Computer Science and Information Technologies
Vol. 6, No. 3, November 2025, pp. 326~334
ISSN: 2722-3221, DOI: 10.11591/csit.v6i3.p326-334

Mediterranean and northern european archaeology: a computational comparison

Hamza Kchan, Saira Noor
College of Humanities and Social Scinces, Louisiana State University, Baton Rouge, United States

Article Info

Article history:

Received May 29, 2025
Revised Jun 20, 2025
Accepted Jul 4, 2025

Keywords:

AR/VR in archaeology
Computational technologies
geographic information system in archaeology
MTC 98% accuracy
Prediction models
Regional methodological

ABSTRACT

Despite the proliferation of computational tools in archaeology, few studies systematically compare their regional adaptations or explore the epistemological assumptions guiding their application. This paper addresses four critical research gaps: (i) the lack of comparative regional analysis between the Mediterranean and Northern Europe in computational archaeology, (ii) the insufficient integration of philosophical and epistemological frameworks in predictive modeling, (iii) the underexplored application of artificial intelligence (AI) and network theory in spatial analysis, and (iv) the limited interdisciplinary synthesis of biological, geospatial, and digital data. By examining representative case studies from both regions, we highlight the methodological innovations, theoretical orientations, and institutional dynamics that shape regional practices. The study underscores the necessity of integrating computational methods with interpretive depth and interdisciplinary collaboration to foster a more reflective and inclusive digital archaeology.

Corresponding Author:

Hamza Kchan
College of Humanities and Social Scinces, Louisiana State University
Baton Rouge, Louisiana, United State, 70803
Email: hamzakchan@gmail.com

1. INTRODUCTION

Archaeological modeling remains fragmented by region and methodology, often overlooking the epistemological implications of computational choices. This paper addresses a multifaceted problem: how computational tools are differentially applied across regions; how theory-driven frameworks-such as the Habitation Model Trend Calculation (MTC)-challenge conventional deterministic models; and why digital archaeology must evolve toward a more philosophically coherent and interdisciplinary methodology. By examining divergent practices, from MTC in the Mediterranean to convolutional neural networks (CNNs) applied to historic landscape mapping in Northern Europe, we demonstrate how regional approaches both reflect and contest prevailing assumptions in archaeological science.

This paper addresses a critical research gap in comparative digital archaeology: the lack of systematic evaluation of how computational methods differ across regions in terms of environmental, institutional, and theoretical variables. While geographic information system (GIS), 3D modeling, and predictive algorithms have been widely applied, few studies explicitly compare their performance and integration across cultural landscapes like the Mediterranean and Northern Europe In recent decades, the integration of digital and computational methods has fundamentally reshaped the field of archaeology [1]. This transformation is not only technological but also epistemological, introducing new ways of thinking about space, data, and interpretation. The problem that this paper addresses stems from the limited systematic comparisons between how computational approaches are applied in distinct geographic and cultural contexts such as the Mediterranean and Northern Europe as shown in Figure 1. This map highlights the two primary regions examined in the study: Northern Europe (in red), where computational archaeology emphasizes environmental reconstruction and predictive modeling, and the Mediterranean (in blue), where theory-driven spatial analysis and interdisciplinary modeling are more prominent. The figure illustrates the study's cross-regional framework, central to its comparative methodology. Existing studies often focus on individual technologies or case studies without synthesizing methodological differences, environmental challenges, or institutional variables that shape archaeological practice [2], [3]. Researchers have increasingly adopted tools such as GIS, light detection and ranging (LiDAR), 3D photogrammetry, predictive modeling, and immersive visualization to document, analyze, and reconstruct past environments and human activities [1], [4].

