PROFILE

DIGITAL APPROACHES TO INVESTIGATING SPACE AND PLACE IN CLASSICAL STUDIES

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Imagine a student reading Odysseus' Cretan tale at *Odyssey* 19.172–84. When faced by a string of unfamiliar names – in addition to 'native Cretans', there are Achaeans, Cydonians and Dorians, as well as the individuals Minos, Deucalion, Idomeneus and the speaker, Aethon (Odysseus in disguise) –, they use their digital edition to find out more about each of these people and their places of origin. A personal name opens an online encyclopaedia entry, while clicking on a place launches an emerging world beyond the single text – an online atlas that provides information about the place's toponymy, form and exact location as well as links to other resources (textual and archaeological, ancient and modern) about this place, including those to which our student has contributed. The year? 2023 (Figure 1).[1]

This scenario summarises an example of current work that uses digital technology to explore notions of space and place in Classical Studies, the most significant achievements of which this review essay attempts to survey.[2] Our aim is to provide a snapshot of the latest digital-based research into ancient spatiality – both places on the ground and those represented in texts – and highlight the ways in which Classical Studies have also contributed to technological innovation. Our remit is particularly wide not only due to the fact that work in 'Spatial Classics' is inherently transdisciplinary, extending far beyond a narrow Graeco-Roman focus, but also because Spatial Humanities itself is a new and emerging multidiscipline.

The methods and applications represented by the description 'a spatial analysis through digital technology' are wide-ranging and diverse. Our review will discuss tools, such as GIS and other mapping software, and practices of annotation and geo-resolution, as well as the emerging technology of Linked Open Data. Throughout we highlight scholarship, projects and initiatives that best illustrate how an

[1]The 'where are we heading?' opening pitch has a long history in Digital Humanities surveys: E. Reiner, 'How We Read Cuneiform Texts', *Journal of Cuneiform Studies* 25 (1973), 3–58; R.J.A. Talbert and T. Elliott, 'Mapping the Ancient World', in: A.K. Knowles (ed.), *Past Time, Past Place: GIS for History* (2002), pp. 145–62; T. Elliott and S. Gillies, 'Digital Geography and Classics', *Digital Humanities Quarterly* 3 (2009); V. Vitale et al., 'Pelagios – Connecting Histories of Place. Part I: Methods and Tools', *International Journal of Humanities and Arts Computing* 15 (2021), 5–32. Even as we acknowledge our debt, we want to emphasise how the specific operations described have recently been realised.

[2]Various online resources attempt to keep an up-to-date record of all initiatives and projects in this area: C. Jones's Roundup of Resources on Ancient Geography, the community-run Digital Classicist Wiki, and the recently established DANES resources. See also C. Palladino, 'Spazi Antichi e Futuri Possibili: La Geografia Classica Nelle Digital Humanities', *Futuro Classico* 4 (2018), 149–77.

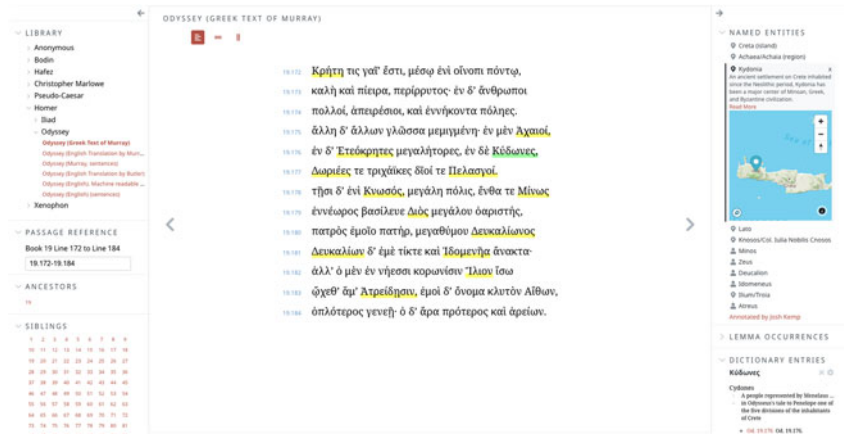

FIGURE 1. The Beyond Translation Odyssey project.

ever-expanding set of geospatial tools and methods are offering new ways of viewing and experiencing ancient places.

THE SPATIAL HUMANITIES

The spatial turn has recently been reinvigorated by technologies with new modalities for visualising and manipulating information, at the same time contributing a renewed emphasis on the impact of spatial perception and social construction of space.[3] This phenomenon has given rise to the multi-disciplinary field of Spatial Humanities.[4] At its core is the idea that technology and particularly digital mapping can support 'locating historical and cultural exegesis more explicitly in space and time'.[5]

Arguably the most influential technological innovation on historical or archaeological research has been GIS (Geographic Information Systems) – a system that facilitates the gathering, management and analysis of data through its plotting in space. By enabling the visualisation and manipulation of data according to location, GIS has contributed fresh perspectives on several important topics, from health policy to conflict,[6] as well as establishing new ways of reading literature and history.[7] However, because it provides a highly precise way of organising information based on point geometry, GIS is less well equipped to address issues of uncertainty, ambiguity and plurality that typically characterise literature.[8]

[3]J. Guldi, 'What Is the Spatial Turn?', n.d.

[4]D.J. Bodenhamer, J. Corrigan and T.M. Harris (edd.), *The Spatial Humanities: GIS and the Future of Humanities Scholarship* (2010).

[5]D.J. Bodenhamer, 'The Potential of Spatial Humanities', in: D.J. Bodenhamer, J. Corrigan and T.M. Harris (edd.), *The Spatial Humanities: GIS and the Future of Humanities Scholarship* (2010), p. 28.

[6]S.E. Dunn, *A History of Place in the Digital Age* (2019).

[7]J.E. Taylor et al., 'Mapping Digitally, Mapping Deep: Exploring Digital Literary Geographies', *Literary Geographies* 4 (2018), 10–19; I.N. Gregory and A. Geddes, *Towards Spatial Humanities: Historical GIS and Spatial History* (2014).

[8]Cf. I.N. Gregory and R.G. Healey, 'Historical GIS: Structuring, Mapping and Analysing Geographies of the Past', *Progress in Human Geography* 31 (2007), 638–53.

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In particular, its use for the study of the past is problematic, since the nature of GIS determines that data is plugged into and viewed via a Cartesian coordinate structure, while pre-modern views of space appear to privilege non-Cartesian modalities of spatial representation[9] and possess different foundational criteria for defining 'place' and scientific authority.[10] Along these lines, the humanities raise fundamental epistemological and ontological concerns for spatial technologies[11] and provide an important challenge for the development of a more diverse array of technologies.

While embracing Spatial Humanities methods and tools, Classical Studies is simultaneously providing a critical lens through which new ways of thinking about 'place' are emerging. One reason for its pioneering role is its transdisciplinary nature.

