork, structures and artefacts, allowing for detailed analysis and digital preservation.

Yet, with these advancements come new challenges. While drones can capture vast areas, they might also inadvertently omit or allow us to misinterpret nuances that a traditional on-ground survey might capture; while 3D scanning offers precision, it can sometimes lack the tactile and experiential insights gained from hands-on examination. This is not a problem *per se*, but is certainly something to consider carefully as practitioners and perhaps mitigate against. Moreover, as these tools become mainstream, there is an emerging shift in the skills and competencies expected of an archaeologist. Knowledge of programming, database management, or 3D and GIS tools is rapidly becoming as desirable or indispensable as understanding stratigraphy or pottery typologies.

Amidst this digital evolution in practice, it is vital to strike a balance. While these tools offer incredible potential, it is essential to remain critically engaged, ensuring that technology complements rather than dictates archaeological inquiry. By being aware of both the affordances and limitations of digital infrastructures and tools, archaeologists can harness their full potential while ensuring that core principles of the discipline (such as the significance of context in our findings, the obligation towards documentation, data stewardship and dissemination, and the necessity of critical thinking and ethical engagement) remain intact.

Inclusive interdisciplinarity: Bridging gaps and exposing bias

Interdisciplinarity emerges as another central theme in this paper, which resonates with the 'grand challenges' of digital archaeology outlined by Huggett elsewhere (2015:83). Collaborative efforts that include archaeologists, computer scientists, data scientists, ethicists, and heritage experts are imperative. By creating avenues for dialogue, shared language and mutual understanding, we can bridge the gaps between these disciplines, ensuring that the development of infrastructures is both inclusive and accountable.

The socio-technical ecosystem surrounding infrastructures, highlighted by Huggett, ultimately necessitates this sort of interdisciplinary collabo-

ration, inviting experts from diverse fields to collectively address the multifaceted implications of data acquisition and knowledge creation. Such collaborations help ensure that technological applications in archaeology are anchored in robust theoretical and ethical frameworks. Engaging with interdisciplinary perspectives should also bring into focus the latent biases and assumptions that might be embedded within digital tools (see for example the discussion by Hacıgüzeller et al. 2021). However, it is crucial to understand that unveiling these biases and assumptions requires inclusivity in our multidisciplinary work. It is essential to include all stakeholders, such as local communities, indigenous groups, broader heritage professionals, policy makers and a representative cross-section of the wider public in the design of our archaeological digital infrastructures. Only by fostering this kind of broad, inclusive dialogue can we really ensure a more holistic and nuanced understanding of the archaeological narrative.

Towards holistic digital archaeology: Practical recommendations

It is, then, essential to acknowledge that the choices made in designing infrastructures, from metadata structures to user interfaces, carry ethical and sociopolitical ramifications. These choices may inadvertently favour certain perspectives and epistemologies while marginalizing others. To counter this, an approach grounded in ethical considerations and critical reflexivity becomes paramount.

Huggett's paper serves as a clarion call for researchers, practitioners and developers invested in archaeological infrastructures. As a response to these imperatives, practical recommendations emerge:

1. Ethical Frameworks: Developers must imbue infrastructures with ethical considerations, accounting for issues of equity, accessibility and representation. The ethical dimensions of data acquisition should be at the forefront of the design process. For instance, it is as imperative when designing infrastructures, as when collecting the archaeological data from the archaeological sites that will populate those infrastructures, to involve local communities and other stakeholders whom the infrastructure could/should serve, ensuring heritage is not appropriated without proper recognition or context.
2. Interdisciplinary Collaboration: We should continue to promote initiatives that gather experts from diverse fields and stakeholders to collaboratively shape and refine infrastructures. These will foster dialogue, cultivate shared vocabularies, and envision infrastructures that holis-

tically serve archaeological research and societal needs. For example, digital project design processes could be structured or workshopped to explicitly combine technology developers, archaeologists and again local stakeholders; these workshops would help develop user experiences that are technologically sound, archaeologically rigorous and locally meaningful.

3. Reflective Practice: Researchers and practitioners who populate our infrastructures should continue to regularly engage in reflective practice. This involves interrogating the biases and limitations imposed by our infrastructures, and critically assessing how data acquisition processes align with archaeological epistemologies. This might, for example, involve reconvening at the end of a digital field season or phase of development work to assess the data quality, potential blind spots or interpretative biases that emerged during the process, refining methodologies for the next season/phase and feeding these observations and awareness back into our infrastructural organizations.

In conclusion, 'Infrastructures in Archaeology' compels us to navigate the complex landscape of digital data acquisition and knowledge creation with a multidimensional perspective. As we forge ahead in the digital age, the transformation of archaeological knowledge hinges on our ability to recognize infrastructures not merely as tools, but as agents in their own right that shape the very essence of our discipline.

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