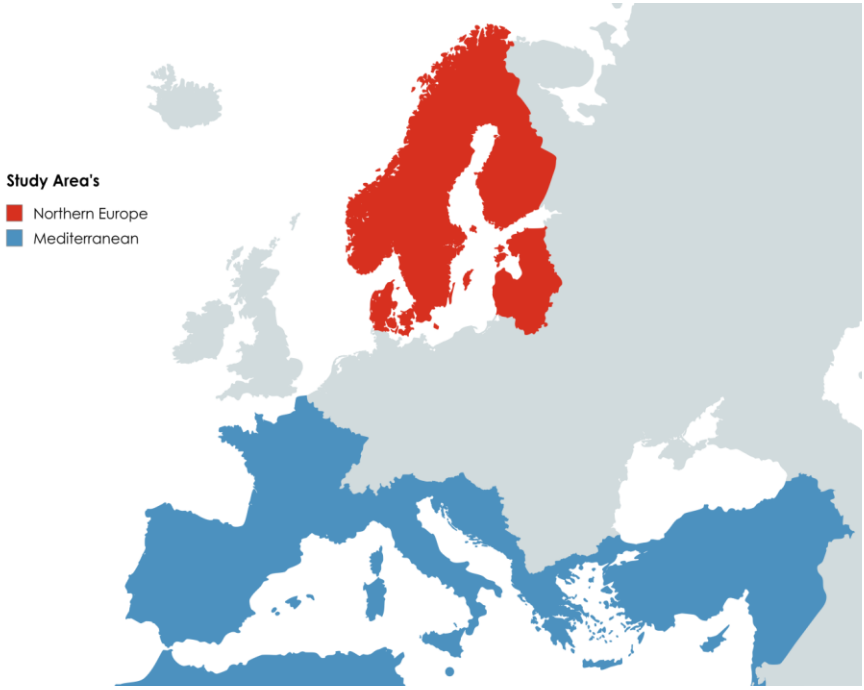

Figure 1. Geographic scope of the comparative analysis

While the adoption of tools such as GIS, 3D reconstruction, and predictive modeling is now widespread, several research gaps persist. First, there is a noticeable absence of systematic regional comparisons that investigate how computational methods adapt to environmental, institutional, and cultural differences-particularly between the Mediterranean and Northern Europe. Second, most predictive models lack a coherent epistemological foundation, often relying on environmental determinism without engaging with theoretical frameworks that could enrich interpretation. Third, although AI and network theory offer promising tools for simulating spatial and social dynamics, their application in archaeology remains nascent and fragmented. Finally, there is a growing need for interdisciplinary synthesis, especially in integrating biological datasets (e.g., aDNA, isotopes) with geospatial analysis and computational modeling. This study directly addresses these gaps through a comparative and theoretically grounded analysis.

Among the scholars who have significantly contributed to this shift, three stand out for their pioneering and interdisciplinary work. George Malaperdas, through the development of the Habitation MTC, offers a critical, theory-driven, and adaptable framework for predictive archaeological modeling in the Mediterranean [5], [6]. Maurizio Forte has been instrumental in promoting cyber-archaeology and in integrating virtual and augmented reality into both fieldwork and public dissemination [7]. Kristian Kristiansen has advanced landscape-scale archaeological analysis, emphasizing the integration of scientific data-such as ancient DNA and isotopic evidence-with digital tools to reconstruct human mobility and social organization in prehistoric Europe [3].

This paper examines how technological approaches in archaeology play out in two distinct geographic contexts. In the Mediterranean, archaeological research often grapples with dense cultural deposits and intricate environmental conditions, which shape the use and interpretation of digital tools. In contrast, Northern Europe has seen the rise of remote sensing and expansive landscape modeling, supported by different environmental and institutional factors [8], [9]. By comparing these regions, we aim to show not only how technological tools facilitate archaeological research, but also how their adoption is shaped by local traditions, academic frameworks, and infrastructural capacities.

2. CASE STUDIES

A key example of innovation in Mediterranean digital archaeology is the introduction of the Habitation MTC by Dr. George Malaperdas [5], [6]. This model represents a significant departure from previous predictive modeling methodologies, as it explicitly incorporates philosophical and epistemological underpinnings into its geospatial logic. Developed to analyze Mycenaean settlement patterns in Messenia, Greece, the MTC is grounded in Karl Popper's theory of the three worlds combining objective physical data (World 1), human perception and decision-making (World 2), and theoretical abstraction (World 3) into a unified spatial analytical model [10].

Whereas older GIS-based models in archaeology tended to rely heavily on environmental determinism, the MTC offers a pluralistic, adaptable framework that accommodates cultural, historical, and sociopolitical dimensions. It employs multi-criteria decision-making tools such as the analytical hierarchy process (AHP) and weighted linear combination (WLC), while introducing new topographical indices including terrain position index (TPI), solar exposure, hillslope categorization, and wind patterns. These factors are combined into a complex weighted formula that produces a habitation suitability index, visualized through high-resolution predictive maps.

The model's validation using 140 archaeological sites highlights its remarkable effectiveness. Specifically, 137 out of 140 known Mycenaean sites in Messenia were correctly predicted to fall within the high or moderate-high probability zones. This high level of accuracy demonstrates not only the model's statistical reliability but also its value in enabling archaeologists to explore alternative interpretations of past human settlement. Rather than relying solely on static environmental data, the MTC supports the development of spatial hypotheses grounded in theoretical perspectives.