ARCHAEOLOGY AND MATERIAL CULTURE

Being rooted in the examination of landscape and human interaction with it, archaeology was an early adopter of GIS technologies and has been at the forefront of their development. Over the past century archaeological practice has evolved increasingly sophisticated quantitative methodologies for the study of a place and its physical traces,[12] where ancient cultures, their activities and settlements are conceived of leaving behind a range of 'signature landscapes' that can be modelled. Alongside these scientific trends, and especially since the 1980s post-processual critique, approaches drawing on phenomenology have emerged, which emphasise historical context and subjective interpretation.[13] This in turn has led to a growing methodological divide between digital-based and more discursive methods of spatial analysis.[14]

Landscape-oriented approaches have increasingly employed GIS methods and tools for the historical analysis of archaeological sites, ancient trackways (so-called 'hollow ways'), palaeo-canals and other human-related or human-made features.[15] Inevitably, over-reliance on exact quantitative analysis leads to abstraction of these signatures and requires a developed qualitative framework into which narratives and models can be incorporated.[16] The quality and variety of datasets are also an important factor. For example, line-of-sight (LOS) calculations across a landscape should also take into account topographical changes over time, vegetation index, the scale of different objects and agents, and seasonal

[9]P. Janni, *La Mappa e Il Periplo: Cartografia Antica e Spazio Odologico* (1984); K. Brodersen, *Terra Cognita: Studien zur römischen Raumerfassung* (1995).

[10]P. Arnaud, 'Critères de vérité chez les géographes anciens', in: O. Guerrrier (ed.), *La Vérité, Colloque de l'Institut Universitaire de France, 2013* (2013), pp. 43–55.

[11]T. Harris, S. Bergeron and L. Rouse, 'Humanities GIS: Place, Spatial Storytelling, and Immersive Visualization in the Humanities', in: M. Dear et al. (edd.), *GeoHumanities: Art, History, Text at the Edge of Place* (2011), pp. 226–40.

[12]I. Hodder and C. Orton, *Spatial Analysis in Archaeology* (1976); D.L. Clarke (ed.), *Spatial Archaeology* (1977).

[13]I. Hodder, *Theory and Practice in Archaeology* (1992), pp. 73–123.

[14]M. Gillings, P. Hacıgüzeller and G. Lock, 'Archaeology and Spatial Analysis', in: *Archaeological Spatial Analysis: a Methodological Guide* (2020), pp. 10–11.

[15]T.J. Wilkinson, *Archaeological Landscapes of the Near East* (2003); T.J. Wilkinson et al., 'Landscape and Settlement in the Neo-Assyrian Empire', *Bulletin of the American Schools of Oriental Research* 340 (2005), 23–56.

[16]E.g. M. Sjölander, 'Non-Spatial Data and Modelling Multiscale Systems in Archaeology', *Open Archaeology* 8 (2022), 578–93.

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environmental factors.[17] Many of these elements cannot easily be measured without taking into account complex embodied experiences of the same landscape across time and through the eyes of different agents.

Much of the recent advancement in spatial archaeology has depended on acquiring increasingly sophisticated remote sensing data.[18] Examples include: historic aerial and spaceborne imagery; multispectral and hyperspectral imagery; synthetic aperture radar or SAR; and LiDAR (Light Detection and Ranging). All these approaches enable the study of land features beyond what can be seen by the naked eye. After the acquisition of spatial data on different scales (from landscape and site to the micro-level of objects and samples), various digital methods can be deployed to analyse and model their historical and social complexity.[19] Many of the breakthroughs in landscape analysis since the 1990s have been due to the creation of digital elevation models and digitised structured data of previous archaeological surveys by LiDAR and SAR technologies. Drone and satellite imagery have also been critical, especially declassified Cold War-era images like those used to construct the Corona Atlas and Referencing System project or U2 aerial photography.[20] Satellite and aerial imagery provide a picture of the region of the Near East prior to its industrialisation and dam construction, which is helping to facilitate more accurate remote and ground surveys (Figure 2).[21]

One topic that has benefited significantly from these new forms of remote sensing and their computational analysis, termed by some the 'geospatial revolution',[22] is the study of urbanism.[23] By enabling the discovery of the structure of different urban spaces and landscapes, these methods are prompting a re-evaluation of the field of early urbanism

[17]M. Gillings and D. Wheatley, 'GIS-Based Visibility Analysis', in: *Archaeological Spatial Analysis* (2020), pp. 316–22.

[18]D.C. Comer and M.J. Harrower (edd.), *Mapping Archaeological Landscapes from Space* (2013).

[19]E.g. J. Casana, 'Rethinking the Landscape: Emerging Approaches to Archaeological Remote Sensing', *Annual Review of Anthropology* 50 (2021), 167–86.

[20]J.A. Ur and E. Hammer, 'Spatial Index of U2 Aerial Photography of the Middle East, 1958–1960' (2018).

[21]C. Hritz, 'Tracing Settlement Patterns and Channel Systems in Southern Mesopotamia Using Remote Sensing', *Journal of Field Archaeology* 35 (2010), 184–203; J. Casana and J. Cothren, 'The CORONA Atlas Project: Orthorectification of CORONA Satellite Imagery and Regional-Scale Archaeological Exploration in the near East', in: D.C. Comer and M.J. Harrower (edd.), *Mapping Archaeological Landscapes from Space* (2013); J.A. Ur, 'CORONA Satellite Imagery and Ancient Near Eastern Landscapes', in: D.C. Comer and M.J. Harrower (edd.), *Mapping Archaeological Landscapes from Space* (2013), pp. 21–31; E. Hammer, 'The City and Landscape of Ur: an Aerial, Satellite, and Ground Reassessment', *IRAQ* 81 (2019), 173–206; E. Hammer and J.A. Ur, 'Near Eastern Landscapes and Declassified U2 Aerial Imagery', *Advances in Archaeological Practice* 7 (2019), 107–26; E.C. Stone, 'Hollow Ways in Southern Mesopotamia', in: D. Lawrence, M. Altaweel and G. Philip (edd.), *New Agendas in Remote Sensing and Landscape Archaeology in the Near East* (2020), pp. 144–53.

[22]A.F. Chase et al., 'Geospatial Revolution and Remote Sensing LiDAR in Mesoamerican Archaeology', *Proceedings of the National Academy of Sciences* 109 (2012), 12916–21; M.D. McCoy, *Maps for Time Travelers: How Archaeologists Use Technology to Bring Us Closer to the Past* (2020).

[23]E.g. E. Hammer, 'Multi-Centric, Marsh-Based Urbanism at the Early Mesopotamian City of Lagash (Tell al-Hiba, Iraq)', *Journal of Anthropological Archaeology* 68 (2022).

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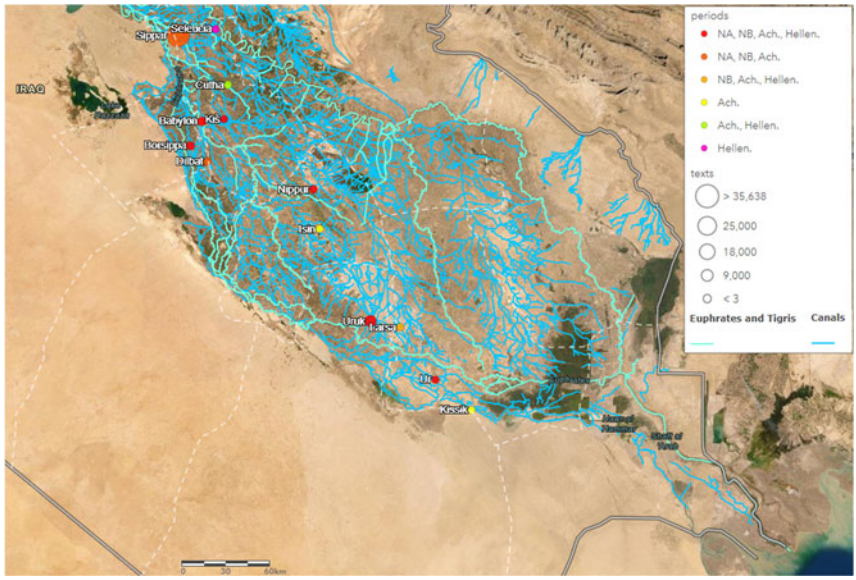

FIGURE 2. Palaeo-canals and rivers of Iraq.[24] Main Babylonian sites of the first mill. BCE with size indicating estimated published and unpublished text numbers (NA: Neo-Assyrian; NB: Neo-Babylonian; Ach.: Achaemenid; Hellen.: Hellenistic).

as established by Gordon Childe. Land use, palaeoclimate, ethnography, settlement patterns and morphology as well as the interaction of site remains with roads and especially water and hydraulic architecture are now being combined to provide a more extensive and nuanced understanding of the form of cities, levels of social inequality, and the interactions between cities and their hinterlands, including harbour areas.[25]

[24]Based on O. Pedersén, 'Waters at Babylon', in: T. Tvedt and T. Oestigaard (edd.), *Water and Urbanization* (2014), pp. 107–29; J. Jotheri, 'Holocene Avulsion History of the Euphrates and Tigris Rivers in the Mesopotamian Floodplain' (Diss., Durham University, 2016).

[25]T.J. Wilkinson, 'Regional Approaches to Mesopotamian Archaeology: the Contribution of Archaeological Surveys', *Journal of Archaeological Research* 8 (2000), 219–67; C. Hritz, 'Landscape and Settlement in Southern Mesopotamia: a Geo-Archaeological Analysis' (Diss., University of Chicago, 2005); S. Rost, A. Hamdani and S. George, 'Traditional Dam Construction in Modern Iraq: a Possible Analogy for Ancient Mesopotamian Irrigation Practices', *Iraq* 73 (2011), 201–20; S. Campana, 'Emptyscapes: Filling an "Empty" Mediterranean Landscape at Rusellae, Italy', *Antiquity* 91 (2017), 1223–40; M. van Ess, 'Water Management in Mesopotamia: Case Study Iraq, with Special Focus on Southern Iraq', in: M. Cotte (ed.), *Cultural Heritages of Water: the Cultural Heritages of Water in the Middle East and Maghreb* (2017), pp. 257–73; M. Altaweel et al., 'New Insights on the Role of Environmental Dynamics Shaping Southern Mesopotamia: from the Pre-Ubaid to the Early Islamic Period', *Iraq* 81 (2019), 23–46; M.-A. Vella et al., 'New Insights into Prehispanic Urban Organization at Tiwanaku (NE Bolivia): Cross Combined Approach of Photogrammetry, Magnetic Surveys and Previous Archaeological Excavations', *Journal of Archaeological Science: Reports* 23 (2019), 464–77; S. Rost (ed.), *Irrigation in Early States: New Directions* (2022).

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Digitisation efforts are increasingly being facilitated on the spot through mobile-device software like Bruce Hartzler's iDig application, with the result that individual excavators can produce 'born-digital' data themselves. A related development has been Agent-Based Modelling (ABM). Using digital reconstructions of landscape and archaeological sites, researchers can place themselves in a virtual space and model their interaction with the environment (Figure 3). In this way, agent-based scenarios can draw attention to relevant parts of a landscape as well as to the possible kinds of interaction.[26] At the same time, ABM easily lends itself to the development of computer games and realistic 3D environments[27] as well as to archaeo-gaming strategies,[28] which can allow scholars to explore different remote sensing methods.[29] The potential of virtual reality (VR) and augmented reality (AR) platforms to model excavation and spatial data in 3D graphics for research and teaching is already being realised in projects such as Virtual Rome and Virtual Pompeii,[30] the 3D model of Babylon[31] and the growing field of virtual heritage at large.[32]

There are, however, still many limitations to and problems with the application of digital technology in archaeological research and pedagogy. First, having an ethical approach to remote sensing is ever more urgent, especially when attempting to survey areas with at-risk heritage or endangered communities, as in the case of the EAMENA project in Africa and the Middle East.[33] Second, even in archaeology not all data models are best viewed within a GIS-framework.[34] Even if they are, critical scrutiny of digital applications needs to be facilitated, especially as the tools become ever more multilayered, complex and hard to understand,[35] such as

[26]E.g. T.J. Wilkinson, M. Gibson and M. Widell (edd.), *Models of Mesopotamian Landscapes: How Small-Scale Processes Contributed to the Growth of Early Civilizations* (2013); L. Sucharyna Thomas, C.R. Wickham-Jones and A.J. Heppenstall, 'Combining Agent-Based Modelling and Geographical Information Systems to Create a New Approach for Modelling Movement Dynamics: a Case Study of Mesolithic Orkney', *Open Archaeology* 8 (2022), 987–1009.

[27]Noteworthy is Assassin Creed's 'Odyssey', which was created in collaboration with academics (e.g. historian Stéphanie-Anne Ruatta).

[28]A. Reinhard, *Archaeogaming: an Introduction to Archaeology in and of Video Games* (2018); M. Lake, 'Spatial Agent-Based Modelling', in: *Archaeological Spatial Analysis* (2020), pp. 247–72.

[29]A. Reinhard and S. Zaia, 'Photogrammetry and GIS in Human-Occupied Digital Landscapes', *Advances in Archaeological Practice* 11 (2023), 198–210.

[30]D. Fredrick and R.G. Vennarucci, 'Putting Space Syntax to the Test: Digital Embodiment and Phenomenology in the Roman House', *Studies in Digital Heritage* 4 (2020), 185–224.

[31]O. Pedersén, *Babylon: The Great City* (2021).

[32]E. Ch'ng, V. Gaffney and H. Chapman (edd.), *Visual Heritage in the Digital Age* (2013); E. Ch'ng et al., *Visual Heritage: Digital Approaches to Heritage Science* (2022).

[33]A. Vafadari, G. Philip and R. Jennings, 'A Tool and Methodology for Rapid Assessment and Monitoring of Heritage Places in a Disaster and Post-Disaster Context: Syria as a Case Study', in: M. Dawson, E. James and M. Nevell (edd.), *Heritage under Pressure – Threats and Solutions: Studies of Agency and Soft Power in the Historic Environment* (2019), pp. 87–100.

[34]M. Sjölander, 'Non-Spatial Data and Modelling Multiscale Systems in Archaeology', *Open Archaeology* 8 (2022), 578–93.