As seen in Figure 1, the MTC model obtained a predictive accuracy of 98%, whereas traditional GIS models averaged around 70%, and AI-driven models showed variability between 75-90% depending on data quality and training set size. The bar chart illustrates the comparative success rates of different computational models used in predictive archaeological analysis. Among them, the Habitation MTC, developed by George Malaperdas, emerges as the most accurate and theoretically robust (Figure 1). With a predictive accuracy of approximately 98%, MTC significantly outperforms other widely recognized models, including traditional GIS-based methods, the strategic environmental assessment of submerged archaeological sites (SASMAP) predictive framework for submerged sites, and recent AI/ML-driven approaches.

The bar chart illustrates the comparative success rates of different computational models used in predictive archaeological analysis. Among them, the Habitation MTC, developed by George Malaperdas, emerges as the most accurate and theoretically robust as shown in Figure 2. The Habitation MTC achieves the highest accuracy (98%), significantly outperforming Traditional GIS (70%), SASMAP (78%), and AI/ML models (75–90%, depending on dataset). Data compiled from published case studies by Malaperdas (2019, 2022), SASMAP project reports, and AI/ML implementations in digital archaeology. With a predictive accuracy of approximately 98%, MTC significantly outperforms other widely recognized models, including traditional GIS-based methods, the SASMAP predictive framework for submerged sites, and recent AI/ML-driven approaches.

What sets the MTC apart is not only its statistical precision but also its methodological innovation. Unlike other models that often rely heavily on environmental variables or automated classification alone, the MTC integrates a multi-layered epistemological framework rooted in Karl Popper's theory of the three worlds. It synthesizes physical data, cognitive factors, and theoretical abstraction into a dynamic and testable spatial logic, combining tools like the AHP, WLC, and advanced topographic analysis.

The MTC is increasingly recognized as a global innovation in computational archaeology. This recognition stems from its high predictive power, adaptability to diverse contexts, and incorporation of philosophical and theoretical depth. As a result, the model marks a paradigm shift by moving predictive archaeology beyond environmental determinism and toward a more interpretive, interdisciplinary understanding of ancient settlement behavior.

Further expanding his contributions, Malaperdas proposed a conceptual bridge between artificial intelligence (AI) and Network Analysis using GIS, detailed in his paper on communication networks in archaeology [11]. Though not yet formally published in peer-reviewed venues, this work represents a forward-looking perspective in which spatial datasets and probabilistic models can be dynamically enhanced using machine learning classifiers. The goal is to simulate and reconstruct communication pathways and information flow within ancient landscapes, extending beyond site prediction to the modeling of socio-territorial systems in antiquity.

This synthesis of AI and archaeology reflects a broader trend toward algorithmic archaeology, where automated reasoning supports human-centered research questions [12]. Malaperdas's vision aligns well with emerging international efforts to embed interpretive intelligence into quantitative models, elevating GIS from a mapping tool to a platform for archaeological theory experimentation. Also Malaperdas have a series of studies that helps archaeologists learn to use GIS and computer sciences [13]–[16].

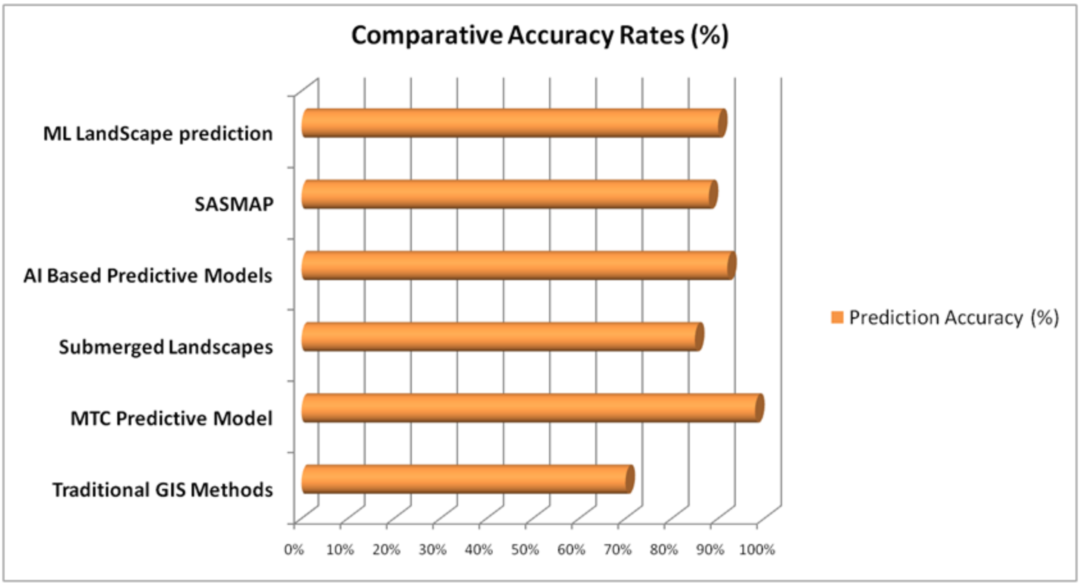

Figure 2. Comparative accuracy rates (%) for five archaeological predictive models