[35]C. Green, 'Challenges in the Analysis of Geospatial "Big Data"', in: *Archaeological Spatial Analysis* (2020), pp. 430–43; P. Hacıgüzeller, J.S. Taylor and S. Perry, 'On the Emerging Supremacy of Structured Digital Data in Archaeology: a Preliminary

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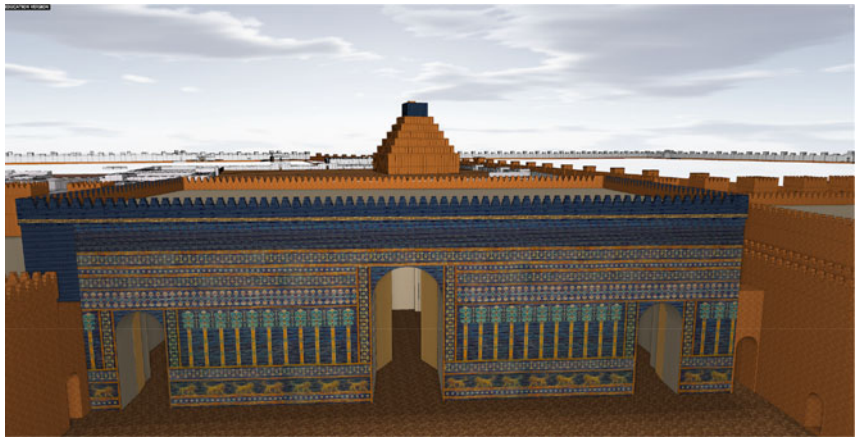

FIGURE 3. Screenshot from Pedersén's virtual 3D model of Babylon, period of Nebuchadnezzar II (604–662 BCE) and Nabonidus (555–539 BCE). Overlooking south onto the Etemenanki Ziggurat from within the South Palace main courtyard, walls decorated with glazed bricks.

connecting remote sensing data with groundtruthing data or the 3D imaging of sites (Figure 4).[36]

Arguably, however, the greatest obstacle to combining narratives reconstructing ancient spaces and spatial data remains the ambiguity in both types of sources. Most attempts at visualising different interpretations of the same landscape at once use different notation methods, such as a variety of coloured dots or lines, half-lines etc. However, the denser a graphical expression, the more it loses its qualitative nature, to the extent that the connections to the sources behind the interpretation become lost, unclear or meaningless.[37] There is an urgent need to develop new digital ways to visualise interpretations in a manner that does not overburden observers with indigestible information. One step is to develop and establish conventions for modelling ambiguity in narratives and archaeological data.[38] Another solution lies in an increasingly popular form of digital application, namely network analysis. Work represented by Classical Studies in this field continues to break new ground, spawning large-scale projects (e.g. on migrations in the ancient Greek

Assessment of Information, Knowledge and Wisdom Left Behind', *Open Archaeology* 7 (2021), 1709–30.

[36]J.A. Ur et al., 'The Erbil Plain Archaeological Survey: Preliminary Results, 2012–2020', *Iraq* 83 (2021), 205–43, on northern Iraq.

[37]J. Drucker, 'Humanities Approaches to Graphical Display', *Digital Humanities Quarterly* 5 (2011).

[38]M. Piotrowski, 'Accepting and Modeling Uncertainty', in: *Die Modellierung des Zweifels – Schlüsselideen und -konzepte Zur graphbasierten Modellierung von Unsicherheiten / Zeitschrift für Digitale Geisteswissenschaften*, Sonderbände 4 (2019); J. Fusco and C. de Runz, 'Spatial Fuzzy Sets', in: *Archaeological Spatial Analysis* (2020), pp. 169–91.

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FIGURE 4. A 20m wide Assyrian dam across the Chai Bastora river, commissioned as part of canal building by the Assyrian King Sennacherib (early 7th century BCE). It is under threat by gravel mining and seasonal flooding. 3D model based on drone imagery © Directorate of Antiquities of Erbil/Khalil Barzinji, 23 January 2017. Results of the Erbil Plain Archaeological Survey (EPAS) led by Jason Ur, see their original model on Sketchfab.

world) or textbooks,[39] as well as to disrupt old paradigms, not least in questioning the notion of single entities like 'Greece' and 'Rome'.[40]

Furthermore, there is a need to correlate remote sensing and ground survey data with other types of historical sources, including ancient texts. Noteworthy GIS mapping projects, which identify archaeological sites with textually known spatial entities of Mesopotamia, include the late third millennium BCE Babylonia[41] as well as Upper Mesopotamia during the second millennium BCE.[42] One impressive manually aggregated site index, covering most of the ancient Near East, is Pedersén's 2007 Google Earth-based dataset, which includes a partial reconstruction of the Mesopotamian water system in the Neo-Babylonian period.[43] Another project, Geomapping Landscapes of Writing (GLoW), has collected all the sites at which cuneiform-bearing documents were found, including the quantities of cuneiform objects themselves (their gazetteer is

[39]E.g. T. Brughmans and M.A. Peeples, *Network Science in Archaeology* (2023).

[40]Cf. I. Malkin, *A Small Greek World: Networks in the Ancient Mediterranean* (2011).

[41]N. Veldhuis et al., 'VI. Geography – Sumerian Networks', in: *Sumerian Networks JupyterBook* (2021), https://niekveldhuis.github.io/sumnet/PartVI-GeographicNames.html; S. Rutishauser et al., 'Main Sites of the 3rd Dynasty of Ur (Modern River Courses, Cities, Sites)', Zenodo, 3 June 2021, https://doi.org/10.5281/ZENODO.4896193.

[42]E. Cancik-Kirschbaum and C. Hess, *Toponyme der mittelassyrischen Texte: Der Westen des mittelassyrischen Reiches* (2017); C. Fink, *Fundorte und Karten* (2017); K.-C. Bruhn, 'TEXTELSEM Mapping Data Package', Zenodo 10 May 2018, https://doi.org/10.5281/zenodo.1244793.

[43]O. Pedersén et al., 'Cities and Urban Landscapes in the Ancient Near East and Egypt with Special Focus on the City of Babylon', in: P.J.J. Sinclair et al. (edd.), *The Urban Mind. Cultural and Environmental Dynamics* (2010), pp. 113–48; Pedersén (n. 22).

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deposited in Zenodo).[44] More recently, using the gazetteer and network analysis of the MAPA project, Clark, Altaweel and Gordin have connected archaeological data with long-term historical records from the southern Mesopotamian city of Uruk, to demonstrate that settlement size can be directly linked to changing state and government policies and local responses to it.[45] Even though this situation is rapidly changing, a serious deficiency remains in the digitisation and linking of ancient placenames from textual sources, modern printed gazetteers and maps.

FROM MAPS AND DATABASES TO TEXTS AND LINKED DATA

While the spatial turn in Classical Philology continues apace[46] (see C. Schliephake's Profile on Ecocriticism, *CR* 72 [2022]), less well recognised are the interventions digital technology has made in more philologically-inclined research. Central to much of this activity has been the creation of place databases from texts and artefacts, which in turn has made it easier to map places encoded in narrative, to explore their discursive spatial configurations and to link to other resources.

The advent of digitisation technologies has revolutionised the management of geographical data about the ancient world. When in 1988 Talbert began work on what would become the *Barrington Atlas of the Greek and Roman World*,[47] use of GIS technology was limited to producing full-colour maps of the Graeco-Roman world, along with a map-by-map directory on CD-ROM. Even at that time, however, there was a realisation that digital technologies could facilitate the management of rich geographic information. This led to the foundation of the Ancient World Mapping Center, which maintains the data backbone of the *Atlas* as well as a collection of open mapping resources for the scholarly community.[48] In recent years the *Tabula Imperii Byzantini* – the first systematic atlas of the Byzantine world from the fourth to the fifteenth centuries CE – has similarly been negotiating the transition from print to digital,[49] enabling new insights into the dynamics of communication and power in the empire.[50]

[44]R. Rattenborg et al., 'An Open Access Index for the Geographical Distribution of the Cuneiform Corpus', *Cuneiform Digital Library Journal* 1 (2021), 1–12.

[45]S. Clark, M. Altaweel and S. Gordin, 'Urbanscape, Land Use Change and Centralization in the Region of Uruk, Southern Mesopotamia from the 2nd to 1st Millennium BCE', *Land* 11 (2022), 1955.

[46]Cf. E.T.E. Barker, 'On Space, Place and Form in Herodotus' Histories', *Histos* 15 (2021), 88–130.

[47]R.J.A. Talbert (ed.), *Barrington Atlas of the Greek and Roman World* (2000). The history of the *Barrington Atlas* and the efforts that preceded it are detailed in Talbert (ed.), *Challenges of Mapping the Classical World* (2019). The following efforts in editing the *Tabula Peutingeriana* are described in several publications, most notably Talbert (ed.), *Rome's World. The Peutinger Map Reconsidered* (2010).

[48]Originally developed by the Ancient World Mapping Center at Chapel Hill, these mapping resources have recently been taken on by the Consortium of Ancient World Mappers, hosted by the University of Iowa.

[49]A. Külzer, V. Polloczek and M. St. Popovič (edd.), *Raum und Geschichte. Der Historische Atlas "Tabula Imperii Byzantini" an der Österreichischen Akademie der Wissenschaften* (2020).

[50]M. St. Popovič, 'A Race against Time. The Impact of Contemporary Environmental and Demographic Changes on the Research of the Historical Geography of Byzantium', in:

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FIGURE 5. Screenshot of a route simulated on *Orbis*.

While cartographic representations from antiquity are invaluable due to their paucity, Graeco-Roman maps such as the *Tabula Peutingeriana* are critically limited by the printed book. Using the affordances of hypertext technology, the digital *Tabula Peutingeriana* includes a detailed database of features and names accompanied by high-resolution images, an extended commentary and geographic data from the *Barrington Atlas*, as well as an interactive viewer. Meanwhile, other initiatives have used GIS to map different aspects of ancient Roman space, such as the Stanford-based projects, the Digital Forma Urbis and Orbis (Figure 5). *Orbis* mixes traditional GIS methods with a probabilistic network model that allows users to simulate conditions of movement in the Roman Mediterranean of the second–third centuries CE and to explore, within the confines of a simulation model,[51] how lived experience was impacted by environmental and geographical factors. *Orbis* provided the basic conceptual and technical framework for the al-Ṯhurayyā Project, the first gazetteer of the Islamicate, which combines traditional atlas information with a network-based geospatial model, allowing the calculation of various pathfinding combinations.

Arguably the most decisive contribution to the field was the launch of Pleiades, an online gazetteer for places of the ancient world, formed out of the digitisation of the core place date of the *Barrington Atlas*. From its inception, *Pleiades* brought a critical cartography approach to the study of ancient geography by disentangling the notion of place from its location. In essence, *Pleiades* defined place not so much as a geographical entity with coordinates, but as a bundle of conceptual associations that exist independently of point geometry: an 'un-GIS' of cultural values, perception, toponymy, bibliography and relations (Figure 6).[52] Freed from the bonds of the printed book, *Pleiades* has continuously pushed the boundaries of the Barrington's Graeco-Roman world. This work has been made possible by the establishment of *Pleiades* as a 'community-based' enterprise, to which a

E. Fiori and M. Trizio (edd.), *24th International Congress of Byzantine Studies. Volume 1. Proceedings of the Plenary Sessions* (2022), pp. 191–210.

[51]C. Palladino, 'Review. Orbis: The Stanford Geospatial Model of the Roman World', *SCS Society of Classical Studies* (*Digital Humanities Reviews Series*), 2019.

[52]Elliott and Gillies (n. 1).

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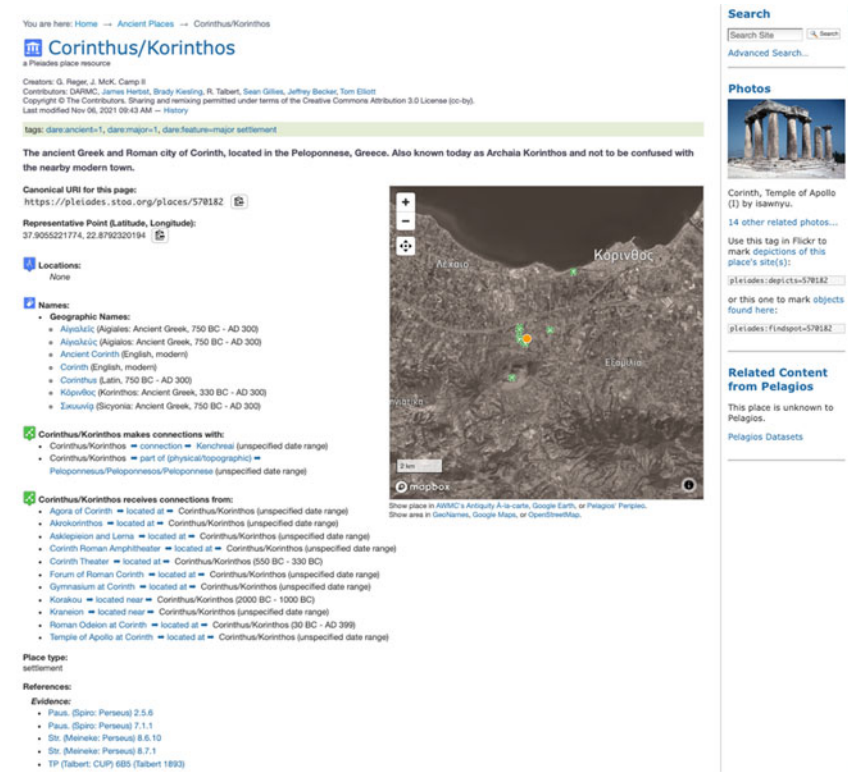

FIGURE 6. Screenshot of *Pleiades* entry.

wide range of scholars contribute data and editing. These two factors have helped enable the creation of similar initiatives in cognate disciplines, such as the Syriaca gazetteer, Norse World, the Mesopotamian Ancient Placenames Almanac (MAPA) and Kima.