The innovative trajectory of Malaperdas finds powerful parallels in the work of Maurizio Forte, who has long been a leading advocate for cyber-archaeology [7]. Forte's research foregrounds immersive technologies such as virtual reality (VR) and augmented reality (AR) as integral to archaeological investigation—not merely as visualization tools but as epistemological interfaces. In his view, VR environments allow archaeologists to engage with simulated pasts in a reflexive, recursive manner, making the interpretive process both transparent and testable. Forte's reconstruction projects, such as the virtual republication of Pompeii's lost architecture, exemplify how digital embodiment transforms not only our perception of archaeological sites but also the nature of scholarly discourse itself [12].

At a different scale, Kristian Kristiansen has spearheaded the integration of Big Data approaches into the long-term study of human societies. A central figure in the so-called Third Science Revolution in archaeology, Kristiansen has promoted the use of isotopic, genetic, and geospatial datasets in the reconstruction of prehistoric European migration and kinship systems [3]. His use of GIS-based landscape models is inseparable from these biological methods, and his theoretical framework insists that the past must be understood as both materially embedded and structurally connected. Through his work on the Bronze Age, Kristiansen has shown how computational methods can facilitate cross-scalar analysis, linking individual agency to macro-historical transformation.

This integrative approach has been significantly strengthened through collaborations with leading molecular anthropologists. Researchers such as Eske Willerslev, Wolfgang Haak, and David Reich have pioneered the extraction and analysis of ancient DNA (aDNA) from archaeological remains, opening new avenues for inquiry [17]–[19]. Their work has not only transformed our understanding of prehistoric population movements—such as the migrations from the Pontic-Caspian steppe during the Bronze Age—but has also fostered a new epistemological model in archaeology, where genetic, isotopic, linguistic, and geospatial data are synthesized into transdisciplinary historical narratives.

A key example of this integrative approach is the seminal work by Haak et al. and Allentoft et al., co-authored by Kristiansen. These studies revealed strong genetic continuity between steppe populations and later European groups, providing compelling evidence for hypotheses regarding Indo-European dispersals. Such breakthroughs were made possible by the close integration of biological data with archaeological context and spatial modeling, particularly through the use of GIS-based analytical frameworks [3], [17], [18].

By forging links between computational modeling and biomolecular science, these scholars exemplify a shift toward a “consilience” model in archaeological interpretation—where multiple lines of evidence are statistically correlated, tested against historical hypotheses, and visualized through digital platforms [3], [19]. This approach does not replace traditional archaeological reasoning but rather augments it with robust, scalable, and reproducible methodologies. Together, these three scholars represent distinct but converging trajectories in digital archaeology: Malaperdas, with a focus on critical geospatial reasoning and network theory in Mediterranean landscapes; Forte, with an emphasis on immersive environments and reflexive interpretation; and Kristiansen, with a commitment to data integration and social modeling across deep time. Each demonstrates that computational archaeology is not simply a technical field, but a philosophical endeavor that reshapes the way we think about the past.

As these methods continue to evolve, their application will depend increasingly on interdisciplinary fluency, theoretical rigor, and ethical reflexivity-qualities that are deeply embedded in the work of these innovators [20]. Northern Europe has emerged as a dynamic and experimental landscape for the deployment of computational technologies in archaeology. The case studies presented here reflect a diversity of approaches, from predictive modeling in submerged landscapes to landscape-scale analysis and AI-driven historical mapping [21], [22].

One notable initiative comes from Denmark, where researcher Paschalina Giatsiatsou has developed a predictive model for locating submerged Mesolithic settlements. Utilizing GIS in combination with deep mapping and machine learning strategies, her methodology integrates photogrammetry, 3D modeling, and virtual reality to assess areas of high archaeological potential. This approach addresses key challenges in underwater archaeology, such as limited visibility, environmental constraints, and logistical complexity, while optimizing resource allocation by identifying predictive high-yield zones before full excavation [4].

A further exemplary project is SASMAP, also based in Denmark, which employs both downscaling and upscaling strategies to investigate prehistoric coastal landscapes. Downscaling involves the generation of high-resolution topographic maps through satellite imagery, LiDAR, and orthophotographs, alongside marine geophysical surveys using multibeam echo sounders and side-scan sonar. Upscaling complements this by selecting sediment cores for palaeoenvironmental analysis and reconstructing paleo-geographies to locate archaeological “hotspots.” The project’s methodological framework demonstrates how multi-scalar data integration can guide sustainable heritage management strategies for submerged cultural resources.