In 1987, the year prior to Talbert's *Barrington Atlas* project, G. Crane founded the *Perseus Digital Library*. First published as two CD-ROMs before being launched online in 1995, *Perseus* has made thousands of classical texts openly accessible. At the same time, by adopting common standards for text markup, namely the use of TEI XML, *Perseus* has enabled the enrichment of texts through annotation, including morphological analysis and, crucially, the tagging of named entities, such as people and places. Using computationally-assisted parsing, i.e. Named Entity Recognition (NER), Perseus published in 2008 English translations of its Greek and Latin corpora in a TEI format with places automatically marked up, thereby enabling their extraction for analysis and mapping. Taking the English TEI text of Herodotus from *Perseus*, the *Hestia* project (2008–2010, AHRC reference AH/F019459/1) used digital technology to interrogate the spatiality of Herodotus' *Histories*. As well as developing and documenting a workflow for spatial analysis from TEI text to GIS visualisation,[53] *Hestia* drew on contemporary geographical

[53]E.T.E Barker, L. Isaksen and J. Ogden, 'Telling Stories with Maps: Digital Experiments with Herodotean Geography', in: E.T.E. Barker et al. (edd.), *New Worlds out of Old Texts: Revisiting Ancient Space and Place* (2016), pp. 181–224.

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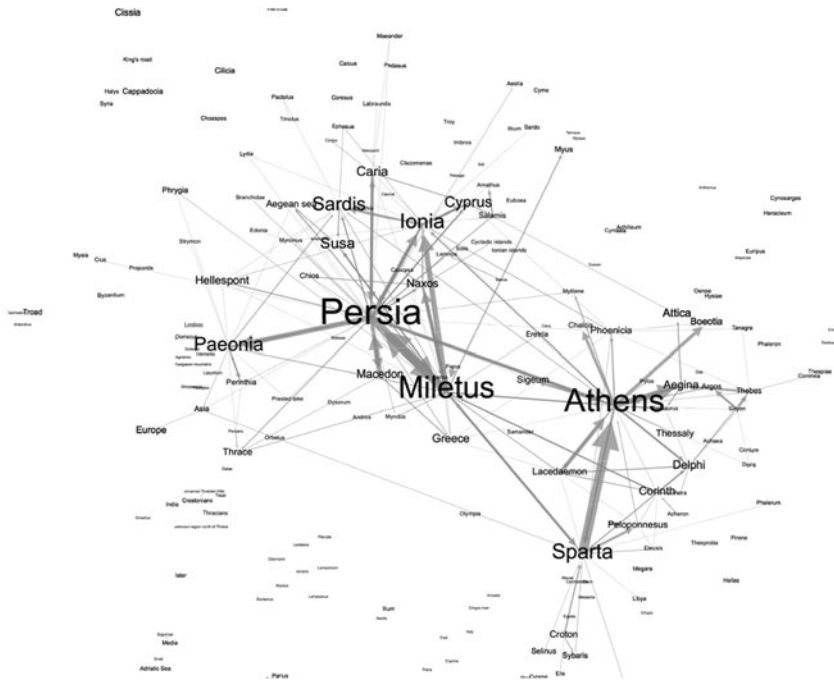

FIGURE 7. A 'network' graph showing the relatedness of places in Herodotus' *Histories* 5. A place's centrality in the network (the frequency with which it is mentioned in relation to other places) is indicated by size of font and position. The graph reorients Herodotus' world around its role in the text rather than where it is on a map.

theory to show how an analysis of the text's topological relations between places and people can reorganise spatial understanding around power and agency, rather than on Cartesian geometry (Figure 7).[54]

Mapping text has a great deal of potential. For example, Homerist J.S. Clay used a series of exhibits in the software application Neatline to reveal the different spatial configurations at play in Homer's Catalogue of Ships: most notably, the radial patterning of the Boeotian contingents around an absent Thebes.[55] Yet, where extracting place names from texts (geoparsing) is relatively trivial with NER (at least with English translations), disambiguating the names and locating each place (geo-resolution) requires far more effort, thereby making it more difficult to scale up. To address this challenge, *Google Ancient Places* (GAP) experimented with automating geo-resolution by linking place names in

[54]S. Bouzarovski and E.T.E. Barker, 'Between East and West: Movements and Transformations in Herodotean Topology', in: E.T.E. Barker et al. (edd.), *New Worlds out of Old Texts: Revisiting Ancient Space and Place* (2016), pp. 155–79; C. Palladino, 'Representing Places in Texts: A Spatial Investigation into Agathemerus, Sketch of Geography', *International Journal of Humanities and Arts Computing* 15 (2021), 261–79.

[55]B. Jasnow, C. Evans and J.S. Clay, 'Poetic and Geographical Organization in the Catalogue of Ships', *Transactions and Proceedings of the American Philological Association* 148 (2018), 1–44.

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texts to entries in *Pleiades*, marked by identifiers unique to that place record – so-called URIs (Uniform Resource Identifiers). While achieving optimal performance from automated geo-resolution remains a distant goal, *GAP*'s initial work not only enabled to map places mentioned in a particular work more efficiently, but also revealed the potential for analysing large corpora through their references to place.

LINKED OPEN (GEO)DATA

The launch of *Pleiades*, with its reorientation of the notion of place away from geometry and towards conceptual and cultural perception, coupled with the subsequent applications of spatial analysis to texts, showed that the representation of ancient space in the digital world was not limited to location and geometry data. Rather, taking place in a digital environment as multi-layered encompasses a range of discipline-specific information: cultural and literary references, language and syntax, material practices of space and travel, environmental impact, indicators of uncertainty and ambiguity, and relations to other entities in the ancient world, including people, events and objects. As well as expanding the conceptual understanding of place, *Pleiades*'s use of gazetteer URIs also presented a technological opportunity: Linked Open Data (LOD).[56]

As defined by Tim Bernes-Lee, LOD 'is about making links, so that a person or machine can explore the web of data. With linked data, when you have some of it, you can find other, related, data'. Working with various international partners from Classical Studies (*Pleiades*, *Perseus*, the German Archaeological Institute), the *Pelagios* initiative (Figure 8) co-created a lightweight but universally applicable method of linking online resources through *common references to places*. Instead of compelling everyone to remodel their data according to an all-embracing ontology, the *Pelagios* method simply states that each provider should annotate the places mentioned in their data with the appropriate gazetteer URI record.[57] Helping to establish Classical Studies at the forefront of LOD innovation in the humanities, *Pelagios*'s pioneering method has inspired the creation of other LOD infrastructures, such as pre-modern Scandinavia[58] and the Americas, and has led to the establishment of the *World Historical Gazetteer*, a single platform for contributions of place name data. Equally, *Pelagios* has fostered an approach to digital data production that privileges information exchange across resources and contribution to publicly open and free LOD repositories such as *Wikidata*. Thanks to the success of LOD, scholarship in digital humanities has turned to the systematic digitisation of place names as a part of growing Linked Open (geo)Data ecosystem,[59] where agreement on data representation enables integration of interdisciplinary knowledge through the semantic web.[60]

The range and diversity of Classical Studies resources publishing LO(geo)D grows year on year.[61] Early adopters such as Nomisma, the Portable Antiquities Scheme, OmnesViae

[56]C. Bizer, T. Heath and T. Berners-Lee, 'Linked Data: The Story so Far', *International Journal on Semantic Web and Information Systems* 5 (2009), 1–22.