In Sweden, landscape archaeology has found strong expression through the work of Kristian Kristiansen, whose studies of Bronze Age burial mounds in northwestern Jutland emphasize the ideological and communicative roles of monuments within structured landscapes. His seminal paper “Decentralized Complexity” offers a digital spatial analysis of the distribution and alignment of tumuli, revealing intentional visual axes and land-use patterns tied to Bronze Age sociopolitical organization [3]. GIS-based mapping in this context supports the reconstruction of prehistoric territorial boundaries and ceremonial topographies, deepening our understanding of cultural complexity during this period.

Another Swedish case exemplifies the application of artificial intelligence in historical landscape reconstruction. Researchers Niclas Ståhl and Lisa Weimann employed deep CNNs to detect and classify wetland features in 19th-century maps from the Generalstabskartan. By training the neural model on manually annotated datasets, they succeeded in extracting historical wetland polygons, which were then transformed into GIS layers to study land-use changes and ecological degradation over time. Their work bridges the gap between environmental archaeology and digital heritage, with implications for both restoration ecology and the historiography of anthropogenic landscape transformation [9].

These projects collectively demonstrate the versatility of computational technologies in Northern European archaeology. Tools such as LiDAR, GIS, deep learning, and virtual reality are being adapted to address both archaeological and ecological questions, reflecting a flexible and innovative technological landscape. Moreover, they reveal a regional emphasis on multi-scalar analysis and environmental integration, which contrasts with—but also complements—the more culturally centered digital approaches commonly used in the Mediterranean as shown in Table 1.

Table 1. Comparative features of Mediterranean vs. Northern European digital archaeology projects

Feature	Mediterranean Region	Northern Europe
Key Researchers	G. Malaperdas, M. Forte	K. Kristiansen, P. Giatsiatsou
Primary Technologies	GIS, Predictive Modeling (MTC), AR/VR	LiDAR, AI/ML, Underwater Mapping
Philosophical Framework	Critical theory, Karl Popper's ontology	Landscape complexity, Consilience model
Focus	Settlement modeling, cultural layers	Submerged sites, landscape change
Data Types	Topography, solar exposure, historic context	LiDAR, bathymetry, ancient DNA
Epistemological Emphasis	Interpretive, reflexive, interdisciplinary	Environmental, multi-scalar, biological
Notable Projects	MTC in Messenia, Virtual Pompeii	SASMAP, CNN-based wetland mapping

3. THEORETICAL FRAMEWORK

Digital archaeology has evolved into a comprehensive and multidimensional scientific discipline that reshapes how archaeological knowledge is produced. No longer just a technological supplement, it now plays a central role in reconfiguring the epistemological foundations of the field. This transformation goes beyond technical improvements in data recording, processing, and analysis, representing a fundamental shift in how archaeological realities are conceptualized and interpreted.

Digital technologies such as GIS, 3D visualization, AI, and machine learning have become powerful epistemic catalysts in archaeological research. These tools do more than enhance technical capacity—they actively enable new ways of questioning, analyzing, and reinterpreting the past [23], [24]. By stabilizing archaeological information and transforming it into various forms of representation, they support multidimensional analyses that deepen our understanding of archaeological reality [25].

At the same time, digital archaeology challenges the traditional objectivism of science [26], [27]. In particular, the integration of artificial intelligence and algorithmic models raises fundamental philosophical issues. The incorporation of AI and algorithmic modeling foregrounds critical philosophical questions regarding the nature of scientific objectivity and the mediation of interpretation through computational means. Although these models are based on quantitative data, they incorporate underlying theoretical assumptions and choices that influence the final interpretation. Archaeology as a science is called to reconsider the relationship between data and theory, recognizing that algorithms do not merely produce "neutral" predictions but shape interpretive frameworks embedded with socio-cultural values.

The Habitation MTC exemplifies the ongoing theoretical evolution within digital archaeology. By incorporating Karl Popper's triadic ontology—comprising the physical world, the realm of human consciousness, and the domain of abstract theoretical constructs—it offers a unified, spatially oriented analytical framework. This reflects an epistemological shift from a primarily descriptive practice toward a more interpretive and theoretically grounded approach, where digital technologies actively shape the production of archaeological knowledge rather than merely supporting it.