[57]Vitale (n. 1); Web Annotation Model: linked places and linked traces.

[58]A. Petrulevich and S. Skovgaard Boeck (edd.), *Digital Spatial Infrastructures and Worldviews in Pre-Modern Societies* (2023).

[59]Vitale (n. 1).

[60]E. Hyvönen, *Publishing and Using Cultural Heritage Linked Data on the Semantic Web* (2012).

[61]The two seminal articles published by *ISAW Papers*, T. Elliott, S. Heath and J. Muccigrosso (*ISAW Papers* 7 [2014]) and S.E. Bond, P. Dilley and R. Horne (*ISAW*

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FIGURE 8. The Pelagios Network.

and Arachne have been joined by recent EU-funded work, such as the Oxford-based projects Crossreads and Change, as well as Itiner-e, a gazetteer for Roman roads. The web and mobile application *ToposText* harnesses LOD connectivity to display place references found in ancient texts at minute levels of granularity, including references to ancient monuments and sites. *Trismegistos* combines a geographical database with systematic references to people, texts and scholarly resources focusing on ancient Egypt.[62] The *Pompeii Artistic Landscape Project* uses LOD to support site-wide discovery, mapping, analysis and sharing of information about Pompeian artworks in their architectural and urban contexts. *MANTO* takes the idea of mapping beyond the confines of the real world, by offering a digital portal based on the network software environment *Nodegoat*, where users can investigate the multiple connections between mythical people, places and events. Crucially, LOD achieves interconnectivity by giving researchers access to information across heterogeneous resources, hosted by different data providers: therefore, a text-based project is not limited to showing textual data, but can access information from digital libraries, museum archives, archaeological and numismatic records, and cultural heritage resources. In so doing, LOD infrastructure enables a 'deep' form of spatial analysis that brings together multiple layers of information.[63]

Papers 20 [2021]), provide comprehensive overviews of the diverse range of applications of LOD for the ancient world.

[62]M. Depauw and T. Gheldof, 'Trismegistos. An Interdisciplinary Platform for Ancient World Texts and Related Information', in: Ł. Bolikowski et al. (edd.), *Theory and Practice of Digital Libraries – TPDL 2013 Selected Workshops* (2014), pp. 40–52.

[63]The notion of 'deep map' is the main conceptual inspiration behind this idea. 'Deep maps' were popularised as representations of narrative space by W. Least Heat-Moon, *PrairyErth: (a Deep Map)* (1999) as a way to overcome the limitations of the one-dimensionality of traditional maps. On the theorisation of the concept in Spatial Humanities see D. Bodenhamer, J. Corrigan and T. Harris (edd.), *Deep Maps and Spatial Narratives* (2015).

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In the process of extending its methodology beyond traditional Classical Studies, *Pelagios* developed a suite of open-source tools. To enable the production of LOD by the domain specialist or curator without need for coding expertise, *Pelagios* created a semantic annotation platform, *Recogito*.[64] *Recogito* facilitates the mark-up of place references in documents (texts, maps, databases), the attribution of semantic labels with tailored or external vocabularies (e.g. defining place type, cultural concepts and so on) and the geo-resolution to global authority records, such as URI-based gazetteers like *Pleiades*. This operation also enables the extraction of other relevant information about an individual place, such as chronological span, alternative names and mentions in other sources. *Recogito* has been widely adopted in research and teaching efforts focusing on places in historical sources, and even for NER to automatically identify place names.[65] In the Agathemerus project Palladino has used semantic annotation and a combined approach of network analysis and GIS to show how computational approaches can provide insights into dynamics of spatial conceptualization in scientific and periplographic geography, and even contribute to the resolution of textual corruptions (Figure 9 and 9A).[66]

In 2017 *Pelagios* also developed an open-source visualisation tool, *Peripleo*, to showcase the potential of LO(geo)D connectivity. *Peripleo* was designed to offer a map view, where users could click on a place and explore the layers of connected information available through interlinking of partner resources, which were associated with the same place by means of gazetteer URIs. This visualisation enabled exploration of a place from a different perspective, enhancing the discovery of connected documents and artefacts.[67]

At the end of the last funding round of *Pelagios* in 2019, the project was re-established as a free open infrastructure, the *Pelagios Network*, where equal partners share knowledge and expertise among different disciplinary groups, driving development of LOD tools and methods. Within this framework of 'distributive resilience',[68] *Peripleo* was reconfigured as an open browser-based tool to host custom LOD visualisations (https://github.com/britishlibrary/peripleo), after initial redevelopment undertaken by the partner project *Digital Periegesis*. The *Digital Periegesis* uses *Recogito* to annotate references to places, people and events in the Greek text of Pausanias' *Periegesis Hellados* and leverages LOD technology to connect the narrative to the spaces it describes. The geo-resolution of individual places to gazetteer URI records allows the reading of the text in dialogue

[64]R. Simon et al., 'Linked Data Annotation without the Pointy Brackets: Introducing Recogito 2', *Journal of Map & Geography Libraries* 13 (2017), 111–32; V. Vitale, R. Simon and E.T.E. Barker, 'Recogito: a Beginner's Guide' (2020); Vitale (n. 1).

[65]C.R. Porter, C.R. Milligan and K. Lilley, 'Hidden Geographies and Digital Humanities: Analysing and Visualising the Literary Corpus of Humphrey Llwyd', *Literary Geographies* 6 (2020), 96–118.

[66]Palladino (n. 54); see also S. Dunn and V. Vitale, 'Linking Texts and Maps: Annotation as a Critical Tool for Teaching in the Spatial Humanities', *Literary Geographies* 7 (2021); M. O'Doherty, 'Medieval Traditions, New Technologies: Linked Open Geodata and Burchard of Mount Sion's Descriptio Terrae Sanctae', *International Journal of Humanities and Arts Computing* 15 (2021), 60–84.

[67]C. Palladino et al., 'Using Linked Open Data to Navigate the Past: An Experiment in Teaching Archaeology', in: *Proceedings of the DH2019 Digital Humanities Conference 2019, Utrecht (the Netherlands), July 9–12* (2019).

[68]R. Kahn et al., 'Pelagios – Connecting Histories of Place. Part II: From Community to Association', *International Journal of Humanities and Arts Computing* 15 (2021), 85–100.

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FIGURE 9 AND 9A. Screenshots of the map generated by *Recogito* from annotations on the *Sketch of Geography* by Agathemerus.

with a mapped visualisation of the spaces mentioned, but also to explore those spaces and the objects (sites, artefacts, stories) located in them through links to external online resources, such as museum collections, digital libraries and archaeological databases (Figure 10). In this way, Pausanias' description can be better contextualised, while the process of bringing together other information can shed light on understanding that description and its function within the narrative.[69] The *Digital Periegesis* offers a test case of LOD as a mechanism to combine different information layers and disciplinary practices through the notion of place.

CURRENT CHALLENGES AND POSSIBLE WAYS FORWARD

In this overview we have presented the current state of spatial analysis in Classical Studies using digital methods and tools. While there have been massive strides in recent years, stimulated and supported by cross-disciplinary innovations, there are still considerable challenges to overcome.

[69]E.T.E. Barker et al., 'Journeying through Space and Time with Pausanias's Description of Greece', *Literary Geographies* 9 (2023), 124–60.

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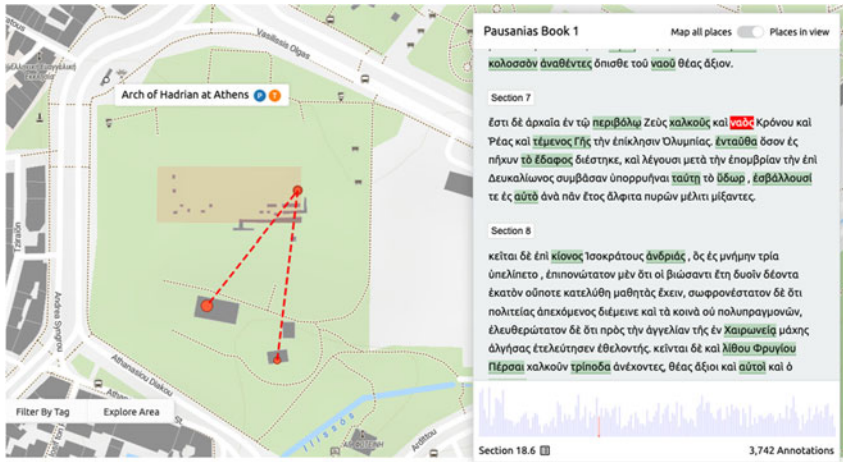

FIGURE 10. *Peripleo* visualisation showing the objects and places annotated (in red) in Pausanias 1.18.7, with the text view on the right, enabling readers to track his route through Athens. Through the power of LOD, *Peripleo* can also reveal aspects of the built environment that Pausanias omits, notably the Arch of Hadrian (indicated in white), where the information is provided by the *Pleiades* gazetteer, precisely because Pausanias does not mention it.

Many parts of the ancient world still lack digital resources. There is yet no full gazetteer for first-millennium Babylonian placenames and water bodies.[70] Crucially, digital (and print) authoritative references for ancient personal names are almost completely missing.[71] Working directly on primary sources in the original language, as in the case of the *Digital Periegesis*, is a relatively new operation and very time-consuming. New methods to perform Named Entity Recognition, i.e. the automatic extraction of place and personal names, are currently being developed leveraging AI and multilingual models, particularly for Latin and ancient Greek,[72] and it remains to be seen what impact they will have. Likewise, while semantic annotation is a tremendously powerful tool to associate concepts

[70]S. Gordin, S. Clark and A. Romach, 'MAPA: A Linked Open Data Gazetteer of the Southern Babylonian Landscape', *Interdisciplinary Digital Engagement in Arts & Humanities* 3 (2022).

[71]Among these, Trismegistos People (Y. Broux and M. Depauw, 'Developing Onomastic Gazetteers and Prosopographies for the Ancient World through Named Entity Recognition and Graph Visualization: Some Examples from Trismegistos People', in: L.M. Aiello and D. McFarland [edd.], *Social Informatics* [2015], pp. 304–13); the Prosopographia Imperii Romani Headwords; and the Lexicon of Greek Personal Names. The SNAP DRGN project (Standards for Networking Ancient Prosopographies: Data and Relations in Greco-Roman Names) started the effort of connecting and enriching digital prosopographical databases, but requires considerable resourcing to progress.

[72]P.J. Burns, 'LatinCy: Synthetic Trained Pipelines for Latin NLP' (2023); T. Yousef et al., 'Named Entity Annotation Projection Applied to Classical Languages', in: *Proceedings of the 7th Joint SIGHUM Workshop on Computational Linguistics for Cultural Heritage, Social Sciences, Humanities and Literature (LaTeCH-CLfL2023)* (2023), pp. 175–82.

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to places, there is a lack of common vocabularies to refer to such concepts in ancient texts, and this creates many obstacles to sharing and reusing the data created in individual projects.[73]

The increasing digitisation of the past does not come without ethical concerns. Just as Cartesian maps are at odds with ancient spatial perceptions, increasing digitally open access information about ancient sites is at risk of exposing information of crucial importance to indigenous communities, not to mention facilitating trade in illicit antiquities. The imposition of the same standards and technologies on the highly diverse civilisations and knowledge systems that fall under the blanket term of 'antiquity' is also epistemologically problematic.[74] As technology advances, these are questions that scholars of the past will have to keep addressing.[75]

Finally, the rapidly growing interdisciplinarity of the methods applied in the digital representation of ancient space is complemented by an increasing diversity of data, including not only texts and maps, but also databases, 3D and virtual reconstructions, audio and video media etc. Such multimediality points to a transformation in academic practice, with an increasing awareness of the need to use, incorporate or at least acknowledge very different types of data, when the traditional monograph-focused publication (still) holds sway in the minds of publishers and tenure committees. There is also a need for greater visual literacy, to help scholars read visual and mapped data, both ancient and modern. Ultimately, when everything can, in principle, be linked, what intellectual choices are to be made about what should be linked? And what design choices are to be made about how to better surface those links? Networks? Deep maps? Whatever form Spatial Classics takes, collaboration – between Classicists, with other disciplines both in and external to the humanities – will play a critical role.

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What might our student reading the same *Odyssey* passage see in the year 2043?

Now the interface does not just provide a list of names and a map. A more refined set of annotations on the text provide better clarifications to the places mentioned in the passage: the 'wine-dark sea' is identified and mapped to the Aegean Sea, while several alternative locations are provided for the debated identification of the Pelasgians. Different map layer options show the shifting location of ancient Knossos through history, and its spatial relation to the road and sea network. Clicking on 'Deucalion' does not open a Wikipedia page but a scholarly resource of classified mythical names, providing a family tree, a network of places and people connected to the king of Crete, as well as further links to their stories in other ancient works or their depictions on artefacts preserved in museums. Satellite images show archaeological sites in the island, the changes of the terrain and hydrographic structure through time; there is a link to a numismatic repository illustrating the different coinages and mints of the island through history, and to an epigraphic collection showing inscriptions from the area through different times. Clicking on 'Crete' populates a network of places mentioned in the *Odyssey*, to illustrate how many times the island is mentioned and what kinds of relationships are established

[73]C. Palladino, 'New Approaches to Ancient Spatial Models: Digital Humanities and Classical Geography', *Bulletin of the Institute of Classical Studies* 59 (2016), 56–70.

[74]Hacıgüzeller, Taylor and Perry (n. 35).

[75]C. Palladino, 'Not the Same Landscape. Rediscussing Digital Approaches to Spatial Knowledge Systems', in: C. Palladino and G. Bodard (edd.), *Can't Touch This* (2023).

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with other people and places throughout the work. Clicking on 'Cydonia' triggers an online gazetteer entry, where the student can inspect other ancient mentions of the place tagged in other digital editions, descriptions and photos of its monuments, and links to other projects illustrating the history of the place during the Minoan, Byzantine and Ottoman Turkish domination. So many different routes, so many different stories to explore.

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