The increasing use of AI in archaeology introduces important challenges related to algorithmic autonomy, transparency, and accountability in interpretation. These concerns highlight the need for a critical epistemological stance that goes beyond technical proficiency. In response, digital archaeology advocates for openness in algorithmic design and calls for explicit recognition of the theoretical assumptions embedded at every stage of the interpretive process.

Overall, digital archaeology functions as a field where technology and theory mutually inform each other, fostering a dynamic dialogue between data, interpretation, and the philosophy of science. In essence, digital archaeology represents a dynamic field characterized by a reciprocal and iterative interplay between technology and theory, fostering a continuous dialogue among empirical data, interpretive frameworks, and the philosophy of science. Beyond this interplay, ethical considerations are increasingly integral to the field, shaping the design, implementation, and implications of computational models.

Beyond this intellectual synergy, ethical considerations are increasingly recognized as integral to the discipline, informing the design, implementation, and broader implications of computational models. The convergence of theoretical, technological, and ethical domains forms a complex yet cohesive framework for practice. The convergence of theoretical, technological, and ethical dimensions establishes a nuanced and cohesive framework that guides contemporary archaeological practice. This triadic relationship is illustrated in the diagram below, highlighting their overlapping contributions and mutual dependencies within computational archaeology. Understanding and respecting this multifaceted foundation is essential for developing methodologies that transcend technological enthusiasm and meaningfully contribute to the renewal of archaeological knowledge as shown in Figure 3. Their convergence supports interpretive depth, methodological rigor, and responsible practice. This triadic model underscores the need for critical reflexivity in digital heritage work

Also, this paper underscores that the future of computational archaeology depends on its ability to embrace complexity by integrating theory and practice through transparent, ethical, and reflexive methodologies. By introducing a novel cross-regional synthesis that contrasts the Mediterranean's focus on critical GIS, AI, and theory-driven modeling with Northern Europe's emphasis on environmental reconstruction and remote sensing, this study highlights important regional distinctions while also revealing shared interdisciplinary approaches involving computer science, geomatics, environmental studies, and historical analysis. Scholars such as Malaperdas, Forte, and Kristiansen exemplify this balanced approach, showing how digital tools like the MTC evolve from technical applications into epistemological frameworks that enrich archaeological science without losing its critical and philosophical foundations as presented in Table 2.

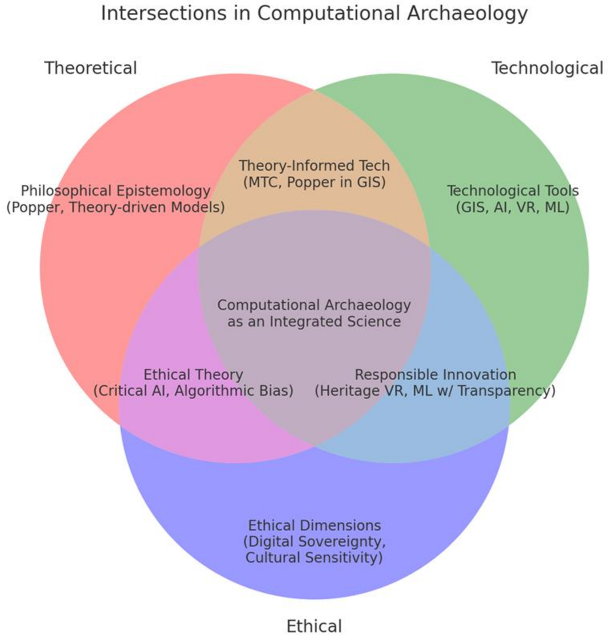

Figure 3. Venn diagram illustrating the intersection of theoretical, technological, and ethical pillars in computational archaeology

Table 2. Key findings from the comparative study of computational archaeology in the Mediterranean and Northern Europe

Aspects	Explanations
Comparative framework:	Introduced a novel cross-regional synthesis of computational archaeology, contrasting the Mediterranean and Northern Europe
Theoretical integration:	Showed how digital tools (e.g., MTC) are evolving into epistemological frameworks rather than remaining purely technical.
Regional distinctions:	Mediterranean: emphasis on critical GIS, AI, and theory-driven modeling.
	Northern Europe: focus on environmental reconstruction, remote sensing, and long-term ecological trends.
Shared interdisciplinarity:	Both regions blend archaeology with computer science, geomatics, environmental studies, and historical analysis.
Path forward:	Advocated for ethical, reflexive, and transparent computational practices to guide the future of digital archaeology.

4. CONCLUSIONS

The novelty of this research lies in its comparative framework and methodological synthesis, which moves beyond the isolated examination of computational models to analyze their cross-regional applicability and theoretical depth. While prior studies in computational archaeology have contributed valuable insights within specific regional contexts, they often lack a broader comparative perspective. By evaluating how methodological, theoretical, and institutional factors differently shape computational practices in the Mediterranean and Northern Europe, this paper expands the analytical scope of digital archaeology and offers a synthesis that has not been systematically presented before. The integration of computational technologies marks a paradigmatic shift, positioning digital archaeology as an epistemological framework that redefines archaeological knowledge, space, and time. In the Mediterranean, pioneers like George Malaperdas illustrate how theory-informed spatial modeling—exemplified by the Habitation MTC—transcends environmental determinism through the fusion of philosophy, historical context, and statistical rigor, while advancing innovative approaches that link AI with socioterritorial dynamics. Meanwhile, Northern Europe demonstrates a distinct but complementary trajectory emphasizing ecological reconstruction, environmental resilience, and heritage science through tools such as LiDAR, machine learning, and submerged predictive modeling. Importantly, both regions share a commitment to interdisciplinarity, blending archaeology with data science, geomatics, environmental studies, and history, thereby challenging and enriching archaeological epistemology. Ultimately, the future of computational archaeology depends on its ability to embrace complexity, integrate theory and practice, and cultivate transparent, ethical, and reflexive methodologies—an endeavor exemplified by the work of Malaperdas, Forte, and Kristiansen, who demonstrate how digital tools can deepen archaeological science while maintaining its critical and philosophical core.

FUNDING INFORMATION

Authors state no funding involved.

AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Hamza Kchan	✓	✓	✓	✓	✓	✓		✓	✓		✓			
Saira Noor	✓	✓	✓		✓			✓	✓		✓			

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

DATA AVAILABILITY

The data availability is not applicable to this paper as no new data were created or analyzed in this study.

REFERENCES

[1] M. Forte, "Virtual reality, cyberarchaeology, teleimmersive archaeology," *3D Recording and Modelling in Archaeology and Cultural Heritage.Theory and best practices*, pp. 113–127, 2014.
[2] G. Malaperdas and N. Zacharias, "A register of the residential Mycenaean sites of Messinia and their geo-environmental data," in *4th ARCH_RNT Symposium Proceedings*, 2020, pp. 24–45.
[3] K. Kristiansen, "Bronze age identities: from social to cultural and ethnic identity," *A Companion to Ethnicity in the Ancient Mediterranean*, pp. 82–96, 2014, doi: 10.1002/9781118834312.ch6.
[4] P. Giatsiatsou, "Predictive modelling in underwater archaeology. A case based on mesolithic coastal settlements in Denmark," *Acta Archaeologica*, vol. 94, no. 1, pp. 3–11, 2023, doi: 10.1163/16000390-09401044.
[5] G. Malaperdas and N. Zacharias, "The habitation model trend calculation (MTC): a new effective tool for predictive modeling in archaeology," *Geo-Spatial Information Science*, vol. 22, no. 4, pp. 314–331, 2019, doi: 10.1080/10095020.2019.1634320.
[6] G. Malaperdas, C. Maggidis, E. Karantzali, and N. Zacharias, "The habitation model trend calculation (MTC): ancient topography - the Mycenaean spercheios valley case study," *Interdisciplinaria Archaeologica*, vol. 13, no. 1, pp. 29–39, 2022.
[7] M. Forte, "Cyber archaeology: a post-virtual perspective," *Between Humanities and the Digital*, pp. 295–310, 2020, doi: 10.7551/mitpress/9465.003.0027.
[8] G. Bailey, N. Galanidou, H. Peeters, H. Jöns, and M. Mennenga, "The archaeology of europe's drowned landscapes: introduction and overview," in *Coastal Research Library*, 2020, vol. 35, pp. 1–23, doi: 10.1007/978-3-030-37367-2_1.
[9] N. Ståhl and L. Weimann, "Identifying wetland areas in historical maps using deep convolutional neural networks," *Ecological Informatics*, vol. 68, 2022, doi: 10.1016/j.ecoinf.2022.101557.
[10] K. Popper, *Three worlds: the Tanner lecture on human values*. Ann Arbor, MI: The University of Michigan, pp. 1–27, 1978.
[11] G. Malaperdas and A. Sarris, "Communication networks in archaeology: the case of Mycenaean Messenia," *Journal of Archaeological Science: Reports*, vol. 51, 2023, doi: 10.1016/j.jasrep.2023.104155.
[12] M. Forte and H. Murteira, D*igital cities: between history and archaeology*. New York, USA: United States of America by Oxford University Press, 2020.
[13] G. Malaperdas, "Practical methods of GIS for archaeologists: spatial division in a large area," *International Journal of Geoinformatics and Geological Science*, vol. 6, no. 1, pp. 1–6, 2019, doi: 10.14445/23939206/ijggs-v6i1p101.
[14] G. D. Malaperdas, "Practical methods of GIS for archaeologists: viewshed analysis - The Kingdom of Pylos example," *Geoplanning*, vol. 8, no. 1, pp. 1–22, 2021, doi: 10.14710/geoplanning.8.1.1-22.
[15] G. Malaperdas and D. Panoskaltsis, "The naval base of Navarino: mapping the fortifications of the Italians in Pylos," *Communications in Computer and Information Science*, vol. 1574, pp. 149–163, 2022, doi: 10.1007/978-3-031-20253-7_13.
[16] G. Malaperdas, "Techniques for drawing and mapping a cultural route," *e-Review of Tourism Research*, vol. 19, no. 2, 2022.
[17] M. E. Allentoft *et al.*, "Population genomics of bronze age Eurasia," *Nature*, vol. 522, pp. 167–172, 2015.
[18] W. Haak *et al.*, "Massive migration from the steppe was a source for Indo-European languages in Europe," *Nature*, vol. 522, no. 7555, pp. 207–211, 2015, doi: 10.1038/nature14317.

[19] D. Reich, *Who we are and how we got here. Ancient DNA and the new science of the human past*. Oxford, England: Oxford University Press, pp. 334–338, 2021.

[20] M. Forte, "Scientific visualization and archaeological landscape: the case study of a terramara, Italy," in *Archaeology And Geographic Information Systems*, 1st Edition, pp. 231–238, 2023.

[21] N. C. Cramer, "From paper maps to artificial intelligence: a historical analysis of cartography and geospatial science," *H.B.S. Thesis*, Department of Geography and Geospatial Science, Oregon State University, Corvallis, Oregon, 2025.

[22] İ. Kutlu, "Scientific mapping of artificial intelligence (AI) assisted applications in historical building conservation," *Journal of Asian Architecture and Building Engineering*, pp. 1–21, 2025, doi: 10.1080/13467581.2025.2505794.

[23] S. Alamri, "The geospatial crowd: Emerging trends and challenges in crowdsourced spatial analytics," *ISPRS International Journal of Geo-Information*, vol. 13, no. 6, 2024, doi: 10.3390/ijgi13060168.

[24] M. Chen *et al.*, "Artificial intelligence and visual analytics in geographical space and cyberspace: research opportunities and challenges," *Earth-Science Reviews*, vol. 241, 2023, doi: 10.1016/j.earscirev.2023.104438.

[25] G. Malaperdas, "The influence and impact of bioclimatic indicators on the evolution of biosociety. a geoarchaeological approach," *World News of Natural Sciences*, pp. 183-198, 2019.

[26] G. Malaperdas, R. Grethe, and N. Zacharias, "Depicting the past: the value of old maps and topographic diagrams in cultural heritage through GIS," *Journal of Archaeological Science: Reports*, vol. 52, 2023, doi: 10.1016/j.jasrep.2023.104276.

[27] A. F. Nsanziyera, H. Rhinane, A. Oujaa, and K. Mubea, "GIS and remote-sensing application in archaeological site mapping in the awsard area (Morocco)," *Geosciences*, vol. 8, no. 6, 2018, doi: 10.3390/geosciences8060207.

[28] A. Sarris, "The polymorphism of archaeological GIS. Unfolding the archaeological dimensions of GIS," *Journal of Greek Archaeology*, vol. 9, pp. 9-19, 2024.

[29] I. C. Nicu, A. Mihu-Pintilie, and J. Williamson, "GIS-based and statistical approaches in archaeological predictive modelling (NE Romania)," *Sustainability*, vol. 11, no. 21, 2019, doi: 10.3390/su11215969.

[30] A. Balla, G. Pavlogeorgatos, D. Tsiafakis, and G. Pavlidis, "Recent advances in archaeological predictive modeling for archeological research and cultural heritage management," *Mediterranean Archaeology and Archaeometry*, vol. 14, no. 4, pp. 143–153, 2014.

BIOGRAPHIES OF AUTHORS

Hamza Kchan is a graduate student at the College of Humanities and Social Sciences, Louisiana State University. His research focuses on computational archaeology, with particular interest in regional modeling, GIS applications, and the theoretical implications of digital methods in archaeological analysis. He can be contacted at email: hamzakchan@gmail.com.

Saira Noor is a graduate student at the College of Humanities and Social Sciences, Louisiana State University. Her academic work centers on the use of AI, spatial analysis, and immersive technologies in archaeology, with an emphasis on ethical and interdisciplinary approaches to digital heritage. She can be contacted at email: NoorSair@gmail.com.